

Union Pacific Railroad Company,
Daniel C. Helix, Mary Lou Helix,
Elizabeth Young, John V. Hook,
Steven Pucell, Nancy Ellicock,
and the Contra Costa County Redevelopment Agency

Feasibility Study

Hookston Station

Pleasant Hill, California

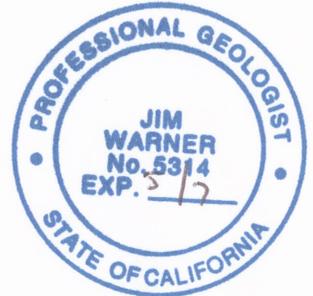
10 July 2006

Environmental Resources Management
1777 Botelho Drive, Suite 260
Walnut Creek, CA 94596

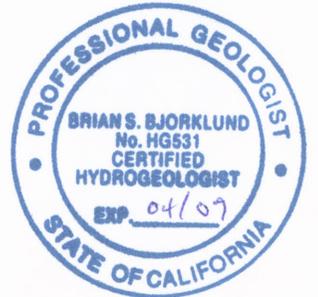
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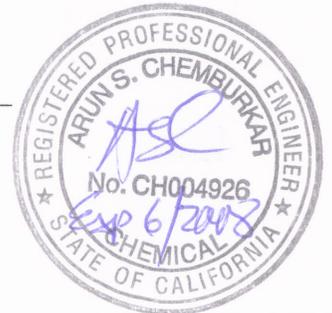


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LIST OF ACRONYMS

<u>Acronym</u>	<u>Definition</u>
ARAR	Applicable or Relevant and Appropriate Requirements
bgs	Below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulation
CHHSL	California Human Health Screening Levels
COC	Contaminant of concern
CPT	Cone penetrometer testing
CTEH	Center for Toxicology and Environmental Health
CVOC	Chlorinated volatile organic compound
DCE	Dichloroethene
ERM	ERM-West, Inc.
EPA	Environmental Protection Agency
ESL	Environmental Screening Level
FS	Feasibility Study
GRA	General Response Action
IRM	Interim Remedial Measure
m ³ /day	Cubic meters of air per day
MCL	Maximum Contaminant Level

<u>Acronym</u>	<u>Definition</u>
mg/kg	Milligram per kilogram
MIP	Membrane interface probe
MNA	Monitored Natural Attenuation
MTBE	Methyl-tert-butyl ether
NCP	National Contingency Plan
NPV	Net present value
O&M	Operation and Maintenance
PCB	Polychlorinate biphenyl
PCE	Tetrachloroethene
pH	Acidity/alkalinity
PPE	Personal protective equipment
PRB	Permeable reactive barrier
RA	Risk Assessment
RAO	Remedial Action Objectives
RI	Remedial Investigation
RP	Responsible Parties
RWQCB	San Francisco Bay Regional Water Quality Control Board
SMP	Soil Management Plan
SVE	Soil Vapor Extraction
SVOC	Semivolatile organic compound
T&R	Treadwell & Rollo

<u>Acronym</u>	<u>Definition</u>
TBC	To be considered
TCE	Trichloroethene
TMV	Toxicity, mobility, and volume
TPH	Total petroleum hydrocarbon
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
μg/kg	Microgram per kilogram
μg/L	Microgram per liter
μg/m ³	Microgram per cubic meter

EXECUTIVE SUMMARY

This Feasibility Study (FS) has been submitted to the Regional Water Quality Control Board San Francisco Bay Region (RWQCB) by ERM-West, Inc. (ERM) on behalf of the Hookston Station Responsible Parties (RPs) for the Hookston Station Parcel in Pleasant Hill, California. The Hookston Station RPs include Union Pacific Railroad, Daniel C. Helix, Mary Lou Helix, Elizabeth Young, John V. Hook, Steven Pucell, Nancy Ellicock, and the Contra Costa County Redevelopment Agency. This FS has been prepared to comply with the requirements of RWQCB Order Number R2-2003-0035 (16 April 2003) and amended Order Number R2-2004-0081 (15 September 2004). The primary environmental concern associated with the Hookston Station Parcel is volatile organic compounds (VOCs) in soil, soil vapor, and ground water. The goal of the FS is to develop a final remediation program that is protective of human health and the environment. This FS has been developed in compliance with the *National Oil and Hazardous Substance Pollution Contingency Plan* (Code of Federal Regulations 40, Part 300 et seq.) and *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation and Liability Act* (United States Environmental Protection Agency [USEPA] 1988).

The *Remedial Investigation Report* (ERM 2004) and *Baseline Risk Assessment* (CTEH 2006) have been submitted to and approved by the RWQCB. These documents provide the basis for the remedial action objectives, cleanup goals, and impacted areas/volume of media that are presented in this FS. A range of potentially applicable remedial approaches were screened according to the criteria of effectiveness, implementability, and cost. The screening process was used to develop six remedial alternatives for further consideration to identify a final remedy. These six alternatives were subjected to a detailed comparative analysis based on the following seven of the nine USEPA evaluation criteria:

- Protection of Human Health and the Environment;
- Compliance with Applicable or Relevant and Appropriate Requirements;

- Long-Term Effectiveness;
- Reduction in Toxicity, Mobility, and Volume;
- Short-Term Effectiveness;
- Implementability; and
- Cost.

Based on the comparative analysis, Remedial Alternative 4 was selected as the final remedy for the Hookston Station Parcel and downgradient study area. This alternative best meets the risk management goals in light of the seven evaluation criteria, and includes the following components:

- Installation of a permeable reaction barrier with zero valent iron in the A-Zone to remediate ground water.
- Implementation of in situ chemical oxidation in the B-Zone to remediate ground water.
- Implementation of vapor intrusion prevention systems to address migration of VOCs from ground water to indoor air in residences.
- Institutional controls for a single isolated area of arsenic in soil on the Hookston Station Parcel that will remain in place, involving implementation of a Soil Management Plan.
- Institutional controls for ground water prohibiting use until water quality goals are met.
- Institutional controls for ground water in the downgradient study area involving prohibiting use until water quality goals are met.

This FS also presents an Implementation Plan for the final remedy. This plan presents the process and schedule that would be followed to implement the remedial program. This plan includes the following primary elements:

- Pre-Design Investigations;
- Remedial Design;

- Pre-Implementation Documentation and Permitting;
- Contracting and Procurement;
- Implementation of Remedy; and
- Effectiveness Monitoring.

The Hookston Station RPs have developed a remedial strategy that addresses the chemicals originating at Hookston Station in a manner that is protective of human health and the environment. The remedial program selected in this FS is designed to address those chemicals. The residential area to the northeast of Hookston Station is also being impacted by chemicals originating from other source areas. The non-Hookston Station sources of those additional ground water contaminants must also be identified and remediated to assure attainment of the final remedial action objectives in the residential area.

1.0 INTRODUCTION

On behalf of the Hookston Station Responsible Parties (Hookston RPs), ERM-West, Inc. (ERM) has prepared this *Feasibility Study* (FS) for the approximately 8-acre property known as the Hookston Station property (hereinafter referred to as “Hookston Station Parcel”) and the mixed ground water plume located northeast of the Hookston Station Parcel (hereinafter referred to as the “downgradient study area”). The Hookston RPs include Union Pacific Railroad Company, Daniel C. Helix, Mary Lou Helix, Elizabeth Young, John V. Hook, Steven Pucell, Nancy Ellicock, and the Contra Costa County Redevelopment Agency. The Hookston Station Parcel is located at the intersection of Hookston and Bancroft Roads in Pleasant Hill, California (Figure 1-1). Chlorinated volatile organic compounds (CVOCs), including trichloroethene (TCE) and other CVOCs, have been detected in soil, soil vapor, ground water, and indoor air at and downgradient of the Hookston Station Parcel. The chemicals of concern that originate from the Hookston Station Parcel include TCE and associated degradation compounds. This document presents a remediation program to protect human health and the environment in accordance with Regional Water Quality Control Board (RWQCB) Order No. R2-2003-0035, dated 16 April 2003 (amended on 15 September 2004 as Order No. R2-2004-0081).

1.1 REPORT ORGANIZATION

This document is organized as follows:

- Section 1.0 states the purpose of this document and presents the Hookston Station Parcel background information;
- Section 2.0 presents a summary of the remedial investigation and the human health risk assessment conducted for Hookston Station Parcel and the downgradient study area;
- Section 3.0 describes previous remedial actions and technology studies that have been completed;

- Section 4.0 develops the Remedial Action Objectives (RAOs) for the FS, and discusses Applicable or Relevant and Appropriate Requirements (ARARs), cleanup goals, and impacted areas/media;
- Section 5.0 identifies and screens potentially applicable remedial technologies and response actions for the Hookston Station Parcel and downgradient study area;
- Section 6.0 describes the remedial alternatives developed for evaluation based on applicable screening criteria;
- Section 7.0 presents a detailed and comparative analysis of remedial alternatives using accepted evaluation criteria to select a final remedy for the Hookston Station Parcel and downgradient study area;
- Section 8.0 presents an implementation plan for the selected remedial alternative; and
- Section 9.0 presents references for the FS.

Tables, figures, and appendices referenced in this report are provided following the text. This report includes 10 appendices as follows:

- Appendix A - Additional Soil Arsenic Sampling;
- Appendix B - Soil Vapor Sampling;
- Appendix C - Chemical Oxidation Treatability Study;
- Appendix D - Fate and Transport Evaluation;
- Appendix E - Soil Vapor Extraction (SVE) Pilot Test;
- Appendix F - Geotechnical Laboratory Report;
- Appendix G - Aquifer Testing;
- Appendix H - Risk-Based Cleanup Concentrations for Chemicals of Concern;
- Appendix I - Ground Water Modeling; and

- Appendix J – Remedial Alternatives Cost Analyses.

1.2

PURPOSE OF REPORT

The objective of this FS is to develop a remediation program for the Hookston Station Parcel and downgradient study area that is protective of human health and the environment. The Remedial Investigation (RI) and FS process represents methodology that has been established by the United States Environmental Protection Agency (USEPA) for characterizing the nature and extent of risks posed by hazardous waste sites and for evaluating potential remedial options to address these risks. The objective of the process is to gather sufficient information to support an informed risk management decision regarding the most appropriate remedy for a site.

The FS serves as the mechanism for the development, screening, and detailed evaluation of alternative remedial actions. The FS utilizes the information developed during the RI and Baseline Risk Assessment (BRA) to:

- Develop specific RAOs and cleanup goals;
- Identify and screen applicable remedial technologies;
- Develop remedial alternatives using applicable technologies and management options;
- Conduct a comparative evaluation of remedial alternatives; and
- Recommend a specific remedial alternative to address the risks posed by site-related chemicals of concern.

This FS has been developed in compliance with USEPA guidance for preparation of FS documents (*Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA, USEPA 1988b]* and the *National Oil and Hazardous Substance Pollution Contingency Plan [Title 40 of the Code of Federal Regulations [CFR], Part 300 et seq.]*).

1.3 *BACKGROUND*

This section summarizes background and historical information regarding the Hookston Station Parcel and the surrounding area.

1.3.1 *Hookston Station Parcel Location and Physical Description*

The Hookston Station Parcel property boundaries are shown on Figure 1-2. The area encompassed by the property boundaries shown on Figure 1-2 is referred to in this FS as the Hookston Station Parcel.

The Hookston Station Parcel is located near the intersection of Hookston Road and Bancroft Road in Contra Costa County, Pleasant Hill, California. Figure 1-1 illustrates the location of the Hookston Station Parcel.

The property boundaries form an elongated strip that runs north to south along a former railroad right-of-way and encompass an area of approximately 8 acres. The physical characteristics of the Hookston Station Parcel are shown on Figure 1-2. The Hookston Station Parcel includes the following four addresses:

- 199 Mayhew Way;
- 222 Hookston Road;
- 228 Hookston Road; and
- 230 Hookston Road.

The eastern half of the Hookston Station Parcel is mostly vacant, with only one structure associated with 230 Hookston Road. Gravel and overgrown vegetation, with limited amounts of asphalt pavement, cover the ground surface of this portion of the Hookston Station Parcel.

The structures and operations associated with 199 Mayhew Way and 222 and 228 Hookston Road are situated on the western portion of the Hookston Station Parcel. The areas surrounding these structures are utilized for parking and driveways and are mostly covered with asphalt pavement with few gravel areas.

Pedestrian access to the Hookston Station Parcel is mostly limited to narrow alleyways that lead from Hookston Road to the north and

Mayhew Way to the south due to chain-link fencing and existing structures. The City of Concord recently installed a pedestrian/bike path that extends the Iron Horse Trail along the eastern property boundary, and now diverts this local foot traffic away from the industrial and commercial operations at the Hookston Station Parcel.

1.3.2 *Historical and Current Uses of the Hookston Station Parcel*

The Hookston Station Parcel was operated by Southern Pacific Transportation Company as a portion of the San Ramon Branch rail line from approximately 1891 to 1965. During that time, the Hookston Station Parcel included a freight-loading platform with railroad sidings and was used as a station for loading fruit and lumber.

Between approximately 1965 and 1983, the land was developed into a mixed light-industrial business complex, and was occupied by auto-related businesses, lumber yards, furniture manufacturing, metal working shops, and masonry works. Additional information related to historical business practices and chemical use at the Hookston Station Parcel is described in the *Site History Data Summary* (ERM 2003a).

The property ownership was transferred from the Southern Pacific Transportation Company to Daniel C. Helix, Mary Lou Helix, Elizabeth Young, John V. Hook, Steven Pucell, and Nancy Ellicock, in 1983. The Contra Costa County Redevelopment Agency subsequently acquired the eastern portion of the Hookston Station Parcel from these owners in 1989. The western portion of the Hookston Station Parcel has been sublet to various auto-related businesses including repair and body shops, as well as warehouse space, a lumber yard, an upholstery shop, a masonry shop, and a feed store. The eastern portion of the Hookston Station Parcel was previously occupied by lumber yards, recycling facilities, auto-related businesses, machining repair shops, and a roofing company.

The Hookston Station Parcel is currently used exclusively for industrial and commercial activities. A feed and pet supply store occupies the majority of the northeastern portion of the Hookston Station Parcel, including the structures at 222 and 228 Hookston Road. The structure at 199 Mayhew Way is divided into several smaller suites, which are occupied by two automobile maintenance and body shops, a window and cabinet (woodworking) shop, a wood milling facility, and storage units. A

concrete batch plant is present on a portion of the eastern half of the Hookston Station Parcel at 230 Hookston Road. The vacant portions on the eastern half of the Hookston Station Parcel were most recently operated as a lumberyard and a recycling facility.

Future use of the Hookston Station Parcel is likely to remain industrial/commercial, similar to current land use. No plans are known to exist for redevelopment of the Hookston Station Parcel. Given this land use, it is not expected that new water supplies (new supply wells) will be developed at the Hookston Station Parcel.

1.3.3 *Surrounding Land Use*

The properties surrounding the Hookston Station Parcel include residential areas and mixed office/commercial/light industrial enterprises (Figure 1-2). Private residences, consisting of single-family homes, town homes, and apartment buildings, are located northeast, east, and south of the Hookston Station Parcel. The Hookston Station Parcel is bordered to the west by mixed-use operations, including business offices, commercial spaces, and some light industry. A bulk fuel storage and distribution facility (Pitcock Petroleum/Chevron Products) is also located immediately west of the Hookston Station Parcel near the northwestern property boundary. A self-storage business and small community park are situated north of the Hookston Station Parcel.

1.3.4 *Beneficial Uses of Ground Water and Surface Water*

The current and future potential beneficial uses of the ground water and surface water are those identified in the *Water Quality Control Plan for the San Francisco Bay Basin* (Basin Plan) (RWQCB 1995) for the Suisun Basin and Ygnacio Valley Ground Water Basin. The current and future potential beneficial uses have been considered in the development of the RAOs for the Hookston Station Parcel and downgradient study area, as described in Section 4.

1.3.4.1 *Existing Beneficial Uses*

The Basin Plan identifies the existing beneficial use of ground water at the Hookston Station Parcel and surrounding areas as domestic water supply. Well surveys conducted by ERM (Section 2.1.1) identified several private

wells on residential properties downgradient of the Hookston Station Parcel. The survey results indicated that the wells were limited to use for irrigation purposes, if used at all, and none of the wells were used for drinking water. Additional existing beneficial uses of ground water at and near the Hookston Station Parcel have not been identified.

The existing beneficial uses of surface water near the Hookston Station Parcel include warm and cold fresh water habitats, fish migration and spawning, and wild life habitat.

1.3.4.2 *Potential Beneficial Uses*

As outlined in the Basin Plan, potential beneficial uses of ground water at and near the Hookston Station Parcel include the following:

- Municipal and domestic water supply;
- Industrial process water supply;
- Industrial service water supply; and
- Agricultural water supply.

In addition to the existing beneficial uses, the Basin Plan identifies the following potential beneficial uses for Walnut Creek, the surface water body closest to the Hookston Station Parcel (additional information regarding surface water is provided in Section 2.1):

- Water contact recreation; and
- Non-contact water recreation.

1.3.5 *Hookston Station Parcel Regulatory Background*

The first environmental investigation at the Hookston Station Parcel was completed on behalf of the Contra Costa County Public Works Department in 1990. Several subsequent phases of soil and ground water investigation were completed between 1990 and 1996. These investigations were completed under the direction of Contra Costa County Hazardous Materials Division, a division of the Contra Costa

County Health Services Department. Copies of those investigation reports were also submitted to the RWQCB.

The RWQCB has overseen investigation and remedial activities conducted at the Hookston Station Parcel and downgradient study area since 2000. On 16 April 2003, the RWQCB issued an Initial Site Cleanup Requirement (Order No. R2-2003-0035) for the Hookston Station Parcel. That Order required completion of the following 10 tasks:

- Task 1 - Source Area Investigation Work Plan (completed);
- Task 2 - Community Relations Plan (completed);
- Task 3 - Risk Assessment Work Plan (completed);
- Task 4 - Area Well Survey (completed);
- Task 5 - RI Work Plan (completed);
- Task 6 - Source Area Investigation/Interim Remedial Measures (IRM) Work Plan (completed);
- Task 7 - Implementation of Source Area IRM (completed [none required]);
- Task 8 - Risk Assessment (completed);
- Task 9 - RI (completed); and
- Task 10 - Feasibility Study (this document).

The RWQCB amended the 16 April 2003 Order on 15 September 2004 (Order No. R2-2004-0081). The amended Order required the following tasks be completed for the Hookston Station Parcel and downgradient study area:

- Task 8a - Indoor Air Sampling Work Plan (completed);
- Task 8b - Baseline Human Health Risk Assessment (completed); and
- Task 8c - Indoor Air Sampling Report (completed).

1.3.6

Adjacent Environmental Sites

In addition to TCE, additional volatile organic compounds (VOCs), including tetrachloroethene (PCE) and methyl tert butyl ether (MTBE) have been detected in ground water at and near the Hookston Station Parcel. The RWQCB has concluded that the PCE and MTBE ground water impacts originate from other nearby properties, not the Hookston Station Parcel (RWQCB 2006b). The sources of these chemicals are discussed below and depicted on Figure 1-3.

- The Pitcock Petroleum site (220 Hookston Road) is characterized by petroleum hydrocarbon impacts to ground water, including MTBE, benzene, and total petroleum hydrocarbons (TPH) at concentrations exceeding the drinking water Maximum Contaminant Levels (MCLs). These ground water impacts flow in a northeasterly direction and have migrated below the Hookston Station Parcel and additional properties located northeast (downgradient) of 220 Hookston Road. The downgradient extent of these ground water impacts has not yet been determined. The RWQCB is requiring the owners of the Pitcock Petroleum site to conduct additional investigation activities of the hydrocarbon impacts (RWQCB 2006c).
- TCE and PCE (a VOC that degrades to TCE and other chlorinated VOCs) have been identified in ground water west of Vincent Road. This PCE/TCE plume is referred to herein after as the "Vincent Road PCE/TCE plume" or "Vincent Road PCE/TCE source area", and is situated upgradient of the Hookston Station Parcel. Ground water within the Vincent Road PCE/TCE ground water plume flows in a northeasterly direction below the northern portion of the Hookston Station Parcel and contains concentrations of PCE and TCE at concentrations exceeding the MCLs. As stated previously, PCE is not a chemical that originates from the Hookston Station Parcel. The RWQCB has required the property owners of 3301-3341 Vincent Road, 3343-3355 Vincent Road, and 81 Mayhew Way to perform soil and ground water investigations in an attempt to identify the source area(s) and responsible party(ies) for these impacts.

The Vincent Road PCE/TCE ground water plume and the Pitcock Petroleum ground water plume mix in the northwestern portion of the Hookston Station Parcel. Chemicals originating from the Hookston

Station Parcel mix with these two other VOC plumes northeast of the Hookston Station Parcel. This mixed plume flows in a northeasterly direction beyond the Hookston Station Parcel and below the neighborhood located northeast of the Hookston Station Parcel. This mixed plume area outside of the Hookston Station Parcel is referred to hereinafter as the “downgradient study area.”

The Hookston RPs are currently investigating specific locations along Bancroft Road to determine if they may be separate additional source(s) of VOCs contributing to the mixed ground water plume in the downgradient study area.

2.0

SUMMARY OF REMEDIAL INVESTIGATION AND HEALTH RISK ASSESSMENT

In accordance with Orders No. R2-2003-0035 and R2-2004-0081, the Hookston RPs have completed the RI and BRA. The results of these activities were presented in the following documents:

- *Remedial Investigation Report* (ERM 2004) (RI Report), conditionally approved by the RWQCB on 19 November 2004; and
- *BRA* (CTEH 2006), approved by the RWQCB on 10 March 2006.

Together, these reports define the constituents of concern; the extent of impacts in soil, soil vapor, ground water, air, surface water, and sediment; and the potential human health risks associated with current conditions. This section of the FS summarizes the portions of the RI and BRA that are relevant to the calculation of clean up goals, technology screening, and selection of an appropriate remedial alternative.

2.1

REMEDIAL INVESTIGATION SUMMARY

RI activities were conducted to evaluate the nature and extent of TCE impacts originating from the Hookston Station Parcel. As part of the RI, the Hookston RPs also conducted limited investigation activities of ground water impacts that originate from the Vincent Road PCE/TCE source area (Section 1.3.6). CVOCs were detected in soil, soil vapor, ground water, and indoor air at the Hookston Station Parcel and in soil vapor, ground water, and indoor air within the downgradient study area. CVOCs were also detected in ground water and soil vapor near the Vincent Road PCE/TCE source area.

This summary of the RI results includes the following:

- A summary of investigation activities;
- A description of the geologic and hydrogeologic setting;
- Identification of chemicals found in soil and description of their nature and extent;
- Identification of chemicals found in soil vapor and description of their nature and extent;

- Identification of chemicals found in ground water and description of their nature and extent;
- Identification of chemicals found in indoor air and description of their nature and extent; and
- Identification of chemicals found in surface water and sediment and description of their nature and extent.

2.1.1 *Field Investigation Activities*

Several preliminary phases of investigations were conducted between 1989 and 1996 on behalf of various parties by different consultants. Those investigation activities included soil, soil vapor, and ground water investigations. For additional information, the reader is referred to the RI Report.

On behalf of the Hookston RPs, ERM conducted the RI in a phased approach between October 2001 and April 2004. Phase I of the RI included:

- Collection and analysis of soil samples and passive soil vapor samples;
- Collection and analysis of sediment and surface water samples from Walnut Creek;
- Collection and analysis of ground water samples from monitoring wells located on the Hookston Station Parcel and in the downgradient study area;
- Water level measurements from monitoring wells;
- Advancement of multilevel cone penetrometer testing borings;
- Surface vapor flux sampling; and
- Water well survey of existing well records on file with the State of California Department of Water Resources.

Phase II of the RI included:

- Source area soil and a regional ground water investigation that included the collection of additional soil and ground water samples from the Hookston Station Parcel;
- Active soil vapor investigation;

- Private well survey;
- Installation and sampling of additional monitoring wells on the Hookston Station Parcel, in the downgradient study area, and in the Vincent Road PCE/TCE ground water plume; and
- Collection of indoor air quality samples from structures located on the Hookston Station Parcel and in the downgradient study area.

For additional details, the reader is referred to the *Remedial Investigation Progress Report* (ERM 2002a), the *Source Area Investigation and Interim Remedial Measures Analysis Report* (ERM 2003b), and the RI Report previously referenced.

On-going activities that have continued include:

- Routine quarterly ground water quality monitoring since March 2001; and
- Routine quarterly soil vapor monitoring since April 2005.

The results of those monitoring events have been documented in quarterly reports prepared by ERM and submitted to the RWQCB.

2.1.2 *Geology and Hydrogeology*

The following sub-sections summarize the geologic, surface water, and ground water conditions of the Hookston Station Parcel and downgradient study area based on data collected during the RI and previous investigations.

2.1.2.1 *Geologic Setting*

The Hookston Station Parcel and surrounding area are underlain by unconsolidated deposits that extend to at least 100 feet below ground surface (bgs), as shown on Figure 2-1 and summarized below:

- Fine-grained clays and silts are present from the ground surface (or immediately below the ground surface cover materials) to depths typically ranging from 30 to 40 feet bgs. This zone has been defined by ERM as the "A-Zone", and contains discontinuous lenses of sands, silty sands, and gravelly sands that are interbedded in the fine-grained deposits. These coarser grained lenses range in thickness from a few inches to approximately 11 feet, but are more commonly only a few feet in thickness.

- Beneath the A-Zone, a relatively continuous sand unit that is interbedded with silt and clay lenses is present between the approximate depths of 30 and 70 feet bgs. This zone has been defined by ERM as the “B-Zone”. The sands of the B-Zone are generally 5 to 10 feet thick and range from well-sorted sands, clayey sands, to gravelly sands; a few gravel zones are also encountered in this unit. The silt and clay lenses within the B-Zone are up to 10 feet thick but are generally less than a few feet thick.
- A clay unit that is 10 to 40 feet thick is present beneath the B-Zone.
- A deeper sand unit, defined by ERM as the “C-Zone”, is present beneath the clay unit and is initially encountered at depths ranging from 65 to 97 feet bgs. The C-Zone is also a continuous sand unit that is interbedded with silt and clay lenses. The C-Zone extends to approximately 100 feet bgs; the deposits deeper than 100 feet bgs have not been characterized.

2.1.2.2 *Surface Water Hydrology*

The Hookston Station Parcel and surrounding area are located within the Suisun Basin watershed of the San Francisco Bay Basin, as defined in the Basin Plan (RWQCB 1995). The nearest surface water body is Walnut Creek. The creek is located approximately 1,300 feet east/northeast (downgradient) of the Hookston Station Parcel and flows in a northerly direction for several miles before emptying into the Suisun Bay. The creek has been modified by the Contra Costa County Flood Control District and is currently part of an engineered storm water drainage network. The creek is unlined in the vicinity of the Hookston Station Parcel and is secured from public access by permanent fencing.

2.1.2.3 *Ground Water*

The Hookston Station Parcel and surrounding area are located within the Ygnacio Valley ground water basin, as outlined in the Basin Plan (RWQCB 1995). Ground water in the A-, B, and C-Zones flows in northeasterly to northerly directions. Ground water potentiometric surface maps for each water-bearing zone (based on the First Quarter 2006 monitoring event) are provided as Figures 2-2 through 2-4. The potentiometric ground water levels in each of these zones have historically ranged from approximately 12 to 23 feet bgs in the A-Zone, 13 to 24 feet bgs in the B-Zone, and 16 to 21 feet bgs in the C-Zone. The overall hydraulic gradients in the three zones have typically ranged from 0.001 to 0.004 foot per foot (ft/ft) across the entire monitored area. Based

on ground water level measurements and stratigraphy, the three water-bearing zones are confined to semi-confined.

2.1.3 *Chemical Occurrence in Soil*

Soil samples were collected at the Hookston Station Parcel for laboratory analysis of VOCs, TPH, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals. Soil analytical results were compared in the RI Report to the RWQCB's Environmental Screening Levels (ESLs) for soil where ground water is a current or potential drinking water source, as defined in *Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater, Volume 1: Summary Tier I Lookup Tables* (RWQCB 2003). Table 2-1 summarizes the soil chemical occurrence with respect to current ESLs (RWQCB 2005). Detailed information regarding soil sampling locations, summary data tables, and laboratory analytical reports are presented in the RI Report.

A total of 273 soil samples collected from 86 locations were analyzed for VOCs. The VOC concentrations in soil throughout the Hookston Station Parcel are generally low, with only a few sample concentrations exceeding the ESLs. TCE was the most frequently detected VOC in soil, but only seven of the 273 soil samples reported TCE concentrations greater than the TCE soil ESL (460 micrograms per kilogram [$\mu\text{g}/\text{kg}$]). The highest concentrations (up to 2,580 $\mu\text{g}/\text{kg}$) were detected in samples collected from 2 to 5 feet bgs from underneath or immediately adjacent to the 199 Mayhew Way structure. The TCE soil concentrations decrease rapidly with depth, with only a few samples reporting elevated TCE concentrations just above the static water level. Figure 2-5 illustrates the distribution of TCE in soil.

Nineteen surface soil samples were collected for metals analysis at the Hookston Station Parcel during the RI and previous investigations. Most of the samples contained metals concentrations and distributions that are consistent with background metals concentrations in California soils. Soil samples from two locations (B-69 and B-84) contained arsenic concentrations that appeared to be higher than background.

In May 2006, additional soil sampling was completed B-69 and B-84. Soil sampling was also conducted in June 2006 at one location (S-09) where arsenic was not previously detected but an elevated reporting limit (500 milligrams per kilogram [mg/kg]) was utilized in the analysis. The results of those studies indicated that arsenic concentrations were not elevated in surface soils at B-69, B-84 or S-09, but did indicate elevated arsenic concentrations in subsurface soils near B-69. The results of those sampling activities, along with a discussion on background concentrations

of arsenic in soils, are provided in Appendix A. Sampling locations and results are illustrated on Figure 2-6.

2.1.4 *Chemical Occurrence in Soil Vapor*

Soil vapor samples (also known as “soil gas” samples) have been collected using the following three methods during the RI, previous investigations by other consultants, quarterly monitoring events, and during recent (June 2006) sampling activities:

- *Passive soil vapor sampling*, which uses small adsorbent traps that are installed at a depth of approximately 3 feet bgs and remain in the subsurface for approximately 2 weeks;
- *Active soil vapor sampling from temporary direct-push sampling equipment* (for one-time sampling events). Active soil vapor samples are collected over a relatively short period of time, typically less than 1 hour per sample collected; and
- *Active soil vapor sampling through fixed soil vapor probes* (for long-term monitoring of particular portions of the study area). Active soil vapor samples are collected over a relatively short period of time, typically less than 1 hour per sample collected.

Passive soil vapor surveys were conducted during the RI and previous investigations by other consultants. These surveys focused on locations within the Hookston Station Parcel and locations along Vincent Road. Elevated concentrations of TCE in soil vapor were found beneath the 199 Mayhew Way structure and other areas of the Hookston Station Parcel toward the northeastern property boundary. Elevated concentrations of PCE were found in soil vapor along Vincent Road. These PCE impacts in the downgradient study area, which are not related to a release at the Hookston Station Parcel, prompted the RWQCB to request investigation activities at properties upgradient of the Hookston Station Parcel, as discussed in Section 1.3.6. Sampling locations, results, and laboratory reports were presented in the RI Report.

The active soil vapor survey conducted during Phase II of the RI focused on evaluating the VOC concentrations in soil vapor at locations where the greatest VOC concentrations were reported in ground water at the Hookston Station Parcel and in the downgradient study area. This work was completed as part of an area-wide vapor intrusion study. Results were compared in the RI Report to the soil vapor ESLs for Residential and Commercial/Industrial land use scenarios (RWQCB 2003) for locations in the downgradient study area and at the Hookston Station Parcel,

respectively. Concentrations of TCE in soil vapor greater than the ESLs were detected at one location at the Hookston Station Parcel and three locations in the downgradient study area. The results of this study led to the collection and analysis of indoor air samples as described in Section 2.1.7.

Permanent soil vapor monitoring probes were installed in April 2005 at 10 locations in the downgradient study area and are sampled on a quarterly basis. The probes are installed at six locations overlying the core of the mixed A-Zone ground water plume and at four locations within underground utility corridors located outside the footprint of the mixed A-Zone ground water plume.

Additional active soil vapor sampling was conducted in June 2006 at three locations in the downgradient study area. A description of those sampling activities and the laboratory analytical report is included in Appendix B.

TCE and PCE are the most frequently detected VOCs in soil vapor (based on data collected through June 2006) overlying the core of the mixed A-Zone ground water plume in the downgradient study area. PCE has also been detected in soil vapor at the some of the locations within the utility corridors. The distribution of PCE, TCE, cis-1,2-dichloroethene (DCE), and vinyl chloride in soil vapor is illustrated on Figures 2-7 and 2-10, respectively. The results are compared with the current soil vapor ESLs (RWQCB 2005) and California Human Health Screening Levels (CHHSLs) (California Environmental Protection Agency [EPA] 2005) for residential land use scenarios in Table 2-1. TCE, cis-1,2-DCE, and vinyl chloride have been detected at concentrations greater than their respective ESLs or CHHSLs at one or more locations. Chemicals not originating from the Hookston Station Parcel (specifically PCE and benzene) have also been detected in soil vapor in the downgradient study area at concentrations above the ESLs or CHHSLs.

2.1.5 *Chemical Occurrence in Ground Water*

Ground water samples were collected during the RI and previous investigations from permanent monitoring wells, soil borings, and direct-push locations and analyzed for VOCs, SVOCs, dissolved metals, and/or petroleum hydrocarbons. Ground water samples are also collected from 44 permanent monitoring wells on a routine, quarterly basis for VOC analyses. Ground water sampling locations, summary data tables, and laboratory analytical reports are included in the RI Report and quarterly monitoring reports. Table 2-1 summarizes the ground water chemical occurrence with respect to current ESLs (RWQCB 2005) and MCLs.

Petroleum hydrocarbons are typically found in wells MW-4 and MW-22A, near the northwestern corner of the Hookston Station Parcel. Chemical impacts in this area are attributable to sources other than the Hookston Station Parcel, most notably the Pitcock Petroleum site.

Ground water samples were analyzed for dissolved metals during the RI. Detections of nine metals exceeded the MCLs. These detections were reported in various monitoring wells, located within and outside the mixed VOC ground water plume footprint (described further below). Based on the concentrations and distribution, these metals detections are attributed to naturally occurring levels of metals in ground water rather than man-made sources.

TCE and degradation products cis-1,2-DCE and 1,1-DCE are the most widespread compounds in A- and B-Zone ground water and are the primary chemicals of concern for the Hookston Station Parcel. Elevated concentrations of PCE have also been detected in A- and B-Zone ground water in the northern portion of the Hookston Station Parcel and along Vincent Road. PCE degrades to TCE, which degrades to less chlorinated compounds such as cis-1,2-DCE. These compounds have been detected at concentrations up to 7,200 micrograms per liter ($\mu\text{g}/\text{L}$) PCE, 22,000 $\mu\text{g}/\text{L}$ TCE, 5,800 $\mu\text{g}/\text{L}$ cis-1,2-DCE, and 1,300 $\mu\text{g}/\text{L}$ 1,1-DCE. The distributions of PCE, TCE, cis-1,2-DCE, and 1,1-DCE in A- and B-Zone ground water (based on First Quarter 2006 data) is illustrated on Figures 2-11 through 2-18. As stated in Section 1.3.6, PCE does not originate from the Hookston Station Parcel.

Few VOC detections have been reported in C-Zone ground water, and none have been detected during the four most recent quarterly monitoring events. Therefore, remediation of C-Zone ground water is not addressed in this FS.

2.1.6 *Chemical Occurrence in Surface Water and Sediment*

Surface water and sediment samples were collected from un-lined portions of Walnut Creek at locations up- and down-stream from the Hookston Station Parcel (Figure 2-19). The samples were analyzed for VOCs and the results were compared in the RI Report to the RWQCB's ESLs for freshwater surface water, Chronic and Acute Freshwater Aquatic Habitat Goals, and Surface Water Quality Standards for Bioaccumulation and Human Consumption of Aquatic Organisms (RWQCB 2003). Table 2-1 summarizes the surface water and sediment chemical occurrence with respect to current ESLs (RWQCB 2005). Sample locations, data summary tables, and laboratory analytical reports are included in the RI Report.

VOCs detected in surface water samples include PCE, TCE, cis-1,2-DCE, toluene, and MTBE. The final surface water ESLs, habitat goals, and surface water quality standards were not exceeded, with one exception. MTBE was detected in one surface water sample at a concentration of 8.3 µg/L, which exceeds the final surface water ESL of 5 µg/L MTBE. As stated in Section 1.3.6, MTBE does not originate from the Hookston Station Parcel.

No VOCs were detected in the sediment samples.

2.1.7 *Chemical Occurrence in Indoor Air*

As part of the RI and risk assessment activities, indoor air samples were collected from locations at the Hookston Station Parcel and in the downgradient study area during the following events:

- Indoor air samples were collected at the Hookston Station Parcel from five locations within the structure at 199 Mayhew Way during December 2003. Samples were analyzed for TCE, cis-1,2-DCE, and 1,1-DCE;
- Indoor air and crawl space air samples were collected from 18 private residences in the downgradient study area between January and September 2004. Samples were analyzed for TCE, cis-1,2-DCE, and 1,1-DCE. PCE results were subsequently quantified for selected samples using laboratory chromatograms; and
- Indoor air and crawl space air samples were collected from 42 private residences in the downgradient study area between August 2005 and January 2006. This sampling program was implemented during Summer 2005 in order to collect additional dry season indoor air quality data for homes sampled during 2004 and to collect samples from homes within the study area that did not participate in 2004. Samples were analyzed for 17 VOCs, including PCE, TCE, cis-1,2-DCE, and 1,1-DCE.

The results of these sampling events were included in the RI Report and the *Indoor Air Sampling Report* (ERM 2006). The indoor air sampling locations, summary data tables, and laboratory analytical results were provided in those documents.

Indoor air samples collected from within the 199 Mayhew Way structure reported concentrations up to 4.9 micrograms per cubic meter (µg/m³) TCE and 1.4 µg/m³ cis-1,2-DCE. Detectable levels of 1,1-DCE were not reported. The TCE concentrations reported in two samples exceeded the

Commercial/Industrial Use Indoor Air ESL ($2.0 \mu\text{g}/\text{m}^3$); the cis-1,2-DCE ESL was not exceeded.

Results of the 2004 and 2005/2006 residential indoor air sampling events were compared to the Residential Use indoor air ESLs (RWQCB 2005) and CHHSLs (California EPA 2005) (Table 2-1). The following is a summary of noteworthy results from the indoor air sampling events, listed in order of frequency of detection:

- **Benzene:** Indoor air samples collected from all 42 residences during the 2005-2006 event contained concentrations of benzene that exceed the CHHSL of $0.084 \mu\text{g}/\text{m}^3$. All crawl space and ambient air samples collected during the 2005-2006 event also reported benzene concentrations above $0.084 \mu\text{g}/\text{m}^3$. Benzene is not a chemical of concern associated with the Hookston Station Parcel.
- **PCE:** Indoor air samples from 43 private residences were analyzed for PCE during the 2004 and 2005/2006 events. Indoor air at 15 of these homes contained concentrations of PCE exceeding the CHHSL of $0.412 \mu\text{g}/\text{m}^3$. These residences are located throughout the downgradient study area. PCE is not a chemical of concern that originates from the Hookston Station Parcel. The residential indoor air PCE results are summarized on Figure 2-21.
- **TCE:** Indoor air samples for TCE analyses were collected from 47 private residences during the 2004 and 2005/2006 events. Indoor air at nine of the private residences contained concentrations of TCE in indoor air that exceed the CHHSL ($1.22 \mu\text{g}/\text{m}^3$ TCE) during the 2004 and/or 2005-2006 events. These residences are generally located within the footprint of the A-Zone mixed ground water plume in the downgradient study area where ground water TCE concentrations greater than approximately $500 \mu\text{g}/\text{L}$. The residential indoor air TCE results are summarized on Figure 2-20.
- **Vinyl chloride:** Indoor air samples for vinyl chloride analyses were collected from 42 homes during the 2005/2006 event. One home (1002 Hampton Drive) contained concentrations of vinyl chloride in indoor air exceeding the CHHSL of $0.0311 \mu\text{g}/\text{m}^3$. The source of this detection is not clear, as vinyl chloride was not detected in the crawl space air or in the ground water monitoring well adjacent to this home. Vinyl chloride was not detected in any other homes.
- **Additional VOCs:** Eight indoor air samples collected from 42 homes reported concentrations of 1,2-dichloroethane that exceed the CHHSL of $0.116 \mu\text{g}/\text{m}^3$. Additionally, 1,1,1-trichloroethane, 1,1-DCE, and

aromatic hydrocarbons (toluene, ethylbenzene, xylenes) were detected within the indoor air at several homes at low concentrations relative to their respective CHHSLs. None of these VOCs (except 1,1-DCE) are chemicals associated with the Hookston Station Parcel.

2.2

REGIONAL GROUND WATER QUALITY

The ground water quality of the area that encompasses the Hookston Station Parcel has been impacted by multiple sources of chemicals of concern, as follows.

- Hookston Station Parcel – TCE source area;
- Pitcock Petroleum – Petroleum hydrocarbon source area, including TPH, benzene, and MTBE; and
- Vincent Road Area – PCE/TCE source area.

Figure 1-3 illustrates the locations of these known source areas.

The Hookston Station Parcel TCE ground water plume originates in the southwestern portion of the Hookston Station Parcel and flows in a northeasterly direction. The Vincent Road Area PCE/TCE plume originates west of Vincent Road and flows in a northeasterly direction across the northern portion of the Hookston Station Parcel. Based on ground water chemistry and ground water flow data collected by the Hookston RPs, the CVOCs detected in monitoring wells MW-1, MW-4, MW-7, and MW-22A/MW-22B, which are located in the northwestern portion of the Hookston Station Parcel (Figures 2-11 to 2-18), are not associated with the Hookston Station Parcel TCE plume. These CVOC impacts, which include PCE and associated degradation products TCE and cis-1,2-DCE, are attributable to the upgradient Vincent Road PCE/TCE ground water plume. The Hookston Station Parcel and Vincent Road Area plumes mix in the northeastern portion of the Hookston Station Parcel and flow beneath the residential neighborhood located northeast of the Hookston Station Parcel. The RWQCB is currently working to identify the responsible party(ies) for the Vincent Road Area PCE/TCE plume.

Petroleum-related ground water impacts originating from the Pitcock Petroleum property flow in a northeasterly direction across the northern portion of the Hookston Station Parcel. Based on the ground water chemistry and flow data collected by the Hookston RPs, the petroleum hydrocarbon impacts detected in wells MW-1, MW-4, and MW-22A/B are

attributed to the Pitcock Petroleum site. These ground water impacts mix with the Vincent Road PCE/TCE plume in the northwestern portion of the Hookston Station Parcel. The downgradient extent of the Pitcock Petroleum ground water plume is currently being investigated by the responsible party.

The mixed plume that flows in a northeasterly direction beyond the Hookston Station Parcel and below the neighborhood located northeast of the Hookston Station Parcel comprises the downgradient study area.

The non-Hookston Station Parcel sources of these additional ground water contaminants must be identified and remediated to assure attainment of the final remedial action objectives in the residential area.

2.3 **RISK ASSESSMENT SUMMARY**

The risk assessment process was initiated with the completion of the *Preliminary Risk Assessment* (ERM 2002b) in October 2002. In April 2004, the *Risk Assessment* (RA) (CTEH 2004) was completed. The RA extended the scope of the Preliminary Risk Assessment and incorporated RWQCB policy changes that occurred in 2003. These two initial documents summarized screening-level evaluations for potential risks associated with the Hookston Station Parcel. Following completion of the RA, the RWQCB requested completion of a more comprehensive BRA. The purpose of the BRA was to determine the need for cleanup and provide a baseline to compare remedial alternatives.

In February 2006, the BRA (CTEH 2006) was prepared and submitted to the RWQCB. The BRA estimates theoretical non-cancer and lifetime cancer risks for human exposure to chemicals of potential concern in each environmental medium. The BRA presented estimates of exposure to individuals at the Hookston Station Parcel and in the downgradient study area. The BRA was approved by the RWQCB on 10 March 2006 (RWQCB 2006a). Tables 2-2 and 2-3 present the exposure pathways and scenarios for the Hookston Station Parcel and downgradient study area, respectively, that were evaluated and the theoretical risk levels calculated for each complete exposure scenario. This summary reviews the exposure scenarios and risk characterization presented in the BRA.

2.3.1 **Exposure Scenarios**

The BRA evaluated potentially exposed individuals at the Hookston Station Parcel and in the downgradient study area and possible exposure pathways (Tables 2-2 and 2-3). The following exposure pathways at the

Hookston Station Parcel were identified as complete and evaluated for potential risk characterization:

- Indoor (i.e., commercial/industrial) Workers
 - Inhalation of volatile chemicals in indoor air – VOCs may be released from subsurface soil or ground water into soil vapor, which can migrate to the surface and into a building;
 - Inadvertent ingestion of chemicals in soil – Workers contact surface soil directly as a component of their normal workday and potentially ingest soil;
 - Skin contact with chemicals in soil – Workers contact surface soil directly as a component of their normal workday and potentially contact soil with skin; and
 - Inhalation of chemicals in dusts or volatilizing from soil or ground water to outdoor air – Outdoor workers have potential to contact soil dusts or VOCs migrating to the surface through inhalation.
- Outdoor (i.e., construction) Workers
 - Inadvertent ingestion of chemicals in soil – Workers contact surface and subsurface soil directly as a component of their normal workday and potentially ingest soil;
 - Skin contact with chemicals in soil – Workers contact surface and subsurface soil directly as a component of their normal workday and potentially contact soil with skin; and
 - Inhalation of chemicals in dusts or volatilizing from soil or ground water to outdoor air – Outdoor workers have potential to contact soil dusts or VOCs migrating to the surface through inhalation.

The following exposure pathways for the downgradient study area were identified as complete pathways and evaluated for potential risk characterization in the BRA:

- Residents in the Downgradient Study Area
 - Inhalation of chemicals in indoor air - VOCs may be released from subsurface ground water into soil vapor and migrate to the surface and into a residence;

- Inhalation of chemicals in indoor/outdoor air released from lawn irrigation with ground water - VOCs may evaporate from ground water used for irrigation into outdoor air;
- Skin contact, incidental ingestion, and inhalation of chemicals in backyard swimming pools using ground water (children only) - ground water used to fill swimming pools could result in exposure to children through dermal contact, ingestion, and inhalation; and
- Inhalation of chemicals in air released from Walnut Creek surface water - volatilization of VOCs in surface water near residential properties.

2.3.2 *Risk Characterization*

The BRA calculated theoretical estimates of non-cancer and lifetime cancer risks based on the results of exposure and toxicity assessments.

Calculated non-cancer and theoretical lifetime cancer risks for individual chemicals were summed for each exposure pathway. For the exposure scenarios (such as ground water used to fill swimming pools) that have multiple exposure pathways (i.e. dermal contact, ingestion, and inhalation), summed risks for each pathway were added together to calculate a cumulative risk calculation for the exposure scenario.

During FS development meetings with the RWQCB, the RWQCB has preliminarily approved the use of theoretical lifetime cancer risk management levels of one in 100,000 (1E-05) for the Hookston Station Parcel (i.e., commercial/industrial/construction workers) and one in 1,000,000 (1E-06) for the downgradient study area (i.e., residents). Theoretical lifetime cancer risks between one in 10,000 (1E-04) and 1E-06 are customary risk management standards that have been deemed acceptable by regulatory agencies, including the USEPA and California EPA.

For non-cancer risk, the USEPA and California EPA have defined that a hazard quotient equal to or less than 1 indicates that adverse non-cancer health effects are unlikely to occur. This hazard quotient will be utilized in this FS as the acceptable non-cancer risk level for all human receptors.

The following subsections, and Tables 2-2 and 2-3, summarize the estimated risks for the exposure scenarios evaluated in the BRA. The reader is referred to the BRA for additional details, including summary tables of calculated potential risks.

2.3.2.1 *Exposure to Chemicals in Indoor Air at the Hookston Station Parcel*

Non-cancer and theoretical lifetime cancer risks were calculated in the BRA for the commercial/industrial worker exposed to VOCs detected in indoor air (TCE and cis-1,2-DCE). The non-cancer risks associated with inhalation of indoor air at the Hookston Station Parcel were not indicative of adverse non-cancer health effects, as indicated by a hazard quotient of less than 1 (Table 2-2). Theoretical lifetime cancer risks associated with inhalation of indoor air were less than 1E-05. Therefore, the indoor air pathway at the Hookston Station Parcel is not addressed in this FS.

2.3.2.2 *Exposure to Chemicals in Soil at the Hookston Station Parcel*

Non-cancer and theoretical lifetime cancer risks were calculated in the BRA for the commercial/industrial worker and construction worker exposed to chemicals detected in soil at the Hookston Station Parcel (Table 2-2). Exposure to chemicals in soil was determined to not result in non-cancer health risks to commercial/industrial or construction workers (hazard quotient less than 1).

Commercial/Industrial Worker

Theoretical lifetime cancer risks for the commercial/industrial worker exposed to chemicals of potential concern in soil were 3.1E-04; arsenic accounted for 98 percent of the theoretical lifetime cancer risk. These elevated risk values were the result of a relatively small data set (19 data points available at that time) and were skewed high based on two soil samples that exhibited arsenic concentrations well above average. As described above, in May 2006 (after the publication of the BRA), additional soil sampling was completed at the two locations where elevated detections of arsenic were previously identified (B-69 and B-84). The results of that study (presented in Appendix A) did not detect the presence of elevated concentrations of arsenic in surface soils. Because the recent (and more extensive) data identified arsenic concentrations in surface soil that are consistent with regional background levels, the commercial/industrial worker exposure pathway (primarily associated with the ingestion and dermal contact of surface soils) is not addressed within this FS.

Theoretical lifetime cancer risk associated with exposure to TCE in soil was approximately 1.1E-7 for a commercial/industrial worker and therefore this pathway is not addressed by this FS.

Construction Worker

Theoretical lifetime cancer risk calculated for the construction worker exposed to chemicals of potential concern in soil was 4.3E-05. As with the commercial/industrial worker, this risk is associated primarily with arsenic. As described above, additional arsenic soil sampling was completed at the two locations in May 2006. The results of that study (presented in Appendix A) found concentrations of arsenic above typical background in subsurface soils; elevated arsenic concentrations were not detected in the surface soils. It is believed that the subsurface soils exceed acceptable risk levels for the construction worker scenario, and therefore, this pathway is addressed in this FS.

Theoretical lifetime cancer risk associated with exposure to TCE in soil was approximately 4.8E-9 for a construction worker, and therefore this pathway is not addressed in this FS.

2.3.2.3 *Exposure to Chemicals in Indoor Air in the Downgradient Study Area*

Risk calculations for residents in the downgradient study area exposed to VOCs in indoor air were calculated in the BRA for all VOCs detected in indoor air, including those that do not originate from the Hookston Station Parcel (such as PCE and benzene) (Table 2-3). A separate risk calculation was also performed in the BRA for the summed risks of TCE, cis-1,2-DCE, and 1,1-DCE. The theoretical risks were calculated for each residence that participated in the 2004 and 2005-2006 indoor air studies, except three residences that were sampled at the end of the 2005-2006 program. The indoor air results for these residences were not available prior to the submittal of the BRA; the concentrations of VOCs detected in indoor air at these locations were less than the maximum detected concentrations at other residences. The non-cancer risks and theoretical lifetime cancer risks calculated for residents in the downgradient study area are summarized in the BRA.

The RWQCB required evaluating two estimates of exposure and theoretical risk potentially resulting from residents in the downgradient study area inhaling VOCs in residential indoor air. The two estimates utilized different inhalation rates, as described below:

- The first exposure estimate utilized an inhalation rate of 13.3 cubic meters of air per day (m^3/day) for an adult and 8.7 m^3/day for a child, as specified in the *Exposure Factors Handbook, Volume I – General Factors* (USEPA 1997); and

- The RWQCB required estimating potential risks utilizing higher inhalation rates (considered by the RWQCB to be upper bound rates) of 20 m³/day for an adult and 10 m³/day for a small child.

In the RWQCB's approval of the BRA (RWQCB 2006a), the RWQCB required the use of the theoretical risks calculated with the higher inhalation rates for preparing this FS. Therefore, only the theoretical risks calculated with the upper bound inhalation rates (the second exposure estimate) are discussed below.

The calculated non-cancer risks for residents in the downgradient study area exposed to all detected VOCs in residential indoor air were less than 1, indicating that exposure to VOCs in indoor air would not result in non-cancer health risks, except at three locations. At these residences, the calculated hazard indices ranged from 1.2 to 1.4 and were mostly attributed to the presence of PCE, benzene, toluene, ethyl benzene, and xylenes in indoor air, which are not chemicals originating from the Hookston Station Parcel.

The calculated theoretical excess lifetime cancer risk for all detected VOCs exceeded 1.0E-06 in 40 homes sampled during 2004 and 2005. The highest calculated theoretical excess lifetime cancer risk from inhalation of all detected VOCs was 8.0E-05. These risks are mostly attributed to detected concentrations of benzene and PCE, which do not originate from the Hookston Station Parcel.

The theoretical cancer risk calculated for TCE, cis-1,2-DCE, and 1,1-DCE exceeded 1.0E-06 in nine homes sampled during 2004 and 2005. The highest calculated theoretical excess lifetime cancer risk from inhalation of TCE, cis-1,2-DCE, and 1,1-DCE was 7.4E-06. Vapor intrusion prevention systems were installed in three of those homes in 2004, resulting in decreased chemical concentrations in indoor air. The calculated theoretical lifetime cancer risk for TCE, cis-1,2-DCE, and 1,1-DCE in those residences is now less than 1.0E-06. Four additional vapor intrusion prevention systems were installed following the 2005 sampling event.

2.3.2.4 *Exposure to VOCs Volatilizing from Ground Water Used for Irrigation in the Downgradient Study Area*

Residents in the downgradient study area are potentially exposed to VOCs volatilizing from ground water obtained from private backyard wells and used for irrigation purposes. As reported in the RI Report, 12 private backyard wells are located within the footprint of the mixed ground water plume in the downgradient study area. Based on the ground water data collected from the private wells, use of the private

wells for irrigation purposes does not pose non-cancer or cancer health risks (hazard quotients less than 1 and theoretical lifetime cancer risks less than 1E-06). The reader is referred to the BRA for potential risk levels calculated for each sampled backyard well. Table 2-3 summarizes the potential risks associated with this exposure scenario.

The RWQCB required evaluating hypothetical exposure and risk associated with using ground water from MW-14A for irrigation purposes. The RWQCB required this evaluation because MW-14A contains the highest TCE ground water concentrations in the downgradient study area. It is important to note that MW-14A is located in the downgradient study area on public land less than 50 feet west of the Hookston Station Parcel property boundary and is only used for ground water monitoring purposes. Therefore, risks calculated for hypothetical users of ground water from MW-14A for irrigation purposes represent “worst case” exposure conditions and is not representative of current exposure conditions. The theoretical non-cancer risk calculated for MW-14A was less than 1 and the theoretical lifetime cancer risk was 6.8E-06 for the irrigation exposure scenario.

2.3.2.5

Exposure to VOCs Volatilizing from Ground Water Used for Swimming Pools in the Downgradient Study Area

Residents in the downgradient study area are potentially exposed to VOCs volatilizing from ground water obtained from private backyard wells used for filling swimming pools. Based on the ground water data collected from the private wells, use of the private wells for filling swimming pools does not pose non-cancer or cancer health risks (hazard quotients less than 1 and theoretical lifetime cancer risks less than 1E-06). The reader is referred to the BRA for potential risk levels calculated for each sampled backyard well. Table 2-3 summarizes the potential risks associated with this exposure scenario.

The RWQCB also required evaluating hypothetical exposure and risk associated with using ground water from MW-14A for filling swimming pools. As stated in the previous section, risks calculated for hypothetical users of ground water from MW-14A represent “worst case” exposure conditions, and do not represent current exposure conditions. For this exposure scenario, the theoretical non-cancer risk calculated for MW-14A was 9.4 and the theoretical lifetime cancer risk was 8.1E-06 for hypothetical users of MW-14A ground water.

2.3.2.6 *Exposure to VOCs in Surface Water in the Downgradient Study Area*

Walnut Creek is currently used as part of an engineered storm water drainage network for the Contra Costa County Flood Control District. The creek collects storm water runoff for the Walnut Creek watershed, which encompasses more than 93,500 acres (Dyett & Bhatia 2006), which can obscure the source(s) of chemicals detected in surface water in the creek.

The theoretical lifetime cancer risk for residents exposed to VOCs volatilizing from surface water, regardless of their source, was calculated to be 1.6E-06. This risk level was calculated using maximum concentrations of VOCs detected in Walnut Creek during the RI. The majority of the theoretical lifetime cancer risk associated with this exposure pathway was due to concentrations of PCE detected in surface water. As stated previously, PCE is not a chemical that originates from the Hookston Station Parcel. The non-cancer risk hazard quotient was less than 1.

The screening level RA evaluated exposures to ground water as potential surface water within the Walnut Creek canal. In this assessment, ground water and surface water data were compared with appropriate surface water ESLs. That evaluation determined that the surface water concentrations were below even the most stringent surface water ESLs (RWQCB 2003), except one detection of MTBE, indicating that the concentrations of chemicals in surface water would not trigger further investigation or remediation. One detection of MTBE exceeded the surface water ESL, which was selected based on taste and odor thresholds (assumes surface water is used for drinking water), rather than the higher surface water criteria that are based on toxicity values. Similarly, the ground water concentrations reported in monitoring wells closest to the canal are all below the Chronic Aquatic Habitat Goal (RWQCB 2003). Because of these low concentrations below the ESLs, these exposure scenarios were not evaluated further within the BRA, and are not included within this FS.

2.3.3 *Risk Management Thresholds as a Basis for Remedial Action Objectives*

RAOs within this FS (discussed in Section 4) are based on an acceptable theoretical lifetime excess cancer risk level of 1E-05 (one in 100,000) for commercial/industrial exposures at the Hookston Station Parcel, and an acceptable theoretical lifetime excess cancer risk level of 1E-06 (one in 1,000,000) for residential exposures in the downgradient study area. Non-cancer human health risks will be managed to a Hazard Index of 1 for all exposures. The RWQCB has accepted these risk management thresholds

at similar sites, and Board staff has indicated that these thresholds are appropriate for use in this FS.

RAOs will be developed for completed exposure pathways with calculated theoretical risks above the risk management thresholds. Based on the results of the BRA, RAOs will address:

- Construction worker exposure to arsenic in subsurface soils at the Hookston Station Parcel;
- Residential exposure in the downgradient study area to indoor air containing chemicals that have originated from the Hookston Station Parcel; and
- Residential exposure in the downgradient study area to ground water containing chemicals that have originated from the Hookston Station Parcel.

Although the BRA determined that commercial/industrial exposure at the Hookston Station Parcel to ground water containing chemicals that originated from the Hookston Station Parcel is not a complete pathway (i.e., there are no current uses of ground water at the Hookston Station Parcel), an RAO will be developed that protects potential future users from existing ground water impacts.

A more complete description of RAOs is provided in Section 4.

3.0 *PREVIOUS MITIGATION ACTIVITIES AND TECHNOLOGY STUDIES*

Several activities have been completed after the completion of the RI and in response to findings of the RA and BRA. These activities are summarized in the following sections.

3.1 *VAPOR INTRUSION PREVENTION SYSTEMS*

The Hookston RPs installed vapor intrusion prevention systems in three homes in response to the findings of the 2004 indoor air sampling event. TCE results from the 2005/2006 sampling event show that all three homes, which previously exceeded the CHHSL for TCE, now contain concentrations below the screening level. The Hookston RPs offered to install vapor intrusion prevention systems in eight additional homes following the 2005/2006 event; systems have been installed in four of those homes. A monitoring program will be implemented for the homes with vapor intrusion prevention systems.

3.2 *BACKYARD WELL ABANDONMENTS*

Twelve private backyard wells located within the downgradient study area were identified during the RI. To eliminate potential exposure to impacted ground water, the Hookston RPs have offered to properly decommission (a.k.a. "abandon") these 12 wells by removing well pumps and electrical systems, followed by pressurized grouting to seal the well from further use. Seven wells have since been abandoned and are no longer used.

3.3 *TECHNOLOGY AND AQUIFER STUDIES*

To support the preparation of this FS, several remedial technology studies and aquifer tests have been completed. These studies included the following:

- **Laboratory bench-scale chemical oxidation treatability study:** In October 2003, ERM's Remediation Technology Group in Lawrenceville, New Jersey, conducted a chemical oxidation treatability study of soils collected from the Hookston Station Parcel. The objective of the study was to evaluate the potential effectiveness of two commonly employed oxidants for the constituents of interest at the

Hookston Station Parcel: potassium permanganate and sodium persulfate. The treatability study tested the total soil permanganate demand and the amount of persulfate consumed by soils, in order to assess the ability of these two oxidants to remediate ground water at the Hookston Station Parcel and downgradient study area in a cost effective manner. Soil oxidant demand is one of the greatest factors affecting viability of in situ chemical oxidation. The results of that study are presented in Appendix C.

- **SVE pilot test** - An SVE field pilot test was conducted at the Hookston Station Parcel in April 2006 in order to obtain parameters for evaluating SVE as a potential remedial alternative for the Hookston Station Parcel and downgradient study area. The pilot test utilized one SVE well and three observation wells and consisted of two tests, a step test and a vacuum test. The objectives of these tests were to measure the system performance, determine the soil permeability with respect to air, and determine the radius of influence for the SVE well. Additional information regarding the pilot test methodology, calculations, and results are presented in Appendix E.
- **Aquifer tests** - In April 2006, ERM performed in situ (slug) aquifer tests and two constant-rate discharge tests at the Hookston Station Parcel. Slug tests were performed at 11 monitoring wells (six A-Zone monitoring wells and five B-Zone monitoring wells). Constant-rate pumping tests were conducted in one A-Zone well and one B-Zone well. Aquifer tests were previously performed at the Hookston Station Parcel during Treadwell and Rollo's (T&R) 1993 subsurface investigation. Information regarding ERM's aquifer test methodology and results is included in Appendix G. The methodology and results of the T&R aquifer tests were documented in the report entitled *Subsurface Investigation* (T&R 1993).

This section develops RAOs and cleanup goals to address metals in soil, VOCs in ground water, and VOCs in residential indoor air. The RAOs are based on existing and anticipated future beneficial uses of resources at the Hookston Station Parcel, in light of RI data and risk assessment. The development of RAOs consists of the following steps:

- Identification and evaluation of ARARs that influence the calculation of remedial goals;
- Development of RAOs that are protective of human health and the environment;
- Development of appropriate cleanup goals that incorporate the steps above and are protective of human health and the environment; and
- Identification of the areas requiring remediation.

Each of these steps is described in the following subsections.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The *National Oil and Hazardous Substance Pollution Contingency Plan* (Title 40 of the CFR, Part 300 et seq.) requires that remedial actions at CERCLA sites must comply with all ARARs under federal or state environmental laws, public health requirements, or facility citing laws. A requirement may either be “applicable” or “relevant and appropriate” as defined below:

“Applicable requirements are those remedial standards, standards of control, or other environmental protection criteria or limitations that are promulgated under federal or state law that specifically address hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at the site.”

Relevant and appropriate requirements are those promulgated federal and state requirements that, while not applicable to the circumstances at the target site, address problems or situations sufficiently similar to those encountered at other sites that their use is well suited to the target site of concern.

USEPA guidance identifies three categories of ARARs (USEPA 1988a and 1989):

- **Chemical-specific ARARs** are numerical standards set by various regulatory and government agencies that indicate the concentrations of certain compounds permitted in air, soil, ground water, surface water, and sediments;
- **Action-specific ARARs** are generally set performance, design, or other similar action-specific controls or restrictions on site activities related to the management of hazardous substances. Action-specific ARARs will impact all activities that may be performed at the Hookston Station Parcel and downgradient study area; and
- **Location-specific ARARs** are restrictions placed on the conduct of activities solely because they are in specific locations. These ARARs may include restrictions such as those imposed on activities conducted in floodplains or in areas that may experience earthquake activity.

Tables 4-1 to 4-3 identify the chemical-, action-, and location-specific ARARs for this FS.

In addition to the three categories of ARARs listed above, criteria, advisories, and guidance issued by regulatory agencies that are not legally binding may also be considered during the development of remedial alternatives for a site. These items are known as “to be considered” (TBCs) guidelines. TBCs may influence the selection of a remedy to allow the optimal remedy to be identified. Table 4-4 identifies the TBCs for this FS.

4.2 *REMEDIAL ACTION OBJECTIVES*

RAOs consist of chemical- and medium-specific goals for protecting human health and the environment. The RAOs specify the media and contaminants of interest, exposure routes and receptors, and proposed cleanup goals. By specifying both exposure pathways and proposed cleanup goals, the RAOs permit a range of remedial alternatives to be developed in the subsequent sections of the FS.

The media and exposure pathways of concern are those identified in the BRA (Section 2.3) as having associated non-cancer hazards greater than 1 and theoretical lifetime cancer risks above 1E-05 for exposures at the Hookston Station Parcel and above 1E-06 for exposures in the downgradient study area with Hookston Station Parcel chemicals of

concern only (TCE and associated degradation compounds). The existing and potential beneficial uses of ground water and surface water outlined in the Basin Plan (RWQCB 1995) were also factored into this evaluation.

The following RAOs have been developed for the Hookston Station Parcel and downgradient study area:

- Protect human health from incidental ingestion, dermal contact, and inhalation of fugitive dusts from subsurface soil (deeper than 0.5 feet bgs) at the single location on the Hookston Station Parcel having concentrations of arsenic exceeding 1E-05 theoretical lifetime excess cancer risk or background concentrations, whichever is greater.
- Protect human health from possible future consumption or contact with ground water containing chemicals above risk-based cleanup goals that originate from the Hookston Station Parcel by preventing future extraction of VOC-impacted ground water for beneficial uses (e.g., domestic, municipal, or industrial water supply) until the final ground water cleanup goals are achieved.
- Protect human health from potentially impacted indoor air by reducing concentrations of chemicals that originate from the Hookston Station Parcel in indoor air to levels of 1E-06 theoretical lifetime excess cancer risk for carcinogens, or a hazard index of 1 for non-carcinogenic risks. [Note this applies only to the downgradient study area.]
- Achieve restoration of ground water impacted by chemicals that originate from the Hookston Station Parcel for existing and potential beneficial uses (Section 1.3.4).

4.3

CLEANUP GOALS

To protect human health and the environment, risk-based cleanup goals were calculated for each completed exposure scenario (Tables 2-2 and 2-3) for soil, ground water, and indoor air that are protective of the risk management thresholds identified in Section 2.3.3. Table 4-5 presents the risk-based cleanup goals; the calculation of these goals is presented in Appendix H. For media with multiple exposure scenarios (e.g., ground water being used for both landscape irrigation and filling of a swimming pool), a cleanup goal was calculated for each scenario. The most conservative risk-based cleanup goal (i.e. the lowest calculated cleanup goal) was selected as the final cleanup goal for media with multiple exposure pathways. The final risk-based cleanup goals selected for the Hookston Station Parcel and downgradient study area impacted by

chemicals that originate from the Hookston Station Parcel are summarized below:

- **Arsenic in subsurface soil at the Hookston Station Parcel:** 31 mg/kg (based on back-calculated 1E-05 risk level for construction worker exposed to subsurface soils, Appendix H); and
- **VOCs in ground water:** California MCLs for drinking water or background water quality, whichever is greater. The current MCLs for chemicals of concern originating from the Hookston Station Parcel are:
 - TCE = 5 µg/L;
 - cis-1,2-DCE = 6 µg/L;
 - trans-1,2-DCE = 10 µg/L;
 - 1,1-DCE = 6 µg/L; and
 - Vinyl chloride = 0.5 µg/L.

As noted above, in addition to the Hookston Station Parcel, several other sources of chemicals of concern have impacted ground water in this region. These non-Hookston Station Parcel sources must also be identified and remediated to assure attainment of the final remedial action objectives in the downgradient study area.

Until the numerous potential contributors to the mixed ground water plume in the downgradient study area have completed their remediation programs (i.e., reduced their contribution to the mixed plume to the MCLs), the cleanup goals for the downgradient study area will be based on background concentrations. For the purposes of this FS, the background concentrations and interim cleanup goals are initially based on the highest concentration of chemicals of concern found within monitoring wells MW-1, MW-4, MW-7, and MW-22A/B. The background concentrations may be refined with time, based on future characterization activities. As stated in Section 2.2, chemicals detected in these wells are not due to a historical TCE release at the Hookston Station Parcel. Although the selected remedy for the Hookston Station Parcel and downgradient study area might potentially treat chemicals that do not originate from the Hookston Station Parcel, the Hookston RPs are not responsible for achieving cleanup of VOC concentrations migrating from other source areas into the downgradient study area. The RWQCB is currently requiring other parties to investigate some of the non-Hookston Station Parcel sources and has stated that they will require those responsible parties

to conduct additional investigation activities and cleanup actions, as necessary (RWQCB 2006b).

- **VOCs in Indoor Air:** The residential indoor air cleanup goals listed below represent concentrations that pose less than or equal to 1E-06 theoretical lifetime excess cancer risk (or a Hazard Index of 1 for non-cancer risks) for residential inhalation, assuming elevated breathing rates in accordance with RWQCB requirements. The calculation of these cleanup goals is presented in Appendix H.
 - TCE = 0.96 $\mu\text{g}/\text{m}^3$;
 - cis-1,2-DCE = 63 $\mu\text{g}/\text{m}^3$;
 - trans-1,2-DCE = 125 $\mu\text{g}/\text{m}^3$;
 - 1,1-DCE = 357 $\mu\text{g}/\text{m}^3$; and
 - Vinyl chloride = 0.025 $\mu\text{g}/\text{m}^3$.

4.4 **AREAS AND VOLUME OF IMPACTED MEDIA**

This section identifies the areas for which remedial actions will be necessary in order to meet the RAOs and cleanup goals for the Hookston Station Parcel and downgradient study area.

4.4.1 **Soil**

As described in Section 2.1.3, activities completed as part of the RI identified two areas at the Hookston Station Parcel of elevated arsenic concentrations in surface soils. Recent sampling completed to support the FS indicated that these two areas do not contain elevated concentrations of arsenic in surface soil, and that one of these areas contains elevated concentrations of arsenic in subsurface soils. Sample location B-69 (A through D), located in the southern portion of the Hookston Station Parcel, contained three subsurface soil samples from 2 feet bgs that exceeded typical background concentrations and the risk-based cleanup goal for arsenic (252 mg/kg arsenic at B-69A, 37.2 mg/kg arsenic at B-69C, and 171 mg/kg arsenic at B-69C).

4.4.2 **Ground Water**

Ground water within the A- and B-Zones will be addressed within the areas that have been impacted by chemicals originating (in whole or in part) from the Hookston Station Parcel.

Although the long-term goal of the ground water remediation program will be to reduce ground water concentrations to drinking water standards (the MCLs), the near-term focus for ground water will be in areas where indoor air impacts have been observed at concentrations above the indoor air cleanup goals. This area generally coincides with ground water concentrations above approximately 500 µg/L TCE in the downgradient study area. This observed relationship between ground water and indoor air concentrations is consistent with the RWQCB's ground water ESL of 530 µg/L for protection of indoor air impacts. The success reducing breathable indoor air concentrations for the Hookston Station Parcel chemicals of concern will be based on a measurement at the exposure area (i.e., inside the residences).

The area within the 500 µg/L TCE contour interval (based on January 2006 data) in the downgradient study area, which is generally where indoor air impacts above the calculated indoor air cleanup goal (0.96 µg/m³ TCE) have been observed, is approximately 5.5 acres (Figure 2-12).

4.4.3

Indoor Air

Although a portion of the TCE present in residential indoor air may be attributable to other sources, this FS assumes that all homes with indoor air TCE concentrations above the proposed cleanup goal of 0.96 µg/m³ will be addressed in this FS, as shown on Figure 4-1. Based on current data, 11 homes have (at one time) contained TCE concentrations in indoor air above this cleanup goal, and with few exceptions, these homes are located over the core of the mixed plume in the downgradient study area where TCE ground water concentrations are 500 µg/L or greater.. With few exceptions, homes with indoor air concentrations exceeding 0.96 µg/m³ are within the first block of residential homes located between Hookston Road, Hampton Drive, Thames Drive, and Stimel Drive (Figure 4-1). Several of these homes now contain TCE concentrations below the cleanup goal because vapor intrusion prevention systems have been installed.

The objective of this section is to identify and screen available remedial technologies for addressing the affected media defined in Section 4. General response actions (GRAs) that are potentially applicable for achieving RAOs are identified. Remedial technology types and associated technology process options for each GRA are presented. Technology process options are screened to eliminate those that are least suitable for addressing impacted media and achieving RAOs. Technology process options are screened based on the USEPA's screening criteria of effectiveness, implementability, and cost (USEPA 1988b).

5.1

GENERAL RESPONSE ACTIONS

General response actions are broadly defined as general types of actions that can reduce or eliminate the risk that contaminants present to human health and the environment. General response actions are media-specific measures that may be taken to satisfy the RAOs. The GRAs identified for soil, ground water, and/or indoor air include:

- No Action (evaluation required by CERCLA);
- Institutional Controls/Limited Action;
- In Situ Treatment;
- Collection/Ex Situ Treatment;
- Removal; and
- Disposal.

Each of the GRAs (except No Action) can be implemented using a variety of remedial technology types; some technology types include multiple technology process options. General response actions, technology types, and technology process options for soil and ground water are summarized in Tables 5-1 and 5-2, respectively. The remedial technology types and process options were identified based on a variety of reference sources including:

- Remediation Technologies Screening Matrix and Reference Guide, Second Edition, (USEPA 1994).

- USEPA Vendor Information System for Innovative Treatment Technologies (VISITT, Version 5.0).
- Federal Databases:
 - USEPA Technology Innovation Program Remediation Databases.
 - Cleanup Information Bulletin Board (CLU-IN).
 - Risk Reduction Engineering Laboratory (RREL) Treatability Database.
 - Superfund Innovative Technology Evaluation (SITE) Program.
- Literature search on various technical journals and conference proceedings.
- In-house consultant and contractor experience.
- Other consultant reports.
- Treatability studies for other sites.
- Literature survey.

5.2 **SCREENING OF REMEDIAL TECHNOLOGY PROCESS OPTIONS**

This section describes the three USEPA primary screening criteria (effectiveness, implementability, and cost) for remedial technology process options. The remedial technology process options selected for the Hookston Station Parcel are identified in Tables 5-1 and 5-2. These process options are screened against the three criteria in the following sections and also in Tables 5-1 and 5-2. Technology process options that fail to meet one or more of the three criteria are not retained for development of remedial alternatives in Section 6. Table 5-3 summarizes the process options that passed the three criteria screening.

5.2.1 **Screening Criteria**

This subsection describes the components of each of the three primary screening criteria.

5.2.1.1 **Effectiveness**

The effectiveness evaluation focuses on the ability of each technology process option to address contaminants of concern (COCs) and protect

human health and the environment relative to competing options. The effectiveness evaluation is based on the following:

- The ability of a technology process option to achieve the desired cleanup goal for each contaminant of concern (described in Section 4.3) and handle the specified areas and volumes (described in Section 4.4);
- The degree of protectiveness to human health and the environment provided by the technology process option during construction and implementation; and
- The reliability of the technology process option with respect to the contaminants and site conditions.

5.2.1.2 *Implementability*

The implementability evaluation focuses on the technical and administrative feasibility of a technology process option. The implementability evaluation is based on the following:

- The institutional aspects of implementation, including the ability to obtain necessary permits and general public acceptance; and
- The availability of support services and equipment, and the degree to which the technology process option has been demonstrated at other sites.

5.2.1.3 *Cost*

This criterion is used to compare the capital and operation and maintenance (O&M) costs of the technology process options. Cost plays a limited role in the screening of process options relative to the two previous criteria. Relative capital and O&M costs are used rather than detailed estimates. Relative costs are determined based on engineering judgment, and each option is evaluated as to whether costs are expected to be low, medium, or high relative to other options.

5.2.2 *Screening of Technology Process Options*

The screening evaluation of remedial technology process options for soil, ground water, and indoor air is summarized in Tables 5-1 and 5-2. Based on the screening, those technology process options least suitable for addressing impacted media and achieving RAOs were eliminated. Those technology process options considered potentially technically effective, implementable given current knowledge of the Hookston Station Parcel and downgradient study area, and cost-effective relative to competing

options were retained. Table 5-3 lists the retained technologies for soil, ground water, and indoor air remediation. These retained technologies are carried forward to Section 6 where remedial alternatives are developed.

5.3 *DESCRIPTION OF RETAINED TECHNOLOGIES*

This section presents a more complete description of the technologies retained following the screening process above. The technologies described in this section are the primary treatment technologies used in the remedial alternatives developed in Section 6.

5.3.1 *Institutional Controls*

The use of institutional controls as a remedial process involves placing restrictions on the current and future uses of the land and ground water impacted by contaminants. The institutional control components retained for use in developing remedial alternatives include restricting land and water use through deed notifications and restrictions. Deed notifications and/or restrictions create legal restrictions on specific activities or uses of land or water by current and future landowners. These restrictions are intended to prevent unauthorized development of the land and water and to protect workers at the Hookston Station Parcel through notification of contamination and instruction on proper work procedures to prevent exposure.

5.3.2 *Vapor Intrusion Prevention Systems*

Vapor intrusion prevention systems eliminate the migration of VOCs into the indoor living space of residences located above the contaminated area. The components of this technology generally consist of both:

- Placement of a vapor barrier either on the soil under residences or on the underside of the floor structure to prevent migration of vapor up into the residence; and
- Low flow vapor extraction performed under the vapor barrier using small, low-vacuum blowers.

5.3.3 *Private Well Removal*

The use of private well removal as a remedial technology involves decommissioning existing private wells, such as the irrigation wells present at a limited number of residences within the downgradient study

area, to eliminate the risk pathway associated with use of the wells and to prevent downward migration of contaminants within the wells. This technology involves decommissioning individual wells using standard well-closure procedures. If the private wells are currently being used as a water supply, the existing public water supply at the residence would be retrofitted to provide service to the disconnected components. This technology requires cooperation by property owners to allow removal of the well.

5.3.4 *Monitored Natural Attenuation*

Monitored Natural Attenuation (MNA) is one option for a long-term mechanism to achieve ground water RAOs. Natural attenuation processes include a variety of physical, chemical, and/or biological processes that act without human intervention to reduce the mass or concentration of contaminants in soil and ground water. Natural attenuation depends on geologic and hydrogeologic characteristics of the aquifer, the physical and chemical properties of the soil, and the metabolic capabilities of native microbes. Natural attenuation comprises several mechanical, physicochemical, and biological processes as follows:

- Mechanical processes including molecular diffusion, mechanical dispersion, and dilution from recharge;
- Physicochemical processes including sorption of the contaminant to the aquifer matrix, hydrolysis, precipitation of the contaminant as an insoluble solid, and volatilization; and
- Biological processes whereby contaminants are degraded by microorganisms in the aquifer and destroyed through use as a primary energy source, use as an electron acceptor by reductive dechlorination, or cometabolization with another energy source.

5.3.5 *Enhanced Anaerobic Bioremediation*

Enhanced anaerobic bioremediation of chlorinated ethenes, such as TCE, involves the stimulation of the natural biological process of reductive dechlorination through the addition of a carbon source that, upon utilization by microbes, results in the stimulation of the microbial population and generation of hydrogen and reducing conditions. The resulting anaerobic conditions are more favorable for reductive dechlorination by the same mechanisms described above for natural attenuation, but at a much more accelerated rate. In some cases, organisms may need to be added, but only if the natural microbial population is incapable of performing the required transformations.

The amendment used to stimulate and enhance bioremediation can include a wide range of products, such as soluble substrates consisting of aqueous solutions of lactate, low-viscosity mixtures of materials including emulsified oils, and high-viscosity pure oils. Aqueous solutions have the benefit of being able to be readily injected in large volumes to increase distribution, but rely on repeated injections to maintain appropriate concentrations of the amendments. Low viscosity liquids can be injected at nearly the rate of soluble products with the added benefit of longer lasting effects. High-viscosity fluids are difficult to inject in large volumes but have the benefit of very long-lasting reactivity. The amendments may also include bacterial cultures to ensure chlorinated ethenes can be completely degraded (known as “bioaugmentation”).

Enhanced anaerobic bioremediation is a well known remedial technology for treatment of CVOCs. However, there are also known short-comings of this technology, due to the need to rely on natural degradation processes within the subsurface. In addition, heterogeneities or preferential flow paths can limit distribution of amendments in the subsurface. The primary concern of this technology is the incomplete dechlorination of TCE to DCE and subsequently to vinyl chloride. Vinyl chloride has been shown to be recalcitrant to biodegradation under some conditions, which may leave the degradation of TCE incomplete. This typically results in increased risk to receptors, particularly if indoor air is a primary risk pathway, as vinyl chloride is both more volatile and more toxic than TCE. Implementation of this technology would require bench and pilot testing to evaluate the completeness of the reductive dechlorination, to determine the most effective amendment, and to assess the need for bioaugmentation.

Implementation of enhanced anaerobic bioremediation would consist of injection of the selected amendment using the most appropriate injection technique. This may include direct-push boreholes, where open space is available for large number of points. Figure 5-1 presents a conceptual view of a direct-push injection setup. Dedicated injection wells provide the ability to periodically inject much larger volumes at a limited number of wells, where space is too limited for use of direct-push points.

5.3.6

In Situ Chemical Oxidation

One of the most common mechanisms for the in situ chemical treatment of VOCs is oxidation. In situ chemical oxidation involves the placement of an oxidant into the subsurface to directly react with the contaminants. The potential benefits from in situ oxidation include in situ contaminant destruction, relatively low cost, reliability, simplicity, and rapid treatment. However, site-specific constraints must be considered. Efficient oxidation

is dependent on the contact between oxidant and contaminant. Subsurface heterogeneities, preferential flow paths, and a high level of organic material may result in inefficient treatment. This is the primary reason why chemical oxidation has been retained only for B-Zone ground water, with its higher conductivity and low oxidant demand.

One of the most common oxidants available for use in the chemical treatment of chlorinated ethenes is potassium permanganate. Delivered to the treatment zone as a dilute (up to 5 percent) solution, permanganate ions cause the solution to turn purple, which provides a visual indicator of the chemical's distribution and activity in ground water. When the permanganate is reduced upon reaction with organic matter, it forms manganese dioxide. Because potassium permanganate is delivered as a dilute solution, it is a relatively safe oxidant to use, while other oxidants, such as hydrogen peroxide (used alone or as a component of the Fenton's Reagent reaction) can generate a significant amount of heat and pressure during implementation. Sodium permanganate is used similarly to potassium permanganate, but is available as a higher concentration solution. This makes sodium permanganate an appropriate alternative to potassium permanganate where a higher concentration reagent is required.

The primary delivery mechanism for in situ chemical oxidation involves the placement, through fluid injection, of the oxidizing material in the zone of contaminated ground water being treated. At the Hookston Station Parcel, chemical oxidation would be expected to be performed using either direct-push injection or injection through dedicated injection wells. Figure 5-1 presents a conceptual view of a direct-push injection setup. The soluble nature of the permanganate ion allows relatively simple injection. Health and safety precautions must be implemented to prevent injury to workers and the public during the application of this technology.

5.3.7 *Zero-Valent Iron Permeable Reactive Barrier*

Permeable reactive barriers (PRBs) are a relatively innovative technology that provides treatment of dissolved contaminants as ground water flows through the PRB, which is installed across the water-bearing zone to be treated. PRBs have applicability for many contaminant groups, including CVOCs such as TCE.

The PRB is developed by placing a zone of reactive material in the path of ground water flow. Figure 5-2 presents a conceptual view of the treatment of ground water using a PRB. The zone of reactivity must be designed using parameters such as contaminant concentrations, ground

water flow velocity, and other hydrogeologic parameters. The reactive medium used for PRBs treating CVOCs is zero-valent iron, which is oxidized once it is added to the reaction cell. The resulting electron activity results in nearly immediate reductive dechlorination of the chlorinated ethenes. The resulting products are relatively harmless chloride ions and ethane. Ethane itself is readily degraded under natural conditions in most aquifer systems.

The two primary installation methods being considered for the PRBs in the remedial alternatives described in Section 6 are trenching and direct injection. Placement of zero-valent iron in a PRB has been commonly performed by trenching in areas where a continuously-excavated trench is possible. The trenching can be performed using several methods, including standard backhoe trenching for shallow trenches, clamshell excavation for very deep trenches, and excavation with a continuous trencher for fast trench installation. The continuous trencher is the most applicable trench installation method installing relatively shallow PRBs. This method uses a chain-saw type apparatus on a heavy crawler-mounted vehicle to dig a narrow, continuous trench while simultaneously placing the reactive wall material as the trencher advances. This method can install reactive material at a faster rate and is more cost effective, relative to the other trenching methods, but can only install PRBs in areas lacking subsurface obstructions, such as underground utilities. This would be the preferred PRB installation method for the Hookston Station Parcel, but may be determined to be infeasible due to the extent of subsurface utilities.

The other PRB installation method that would be further examined is direct injection of zero-valent iron. Direct injection has been performed using several methods, some of which are proprietary methods specific to individual contractors. The primary direct injection methods reviewed during this FS are hydraulic fracturing and jetting. These methods involve injecting iron in a powder or granular form or as a gel or slurry mixture of iron and a biodegradable substrate. The material is injected at a high pressure to either create fractures that are filled with the injected iron mixture (hydraulic fracturing) or to erode the subsurface soil enough to mix the injected iron with the soil (jetting). These installation methods are less likely to be affected by subsurface utilities than traditional trenching methods.

5.3.8 *Ground Water Extraction, Treatment, and Disposal*

Ground water extraction, treatment, and disposal, commonly referred to as pump and treat, is a set of traditional technologies and process options for ground water remediation through contaminant migration control and

contaminant mass removal methods. While several process options are available to extract ground water from the subsurface (trenches, horizontal piping, vacuum systems, etc.), the process option identified and screened for the Hookston Station Parcel, based on site-specific conditions, involves the use of traditional vertical ground water pumping wells placed at specific locations to ensure capture of contaminated ground water. Dissolved VOCs would be captured via pumping, conveyed to a central treatment system, physically or chemically treated, and disposed of through the sanitary sewer system. Figure 5-3 presents a conceptual view of the components of a typical ground water extraction, treatment, and disposal system.

In this section, the technologies and process options that were retained through the initial screening in Section 5 are combined into workable remedial systems (alternatives) that address the RAOs developed in Section 4. General response actions and the process options chosen to represent the various technology types are combined to form several alternatives for the Hookston Station Parcel and downgradient study area as a whole.

Section 6.1 describes the general approach used to assemble media and areas for the development of remedial alternatives. Section 6.2 introduces the methodology used to estimate remedial timeframes for each component of the remedial alternatives. Section 6.3 describes the components that are common to all of the “active remediation” alternatives (i.e., all of the remedial alternatives with the exception of No Action). The sections that follow present the remedial action alternatives developed for the affected media at the Hookston Station Parcel and downgradient study area.

The remedial alternatives developed in this section are based on conceptual-level designs for the implementation of the screened remedial technologies described in Section 5. The design parameters used to develop the remedial alternatives are based on engineering judgment, knowledge of current conditions at the Hookston Station Parcel and downgradient study area, the performance of pilot studies, and ground water modeling.

The remedial alternatives have been developed to meet the RAOs developed in Section 4.2, as well as the requirements of Section 430 of the *National Oil And Hazardous Substances Pollution Contingency Plan* (NCP) (40 CFR 300.430), which stipulates the FS remedy selection process. The NCP requires that the FS evaluate:

- A range of remedial alternatives in which treatment that reduces the toxicity, mobility, or volume (TMV) of hazardous substances, pollutants, or contaminants is a principal element. As appropriate, this range shall include an alternative that removes or destroys hazardous substances, pollutants, or contaminants to the maximum extent feasible, eliminating or reducing, to the degree possible, the need for long-term management; and

- One or more remedial alternatives that involve little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants through engineering controls.

6.1 *MEDIA AND AREAS CONSIDERED*

Areas of impacted media were identified in Section 4.4 based on the RAOs and exceedances of cleanup goals. These are areas for which technologies and process options are selected to comprise each remedial alternative. The areas for which remedial alternatives have been developed are:

- Soil;
- A-Zone Ground Water;
- B-Zone Ground Water; and
- Residential Indoor Air.

These areas are described in the following sections.

6.1.1 *Soil*

As described in Section 4.4.1, sampling activities have indicated the presence of arsenic in subsurface soil at levels exceeding risk to industrial and/or construction workers. This is based on limited detections of arsenic above the acceptable risk-based concentration (31 mg/kg) in subsurface soil (deeper than 0.5 feet bgs) in the vicinity of sampling location B-69.

6.1.2 *A-Zone Ground Water*

As discussed in Section 4.4.2, the area of A-Zone ground water addressed in this FS includes areas within the Hookston Station Parcel and the downgradient study area that have been impacted in whole or in part by chemicals originating from the Hookston Station. The A-Zone downgradient study area is the area of A-Zone ground water downgradient of the Hookston Station Parcel impacted by VOCs at concentrations exceeding cleanup goals described in Section 4.3, that have originated from the Hookston Station Parcel.

6.1.3 *B-Zone Ground Water*

Similar to A-Zone ground water, the area of B-Zone ground water addressed in this FS includes areas within the Hookston Station Parcel and downgradient study area that have been impacted in whole or in part by chemicals originating from the Hookston Station Parcel. The B-Zone downgradient study area is the area of B-Zone ground water downgradient of the Hookston Station Parcel impacted by VOCs at concentrations exceeding cleanup goals described in Section 4.3, that have originated from the Hookston Station Parcel.

6.1.4 *Residential Indoor Air*

The residential indoor air pathway addressed by this FS is limited to exposure to indoor air in residences that generally overlay the portion of the A-Zone downgradient study area that contains TCE at concentrations of 500 µg/L or greater. The remedial alternatives described in this section include remedies for indoor air where impacts have been observed, or are expected to be observed based on a home's location relative to the ground water plume.

6.2 *REMEDATION DURATION ESTIMATES*

In order to accurately estimate relative cost for each of the remedial alternatives, treatment durations (i.e., the time required to meet cleanup goals) were estimated for each individual technology. Remedial timeframes are a critical component of the detailed and comparative analysis of the remedial alternatives presented in Section 7. Remedial timeframes directly influence the evaluation of several of the criteria, most notably overall protection of human health and the environment, short-term effectiveness, and cost.

Appendix I describes details on the modeling methodology that was used to estimate timeframes for each of the active remedial alternatives. The estimated durations used in this FS are based on calculated or measured contaminant decay rates, experience with the technologies at similar sites, modeling, and engineering judgment.

6.3 *THREE COMPONENTS COMMON TO "ACTIVE REMEDIATION" ALTERNATIVES*

Six remedial alternatives have been developed for the Hookston Station Parcel (discussed further in Section 6.4). Remedial Alternative 1 is the No

Action alternative, which is required by the NCP. Remedial Alternatives 2 through 6 are “active remediation” alternatives and include several presumptive remedies and mitigation measures that are common to each of these five remedial alternatives. The three common components include:

- Institutional controls for arsenic-impacted subsurface soil in the form of a Soil Management Plan (SMP);
- Vapor intrusion prevention components for residences in the downgradient study area in which TCE is present in indoor air at concentrations that exceed the associated indoor air cleanup goals; and
- Removal of private wells, which are used for irrigation and filling swimming pools, from residences that overlie the commingled plume in the downgradient study area.

These components are described in the following sections. Additional components associated with Remedial Alternatives 2 through 6 that are not common to all five of these remedial alternatives are discussed in Section 6.4.

6.3.1

Soil Management Plan for Arsenic in Soil

Soil that contains arsenic concentrations above the applicable cleanup goal is limited to subsurface soil (deeper than 0.5 feet bgs) on a small portion of the Hookston Station Parcel. Risks to human health associated with the arsenic in soil are limited to construction workers that may be exposed to the soil during invasive activities at the Hookston Station Parcel. Because of the limited scale and risk of the contamination, arsenic-impacted soil is expected to be left in place. Therefore, the soil that is impacted by arsenic does not warrant full evaluation of alternative technologies.

Under Remedial Alternatives 2 through 6, arsenic-impacted soil would be addressed through the use of institutional controls. An SMP would be developed to provide standard procedures for subsurface work at the Hookston Station Parcel that may expose soil containing concentrations of arsenic above background levels. The SMP would include procedures for determining the presence of arsenic within the work zone, as well as procedures for protecting workers through monitoring and protective equipment. In addition, the SMP would provide procedures for proper management of arsenic-impacted soil, if encountered during subsurface work at the Hookston Station Parcel. Enforcement of the SMP would be accomplished through a deed restriction and notification that will link the SMP to ownership of the Hookston Station Parcel.

6.3.2

Vapor Intrusion Prevention Systems

Remedial Alternatives 2 through 6 include the use of vapor intrusion prevention systems to prevent exposure to VOCs in residential indoor air in the downgradient study area. It is expected that residential buildings present within the footprint of the ground water plume that contains TCE at concentrations greater than 530 µg/L would undergo voluntary indoor air sampling to evaluate the extent of indoor air impacts to determine which residences require mitigation. Based on data collected to date from residences with crawl-space vapor prevention systems, the use of vapor intrusion prevention components implemented at other individual residences impacted by TCE in indoor air is expected to be an effective method of reducing the risks associated with this pathway. This technology is expected to be a cost-effective and low-impact method of intercepting TCE prior to reaching indoor air.

Installation of the vapor intrusion prevention systems would consist of installation of a vapor barrier on the soil under residences to prevent migration of vapor up into the residence. Under the vapor barrier, low flow vapor extraction would be performed as an enhancement to the vapor barrier. The low flow extraction would enhance the removal of TCE and degradation products from soil vapor.

Annual maintenance or inspection of the system components would also be performed. It is expected that operation of the systems would be required for approximately 1 year beyond the point at which TCE in A-Zone ground water is treated to below the concentration at which indoor air impacts are expected (530 µg/L screening level described in Section 4.4.2), based on the installation of 20 vapor prevention systems. This 1-year period allows soil vapor to be flushed of TCE to the point at which the vapor intrusion risk pathway is mitigated. The modeling contained in Appendix I presents the estimated time frame for each of the remedial alternatives to reach the 530 µg/L concentration.

6.3.3

Private Well Removal

A limited number of residences located within the footprint of the downgradient study area have private extraction wells used to provide water for landscape irrigation and filling swimming pools. In order to reduce the potential risks posed by use of VOC-impacted ground water for pool filling, as described in Section 2.2, Remedial Alternatives 2 through 6 include decommissioning of private wells located within the footprint of the downgradient study area. Because the construction of these wells is unknown, this action also serves to eliminate potential cross-contamination between various aquifer units. The systems supplied by

the private wells would be connected to the existing public water system. Due to the small number of residences with private wells, the expected varying degree of construction required for completion of the re-plumbing, and the consistency of inclusion of this component in the five remedial alternatives with other associated costs, this component was not included in the cost estimates for Remedial Alternatives 2 through 6.

6.4 *DESCRIPTION OF REMEDIAL ALTERNATIVES*

The following sections provide descriptions of each of the remedial alternatives. A summary of each remedial alternative is provided in Table 6-1. These remedial alternatives are compared to one another in Section 7 to select a final remedy for implementation.

6.4.1 *Remedial Alternative 1*

Remedial Alternative 1 is the No Action alternative. No action would be taken under this remedial alternative to address COCs in all impacted areas and media. Under this remedial alternative, no remediation, monitoring, or engineering and institutional controls would be implemented. Ground water monitoring would be discontinued, and no tracking of plume stability or migration would be conducted. The inclusion and evaluation of the No Action alternative is required by the NCP to serve as a baseline against which the performance of other alternatives is evaluated. A conceptual view of the impacted areas and the respective lack of treatment components for these areas are presented on Figure 6-1.

6.4.2 *Remedial Alternative 2*

Remedial Alternative 2 would leave COCs in place while institutional controls and natural degradation processes are utilized to reduce contaminant TMV.

Table 6-1 lists the components of Remedial Alternative 2. Figure 6-2 presents a conceptual cross-sectional view of the components of Remedial Alternative 2. Figure 6-3 presents a plan view of the components of Remedial Alternative 2, which include:

- MNA of A- and B-Zone ground water; and
- The common remedial alternative components described in Section 6.3.

These components are discussed in the following paragraphs.

6.4.2.1 *A- and B-Zone Ground Water*

As part of this remedial alternative, TCE in A- and B-Zone ground water would be addressed using MNA. Implementation of MNA at Hookston Station would generally involve the following:

- Preparation of an MNA work plan;
- Installation of 20 new nested A- and B-Zone monitoring wells at the locations depicted on Figure 6-3;
- Collection of ground water samples at 60 monitoring wells for VOCs and 30 wells for geochemical indicators of MNA for 30 or more years according to the following schedule:
 - Quarterly sampling during years 1 through 5,
 - Semi-annual sampling during years 6 through 10, and
 - Annual sampling during years 11 through 30, and;
- Abandonment of the monitoring wells at the conclusion of the program.

6.4.2.2 *Common Remedial Alternative Components*

This remedial alternative also includes the three common components of Remedial Alternatives 2 through 6 described in Section 6.3. These three components are the SMP for arsenic-impacted soil on the Hookston Station Parcel, vapor intrusion prevention systems for residences as necessary, and private well closures. This remedial alternative is expected to require operation of the vapor intrusion prevention systems for 30 years or more. For costing purposes, a duration of 30 years was used.

6.4.3 *Remedial Alternative 3*

Remedial Alternative 3 incorporates active ground water remediation in A- and B-Zone ground water in addition to the components of Remedial Alternative 2. Table 6-1 outlines the components of Remedial Alternative 3 and Figure 6-4 presents a conceptual cross-section view of the components. Figures 6-5 through 6-8 present conceptual views of the proposed remedial systems.

Remedial Alternative 3 consists of the following components:

- Enhanced bioremediation of A-Zone ground water;

- Chemical oxidation of B-Zone ground water; and
- The three common remedial alternative components discussed in Section 6.3.

6.4.3.1 *A-Zone Ground Water*

Under this remedial alternative, enhanced anaerobic bioremediation would be implemented to address VOCs in A-Zone ground water on both the Hookston Station Parcel and the downgradient study area. Treatment by enhanced anaerobic bioremediation would consist of injection of an amendment to promote reductive dechlorination of TCE. The treatment performed within the Hookston Station Parcel would consist of direct-push injections of the amendment. Treatment in the downgradient study area would consist of a row of dedicated injection wells placed perpendicular to ground water flow direction to provide treatment under adjacent residential blocks.

The amendment used to stimulate and enhance bioremediation may include products commonly used for inducing accelerated reductive dechlorination, such as emulsified soybean oil or lactate mixtures. The amendments may also include bacterial cultures to ensure chlorinated ethenes can be completely degraded (i.e. bioaugmentation). For the purpose of developing a cost estimate for this component of Alternative 3, the use of an emulsified soybean oil without the need for bioaugmentation was assumed.

The treatment provided by this alternative is expected to reduce concentrations of TCE to below the level at which indoor air impacts would be expected in a period of 5 years, allowing operation of the vapor intrusion prevention systems to cease after approximately 6 years. The estimated period for the bioremediation system to result in achievement of RAOs applicable to the downgradient study area is likely to be 30 years or greater (achieving ground water MCL). The period to achieve RAOs applicable to the Hookston Station parcel using bioremediation is expected to be approximately 10 years.

Following completion of the active remediation by enhanced anaerobic bioremediation, further long-term reduction of VOCs in A-Zone ground water would be accomplished through residual biological activity, as well as other natural degradation processes.

Figure 6-5 presents an overview of the area of enhanced anaerobic bioremediation treatment in A-Zone ground water. Figure 6-6 presents the layout of A-Zone direct-push injection points within the Hookston

Station Parcel and Figure 6-7 presents the layout of dedicated injection wells in the downgradient study area.

Implementation of the enhanced anaerobic bioremediation alternative for A-Zone ground water would generally involve:

- Preparation of a remedial action work plan and obtaining appropriate permits;
- Performance of bench testing and pilot testing to evaluate optimal amendment mixture specifications and volume required to achieve cleanup goals;
- Installation of 10 A-Zone ground water monitoring wells to evaluate performance of this remedial action (Figure 6-5);
- Direct-push injection on the Hookston Station Parcel of the selected amendment mixture in rows oriented perpendicular to ground water flow with a 20-foot spacing between injection points within the row and with 60-foot spacing between rows (Figure 6-6);
- Installation of eight dedicated injection wells screened within the A-Zone in the downgradient study area across the width of the commingled ground water plume containing concentrations of 500 µg/L or greater TCE (Figure 6-7);
- Injection of the selected amendment mixture at the dedicated injection wells;
- Repeated amendment injections as needed to maintain appropriate carbon source concentrations and required reducing conditions (expected to be approximately annually) for approximately 3 years on the Hookston Station Parcel and 10 years in the downgradient study area;
- Collection and analysis of ground water samples from the Hookston Station Parcel at approximately 15 A-Zone monitoring wells for VOCs and eight A-Zone monitoring wells for geochemical parameters for 10 years according to the following schedule:
 - Quarterly sampling during years 1 through 5, and
 - Semi-annual sampling during years 6 through 10;
- Collection and analysis of ground water samples from the downgradient study area at approximately 15 A-Zone monitoring

wells for VOCs and eight A-Zone wells for geochemical parameters for 30 years or more according to the following schedule:

- Quarterly sampling during years 1 through 5,
- Semi-annual sampling during years 6 through 10, and
- Annual sampling during years 11 through 30; and
- Abandon the monitoring wells at the conclusion of the program.

6.4.3.2

B-Zone Ground Water

Under this remedial alternative, chemical oxidation would be implemented to address VOCs in B-Zone ground water. This remedial alternative assumes that an oxidant would be applied in a limited area of approximately 60,000 square feet surrounding the area where TCE concentrations are highest.

As documented in the 18 June 2003 evaluation by ERM's Remedial Technology Center (Appendix C), the most promising oxidant for this application is potassium permanganate. Bench testing determined that soil oxidant demand for potassium permanganate was 0.5 to 1 pound per cubic yard of B-Zone soil, which is considered a "low" oxidant demand, and that the use of potassium permanganate could be cost-effectively implemented based on the chemistry. It should be noted that alternative oxidants may be used based on evaluations of other oxidation products and the results of pilot testing, but for the purposes of this FS, the use of potassium permanganate has been assumed.

Based on the impacted area size, soil oxidant demand, and chemical demand, it is estimated that approximately 32 tons of solid potassium permanganate powder would be required to treat TCE present in the B-Zone. The powder would be mixed at the Hookston Station Parcel with tap water to produce a 3-percent solution. The oxidant solution would be introduced into the subsurface by pressure injection using direct-push drilling techniques. Angled injection techniques would be used to deliver oxidant beneath existing buildings. Based on a target goal of 5-percent soil pore volume displacement, each event would require injection of 560 gallons of 3-percent solution at 150 injection points, distributed around the highest concentration B-Zone ground water on 20-foot centers. To promote lateral distribution, the solution is planned to be injected over three injection events. The potential layout of the potassium permanganate injection points are shown on Figure 6-8.

Reduction of VOCs to RAOs would occur through the significant mass removal achieved by chemical oxidation and natural degradation processes.

Implementation of chemical oxidation for B-Zone ground water would generally involve:

- Preparation of a remedial action work plan and obtaining appropriate permits;
- Performance of a pilot test to evaluate optimal permanganate dosage, volume, and injection pressures required to achieve cleanup goals;
- Installation of 10 B-Zone ground water monitoring wells to evaluate performance of this remedial action (Figure 6-5);
- Performance of three injection events over a 6-month period. Each event would include injection of 560 gallons of 3-percent solution at 150 injection points (Figure 6-8);
- Collection of ground water samples at approximately 30 B-Zone monitoring wells for VOCs and 15 B-Zone wells for geochemical parameters for 30 years according to the following schedule:
 - Quarterly sampling during years 1 through 3,
 - Semi-annual sampling during years 4 through 8, and
 - Annual sampling during years 9 through 30; and
- Abandonment of the monitoring wells at the conclusion of the program.

6.4.3.3 *Common Remedial Alternative Components*

This remedial alternative also includes the three common components of Remedial Alternatives 2 through 6 described in Section 6.3. These three components are the SMP for arsenic-impacted soil on the Hookston Station Parcel, vapor intrusion prevention systems for residences as necessary, and private well closures. The use of enhanced bioremediation in the downgradient study area reduces the required duration of the vapor intrusion prevention to approximately 6 years.

6.4.4 *Remedial Alternative 4*

Remedial Alternative 4 incorporates many components of Remedial Alternatives 2 and 3, while utilizing a reactive barrier technology for treatment of VOCs in A-Zone ground water. Table 6-1 outlines the components of Remedial Alternative 4. Figure 6-9 presents a conceptual cross-section view of the components of Remedial Alternative 4, while Figures 6-10 and 6-11 present a conceptual view of the proposed remedial systems.

Remedial Alternative 4 consists of the following components:

- Zero-valent iron PRB for A-Zone ground water;
- Chemical oxidation for B-Zone ground water; and
- The three common remedial alternative components discussed in Section 6.3.

6.4.4.1 *A-Zone Ground Water*

This remedial alternative would consist of installation of a zero-valent iron PRB to provide treatment of A-Zone ground water. The PRB would be installed in a location in the downgradient study area capable of treating ground water prior to flowing beneath the downgradient residences that have been impacted by vapor intrusion. The treatment provided by the PRB is expected to reduce concentrations of TCE to below the level at which indoor air impacts would be expected in a period of 3 years, allowing operation of the vapor intrusion prevention systems to cease after approximately 4 years. The estimated period for the PRB to result in achievement of RAOs applicable to the downgradient study area is likely to be greater than 30 years (achieving ground water MCL). The proposed location of the PRB is presented on Figure 6-10. Implementation of this remedial action alternative for A-Zone ground water would generally involve:

- Preparation of a remedial action work plan and obtaining appropriate permits;
- Performance of bench column testing to develop specifications for the PRB;
- Installation of 10 A-Zone ground water monitoring wells to evaluate performance of this remedial action (Figure 6-10);

- Installation of the permeable reactive barrier, consisting of an approximately 500-foot long and 40-foot deep placement of zero-valent iron within a dug trench or using slurry injection techniques;
- Collection of ground water samples at 30 A-Zone monitoring wells for VOCs and 15 A-Zone monitoring wells for geochemical parameters for 30 years or greater according to the following schedule:
 - Quarterly sampling during years 1 through 5,
 - Semi-annual sampling during years 6 through 10, and
 - Annual sampling during years 11 through 30; and
- Abandonment of the monitoring wells at the conclusion of the program.

6.4.4.2 *B-Zone Ground Water*

Under this remedial alternative, chemical oxidation would be implemented to address VOCs in B-Zone ground water as shown on Figure 6-11. The implementation of this component of Remedial Alternative 4 is proposed as described for Remedial Alternative 3, in Section 6.3.3.

6.4.4.3 *Common Remedial Alternative Components*

This remedial alternative also includes the three common components of Remedial Alternatives 2 through 6 described in Section 6.3. These components are the SMP for arsenic-impacted soil on the Hookston Station Parcel, vapor intrusion prevention systems at residences as necessary, and private well closures. The use of the A-Zone PRB reduces the required duration of the vapor intrusion prevention systems to approximately 4 years.

6.4.5 *Remedial Alternative 5*

Remedial Alternative 5 incorporates many of the components of Remedial Alternative 4 with the exception that B-Zone ground water is treated using a PRB installed similar to the A-Zone ground water PRB discussed above for Remedial Alternative 4. Table 6-1 outlines the components of Remedial Alternative 5. Figure 6-12 presents a conceptual cross-section view of the components of Remedial Alternative 5. Figure 6-13 presents a conceptual plan view of the proposed remedial systems.

Remedial Alternative 5 consists of the following:

- PRB for A-Zone ground water;
- PRB for B-Zone ground water; and
- The three common remedial alternative components discussed in Section 6.3.

6.4.5.1 *A- and B-Zone Ground Water*

This remedial alternative would consist of installation of a zero-valent iron PRB to provide treatment of A- and B-Zone ground water. The PRB would be installed in the downgradient study area in a location capable of treating ground water prior to flowing beneath the downgradient residences. Since the PRB would be installed to the bottom of the B-Zone, at a depth up to 70 feet bgs, a high-pressure injection method would be required to place the zero-valent iron across the two water-bearing zones.

The treatment provided by the PRB is expected to reduce concentrations of TCE to below the level at which indoor air impacts would be expected in a period of 3 years, allowing operation of the vapor intrusion prevention systems to cease after approximately 4 years. The estimated period for the PRB to result in achievement of all RAOs is likely to be greater than 30 years (achieving ground water MCL). The proposed location of the A- and B-Zone PRBs is presented on Figure 6-13. Implementation of this remedial action alternative for A- and B-Zone ground water would generally involve:

- Preparation of a remedial action work plan and obtaining appropriate permits;
- Performance of bench column testing to develop specifications for the PRB;
- Installation of 20 A- and B-Zone ground water monitoring to evaluate performance of this remedial action (Figure 6-13);
- Installation of the permeable reactive barrier, consisting of an approximately 500-foot long and 70-foot deep placement of zero-valent iron using slurry injection methods (Figure 6-13);
- Collection of ground water samples at 60 monitoring wells for VOCs and 30 wells for geochemical parameters for 30 or more years according to the following schedule:
 - Quarterly sampling during years 1 through 5,

- Semi-annual sampling during years 6 through 10, and
- Annual sampling during years 11 through 30; and
- Abandonment of the monitoring wells at the conclusion of the program.

6.4.5.2 *Common Remedial Alternative Components*

This remedial alternative also includes the three common components of Remedial Alternatives 2 through 6 described in Section 6.3. These components are the SMP for arsenic-impacted soil on the Hookston Station Parcel, vapor intrusion prevention systems at residences as necessary, and private well closures. The use of the A-Zone PRB reduces the required duration of the vapor intrusion prevention systems to 4 years.

6.4.6 *Remedial Alternative 6*

Remedial Alternative 6 utilizes ground water extraction with ex situ physical treatment and discharge to the local publicly-owned treatment works to address A- and B-Zone ground water. This combination of extraction and treatment technologies, commonly referred to as pump and treat, is designed to provide eventual treatment of VOCs in ground water and prevent further downgradient migration of impacted ground water. Figure 6-14 presents a conceptual cross-section view of the components of Remedial Alternative 6. Figure 6-15 presents a conceptual plan view of the proposed remedial systems.

Remedial Alternative 6 includes the following:

- Pumping water from A-Zone ground water extraction wells on both the Hookston Station Parcel and the downgradient study area and treatment prior to discharge to a publicly-owned treatment works;
- Pumping water from B-Zone ground water extraction wells on both the Hookston Station Parcel and the downgradient study area and treatment prior to discharge to a publicly-owned treatment works; and
- The three common remedial alternative components discussed in Section 6.3.

6.4.6.1 *A- and B-Zone Ground Water*

This remedial alternative involves the installation of ground water extraction wells placed within the A- and B-Zone Hookston Station TCE

plume. Extraction wells would be placed within the Hookston Station Parcel as well as the downgradient study area to capture ground water exceeding cleanup goals. Figure 6-15 presents a conceptual layout of the ground water extraction wells, as well as monitoring wells used to evaluate performance of the remedial action. The treatment provided by the A-Zone ground water extraction is expected to reduce concentrations of TCE to below the level at which indoor air impacts would be expected in a period of 2 years, allowing operation of the vapor intrusion prevention systems to cease after approximately 3 years. Ground water modeling performed to evaluate placement of extraction wells and operation duration determined that ground water extraction should be performed for 30 years or greater for A- and B-Zone ground water to achieve the MCL for TCE across the plume.

Implementation of this remedial action alternative for A- and B-Zone ground water would generally involve:

- Preparation of a remedial action work plan and obtaining appropriate permits;
- Installation of 20 A- and B-Zone ground water monitoring wells to evaluate performance of this remedial action (Figure 6-15);
- Installation of 15 A-Zone extraction wells, each constructed with 4-inch diameter casing and screen and including submersible pumps designed to operate at approximately 2 gallons per minute, based on recent aquifer tests conducted for the Hookston Station Parcel (Appendix G);
- Installation of five B-Zone extraction wells, each constructed with 6-inch diameter casing and screen and including submersible pumps designed to operate at approximately 50 gallons per minute, based on recent aquifer tests conducted for the Hookston Station Parcel (Appendix G);
- Installation of a tray air stripping system, including off-gas treatment by activated carbon, in the northeastern corner of the Hookston Station Parcel, designed to treat the total capacity of the A- and B-Zone ground water extraction wells described above;
- Subgrade piping of the extracted ground water to the above water treatment facility;
- Subgrade piping of the treated ground water to the nearest sanitary sewer connection;

- Subgrade conduit for electrical and instrumentation wiring of the well pumps to the above water treatment facility;
- Operation of the ground water extraction system for 30 or more years, including monthly water and air discharge sampling, monthly maintenance of treatment system equipment, and reporting;
- Collection of ground water samples at 60 monitoring wells for VOCs and 30 wells for geochemical parameters for 30 or more years according to the following schedule:
 - Quarterly sampling during years 1 through 5,
 - Semi-annual sampling during years 6 through 10, and
 - Annual sampling during years 11 through 30; and
- Abandonment of the treatment system, extraction wells, and monitoring wells upon achievement of ground water cleanup goals to the extent practicable or when treatment effectiveness has diminished to asymptotic levels.

6.4.6.2 *Common Remedial Alternative Components*

This remedial alternative also includes the three common components of Remedial Alternatives 2 through 6 described in Section 6.3. These components are the SMP for arsenic-impacted soil on the Hookston Station Parcel, vapor intrusion prevention systems at residences as necessary, and private well closures. The use of the A-Zone ground water extraction reduces the required duration of the vapor intrusion prevention systems to 3 years.

DETAILED COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Federal and California State statutory regulations require that remedial actions selected in the FS process must:

- Be protective of human health and the environment;
- Attain ARARs (or provide grounds for invoking a waiver);
- Be cost-effective;
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent possible; and
- Satisfy the preference for treatment that reduces TMV as a principal element or provide an explanation as to why it does not.

To demonstrate compliance with these requirements, this section provides a detailed and comparative analysis of the remedial alternatives developed in Section 6. The detailed analysis of each alternative involves:

- An evaluation of each remedial alternative with respect to the seven federal evaluation criteria described above; and
- An assessment of each remedial alternative with respect to its effectiveness in achieving RAOs.

The nine federal evaluation criteria as set forth in the NCP (40 CFR 300.430[e][9][iii]) are categorized into two threshold criteria, five balancing criteria, and two modifying criteria. The threshold criteria which must be met are:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

Balancing criteria represent the primary criteria upon which the detailed and comparative analyses are based. The balancing criteria are:

- Long-term effectiveness and permanence;
- Reduction in TMV through treatment;
- Short-term effectiveness;

- Implementability; and
- Cost.

The modifying criteria, which will be evaluated by the RWQCB following review of the FS, are:

- State acceptance; and
- Community acceptance.

The components of the Remedial Alternatives, including costs, are summarized in Table 7-1. The detailed analysis for each alternative is presented in Section 7.2 and summarized in Tables 7-2 through 7-7. The comparative analysis is presented in Section 7.3 and summarized in Table 7-7. The development of detailed cost estimates for each of the alternatives is presented in Appendix J.

7.1 ***DETAILED EVALUATION CRITERIA***

The nine federal evaluation criteria are described in the following subsections and are later used in the detailed alternatives analysis. The detailed and comparative analyses are based primarily on threshold and balancing criteria.

7.1.1 ***Federal Evaluation Criteria***

7.1.1.1 ***Overall Protection of Human Health and the Environment***

According to Federal FS guidance (USEPA 1988), overall protection of human health and the environment generally serves as a threshold determination, which must be met for an alternative to be eligible for selection as the preferred alternative. Thus, this criterion serves as a final “check” to assess whether each alternative provides adequate protection of human health, the environment, and the beneficial uses of ground water. It evaluates how risks posed by COCs are being eliminated, reduced, or controlled through treatment, engineering, or institutional controls. It also evaluates the degree to which the alternative satisfies RAOs.

7.1.1.2 ***Compliance with Applicable, or Relevant and Appropriate Requirements***

This evaluation criterion is used to determine whether each alternative will meet ARARs, as presented in Section 4. Similar to protection of human health and the environment, this criterion generally serves as a

threshold determination which must be met for an alternative to be eligible for selection as the preferred alternative. Each alternative will be evaluated to determine compliance with chemical-, action-, and location-specific ARARs. Additionally, compliance with other applicable criteria, advisories, and guidelines (TBCs) will be considered.

7.1.1.3 *Long-Term Effectiveness and Permanence*

The long-term effectiveness and permanence criterion evaluates the long-term reliability of the proposed equipment and process and the permanence of the proposed alternative. This criterion evaluates the magnitude of residual risk posed by the presence of untreated waste or treatment residuals and the adequacy of institutional actions or containment measures needed to manage residual risk.

7.1.1.4 *Reduction of Toxicity, Mobility, or Volume through Treatment*

This criterion addresses the statutory preference for selecting remedial actions that employ treatment to permanently reduce TMV. It evaluates the degree to which the treatment is irreversible and the residual compounds that will remain following treatment. This criterion favors alternatives that utilize treatment to the maximum extent possible and generate little or no residual wastes.

7.1.1.5 *Short-Term Effectiveness*

The short-term effectiveness criterion measures the short-term risks to the community or remediation construction personnel that might occur during implementation of the remediation. This criterion also assesses the potential impact on the environment during remediation and the time required to meet remedial response objectives (e.g., cleanup goals).

7.1.1.6 *Implementability*

The implementability criterion evaluates technical and administrative feasibility of an alternative, and the availability of services and materials needed to implement the alternative. Evaluation of technical feasibility includes an assessment of the reliability of technologies and ease of undertaking additional remedial action, if necessary. This criterion favors proven technologies that are widely available and simple to implement or construct and operate.

7.1.1.7 *Cost*

The cost criterion assesses the financial burden associated with implementing the alternative. The factors that are addressed include capital costs, both direct and indirect, and O&M costs. Direct capital costs include construction costs or expenditures for labor, materials, equipment, and subcontractors associated with the remedial action. Indirect capital costs include expenditures for engineering, permitting, construction management, and other services necessary to carry out the remedial action. O&M costs include operational labor and maintenance materials associated with the extended O&M and reporting for each alternative. Costs are provided as net present value (NPV) costs. A discount rate of 7 percent is used for annual costs, which is the default discount rate recommended in the USEPA guidance, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA 2000).

7.1.1.8 *State and Community Acceptance*

The State and community acceptance criteria are typically addressed together. The State acceptance criterion evaluates the technical and administrative issues and concerns that the State may have regarding each of the alternatives. The community acceptance criterion addresses the issues and concerns the public may have regarding each of the alternatives. These criteria are typically evaluated by the lead regulatory agency following regulatory and public review of the FS. Due to the uncertainty associated with these criteria at this stage, detailed evaluation of State and community acceptance is not included in this FS.

7.2 ***DETAILED EVALUATION OF REMEDIAL ALTERNATIVES***

The detailed analyses of the remedial alternatives are presented in the following subsections. The components of each alternative, as well as the costs, are summarized in Table 7-1. Detailed cost estimates for each remedial alternative are presented in Appendix J. Tables 7-2 through 7-7 summarize the detailed analysis of each alternative. The evaluation balancing criteria long-term effectiveness, reduction of TMV, short-term effectiveness, and implementability were evaluated based on a numeric rating of 0 (no/none) to 5 (high) to quantify the degree to which the remedial alternative meets the criteria.

7.2.1 ***Remedial Alternative 1 (No Action)***

The detailed analysis of Remedial Alternative 1 against the nine federal evaluation criteria is presented below and summarized in Table 7-2.

Overall Protection of Human Health and the Environment. As no actions would be taken to address RAOs, this alternative would provide no protection of human health and the environment (score = No).

Compliance with ARARs. This alternative would not meet ARARs identified for the Hookston Station because no remedial actions would be taken (score = No).

Long-Term Effectiveness and Permanence. The No Action alternative provides no effectiveness in the long term, as residual risks would be similar to, or greater than, baseline risks. No actions would be taken under this alternative, and therefore affected media would continue to pose a threat to human health and ground water quality. Therefore, this alternative has no long-term effectiveness (score = 0).

Reduction of TMV through Treatment. The No Action alternative does not involve treatment to address Hookston Station chemical constituents, and therefore this alternative does not provide any reduction in TMV. Therefore, this alternative has no reduction of TMV (score = 0).

Short-Term Effectiveness. This alternative is considered to have low - moderate short-term effectiveness. Although there would be no short-term risk to the community or workers related to implementation (because no actions are taken), the duration until cleanup goals would be met would be much greater than 30 years. Therefore, this alternative has low-moderate short-term effectiveness (score = 2).

Implementability. As no actions would be taken for this alternative, this alternative is highly implementable (score = 5).

Cost. No costs are associated with this alternative, as no remedial actions would be conducted. Because this alternative has no cost, it ranks highest compared with the other alternatives (score = 5).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.2.2

Remedial Alternative 2 (MNA and Common Components)

The detailed analysis of Remedial Alternative 2 against the nine federal evaluation criteria is presented below and summarized in Table 7-3.

Overall Protection of Human Health and the Environment. The remaining components of this alternative (i.e., vapor intrusion prevention and private well removal) would provide immediate protection of human health. However, as the time required to achieve the RAOs would be

significant, this alternative would not fulfill the criteria for protection of human health and environment (score = No).

Compliance with ARARs. While this alternative may eventually be able to reduce VOCs from the Hookston Station Parcel to below ARARs in certain areas, it is not expected to achieve ARARs in all areas. (score = No).

Long-Term Effectiveness and Permanence. MNA, when applied appropriately, can be both highly effective and permanent in the long term. However, in areas that are not conducive to biodegradation (e.g., where low organic carbon is present), intrinsic biodegradation may occur at very slow rates. Monitoring would ensure that geochemical conditions remain conducive to biodegradation throughout the attenuation period, and would be used to determine residual concentrations and/or the need to implement further treatment. Therefore, this alternative has low long-term effectiveness (score = 1).

Reduction of TMV through Treatment. The biodegradation component of MNA is capable of completely converting the TCE present on the Hookston Station Parcel into carbon dioxide, water, and chloride ions, although partial dechlorination may result in intermediate daughter compounds (i.e., vinyl chloride) that exhibit higher toxicity than the parent compound; therefore, care must be taken to ensure that conditions are appropriate for full dechlorination. Mobility reduction is achieved by two primary MNA mechanisms: through the destruction of COCs by biodegradation, and by physical adsorption into the aquifer matrix. Volume reduction is attained through destruction of contaminants through biodegradation.

As the primary receptor of VOC-impacted ground water from the Hookston Station Parcel is indoor air in the downgradient study area, significant reduction of toxicity is achieved through implementation of vapor intrusion prevention systems at residences with impacts, but the slow reduction of A-Zone VOCs in the downgradient study area may result in a temporarily expanded area of indoor air impacts. Therefore, this alternative has a low reduction of TMV (score = 1).

Short-Term Effectiveness. This alternative poses little risk to local receptors during implementation, and requires only the installation of new monitoring wells. However, the time required for this alternative to meet cleanup goals is lengthy and therefore this alternative has only moderate short-term effectiveness (score = 3).

Implementability. This alternative requires standard ground water sampling and analytical techniques, and therefore is considered readily implementable. The remaining components of this alternative (i.e., vapor intrusion prevention and private well removal) utilize readily available and easily implemented construction methods, but would require cooperation by residents to be effective. Therefore, this alternative has moderate-high implementability (score = 4).

Cost. The costs associated with this alternative are primarily long-term costs for ground water monitoring and sampling, expected to continue for 30 or more years under this alternative. In addition, costs associated with installation and maintenance of vapor intrusion prevention systems are included with this alternative, with maintenance expected to be required for approximately 30 years. The total estimated cost (NPV) of Remedial Alternative 2 is \$2,575,000. Of this total, \$314,010 is direct and indirect capital cost, \$2,261,000 is O&M cost (NPV). These costs are the lowest of the five alternatives with costs associated with remedial action (score = 4).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.2.3

Remedial Alternative 3 (A-Zone Bioremediation, B-Zone Chemical Oxidation, and Common Components)

The detailed analysis of Remedial Alternative 3 against the nine federal evaluation criteria is presented below and summarized in Table 7-4.

Overall Protection of Human Health and the Environment. Immediate risks due to VOCs in ground water would be addressed through vapor intrusion prevention systems and private well removal. Bioremediation of A-Zone ground water is expected to reduce VOC concentrations and prevent expansion of the ground water plume. However, given the discontinuous nature of the A-Zone, the effective distribution of biological amendments may prove to be difficult, which could result in additional work to ensure consistent and complete destruction of the contaminants.

The B-Zone chemical oxidation is capable of oxidizing chloroethenes into harmless byproducts with relatively high certainty. This alternative provides a moderate level of short- and long-term effectiveness and is expected to eventually meet risk-based RAOs. Therefore, this alternative is considered protective of human health and the environment (score = Yes).

Compliance with ARARs. Remedial Alternative 3 may be able to satisfy chemical-, action-, and location-specific ARARs. However, the ability of

this treatment method to destroy intermediate byproducts, such as cis-1,2-DCE and/or vinyl chloride, is less predictable. B-Zone VOCs are expected to be treated to chemical-specific ARARs through treatment by oxidation. This alternative is compliant with ARARs, recognizing that some uncertainty in the effectiveness of bioremediation exists (score = Yes).

Long-Term Effectiveness and Permanence. Nearly immediate and permanent reduction of the most highly concentrated VOCs in B-Zone ground water is expected with this alternative by chemical oxidation. This alternative is expected to result in limited residual contamination following completion and utilizes reliable technologies to achieve treatment.

The enhanced bioremediation can be implemented extensively across the portion of the A-Zone on the Hookston Station Parcel, but the accessibility of the downgradient study area is lower, resulting in a limited area of influence from the injected bioremediation amendment. This could produce a potential for localized areas of reduced treatment effectiveness and residual risk within the downgradient study area. Therefore, this alternative has moderate long-term effectiveness (score = 3).

Reduction of TMV through Treatment. Reduction of TMV of VOC-impacted ground water may be achieved through treatment by enhanced bioremediation (A-Zone) and chemical oxidation (B-Zone). Chemical oxidation of B-Zone TCE is expected to reliably reduce TMV in that water-bearing zone. The completeness of A-Zone bioremediation is uncertain, particularly within the downgradient study area, with the potential for localized untreated areas as well as temporary or permanent residual concentrations of vinyl chloride as a result of incomplete reductive dechlorination. The incomplete biodegradation may result in increased TMV, due to the increased mobility and toxicity of vinyl chloride, relative to its parent compound, TCE. Therefore, this alternative has low-moderate reduction of TMV (score = 2).

Short-Term Effectiveness. This alternative presents minimal risk to the community because the technology with the greatest risk associated with implementation, chemical oxidation, is limited to ground water on the Hookston Station Parcel. Workers performing the chemical oxidation injections would be in contact with potassium permanganate, which is an oxidizer that requires special handling. However, worker exposure can be minimized by the use of appropriate health and safety protocols and personal protective equipment (PPE). The technology used for A-Zone ground water, in situ bioremediation, utilizes harmless food-grade materials for enhancement that do not pose an immediate threat to workers or the community. Immediate contaminant risks would be

reduced through vapor intrusion prevention systems and removal of private supply wells. However, the expected long duration of bioremediation within the downgradient study area, due to the limited area over which this can be implemented within the footprint of the downgradient study area, results in reduced short-term effectiveness. Therefore, this alternative has moderate short-term effectiveness (score = 3).

Implementability. Materials and services needed for remedial action are readily available, and technologies are reliable and proven, with the exception of enhanced bioremediation for which reliability must be proven on a site-specific basis. Installation of monitoring wells and bioremediation injection wells and periodic injection of a bioremediation amendment within the downgradient study area would require coordination with city agencies. Installation of vapor intrusion prevention systems and decommissioning of private wells would require cooperation with residents. Therefore, this alternative has a moderate level of implementability (score = 3).

Cost. The cost associated with this alternative includes design of the injection systems, chemical injection, and long-term ground water monitoring. In addition, costs associated with installation and maintenance of vapor intrusion prevention systems are included with this alternative, with maintenance expected to be required for approximately 6 years. The total estimated cost (NPV) of Remedial Alternative 3 is \$4,930,000. Of this total, \$3,014,000 is direct and indirect capital cost, \$1,916,000 is O&M cost (NPV). These are mid-range costs compared with the other alternatives (score = 3).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.2.4

Remedial Alternative 4 (A-Zone PRB, B-Zone Chemical Oxidation, and Common Components)

The detailed analysis of Remedial Alternative 4 against the nine federal evaluation criteria is presented below and summarized in Table 7-5.

Overall Protection of Human Health and the Environment. Immediate risks due to VOCs in ground water would be addressed through vapor intrusion prevention systems and private well removal. Placement of a zero-valent iron PRB would be expected to quickly reduce VOC concentrations under residences to concentrations below levels that will prevent unacceptable indoor air impacts. Zero-valent iron has been shown to successfully treat chlorinated ethenes such as TCE. Future

protection of B-Zone ground water would be accomplished through treatment using chemical oxidation, as in Remedial Alternative 3. This alternative provides a high level of short- and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment (score = Yes).

Compliance with ARARs. This alternative is expected to be able to satisfy chemical-, action-, and location-specific ARARs. A-Zone ground water is expected to reach ARARs within a reasonable time frame, particularly the 530 µg/L ground water screening level for protection of residential indoor air. A-Zone ground water would take longer to reach the ARAR of the MCL for ground water. B-Zone VOCs are expected to be treated to chemical-specific ARARs through treatment by oxidation. Therefore, this alternative is compliant with ARARs (score = Yes).

Long-Term Effectiveness and Permanence. This alternative would be effective in the long term for A-Zone ground water by providing immediate and permanent destruction of VOCs as ground water flows through the PRB. Nearly immediate and permanent reduction of the most highly concentrated VOCs in B-Zone ground water is expected with this alternative by chemical oxidation. This alternative is expected to result in limited residual contamination following completion and utilizes reliable technologies to achieve treatment. Therefore, this alternative has a high level of long-term effectiveness (score = 5).

Reduction of TMV through Treatment. Significant reduction of TMV of VOC-impacted ground water is expected within the area and water-bearing zone with the greatest risk to receptors, A-Zone ground water below residential properties. The PRB is expected to immediately reduce the toxicity of A-Zone ground water as it passes through the PRB. Treatment of B-Zone ground water by chemical oxidation would reduce TMV across the plume extent. Therefore, this alternative has moderate-high reduction of TMV (score = 4).

Short-Term Effectiveness. Trenching or injection performed to place zero-valent iron PRB would pose a predictable risk to construction workers, although this construction method is well established. Construction controls would be required to reduce risk to community members. Workers performing the chemical oxidation injections would be in contact with potassium permanganate, which is an oxidizer that requires special handling. However, worker exposure can be minimized by the use of appropriate health and safety protocols and PPE. Immediate contaminant risks would be reduced through vapor intrusion prevention systems and removal of private supply wells. The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to

be short, while achieving the ultimate cleanup goal of the MCL for ground water would take longer, without posing immediate risks. The limited risks to community during implementation and the long duration of some components of this alternative results in a moderate-high short-term effectiveness (score = 4).

Implementability. Materials and services needed for remedial action are readily available, and technologies are reliable and proven. Installation of the PRB would require significant construction and proper coordination with residences and city agencies. This would be true of either a trenched or injected PRB, with the trenched PRB presenting greater installation difficulties, due to potential presence of subsurface utilities. Installation of vapor intrusion prevention systems and decommissioning of private wells would require cooperation with residents. Therefore, this alternative has a moderate level of implementability (score = 3).

Cost. The cost associated with this alternative includes performing a reaction column test, performing hydrogeologic testing, designing the iron PRB, trenching and installing the PRB, and long-term ground water monitoring. In addition, chemical injection would be performed on the Hookston Station Parcel and costs associated with installation and maintenance of vapor intrusion prevention systems are included with this alternative, with maintenance expected to be required for approximately 4 years. The total estimated cost (NPV) of Remedial Alternative 4 is \$5,194,000. Of this total, \$3,214,000 is direct and indirect capital cost, \$1,980,000 is O&M cost (NPV). These are mid-range costs compared with the other alternatives (score = 3).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.2.5 *Remedial Alternative 5 (A-Zone and B-Zone PRB and Common Components)*

The detailed analysis of Remedial Alternative 5 against the nine federal evaluation criteria is presented below and summarized in Table 7-6.

Overall Protection of Human Health and the Environment. This alternative is identical to Remedial Alternative 4 with addition of a PRB to treat B-Zone ground water similar to the PRB specified for A-Zone ground water in Remedial Alternative 4. Immediate risks due to VOCs in ground water are addressed through vapor intrusion prevention systems and private well removal. Placement of a zero-valent iron PRB is expected to quickly reduce VOC concentrations in A-Zone ground water under residences to concentrations below levels that will prevent further indoor

air impacts. The B-Zone PRB is expected to prevent further migration of VOCs in the downgradient study area. This alternative provides a moderately high level of short- and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment (score = Yes).

Compliance with ARARs. This alternative is expected to satisfy chemical-, action-, and location-specific ARARs in the downgradient study area within a reasonable time frame, as ground water is treated as it passes through the A- and B-Zone PRBs. Ground water would take longer to reach the ARAR of the MCL for ground water. Therefore, this alternative is compliant with ARARs (score = Yes).

Long-Term Effectiveness and Permanence. This alternative would be effective in the long term for A- and B-Zone ground water by providing immediate and permanent destruction of VOCs as ground water flows through the PRB. This alternative utilizes reliable technologies to achieve treatment where the primary risk pathways are present, but may have the potential for residual contamination (B-Zone within the Hookston Station Parcel) following completion. Therefore, this alternative has a moderate-high level of long-term effectiveness (score = 4).

Reduction of TMV through Treatment. Significant reduction of TMV of VOC-impacted ground water is expected within the area and water-bearing zone with the greatest risk to receptors, A-Zone ground water below the residential property. The PRB is expected to immediately reduce the toxicity of ground water. The TMV of ground water within the Hookston Station Parcel is expected to eventually reduce as a result of natural degradation processes, but this is expected to take a significant amount of time. Therefore, this alternative has moderate reduction of TMV (score = 3).

Short-Term Effectiveness. This alternative is expected to use an injection method to place a zero-valent iron PRB. This construction would pose a predictable risk to construction workers and potentially community members. Construction controls would be required to reduce risk to community members. The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to be short, while achieving the ultimate cleanup goal of the MCL for ground water would take significantly longer without posing immediate risks.

The limited risks to community during implementation and the long duration of some components of this alternative results in a moderate-high short-term effectiveness (score = 4).

Implementability. Materials and services needed for remedial action are readily available, and technologies are reliable and proven. Installation of the PRB would require significant construction and proper coordination with residences and city agencies. The deeper A- and B-Zone placement of the PRB would require a greater time frame and the use of innovative injected PRB methods. Installation of vapor intrusion prevention systems and decommissioning of private wells would require cooperation with residents. Therefore, this alternative has a moderate level of implementability (score = 3).

Cost. The cost associated with this alternative includes performing a reaction column test, performing hydrogeologic testing, designing the iron PRB, trenching and installing the PRB, and long-term ground water monitoring. In addition, maintenance of vapor intrusion prevention systems are included with this alternative, with maintenance expected to be required for approximately 4 years. The total estimated cost (NPV) of Remedial Alternative 5 is \$8,739,000. Of this total, \$7,068,000 is direct and indirect capital cost, \$1,671,000 is O&M cost (NPV). These are medium to high range costs compared with the other alternatives (score = 2).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.2.6

Remedial Alternative 6 (Ground Water Extraction, Treatment, and Disposal, and Common Components)

The detailed analysis of Remedial Alternative 6 against the nine federal evaluation criteria is presented below and summarized in Table 7-7.

Overall Protection of Human Health and the Environment. Immediate risks due to VOCs in ground water addressed through vapor intrusion prevention systems and private well removal. Ground water extraction and treatment across A- and B-Zone plumes would prevent further migration of VOCs. Ground water extraction is expected to quickly reduce TCE concentrations in A-Zone ground water to below the 530 µg/L screening level for residential indoor air impacts. However, achievement of MCLs across the A- and B-Zone plume extent is expected require long-term operation of the active pump and treat system. This alternative provides a moderately high level of short- and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment (score = Yes).

Compliance with ARARs. This alternative is expected to satisfy chemical-specific ARARs for ground water (score = Yes).

Long-Term Effectiveness and Permanence. Plume-wide ground water extraction is expected to provide effective and relatively fast reduction of A-Zone TCE to concentrations reducing associated risks associated with migration to indoor air. However, this alternative relies on long-term O&M of an extraction and treatment system to achieve MCLs in A- and B-Zone ground water. Therefore, this alternative has a moderate-high level of long-term effectiveness (score = 4).

Reduction of TMV through Treatment. Reduction of TMV is expected with this alternative, through extraction of TCE-impacted ground water. However, the contaminants are simply removed from ground water, rather than being destroyed in situ. Contaminants would be transferred between media at several stages of the treatment process. In addition, the highly stratified soils in the A-Zone may limit the effective hydraulic capture zones, resulting in localized untreated zones and higher residual TMV. Pumping may also significantly alter the local hydraulic gradients, which could result in the migration of chemicals from other (non-Hookston) sources into the neighborhood. Therefore, this alternative has moderate reduction of TMV (score = 3).

Short-Term Effectiveness. This alternative would require significant infrastructure associated with the treatment. Numerous extraction wells would be constructed within the downgradient study area, resulting in potential impacts to residents. However, construction methods are standard, with easily mitigated effects. The long duration of system O&M for this alternative reduces the level of short-term effectiveness. The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to be short, while achieving the ultimate cleanup goal of the MCL for ground water would take significantly longer without posing immediate risks. The limited risks to community during implementation and the long duration of some components of this alternative results in a moderate-high short-term effectiveness (score = 4).

Implementability. This alternative requires construction, operation, and maintenance of significant infrastructure to implement plume-wide ground water extraction and treatment. Most of the construction would be within the community in the downgradient study area and would be relatively intrusive, considering the number of wells and extent of trenching required for conveyance piping and wiring. However, the construction methods and equipment are readily available and implementable. Installation of vapor intrusion prevention systems and decommissioning of private wells would require cooperation with residents. Therefore, this alternative has a low to moderate level of implementability (score = 2).

Cost. The cost associated with this alternative includes installation of 15 A-Zone and five B-Zone ground water extraction wells, installation of conveyance piping from the wells to a treatment center located on the Hookston Station Parcel, and construction of the treatment system consisting of an air stripper with activated carbon off-gas treatment and associated equipment. The extraction and treatment system would be operated for at least 30 years, including performance of long-term ground water monitoring. In addition, costs associated with installation and maintenance of vapor intrusion prevention systems is included with this alternative, with maintenance expected to be required for approximately 3 years. The total estimated cost (NPV) of Remedial Alternative 6 is \$12,807,000. Of this total, \$1,900,000 is direct and indirect capital cost, \$10,906,000 is O&M cost (NPV). These costs are high compared with the other alternatives (score = 1).

State and Community Acceptance. The State and community acceptance criteria were not evaluated in this FS.

7.3 *COMPARATIVE ANALYSIS*

In this section, the six alternatives evaluated in the sections above are evaluated relative to one another for each evaluation criteria. The comparative analysis identifies the relative advantages and disadvantages of each alternative. Table 7-8 summarizes the results of the comparative analysis.

7.3.1 *Overall Protection of Human Health and the Environment*

The overall protection of human health and the environment criterion serves as a final check to ensure that each alternative provides adequate protection of human health and the environment. This criterion draws on the assessment of other evaluation criteria to determine if this protection is achieved and serves as a final check for overall acceptability of the alternative. During the comparative analysis of alternatives, overall protection of human health and the environment serves as a threshold criterion that must be met for eligibility of selection (USEPA 1988).

As described in Section 7.2, two of the six alternatives evaluated during this FS did not meet the threshold of overall protection of human health and the environment, Remedial Alternatives 1 and 2. These alternatives have low levels of long-term effectiveness and reduction of TMV, and therefore are not protective of human health and the environment. Remedial Alternatives 3 through 6 were all determined to be protective of

human health and the environment, and would be acceptable for selection.

7.3.2 *Compliance with ARARs*

Similar to overall protection of human health and the environment, the compliance with ARARs criterion serves as a final check based on overall performance of the alternatives. This criterion is used to ensure that each alternative is expected to meet ARARs following implementation. During the comparative analysis of alternatives, compliance with ARARs serves as a threshold criterion that must be met for eligibility of selection (USEPA 1988).

For ground water, the primary ARAR for which the alternatives and associated technologies were designed to meet is the 530 µg/L TCE screening level for protection of residential indoor air in the downgradient study area. The secondary ARAR considered is the MCL for TCE and associated VOCs. Remedial Alternatives 1 and 2 are not expected to meet these ARARs within a reasonable time frame. Remedial Alternatives 3 through 6 are expected to take varying but similar durations to achieve respective ARARs.

7.3.3 *Long-Term Effectiveness and Permanence*

Remedial Alternative 4 provides the highest level of long-term effectiveness and permanence because this alternative utilizes a proven treatment technology to completely and permanently destroy TCE in A-Zone ground water migrating toward residences within the downgradient study area. In addition, this alternative incorporates an aggressive treatment of VOCs in B-Zone ground water designed to permanently destroy contaminants and reduce the potential for further migration in that water-bearing zone. This alternative would result in the lowest residual risk because of the ability of the technology to completely destroy contaminants and achieve low cleanup concentrations.

Remedial Alternative 5 provides a slightly lower level of long-term effectiveness and permanence than Remedial Alternative 4 due to the lack of treatment of B-Zone ground water on the Hookston Station Parcel.

Remedial Alternative 6 provides a similar level of long-term effectiveness and permanence as Remedial Alternative 5 due to the lack of B-Zone ground water source zone treatment. Pump and treat does offer reduced risk associated with the need for replacement, due to the adaptability of pump and treat. Although the pump and treatment associated with this alternative provides a slightly faster reduction in A-Zone ground water

concentrations than a PRB, the ability for pump and treat to achieve low cleanup values is not proven. The residual risk posed by these higher remaining concentrations offsets the benefit derived from the adaptability.

If completely successful, Remedial Alternative 3 has the potential to result in a high long-term effectiveness and permanence, as it combines in situ treatment in the A-Zone on both the Hookston Station Parcel and downgradient study area with in-situ treatment in the B-Zone on the Hookston Station Parcel. When effective, enhanced anaerobic bioremediation is capable of treating to very low concentrations, thus lowering the residual risk. However, it is uncertain whether the biological amendments can be sufficiently distributed throughout the A-Zone, or whether enhanced bioremediation would be able to achieve permanent and complete destruction of TCE without the final production of 1,2-DCE and/or vinyl chloride. In addition, the areas where implementation of bioremediation is possible within the downgradient study area is limited, resulting in areas with limited treatment. These uncertainties increase the potential that this alternative would need to be altered at a later date to increase the distribution of the biological amendments or to provide additional treatment of residual 1,2-DCE and/or vinyl chloride that may pose a residual risk to residential indoor air. Therefore, this alternative has the lowest long-term effectiveness of all the “active remediation” alternatives.

Remedial Alternative 2 provides some level of long-term effectiveness by implementing vapor intrusion prevention at residences within the downgradient study area with known indoor air impacts from VOCs in ground water from the Hookston Station Parcel. However, with the lack of treatment beyond the natural mechanisms used in MNA and the uncertainty of complete degradation, Remedial Alternative 2 has a lower long-term effectiveness.

Based on this analysis, Remedial Alternative 4 ranks highest (score of 5) for long-term effectiveness, with Remedial Alternatives 5 and 6 (score of 4) ranking just below Remedial Alternative 4. Remedial Alternatives 3 (score = 3), 2 (score = 1), and 1 (score = 0) rank progressively lower for long-term effectiveness and permanence.

7.3.4 *Reduction of Toxicity, Mobility, or Volume through Treatment*

Remedial Alternatives 3 through 6 are expected to reduce TMV of TCE-impacted ground water from the Hookston Station Parcel through active remediation. All of these alternatives rely upon technologies that permanently destroy or remove contaminants in ground water, and therefore are not “reversible” processes.

Remedial Alternative 4 is expected to most reliably reduce TMV through in situ treatment by the A-Zone PRB and B-Zone chemical oxidation. Remedial Alternative 3 may be capable of achieving similar reduction of TMV through in situ anaerobic bioremediation of A-Zone ground water, but the uncertainty of complete destruction of TCE by this method results in a lower ranking for this alternative.

Remedial Alternative 5 would similarly treat A-Zone ground water as Remedial Alternative 4. However, Remedial Alternative 4 addresses the higher concentrations within the B-Zone more directly, and therefore carries a higher ranking for this evaluation criterion than Remedial Alternative 5. Remedial Alternative 6 is also expected to reduce TMV of TCE-impacted ground water, but only through phase-transfer processes, rather than in situ destruction. The low conductivity of the A-Zone is expected to decrease the ability of the A-Zone pump and treat component of Remedial Alternative 6 to reduce volume of low-concentration ground water as much as other in situ technologies. Chemicals from other (non-Hookston) sources could also be mobilized by this system due to the increased hydraulic gradients that would be created. Therefore, this alternative carries a lower ranking than the technologies with active, proven remedial technologies.

Remedial Alternative 2 is expected to reduce TMV through contaminant destruction (biodegradation) and reduction in mobility (adsorption). However, MNA may result in a temporary expansion of the ground water plume before natural degradation processes can begin reducing TMV, especially in the B-Zone where greater concentrations of VOCs are present. As a result, this alternative ranks lower than all active remediation alternatives.

Based on this analysis, Remedial Alternative 4 ranks highest (score of 4) for reduction of TMV. Remedial Alternatives 5 and 6 (score of 3) rank below Remedial Alternative 4, followed by Remedial Alternatives 3 (score of 2), 2 (score of 1), and 1 (score of 0) for achievement of reduced TMV.

7.3.5 *Short-Term Effectiveness*

As described in Section 7.1.1.5, the comparative analysis using the short-term effectiveness criterion focuses on two separate factors: 1) which technologies have the lowest risk to residents and construction workers *during implementation*, and 2) which alternatives can most rapidly achieve cleanup goals. For purposes of this comparative analysis, each of these two factors have been considered separately and the results merged into a single scoring and ranking for the alternatives. Treatment duration has been weighted slightly higher in this evaluation due to the reliance upon

the selected alternative to be protective of human health, and the ability to effectively mitigate construction and implementation risks.

All five alternatives that incorporate the vapor intrusion prevention systems and private well removal (i.e., Remedial Alternatives 2 through 6) have a similar immediate reduction of the primary risks associated with TCE in ground water. With respect to treatment duration, two endpoints have been considered: 1) the time until MCLs are met, and 2) the time until vapor intrusion should no longer present an unacceptable risk. Of the five treatment alternatives, Remedial Alternative 2 has the longest treatment time until MCLs would be met. Therefore, this alternative ranks the lowest (with the exception of No Action) in this respect. The remaining treatment alternatives (Remedial Alternatives 3 through 6) all require 30 or more years to meet MCLs and therefore all score similarly based on this factor.

With regard to the time required to reduce ground water concentrations such that no unacceptable risk is posed to residents in the downgradient study area, the treatment durations provided in Table 7-1 are referenced. Of the treatment alternatives, Remedial Alternative 2 has the longest treatment duration. Remedial Alternative 6 has the shortest duration, with Remedial Alternatives 4 and 5 both requiring slightly longer. Of the active remediation alternatives, Remedial Alternative 3 has the longest duration until indoor air is no longer expected to present an unacceptable risk based on ground water concentrations.

Regarding implementation risk to residents and construction workers, Remedial Alternatives 1 and 2 present the lowest risk as little to no construction is required. Remedial Alternative 3 has slightly more implementation risk due to the use of drilling and injecting equipment, and the handling of oxidizing chemicals (i.e., potassium permanganate) as part of the remedy. Similarly, Remedial Alternative 6 carries some implementation risk due to the installation of large amounts of equipment and piping in a residential area. Remedial Alternatives 4 and 5 carry the highest implementation risk due to installation of the PRB and the associated construction risks. Although the PRB in Remedial Alternative 4 is only designated for the A-Zone and therefore has less risk associated with the PRB installation component, this alternative also involves handling of oxidants, and thus the benefit is off-set.

Based on this analysis, and combining consideration of the two primary elements of short-term effectiveness (i.e., implementation risk and treatment duration), Remedial Alternatives 4, 5, and 6 rank highest (score of 4), followed by Remedial Alternatives 2 and 3 (score of 3), and Remedial Alternative 1 (score of 2) for short-term effectiveness.

7.3.6 *Implementability*

Remedial Alternatives 1 and 2 are considered highly implementable. Remedial Alternative 1 requires no action and is therefore by definition highly implementable. Remedial Alternative 2 involves long-term monitoring of ground water, as well as implementation of vapor intrusion prevention components and private well removal. The need to access private residences for these components slightly lessens the implementability of the alternative.

Remedial Alternatives 3 through 6 also utilize, in addition to vapor intrusion prevention components and private well removal, the addition of remedial technologies that present technical and administrative hurdles. Each of these alternatives possess similar administrative and technical feasibility associated with the permitting, implementation, and construction of the remedial components. All of the alternatives require access to private land, including residences, and involve the injection or extraction of materials into or from the subsurface. Remedial Alternative 6 is slightly less implementable because it is a long-term active system that would require the largest infrastructure development and high maintenance.

Based on this analysis, Remedial Alternative 1 ranks highest (score of 5) followed by Remedial Alternative 2 (score of 2), Remedial Alternatives 3, 4, and 5 (score of 3), and Remedial Alternative 6 (score of 2) for implementability.

7.3.7 *Cost*

Remedial Alternative 6 is the most costly alternative at \$12,807,000. Remedial Alternative 2 is the least costly of the active alternatives at \$2,575,000. No cost is associated with Remedial Alternative 1. Remedial Alternatives 3, 4, and 5 have progressively greater costs of \$4,930,000, \$5,194,000, and \$8,739,000, respectively.

7.3.8 *State and Community Acceptance*

The State and community acceptance criteria were not evaluated in this FS.

7.4 *PREFERRED REMEDIAL ALTERNATIVE*

The purpose of the detailed and comparative analysis presented in Sections 7.2 and 7.3 is to provide a basis for determining which remedial

alternative is most appropriate for protecting human health and the environment and managing long-term risk. This section summarizes the results of the detailed and comparative analysis in Section 7, and recommends a preferred alternative based on the comparative analysis. The final selection of a preferred alternative will be made following agency and public response. Table 7-8 summarizes the results of the comparative analysis.

Remedial Alternative 4 is the preferred remedial alternative. As shown in Table 7-8, and described in Section 7.3, Remedial Alternative 4 consistently ranks higher or as high as the other alternatives evaluated in this FS for every evaluation criteria. In addition, this alternative has a total cost that falls at a mid-point between the other active alternatives. Remedial Alternative 4 satisfies the threshold criteria of protectiveness and compliance with ARARs. This alternative is moderately to highly effective at satisfying all balancing and modifying criteria (long-term effectiveness and permanence, reduction of TMV through treatment, short-term effectiveness, implementability, and State and community acceptance).

The components of Remedial Alternative 4 are more completely described in Section 8.0.

This section provides an initial Implementation Plan that describes the work components and preliminary procedures that would be necessary to implement the preferred remedial alternative for the Hookston Station Parcel. Remedial Alternative 4, as described above in Sections 6 and 7, utilizes a combination of institutional controls, engineering controls, and in situ ground water treatment to achieve RAOs.

This Implementation Plan constitutes an initial conceptual design, and due to the preliminary nature, is subject to change, based on agency review and public comments on the FS. In addition, components of work described herein for Remedial Alternative 4 may be refined following completion of treatability studies, field pilot tests, and more intensive Remedial Design.

The selected preferred alternative (Remedial Alternative 4), includes the following components:

- Zero-valent iron PRB for A-Zone ground water;
- Chemical oxidation for B-Zone ground water;
- Institutional controls for arsenic-impacted subsurface soil in the form of an SMP;
- Vapor intrusion prevention systems; and
- Removal of private wells, which have been used for irrigation and filling swimming pools, from residences that overlie the downgradient study area.

This section is divided into five primary sections:

- Section 8.1 describes the field investigations necessary to complete a full-scale design of the remediation systems;
- Section 8.2 describes work plans and permits that may be necessary;
- Section 8.3 describes the general scope of the remedial action implementation;
- Section 8.4 describes the effectiveness monitoring program; and
- Section 8.5 provides an approximate implementation schedule.

8.1 *PRE-DESIGN INVESTIGATIONS*

Prior to development of a full-scale design for the selected remedial action, additional investigation activities would be performed to refine design parameters for implementation. Several investigation tasks, described below, would be performed supporting implementation of the zero-valent iron PRB, chemical oxidation, and vapor intrusion prevention.

8.1.1 *Monitoring Well Installation and Baseline Sampling*

Several additional monitoring wells would be installed to provide a more complete ground water monitoring network for evaluating the performance of the remedial action components. Installation and sampling of these wells prior to final design of the remedial action components would allow more accurate design of the scale of the remedial action.

As part of this task, several new monitoring wells within the A- and B-Zones would be installed. These wells would be installed prior to completion of the final design of the A-Zone PRB and B-Zone chemical oxidation. The wells would be installed using the standard operating procedures developed for the Hookston Station Parcel (ERM 2000). Monitoring wells would be placed to maximize their value as performance monitoring points for the PRB (i.e., spaced at various distances up- and downgradient of the barrier's planned location).

Following installation of the wells described above, a complete ground water sampling event would be performed to provide baseline conditions of VOC concentrations. Ground water would be sampled from monitoring wells within the study area. Samples from all monitoring wells sampled would be analyzed for VOCs. Samples from a subset of the wells sampled would be analyzed for geochemical parameters, including:

- Dissolved gases (methane, ethane, ethene, hydrogen);
- Dissolved and total metals (iron and manganese);
- Ions (chloride, sulfate, nitrate);
- Total organic carbon; and
- Alkalinity.

Physical parameters, such as temperature, acidity/alkalinity (pH), dissolved oxygen, and oxidation-reduction potential, would also be collected during the well sampling program.

8.1.2 *Direct-Push Sampling*

In addition to the monitoring well program described above, a ground water investigation would be completed along the proposed length of the PRB. In order to further delineate the subsurface geology and distribution of VOCs, an in-situ, real-time investigation tool (e.g., cone penetrometer testing [CPT] rig equipped with a membrane interface probe [MIP] or a Waterloo Profiler™ device) would be utilized. It is anticipated that a CPT/MIP or Waterloo Profiler™ sampling location would be completed approximately every 50 feet along the proposed length of the PRB (Figure 6-10). Borings would be completed to a depth of approximately 70 feet (just below the bottom of the B-Zone aquifer). The objective of this pre-design study is to optimize the placement (depth and length) of the PRB for maximum benefit.

A similar sampling program would be completed in the vicinity of MW-11B, located on the western property line behind the commercial building at 199 Mayhew Way. MW-11B contains considerably higher concentrations of TCE than the co-located A-Zone well, MW-11A. Previously, five HydroPunch borings (B-101 through B-105) were completed at locations upgradient of MW-11B in attempt to locate a potential upgradient source for this contamination. No TCE was found during that investigation. Additional sampling is proposed to verify these previous HydroPunch data and to support the Remedial Design. Four borings (either CPT/MIP or Waterloo Profiler™) would be completed along the western property boundary and at locations in the downgradient study area near MW-11B (Figures 6-10 and 6-11). Borings would be completed to a depth of approximately 70 feet (just below the bottom of the B-Zone aquifer). This pre-design investigation is intended to better determine the optimal locations for the B-Zone chemical oxidation injections.

A work plan outlining the scope of work and sampling procedures would be developed, and would be submitted to the RWQCB for approval prior to implementing the investigation activities.

8.1.3 *PRB Bench-Scale Testing*

Prior to completing the detailed Remedial Design for the zero-valent iron PRB, bench testing must be completed to obtain data to determine design parameters. Data from the bench testing would be used to specify the quantity and grain-size of iron material to use in the PRB, the required residence time, the dimensions of the barrier, and the expected effectiveness of the reduction.

Bench testing would be performed in a column, simulating the conditions of the PRB. A-Zone ground water would be collected from monitoring wells in the vicinity of the proposed PRB and would be used in the bench test. Ground water would be pumped through the column at a rate simulating the A-Zone ground water flow velocity.

Following startup of the column test, effluent samples would be collected at discrete locations within the column at specific periods following startup. Samples would be analyzed for the COCs, TCE and daughter products, as well as for other parameters indicative of performance of the PRB, such as cations (iron, sodium, manganese, calcium, potassium, etc.), anions (nitrate, chloride and sulfate), alkalinity, and standard water quality parameters (pH, oxidation-reduction potential, conductivity, etc.).

The column test would be performed over several weeks. Based on the results of the column test, a more accurate estimate of the scale and cost of the PRB would be possible. This would allow the PRB construction specifications to be finalized for design and contracting purposes.

8.1.4 *Chemical Oxidation Pilot Testing*

Bench-scale treatability testing was previously performed to determine the potential effectiveness of chemical oxidation at Hookston Station (Appendix C). The bench testing indicated that chemical oxidation using potassium permanganate solution could be cost-effectively applied to B-Zone ground water due to a low soil oxidant demand. This bench test also resulted in an approximate value for soil oxidant demand of 1.9 pound of potassium permanganate per cubic yard within the B-Zone.

Prior to full-scale implementation, an in-field pilot study would be performed to support the final Remedial Design (i.e., determine optimal injection rates, well spacing, etc.) and verify the effectiveness of this chemical treatment within the aquifer. The pilot study would consist of a small network of direct-push injections of potassium permanganate near the upgradient boundary of the B-Zone TCE plume. The pilot study would strive to test the effectiveness of chemical oxidation in the area of the plume with the highest TCE concentrations. Temporary monitoring wells would be installed at varying distances downgradient of the injection points. Monitoring of ground water conditions prior to and following the injection would be used to evaluate the effectiveness of the technology and refine design parameters to be incorporated into the Remedial Design. A work plan outlining the scope of work and sampling procedures would be developed prior to implementation for review and approval by the RWQCB.

8.2 *REMEDIAL DESIGN, DOCUMENTATION, AND PERMITTING*

Several phases of documentation would be required prior to implementation of the components of Remedial Alternative 4. The expected documentation phases are described below.

8.2.1 *Pre-Design Investigation Work Plan*

This work plan would provide specifications for the investigation phases described above in Section 8.1. This document would include provisions for permitting monitoring well installation with the Contra Costa County Environmental Health Division.

8.2.2 *Remedial Design*

Following completion of the pre-design investigation phases, a Remedial Design would be developed that documents the detailed construction specifications for implementation of the components of Remedial Alternative 4. These components include the A-Zone PRB, the B-Zone chemical oxidation, as well as the vapor intrusion prevention systems and private well removal. The Remedial Design would be conducted in phases to allow an initial design to be used to work with PRB contractors to select the most appropriate installation method and incorporate components specific to that method into final designs. This design would provide details for the permitting process for all of the construction components.

8.2.3 *Soil Management Plan*

As described in Section 7, arsenic in soils does not currently present an unacceptable risk to commercial/industrial workers. Impacted soils would remain in place under this alternative, and potential future exposures to the single location of elevated arsenic in subsurface soils by construction workers would be addressed through an SMP. This document is the primary component of the institutional controls used to protect construction workers from arsenic-impacted shallow soil at the Hookston Station Parcel. The SMP would be developed in cooperation with all current Hookston Station property owners. The SMP would provide standard operating procedures for all subsurface construction performed on the Hookston Station Parcel, including construction of subsurface utilities and larger-scale excavation work. The SMP would also provide procedures for handling and disposal of soil excavated during construction activities.

8.3

IMPLEMENTATION OF ALTERNATIVE COMPONENTS

This section describes the implementation of the remedial action components of Remedial Alternative 4. This discussion is intended to provide a preliminary description of how the specific components of this alternative would be implemented.

8.3.1

A-Zone Zero-Valent Iron PRB

Based on the results of the PRB bench testing and baseline ground water sampling described in Section 8.1, and a survey of the proposed location of the PRB, the installation methods for the PRB would be evaluated. Due to the relatively shallow depth of the A-Zone, multiple installation methods are available with varying benefits. This section provides only a general description of installation of the PRB, as the installation method has not yet been determined. The general location of the A-Zone PRB is presented on Figure 6-10. This location may be refined based on the results of the baseline ground water sampling described in Section 8.1.

The two primary installation methods being considered for the PRB are trenching and direct injection. Placement of zero-valent iron in a PRB has been commonly performed by trenching in areas where a continuously-excavated trench is possible. The trenching can be performed using several methods, including standard backhoe trenching for shallow trenches, clamshell excavation for very deep trenches, and excavation with a continuous trencher for fast trench installation. In addition, several innovative methods exist for ensuring the trench does not collapse during excavation (e.g., pre-injection of a stabilizing agent).

The continuous trencher is the most applicable trench installation method for the PRB proposed for A-Zone ground water. This method uses a trenching apparatus on a heavy crawler-mounted vehicle to dig a narrow, continuous trench while simultaneously placing the reactive wall material as the trencher advances. This method can install reactive material at a faster rate and is more cost effective, relative to the other trenching methods, but relies on the lack of subsurface obstructions, which result in discontinuities of the wall. This would be the preferred PRB installation method for the Hookston Station Parcel, but may be determined to be infeasible due to the extent of subsurface utilities.

The other PRB installation method that would be further examined for the proposed A-Zone PRB is direct injection of zero-valent iron. Direct injection has been performed using several methods, some of which are proprietary methods specific to individual contractors. The primary direct injection methods reviewed during this FS are hydraulic fracturing

and jetting. These methods involve injecting iron alone in a powder or granular form or a mixture of iron and a biodegradable substrate of gel or slurry. The material is injected at a high pressure to either create fractures that are filled with the injected iron mixture (hydraulic fracturing) or to erode the subsurface soil enough to mix the injected iron with the soil (jetting). These installation methods are less likely to be affected by subsurface utilities than traditional trenching methods. Methods exist for verifying that the injection has created a continuous “trench”.

Following completion of the PRB bench testing and initial design of the PRB, contractors and installation methods would be investigated further to determine the most appropriate and cost-effective method for installation. Further discussion of the components and procedures of the selected installation method would be incorporated into the final design documents.

8.3.2 *B-Zone Chemical Oxidation*

The chemical oxidation component of the preferred remedial alternative provides for localized treatment of high concentration TCE in B-Zone ground water to prevent TCE from migrating vertically or further downgradient. Chemical oxidation is an effective remedy for destruction of TCE under appropriate conditions. These conditions include low concentrations of non-contaminant oxidizable material and hydraulic conditions that allow injection of appropriate volumes of solution to achieve distribution and interaction of the oxidant with the chemicals of concern. Results of the chemical oxidation pilot study would be used to refine quantities and locations for the delivery of the oxidant solution. This section provides a description of the preliminary plan for performance of chemical oxidation in B-Zone ground water at the Hookston Station Parcel.

The chemical oxidation component of the preferred remedial alternative involves direct-push injection of a dilute solution of potassium permanganate. Common direct-push injection equipment, including direct-push drilling rig, mixing system with tank and mixer, injection pumps, and piping, hoses, and valves would be assembled and mobilized to the Hookston Station Parcel. All equipment would be constructed of materials resistant to the permanganate oxidant.

Solid potassium permanganate would be mixed at the Hookston Station Parcel with tap water to a concentration of approximately 3 percent by weight. Following mixing, the oxidant solution would be injected into standard direct-push boreholes from the top of the B-Zone (approximately 50 feet bgs) to the bottom depth of the B-Zone (approximately 70 feet bgs)

in the impacted area shown on Figure 6-7. A volume of approximately 560 gallons of oxidant solution would be injected at each of the 150 injection points spaced across the impacted area. The 560-gallon volume of 3-percent solution contains approximately 143 pounds of potassium permanganate. These quantities may be adjusted based on the results of the pilot study.

Several of the injection points would be installed at the perimeter of the 199 Mayhew Way building. In order to provide additional treatment under the building, direct-push borings would be installed at a slight angle toward the center of the building, resulting in injection of the oxidant solution further under the building.

The chemical oxidation proposed for B-Zone ground water would consist of repeating the injections described above over three separate injection events.

8.3.3 *Vapor Intrusion Prevention Systems*

The existing residential indoor air risks associated with vapor intrusion of TCE in ground water within the downgradient study area (discussed in Section 2.3.2) would be addressed through vapor intrusion prevention systems designed specifically for the residence being addressed.

Implementation of the systems would consist of installation of a vapor barrier on the soil under residences to prevent migration of vapor up into the residence. Under the vapor barrier, low flow vapor extraction would be performed as an enhancement to the vapor barrier. The low flow extraction would enhance the removal of TCE and degradation products from soil vapor. Annual maintenance or inspection of the system components would also be performed.

8.3.4 *Private Well Removal*

The existing private irrigation wells located at residences within the downgradient study area are proposed to be decommissioned as a component of the preferred remedial alternative. The wells are currently only used for irrigation and/or filling of swimming pools. Following removal of the wells, the components that were plumbed to the well would be connected to the existing public water supply connection for the house.

The procedures for decommissioning the private wells would be outlined in the Remedial Design, following a survey of the locations and specifications for each of the wells. These factors would dictate how the

wells would be decommissioned and the level of effort required to connect the irrigation/swimming pool systems that were previously fed by the wells.

8.3.5 *Land Use Restrictions and Institutional Controls*

Land use restrictions would be implemented for the neighborhood located within the mixed ground water plume area according to guidelines set forth by regulatory agencies and State and local governments. The land use restrictions would ensure that current and future landowners are not permitted to install water supply wells until the final ground water cleanup goals are achieved (Table 4-5).

In addition, the SMP would be developed as a component of the restrictions, requiring current and future landowners of the Hookston Station Parcel to follow the guidelines that it provide for the handling and off-site disposal of a small quantity of subsurface soil that may contain elevated concentrations of arsenic that may pose a risk to construction workers.

8.4 *EFFECTIVENESS MONITORING*

This section describes the monitoring proposed to evaluate the effectiveness of the remedial action at achieving RAOs. Ground water monitoring would evaluate the direct effectiveness of the PRB and chemical oxidation for destroying VOCs in the respective treatment zones, as well as evaluate the ability of natural degradation processes to reduce VOCs. In addition, air quality monitoring would be performed to ensure effectiveness and completeness of the vapor intrusion prevention.

8.4.1 *Ground Water Monitoring*

To ensure ground water RAOs are achieved, water quality monitoring would be conducted as a component of the preferred remedial alternative. Ground water monitoring would be conducted periodically and samples would be analyzed for the same parameters as the proposed baseline sampling (Section 8.1.1). The proposed monitoring schedule utilizes a regressive sampling frequency to provide closely spaced data during the initial several years following completion of the remedial actions, followed by less frequent monitoring to ensure completion of treatment and shrinking of the A- and B-Zone ground water plumes. The proposed monitoring schedule for the A-Zone is as follows:

- Quarterly sampling during years 1 through 5;

- Semi-annual sampling during years 6 through 10; and
- Annual sampling for years 11 through 30.

The proposed chemical oxidation for B-Zone ground water on the Hookston Station Parcel is expected to result in a more rapid reduction of VOC ground water concentrations compared to the proposed remedial action for the A-Zone. Therefore, the following monitoring schedule is proposed for the B-Zone:

- Quarterly sampling during years 1 through 3;
- Semi-annual sampling during years 4 through 7; and
- Annual sampling for years 8 through 30.

With the approval of the RWQCB, the duration of sampling may be shortened or lengthened based upon the performance of the remedial systems.

8.4.2 *Indoor Air Monitoring*

To ensure effectiveness of the vapor intrusion prevention systems installed in residences within the downgradient study area, annual indoor air sampling would be conducted. Vapor samples would be collected and analyzed for VOCs using the currently employed methods. Similar to the construction of the vapor intrusion prevention systems, the sampling protocol for the homes would be designed based on the construction method and layout of each home.

In addition to annual sampling at residences where vapor intrusion prevention systems have been installed, homes within the area of current A-Zone TCE concentrations above the ground water screening value (530 µg/L for prevention of residential indoor air impacts) would be included in the annual indoor air sampling schedule. This sampling would allow determination of the need to expand the network of vapor intrusion prevention systems. The length of time necessary to continue the indoor air monitoring program would be determined based on ground water, soil vapor, and indoor air data trends observed within the initial 5 years of construction of the PRB. These data would be evaluated annually, and recommendations for modifications to the monitoring frequency would be made as appropriate. The success of these systems is dependent on private property access and cooperation with individual impacted residents.

8.5

IMPLEMENTATION SCHEDULE

A preliminary schedule for the components of this Implementation Plan is shown in Table 8-1. This schedule is subject to change based on the progress of individual components and other implementation issues. Some of the tasks can be performed concurrently. A more comprehensive construction schedule would be provided in the Remedial Design, which would be prepared following approval of the FS.

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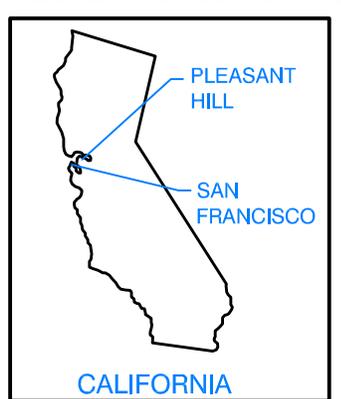
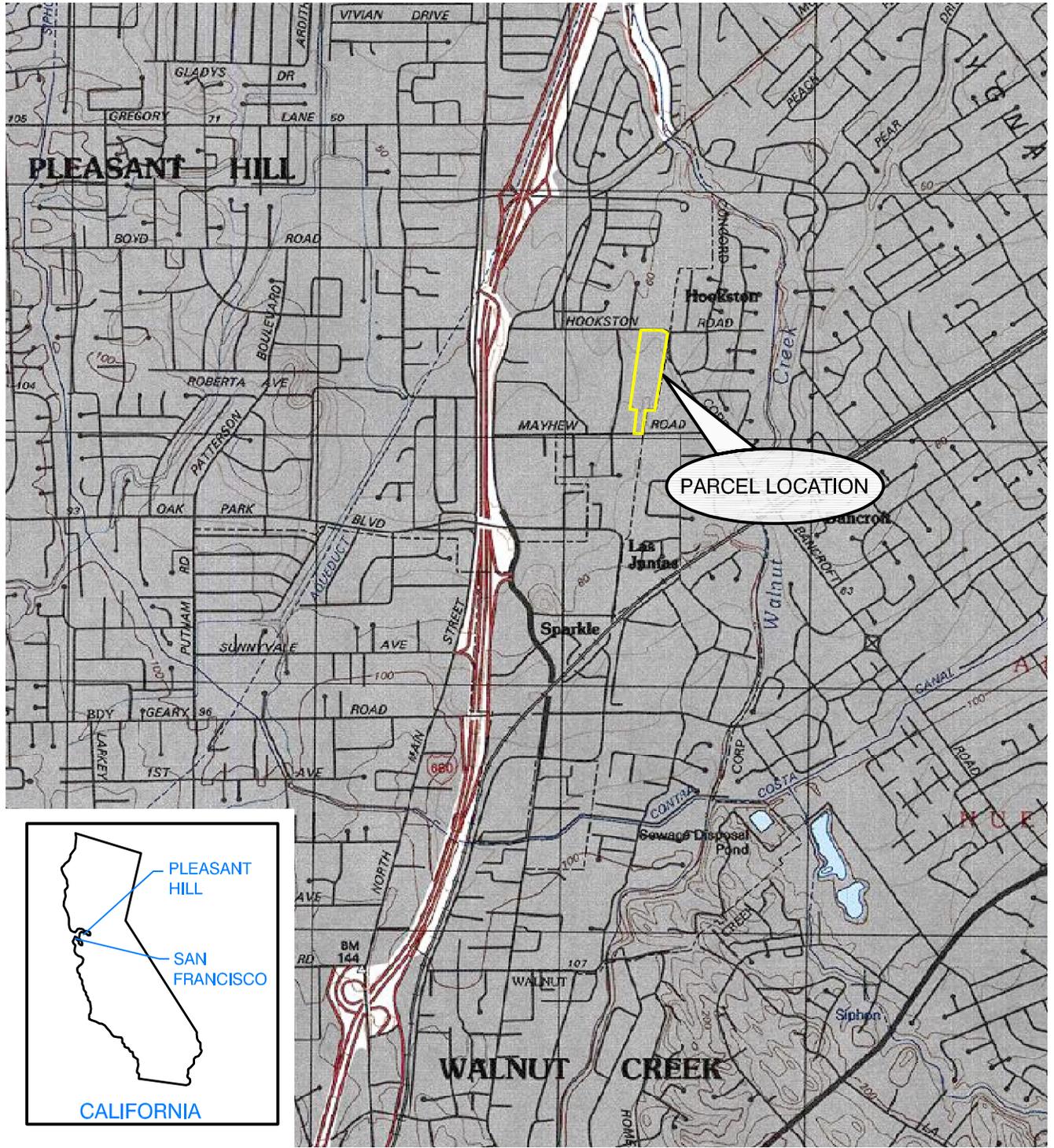
Figures

Project No.
0020557

Date:
07/01/06

Drawn By:
J. Estrada

CAD File:
g:\0020557\Site Location.dwg



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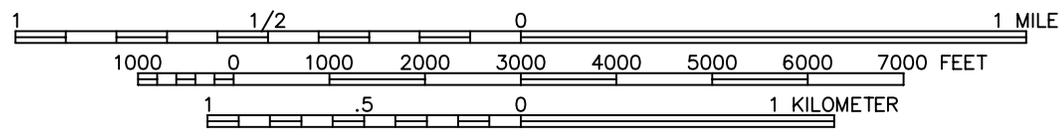
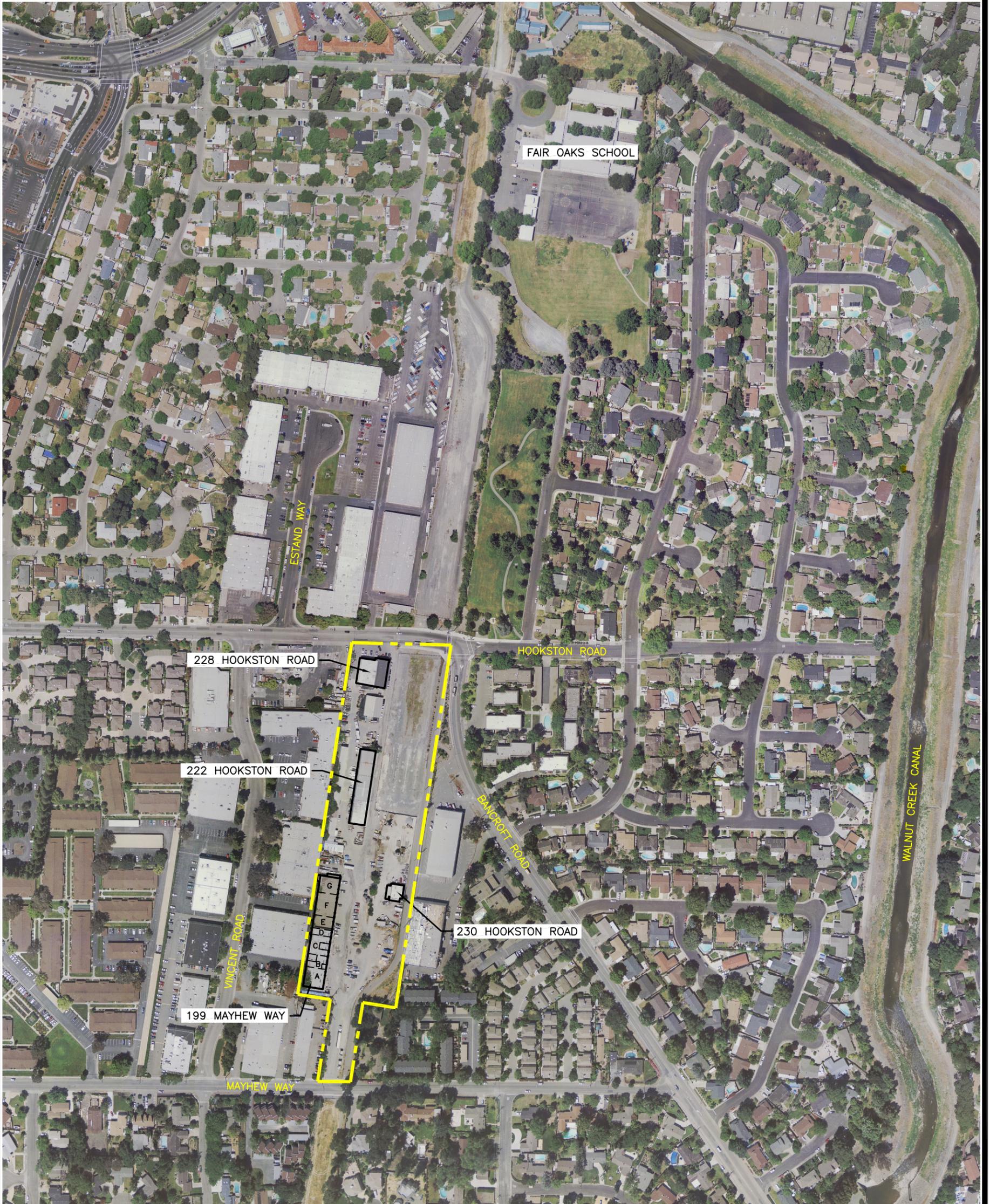


Figure 1-1
*Parcel Location Map
Hookston Station
Pleasant Hill, California*

References:
TOPO!® Software
U.S.G.S. 7.5 Minute Series (Topographic) Quadrangle,
Walnut Creek, California
Dated: 1995



Aerial photograph from HJW Geospatial, Inc.
Date of photograph is May 15, 2006

LEGEND

--- Hookston Station Parcel
Property Boundary

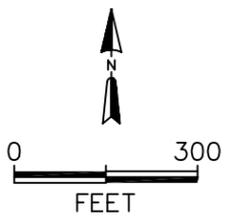
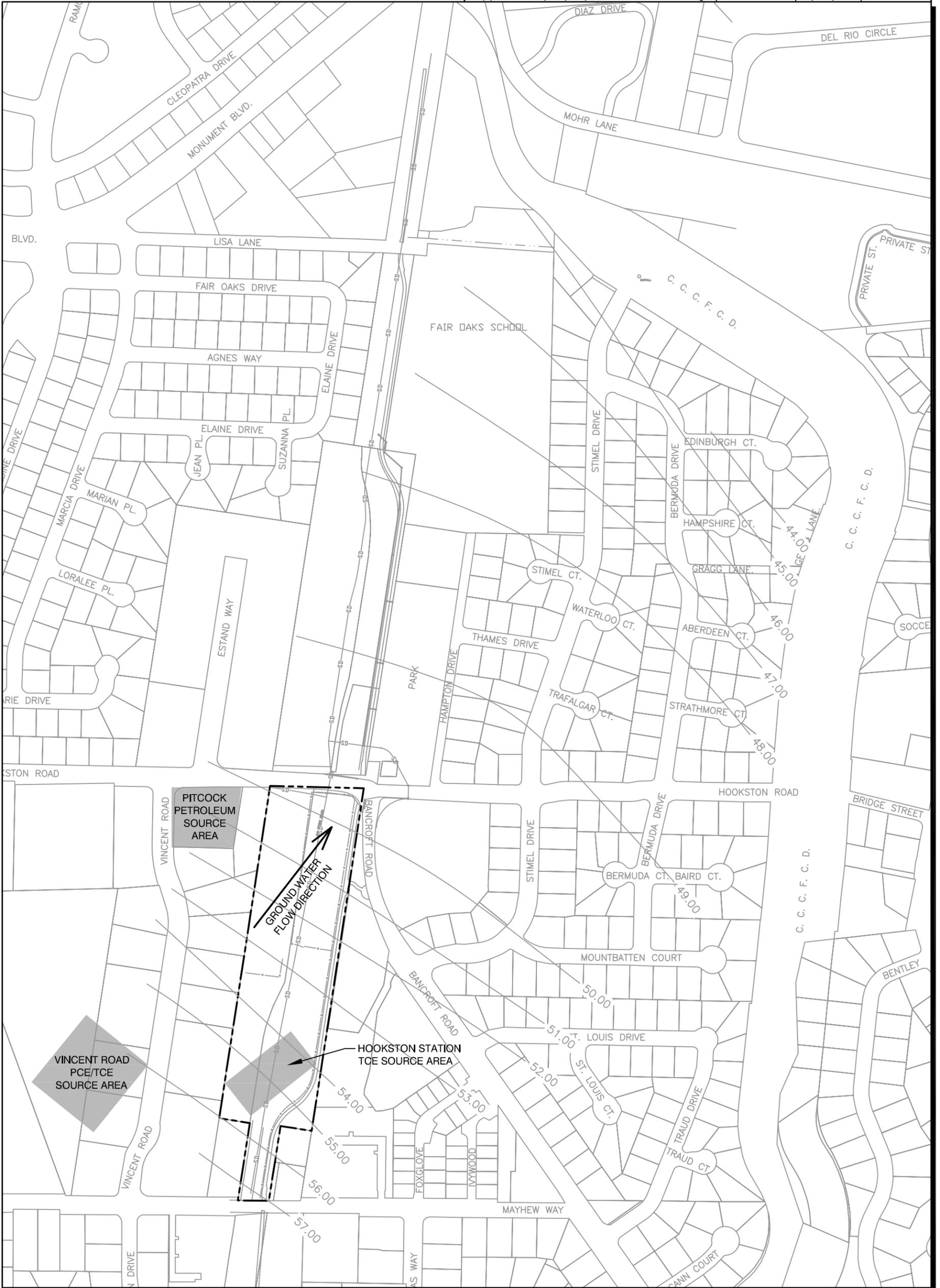


Figure 1-2
Hookston Station Vicinity Map
Hookston Station
Pleasant Hill, California



LEGEND

- Hookston Station Parcel Property Boundary
- 53.00 — Ground Water Elevation Contour, A-Zone, 23 January 2006 (feet above mean sea level)

Note: Source areas depicted are schematic to illustrate relative positions.

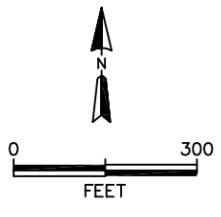
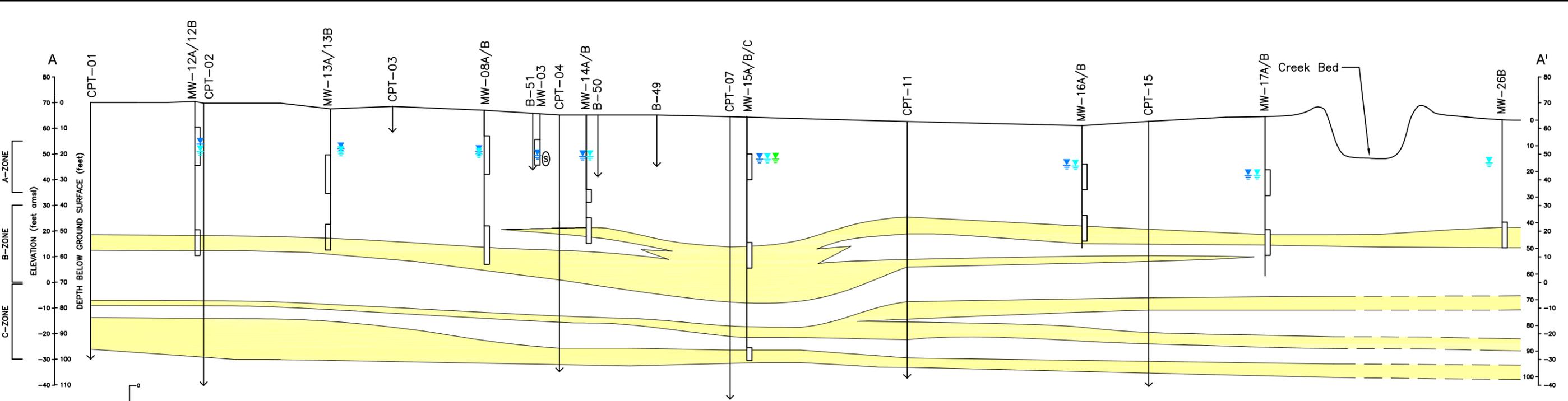
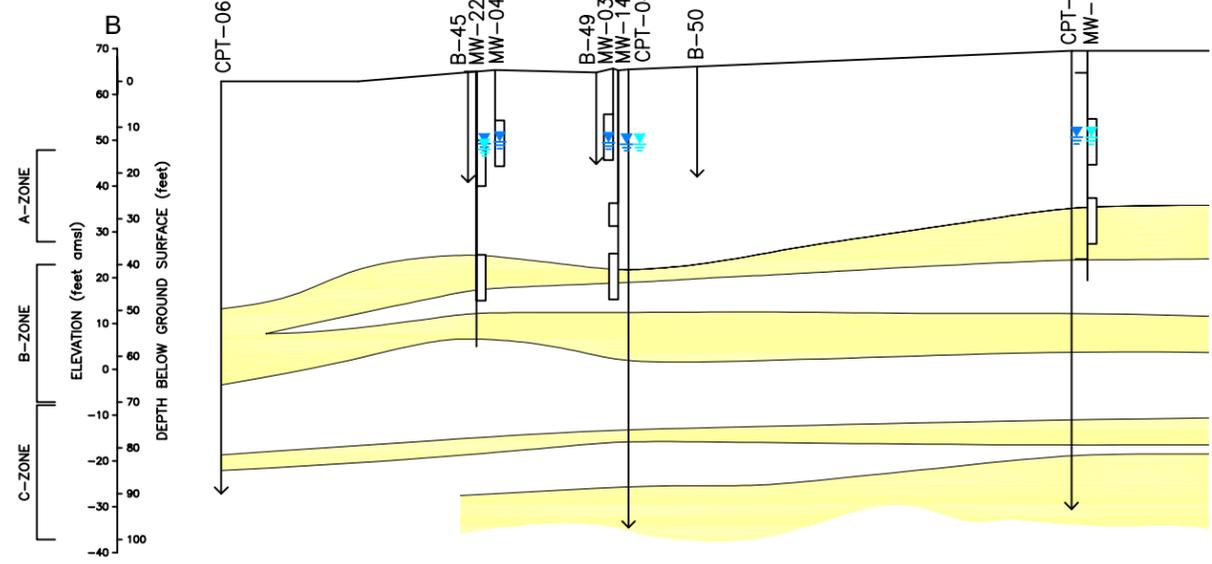


Figure 1-3
*Hookston Station and
 Adjacent Environmental Sites*
 Hookston Station
 Pleasant Hill, California

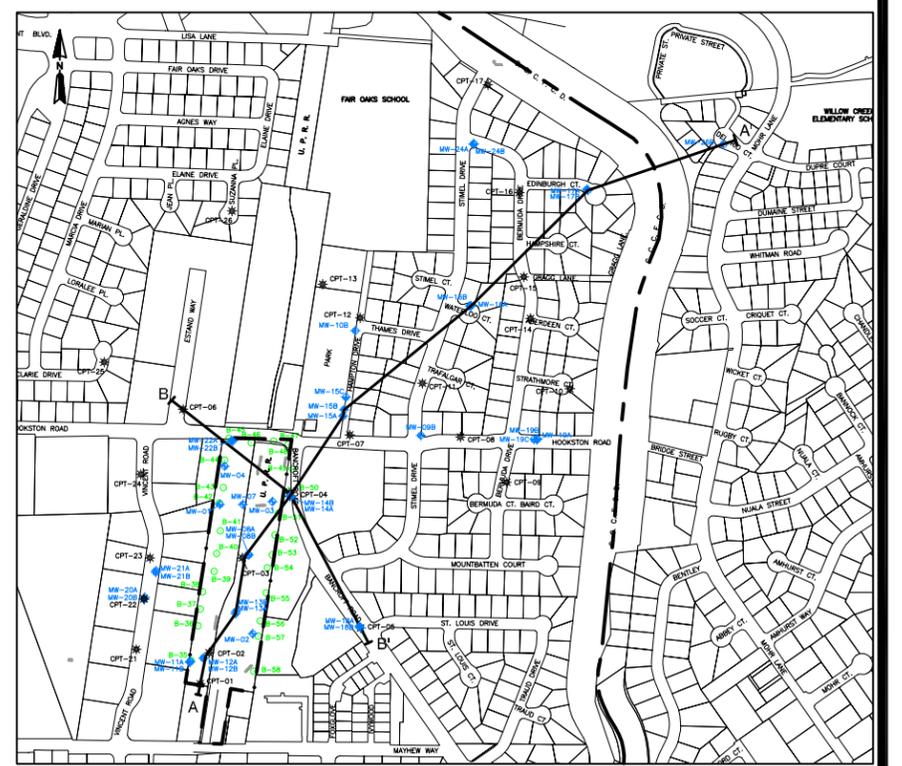


VERTICAL SCALE IN FEET
 1" = 40'
 (Vertical Exaggeration = 10X)
 HORIZONTAL SCALE IN FEET
 1" = 400'



VERTICAL SCALE IN FEET
 1" = 40'
 (Vertical Exaggeration = 10X)
 HORIZONTAL SCALE IN FEET
 1" = 400'

CROSS SECTION LOCATION MAP



0 400 800
 FEET

--- Hookston Station Parcel Property Boundary

Legend

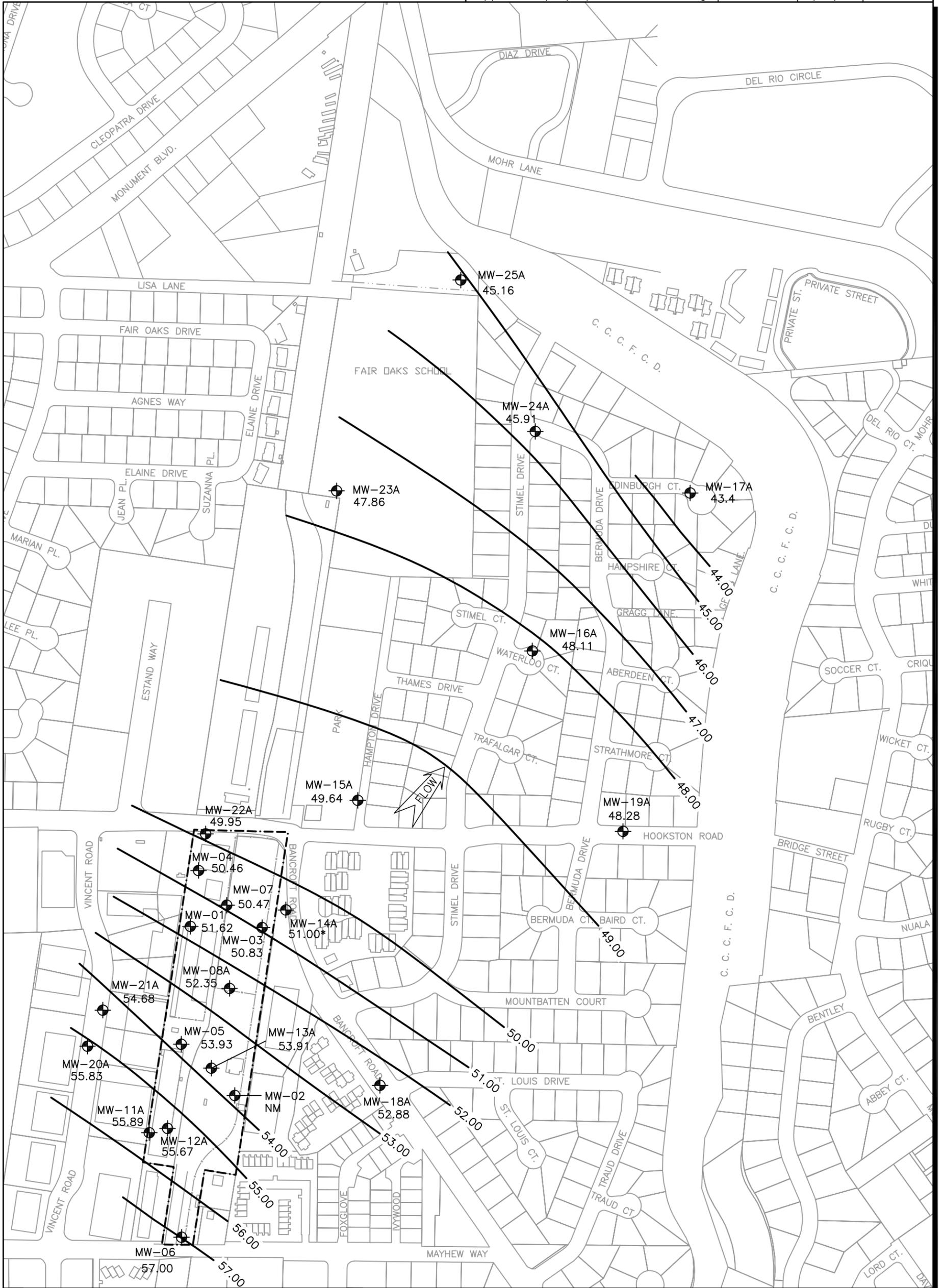
- Monitoring Well, A Zone
- Monitoring Well, B Zone
- Monitoring Well, C Zone
- CPT Ground Water Sample Location
- Shallow Hydropunch Location
- Sewer Pipe

- A-Zone A-Zone Aquifer; Generally 15-35 ft below ground surface
- B-Zone B-Zone Aquifer; Generally 40-70 ft below ground surface
- C-Zone C-Zone Aquifer; Generally 70-100 ft below ground surface

- A-Zone Ground Water Elevation (ft amsl)
 - B-Zone Ground Water Elevation (ft amsl)
 - C-Zone Ground Water Elevation (ft amsl)
- Note: Water Levels measured on 19 April 2004.

- MONITORING WELL
- HYDROPUNCH/CPT BORINGS
- Screened Interval
- Coarse-Grained Deposits

Figure 2-1
 Geological Cross Sections
 Hookston Station
 Pleasant Hill, California



LEGEND

- Monitoring Well, A Zone
- Hookston Station Parcel Property Boundary
- Ground Water Elevation Contour, 1 Foot Interval
- Datum Not Used for Contouring
- Not Measured
- Ground Water Flow Direction

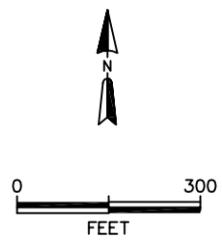


Figure 2-2
 Ground Water Elevation Map, A Zone
 23 January 2006
 Hookston Station
 Pleasant Hill, California

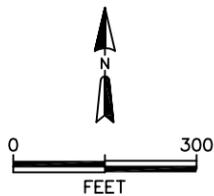
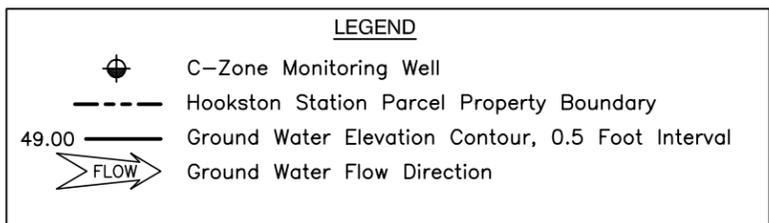
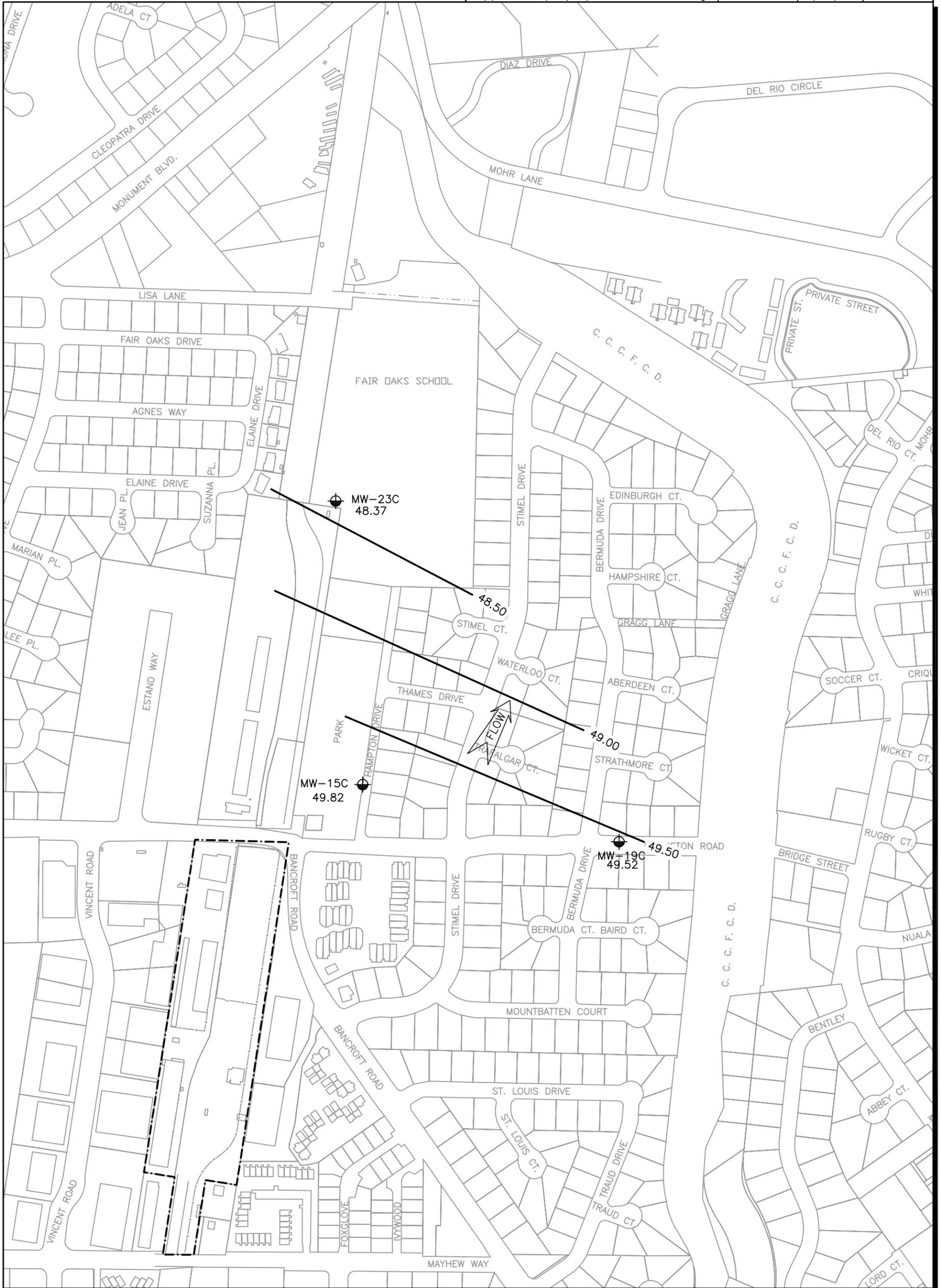
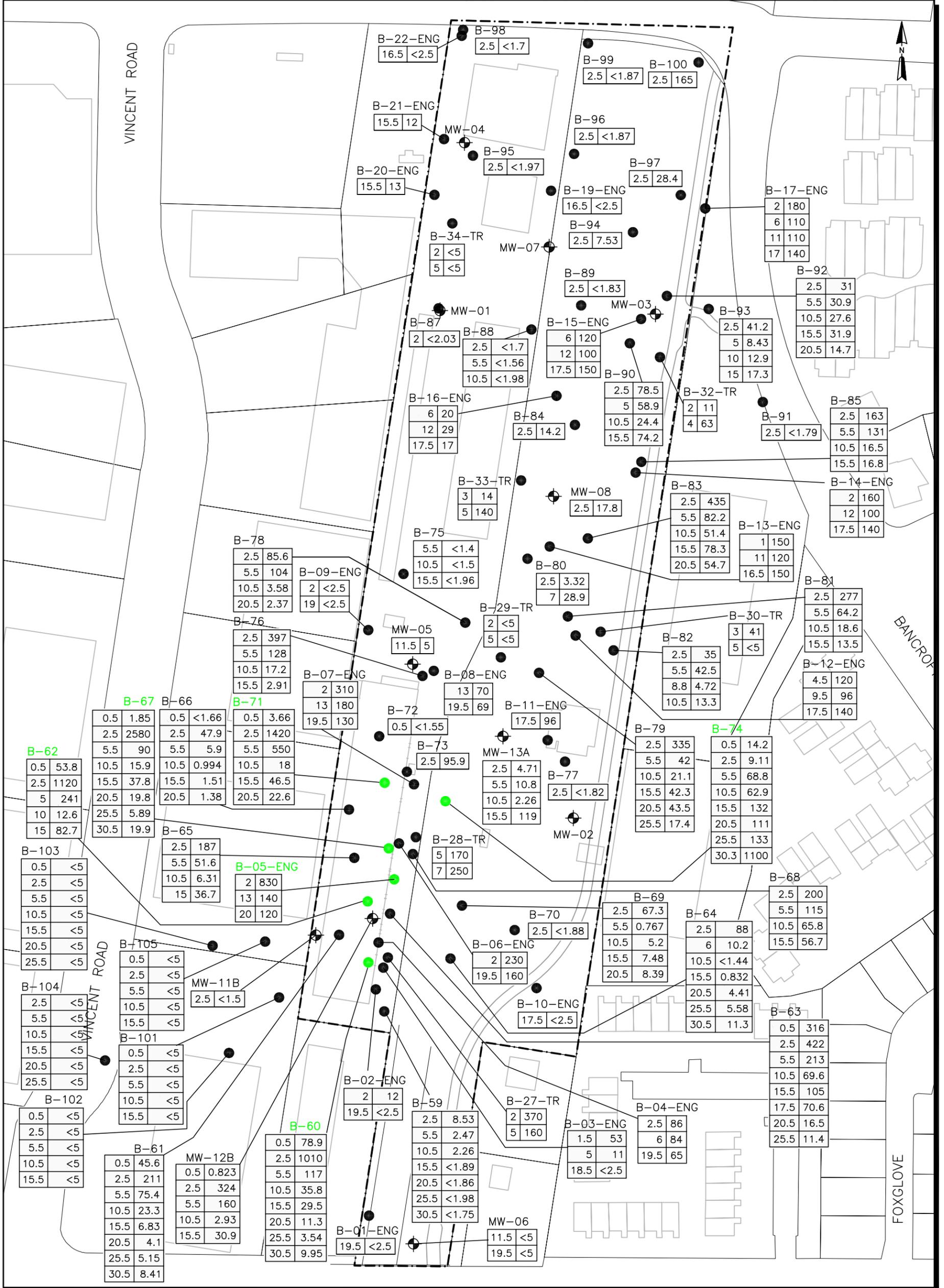


Figure 2-4
 Ground Water Elevation Map, C-Zone
 23 January 2006
 Hookston Station
 Pleasant Hill, California

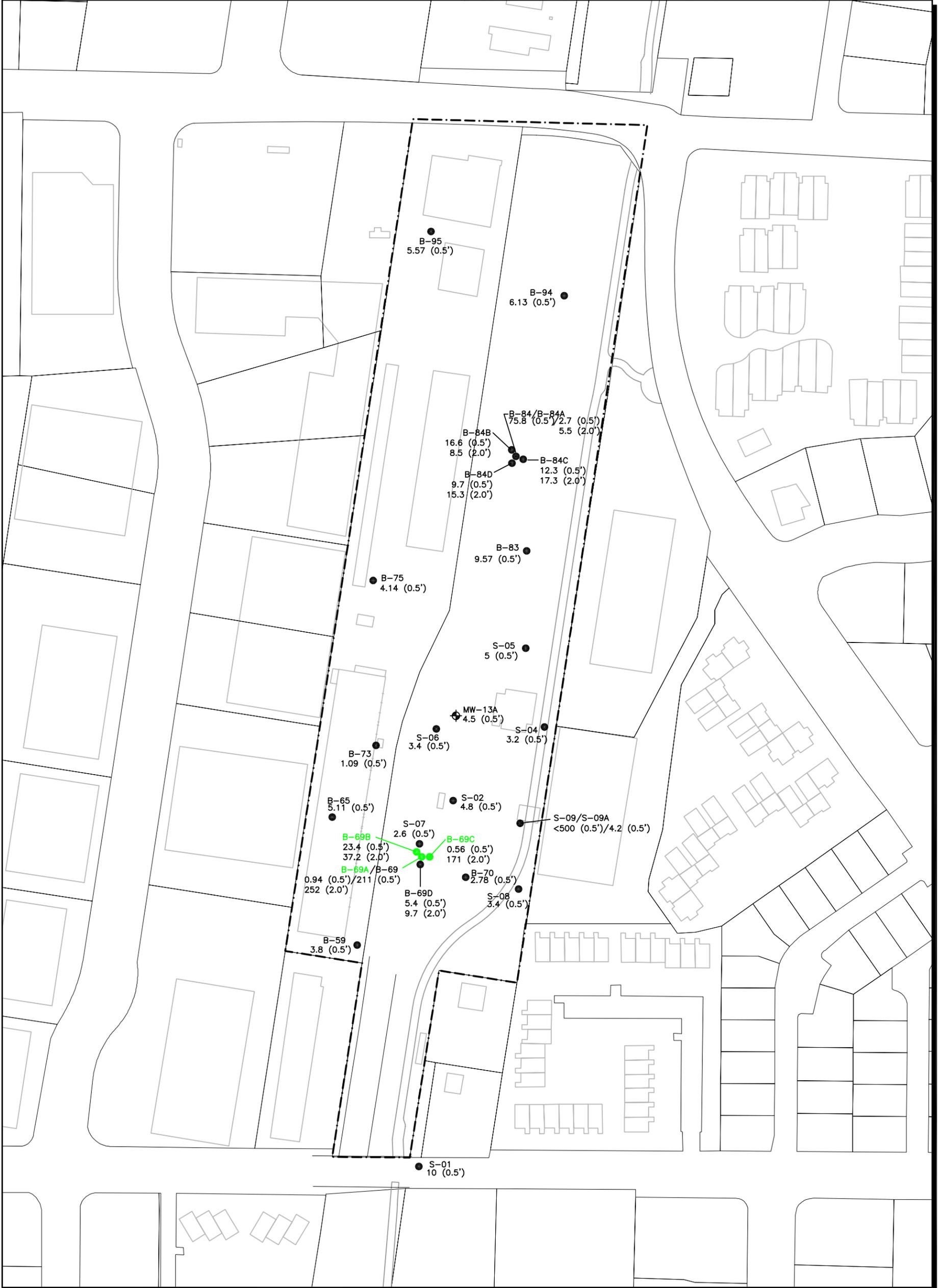


LEGEND

- Soil Boring Location
 - ⊕ Monitoring Well Location
 - One or More Sample Exceeded the RWQCB Soil ESL ($460 \mu\text{g}/\text{kg}$ TCE)
- 19.5 | <2.5 — TCE Concentration in Soil, $\mu\text{g}/\text{kg}$
- Depth — Feet bgs
- Hookston Station Parcel Property Boundary



Figure 2-5
TCE Concentrations in Soil
Hookston Station
Pleasant Hill, California



LEGEND

-
- Monitoring Well Location 10 (0.5') Arsenic Concentration in Soil (mg/Kg);
- Soil Boring Location Sample Depth (feet bgs)
- Hookston Station Parcel < = Not Detected Above Reported Limit
- Property Boundary
- One or More Sample Exceeds Background Levels for Arsenic in Bay
- Area Soils (31 mg/kg). B-69 and B-84 Based on May 2006 Sampling
- Results for B-69A/B/C/D and B-84A/B/C/D

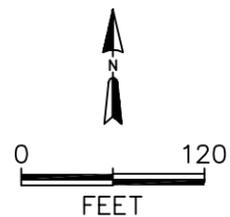
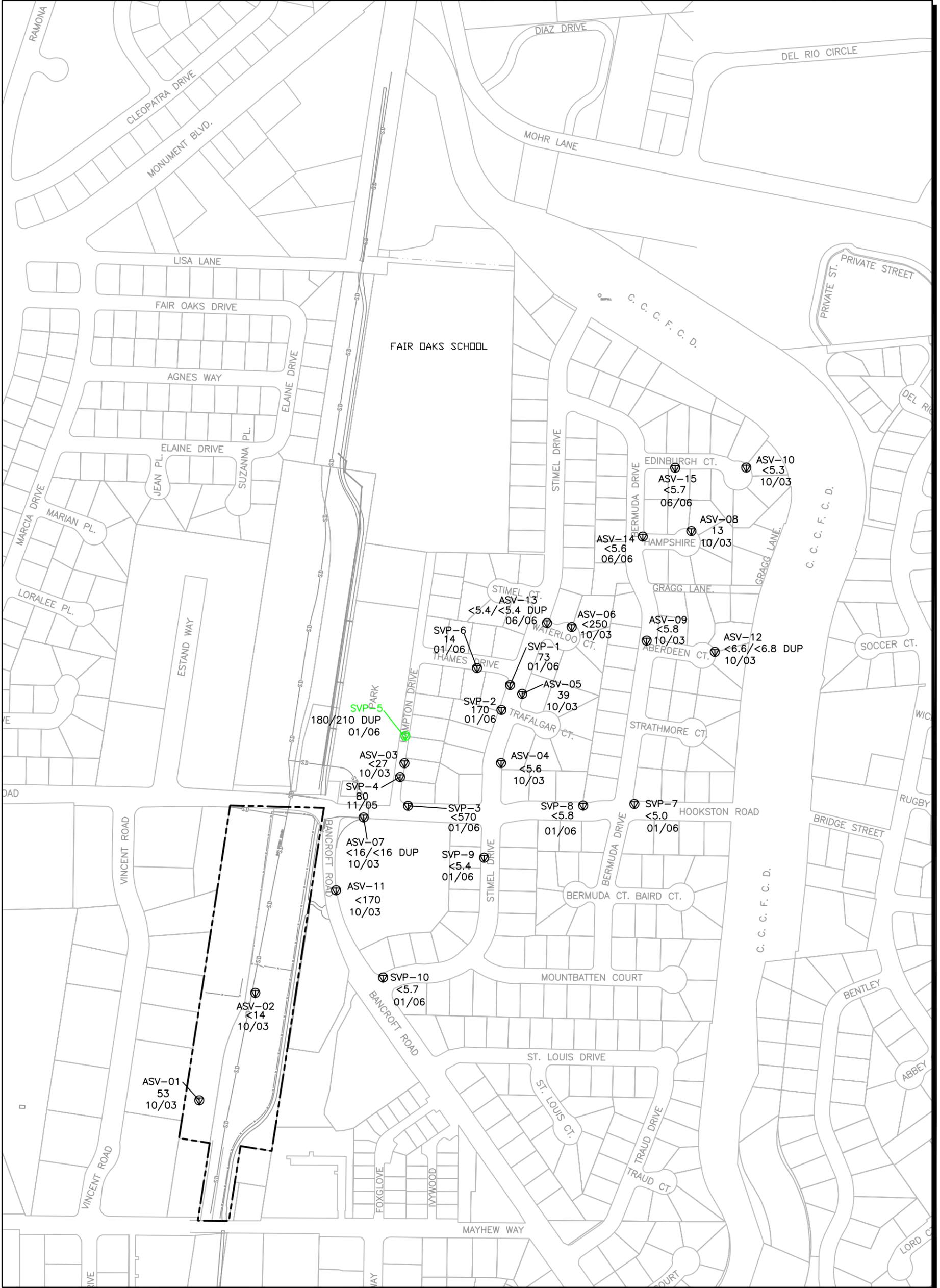


Figure 2-6
Soil Arsenic Concentrations
Hookston Station
Pleasant Hill, California



LEGEND

- Soil Vapor Monitoring Probe Location
- Hookston Station Parcel Property Boundary
- 53 PCE Soil Vapor Concentration ($\mu\text{g}/\text{m}^3$)
- DUP Duplicate
- Result Exceeds the Residential Landuse Soil Vapor CHHSL ($180\mu\text{g}/\text{m}^3$ PCE) (Downgradient Study Area Locations) or the Commercial/Industrial Landuse Soil Vapor CHHSL ($603\mu\text{g}/\text{m}^3$) (Hookston Station Parcel Locations)

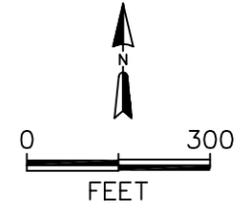
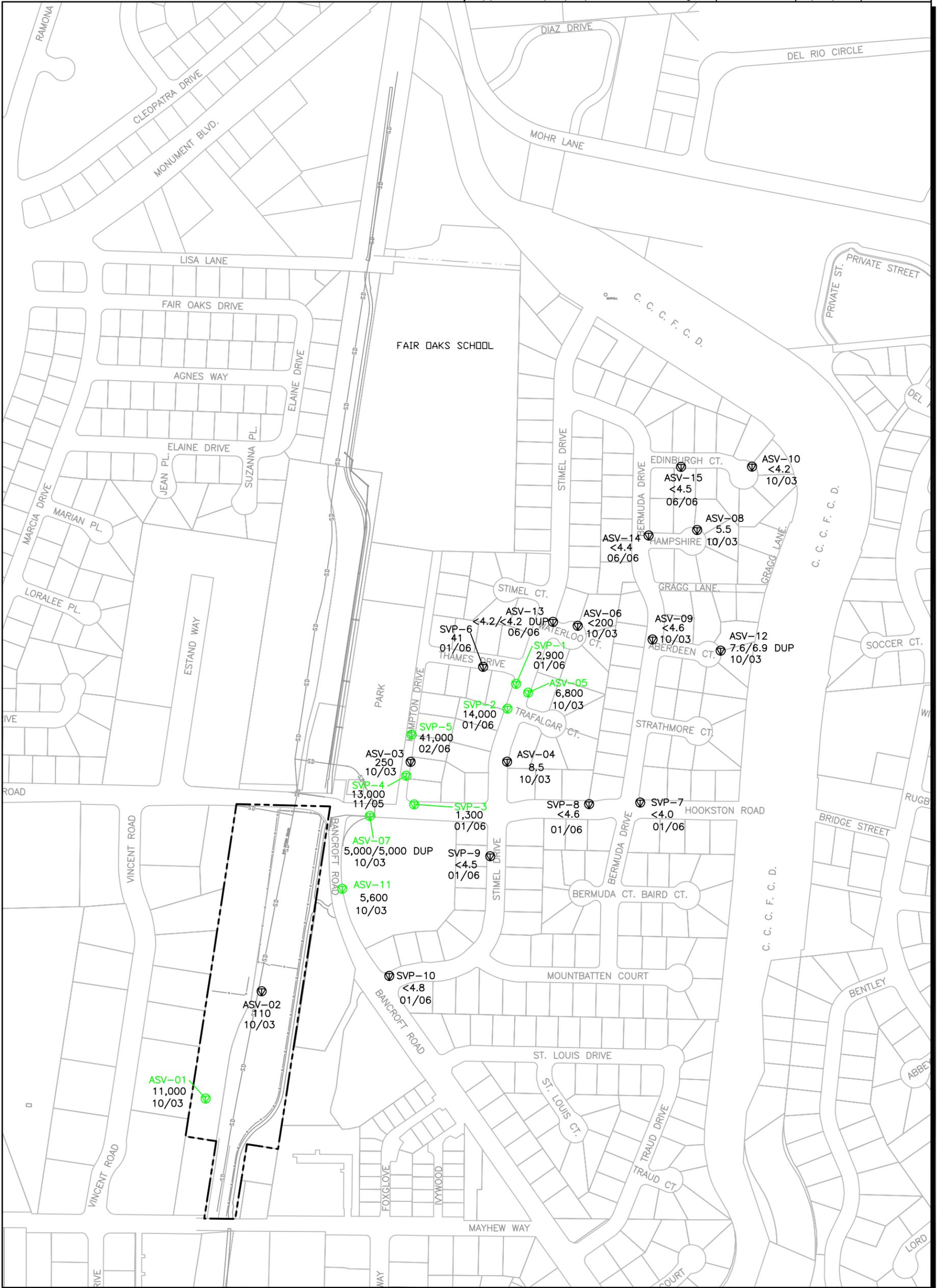


Figure 2-7
*PCE in Active Soil Vapor Samples
 October 2003 - June 2006
 Hookston Station
 Pleasant Hill, California*



LEGEND

- ⊙ Soil Vapor Monitoring Probe Location
- Hookston Station Parcel Property Boundary
- 110 TCE Soil Vapor Concentration (µg/m³)
- DUP Duplicate
- ⊙ Result Exceeds the Residential Landuse Soil Vapor CHHSL (528µg/m³ TCE) (Downgradient Study Area Locations) or the Commercial/Industrial Landuse Soil Vapor CHHSL (1,770 µg/m³) (Hookston Station Parcel Locations)

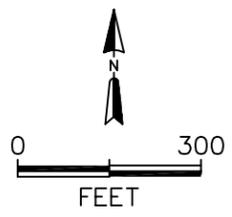
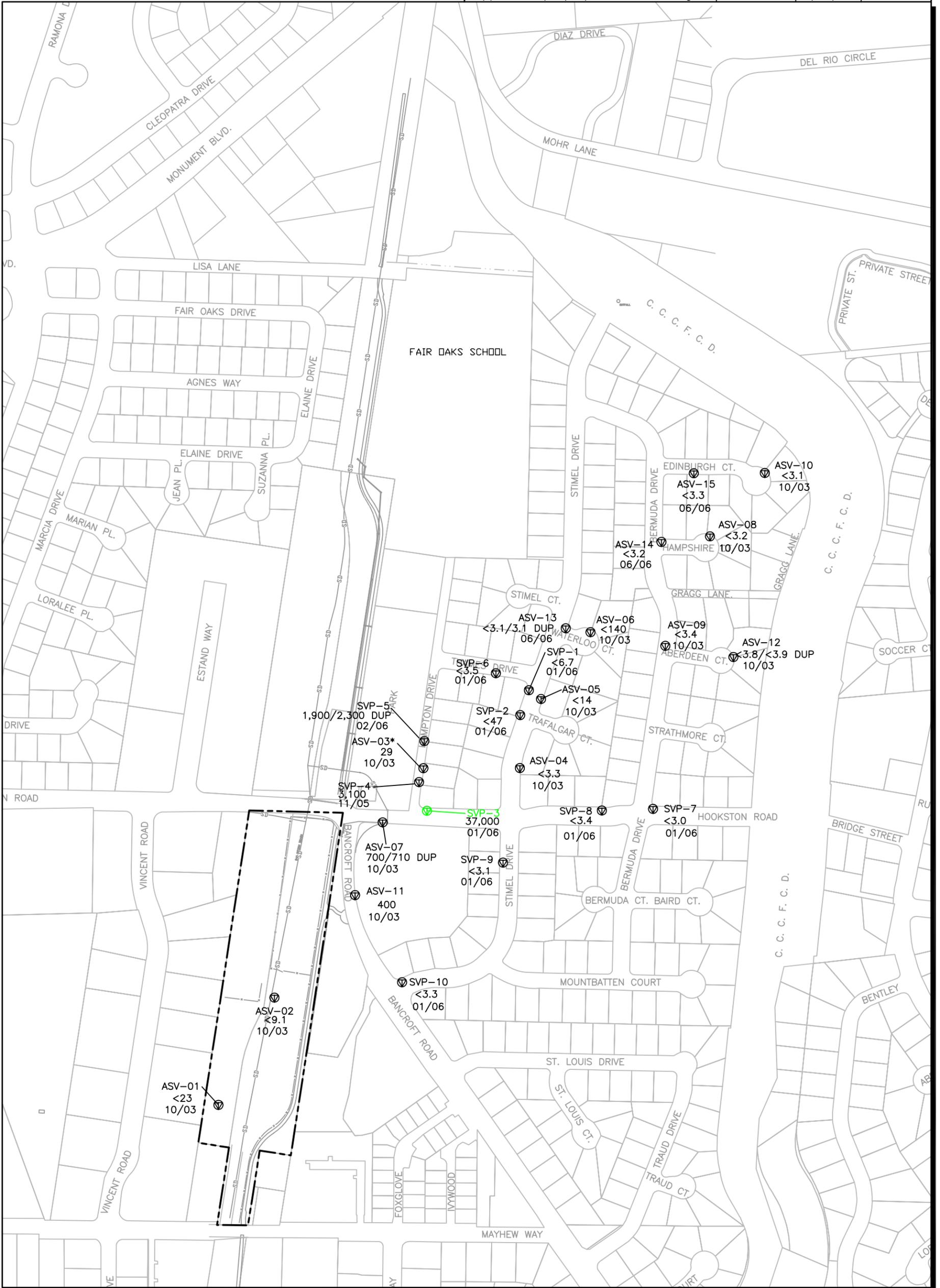


Figure 2-8
TCE in Active Soil Vapor Samples
October 2003 - June 2006
Hookston Station
Pleasant Hill, California



LEGEND

- Soil Vapor Monitoring Probe Location
- Hookston Station Parcel Property Boundary
- 400 cis-1,2-DCE Soil Vapor Concentration ($\mu\text{g}/\text{m}^3$)
- DUP Duplicate
- * Data Not Used For Contouring
- Result Exceeds the Residential Landuse Soil Vapor CHSL ($15,900 \mu\text{g}/\text{m}^3$ cis-1,2-DCE) (Downgradient Study Area Locations) or the Commercial/Industrial Landuse Soil Vapor CHSL ($44,400 \mu\text{g}/\text{m}^3$ cis-1,2-DCE) (Hookston Station Parcel Locations)

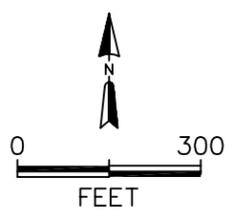
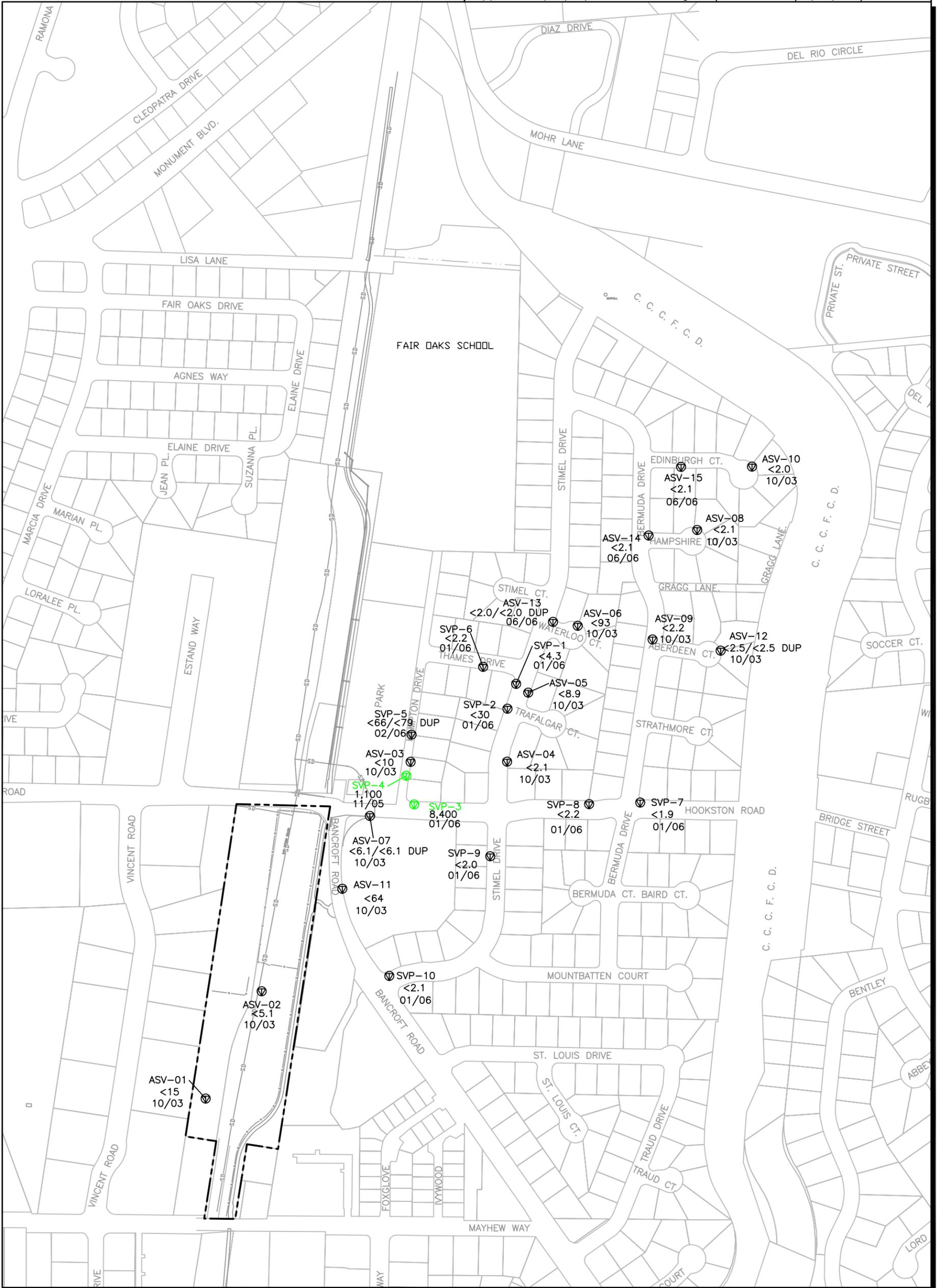


Figure 2-9
cis-1,2-DCE in
Active Soil Vapor Samples
October 2003 - June 2006
Hookston Station
Pleasant Hill, California



LEGEND	
	Soil Vapor Monitoring Probe Location
	Hookston Station Parcel Property Boundary
<15	Vinyl Chloride Soil Vapor Concentration ($\mu\text{g}/\text{m}^3$)
DUP	Duplicate
NS	Not Sampled
	Result Exceeds the Residential Landuse Soil Vapor CHHSL ($13.3 \mu\text{g}/\text{m}^3$ Vinyl Chloride) (Downgradient Study Area Locations) or the Commercial/Industrial Landuse Soil Vapor CHHSL ($44.8 \mu\text{g}/\text{m}^3$ Vinyl Chloride) (Hookston Station Parcel Locations)

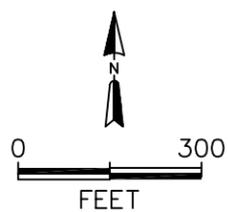
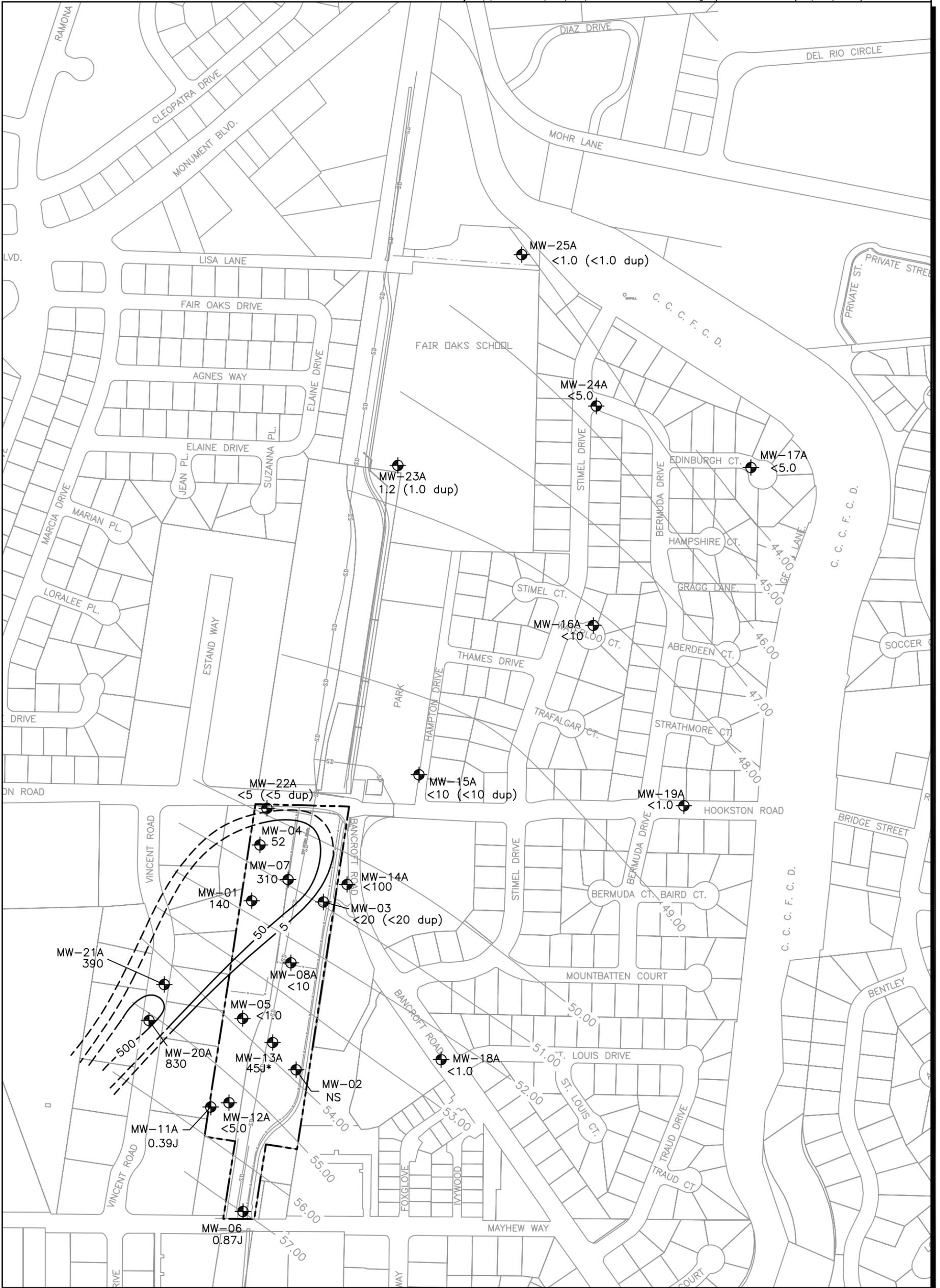


Figure 2-10
*Vinyl Chloride in
 Active Soil Vapor Samples
 October 2003 - June 2006
 Hookston Station
 Pleasant Hill, California*



LEGEND

- Monitoring Well Location
- 470 PCE Concentration (µg/L)
- 50 PCE in Ground Water Contour, Solid Based On First Quarter 2006 Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Groundwater Sampling.
- Hookston Station Parcel Property Boundary
- 53.00 Ground Water Elevation Contour, A-Zone, 23 January 2006 (feet above mean sea level)
- J Estimated Values
- NS Not Sampled
- * Not Used in Contouring Based on Historical Data

The Maximum Contaminant Level for PCE in Drinking Water is 5 µg/L.
 Note: MW-07 Data Not Used for Contouring Purposes.

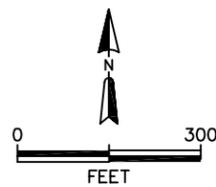
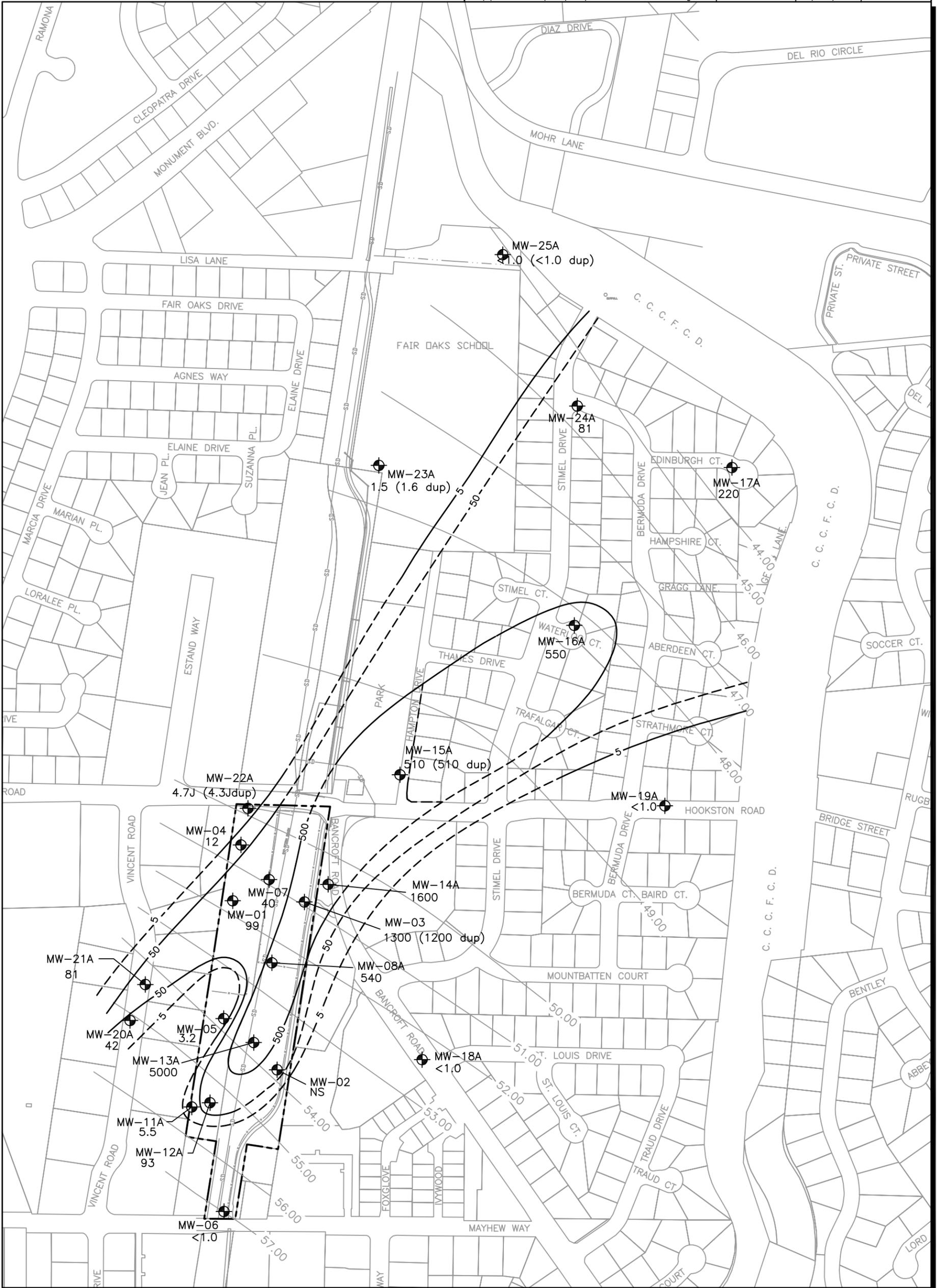


Figure 2-11
 PCE Isoconcentration Map
 A Zone Ground Water
 First Quarter 2006
 Hookston Station
 Pleasant Hill, California



LEGEND

- Monitoring Well Location
- 5.5 TCE Concentration ($\mu\text{g/L}$)
- 50 TCE in Ground Water Contour, Solid Based on First Quarter 2006 Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sampling.
- Hookston Station Parcel Property Boundary
- 53.00 Ground Water Elevation Contour, A-Zone, 23 January 2006 (feet above mean sea level)
- J Estimated Values
- NS Not Sampled
- * Not Used for Contouring Based on Historical Data

The Maximum Contaminant Level For TCE in Drinking Water is $5 \mu\text{g/L}$.
 Note: MW-07 Data Not Used for Contouring Purposes.

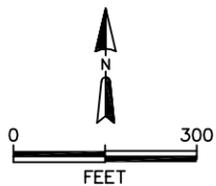
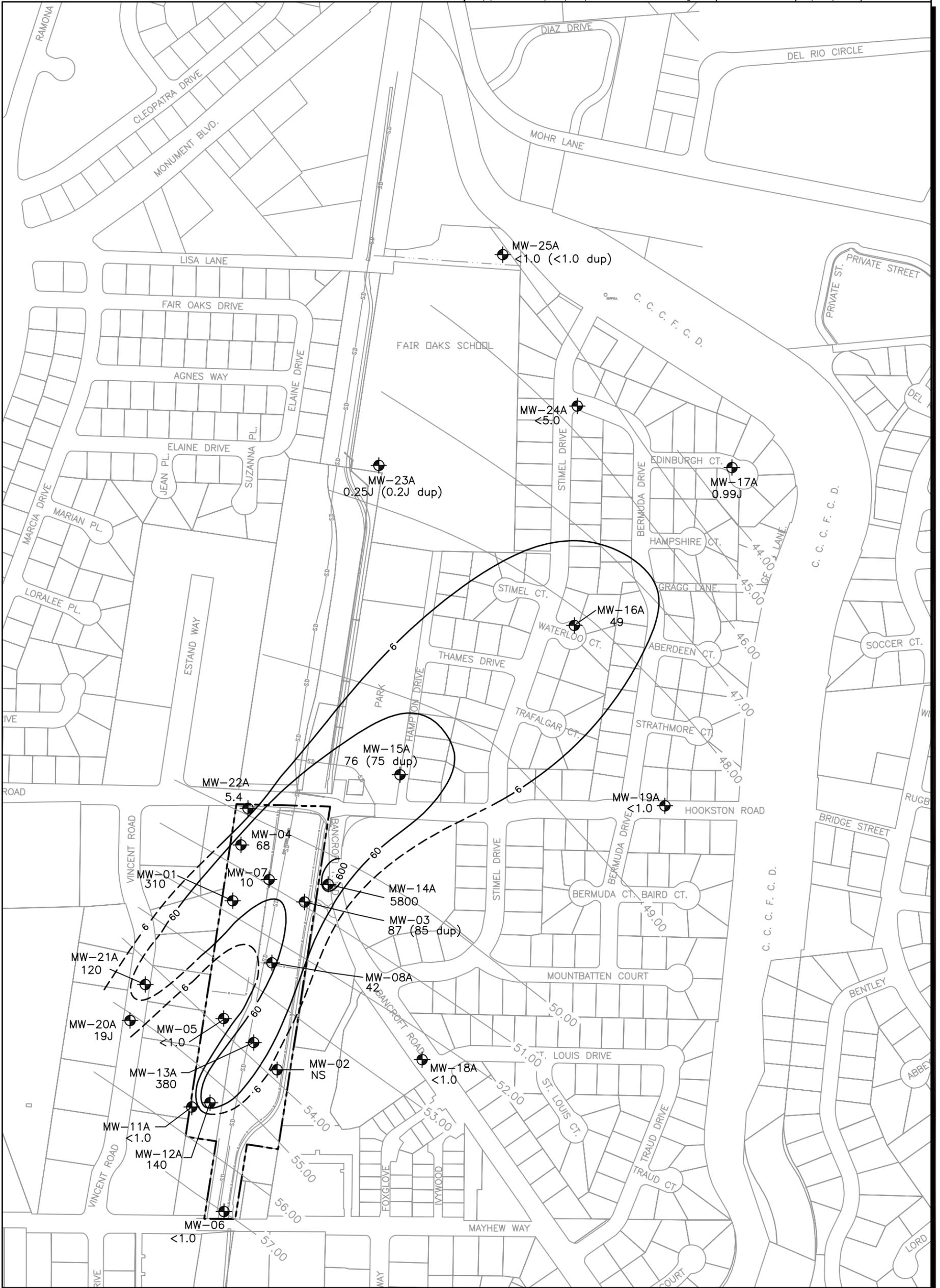


Figure 2-12
TCE Isoconcentration Map
A Zone Ground Water
First Quarter 2006
Hookston Station Project
Pleasant Hill, California



LEGEND

- Monitoring Well Location
- 42 cis-1,2-DCE Concentration ($\mu\text{g/L}$)
- 60 cis-1,2-DCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
- Hookston Station Parcel Property Boundary
- 53.00 Ground Water Elevation Contour, A-Zone, 23 January 2006 (feet above mean sea level)
- J Estimated Values
- NS Not Sampled

The Maximum Contaminant Level for cis-1,2-DCE in Drinking Water is 6 $\mu\text{g/L}$.
 Note: MW-07 Data Not Used for Contouring Purposes.

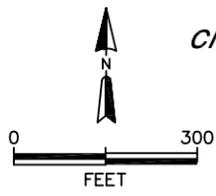
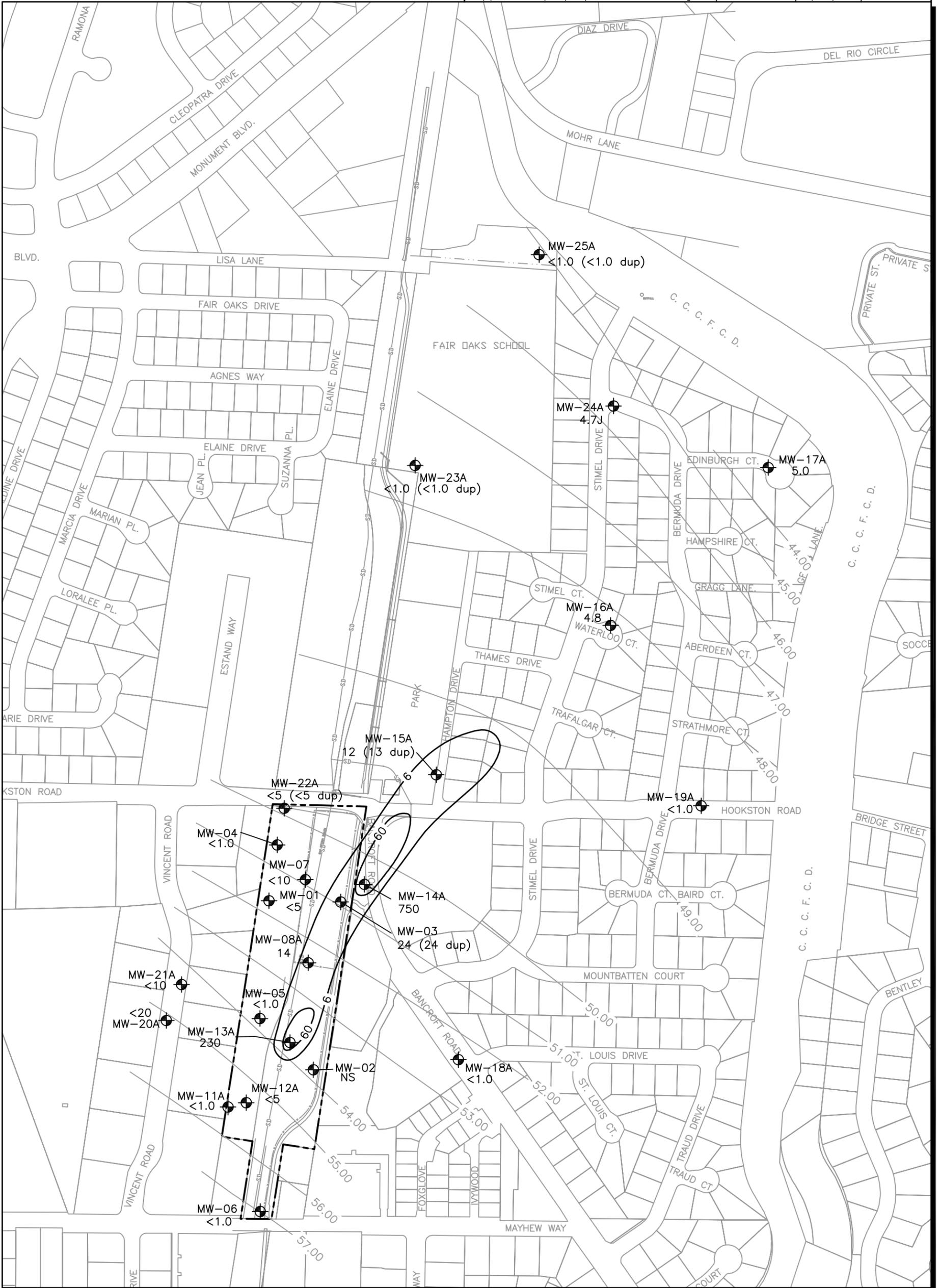


Figure 2-13
cis-1,2-DCE Isoconcentration Map
A Zone Ground Water
First Quarter 2006
Hookston Station
Pleasant Hill, California



LEGEND

- Monitoring Well Location
- 910 1,1-DCE Concentration (µg/L)
- 60 1,1-DCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
- Hookston Station Parcel Property Boundary
- 53.00 Ground Water Elevation Contour, A-Zone, 23 January 2006 (feet above mean sea level)
- J Estimated Values
- NS Not Sampled

The Maximum Contaminant Level for 1,1-DCE in Drinking Water is 6 µg/L.
 Note: MW-07 Data Not Used for Contouring Purposes.

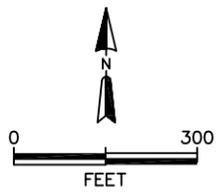
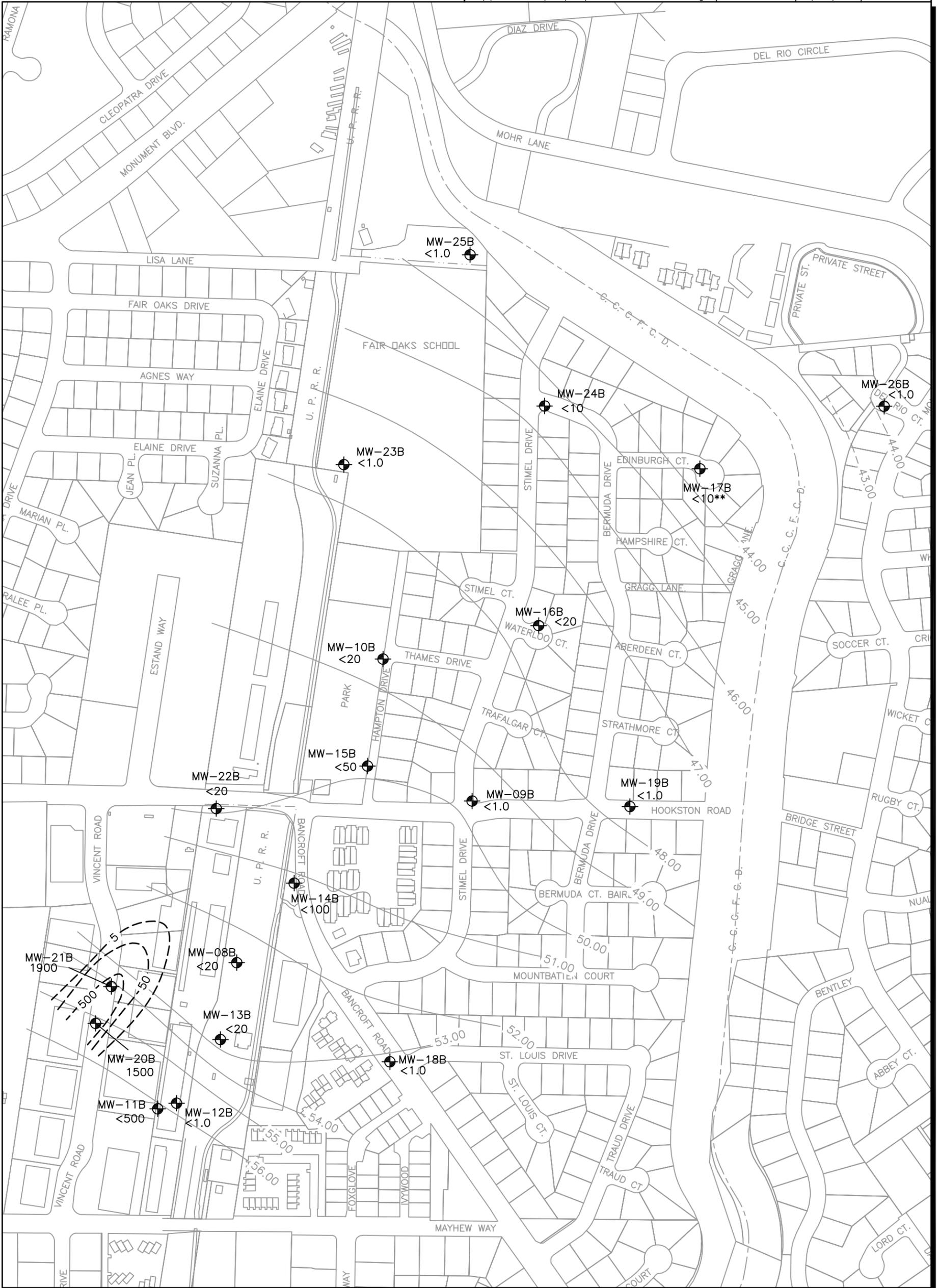


Figure 2-14
1,1-DCE Isoconcentration Map
A Zone Ground Water
First Quarter 2006
Hookston Station
Pleasant Hill, California



LEGEND

- Monitoring Well Location
- 650 PCE Concentration ($\mu\text{g/L}$)
- 50 PCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
- Hookston Station Parcel Property Boundary
- 51.00 Ground Water Elevation Contour, B-Zone, 23 January 2006 (feet above mean sea level)
- **** Multiple Sample Were Collected at Various Depths Within the Well Screen. The Highest Result is Posted

The Maximum Contaminant Level for PCE in Drinking Water is 5 $\mu\text{g/L}$.

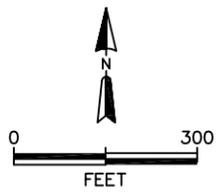
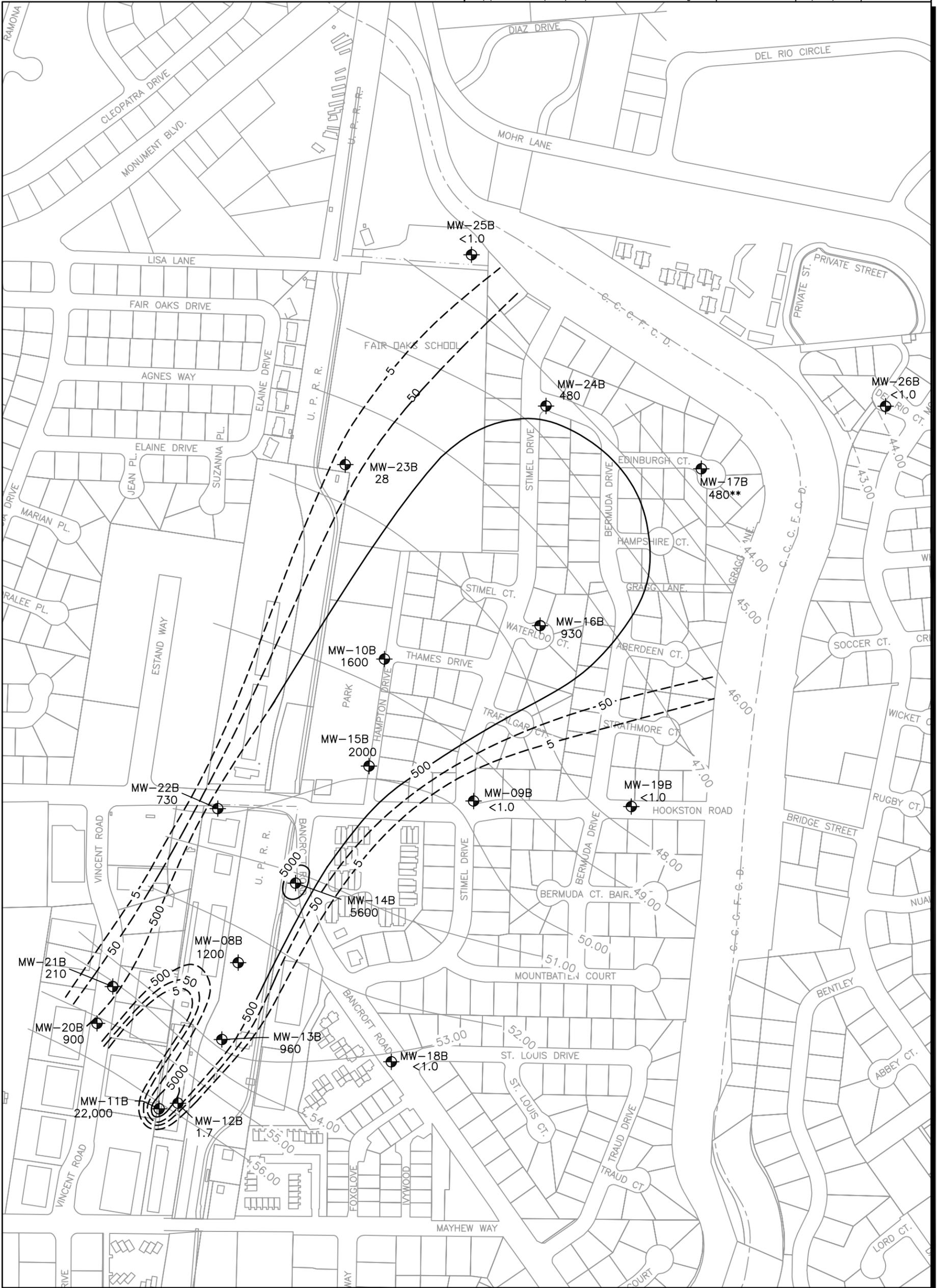


Figure 2-15
*PCE Isoconcentration Map
 B Zone Ground Water
 First Quarter 2006
 Hookston Station
 Pleasant Hill, California*



LEGEND

- Monitoring Well Location
- 59 TCE Concentration ($\mu\text{g/L}$)
- 50 TCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
- Hookston Station Parcel Property Boundary
- 51.00 Ground Water Elevation Contour, B-Zone, 23 January 2006 (feet above mean sea level)
- ** Multiple Sample Were Collected at Various Depths Within the Well Screen. The Highest Result is Posted

The Maximum Contaminant Level for TCE in Drinking Water is 5 $\mu\text{g/L}$.

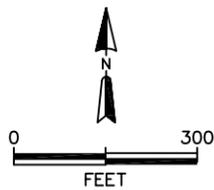
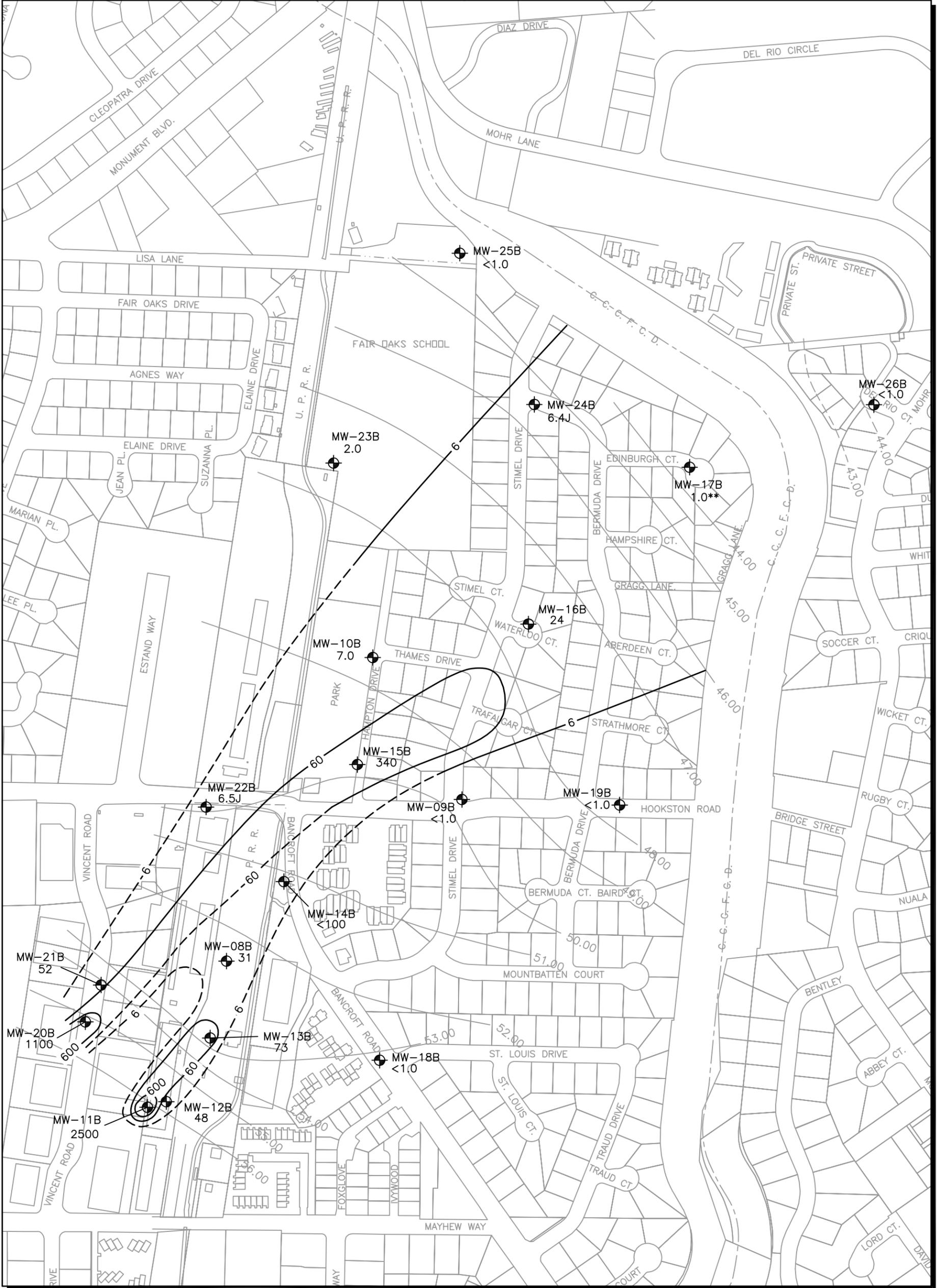


Figure 2-16
TCE Isoconcentration Map
B Zone Ground Water
First Quarter 2006
Hookston Station
Pleasant Hill, California



LEGEND	
	Monitoring Well Location
21	cis-1,2-DCE Concentration ($\mu\text{g/L}$)
60	cis-1,2-DCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
	Hookston Station Parcel Property Boundary
51.00	Ground Water Elevation Contour, B-Zone, 23 January 2006 (feet above mean sea level)
J	Estimated Values
**	Multiple Sample Were Collected at Various Depths Within the Well Screen. The Highest Result is Posted
	The Maximum Contaminant Level for cis-1,2-DCE in Drinking Water is 6 $\mu\text{g/L}$.

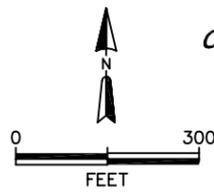
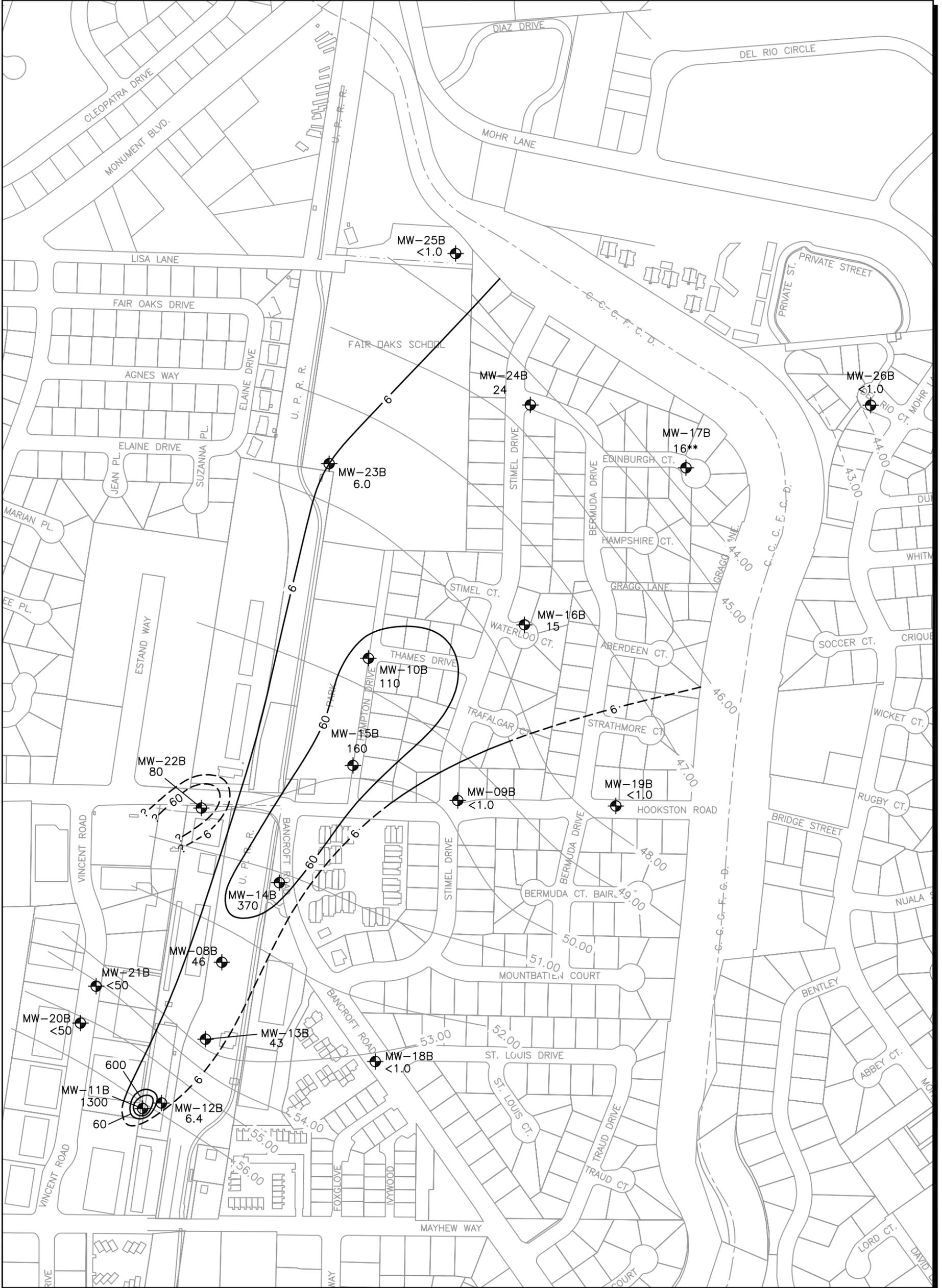


Figure 2-17
cis-1,2-DCE Isoconcentration Map
B Zone Ground Water
First Quarter 2006
Hookston Station
Pleasant Hill, California



LEGEND	
	Monitoring Well Location
23	1,1-DCE Concentration ($\mu\text{g/L}$)
60	1,1-DCE in Ground Water Contour, Solid Based on First Quarter Monitoring Well Data, Dashed Where Inferred from Non-Hookston Station Investigation Data or Historical Grab Ground Water Sample Data.
	Hookston Station Parcel Property Boundary
51.00	Ground Water Elevation Contour, B-Zone, 23 January 2006 (feet above mean sea level)
**	Multiple Sample Were Collected at Various Depths Within the Well Screen. The Highest Result is Posted
The Maximum Contaminant Level for 1,1-DCE in Drinking Water is 6 $\mu\text{g/L}$.	

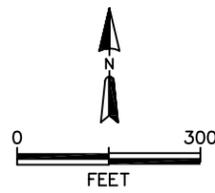
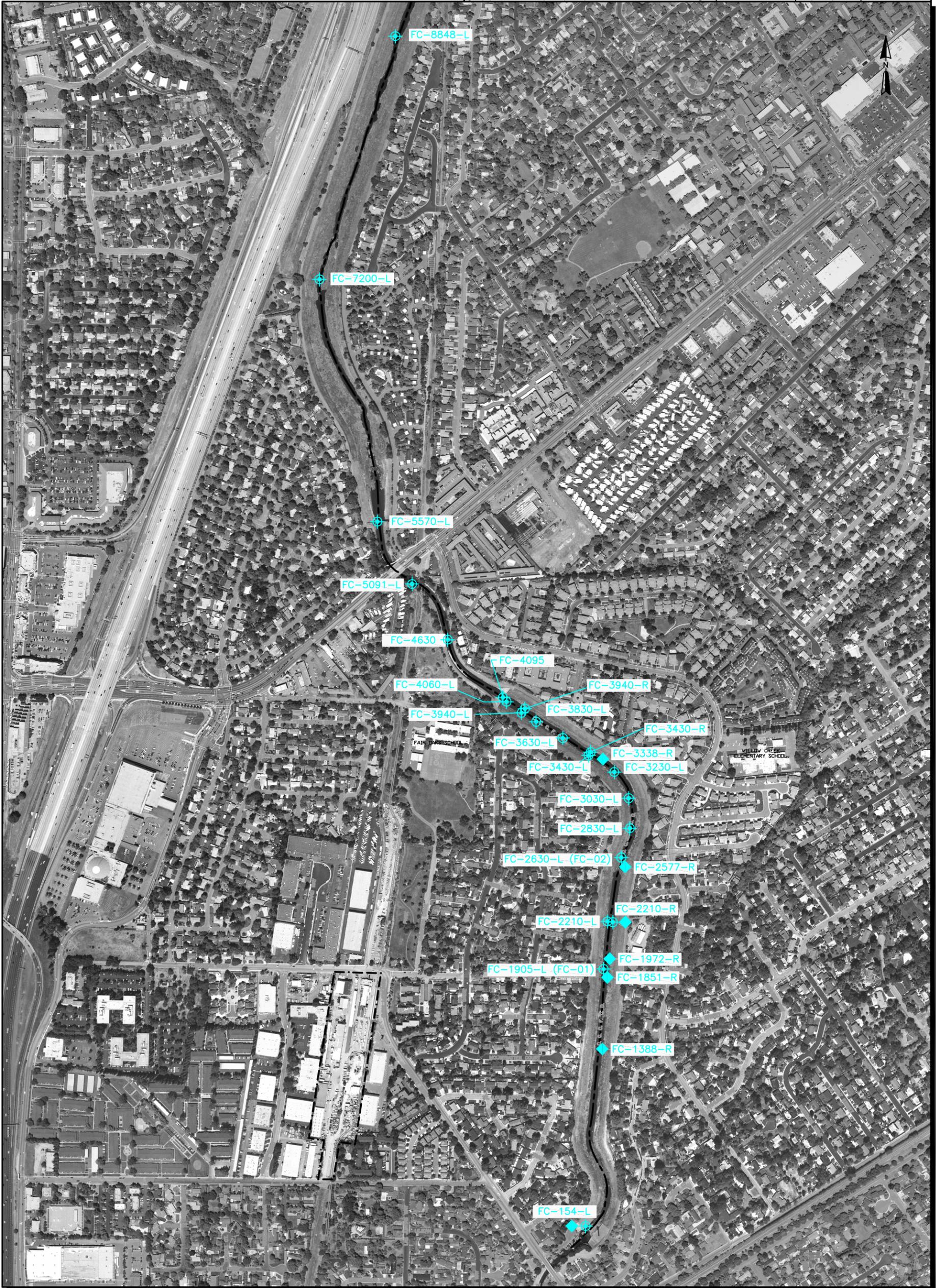


Figure 2-18
 1,1-DCE Isoconcentration Map
 B Zone Ground Water
 First Quarter 2006
 Hookston Station
 Pleasant Hill, California



LEGEND

FC-154-L ⊕ Canal Surface Water Sample
 FC-154-L ◆ Canal Sediment Sample
 - - - - - Hookston Station Parcel Property Boundary

Note: Aerial Photos Taken May 2000.

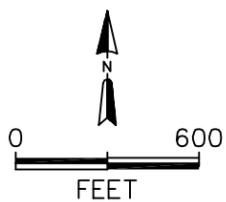
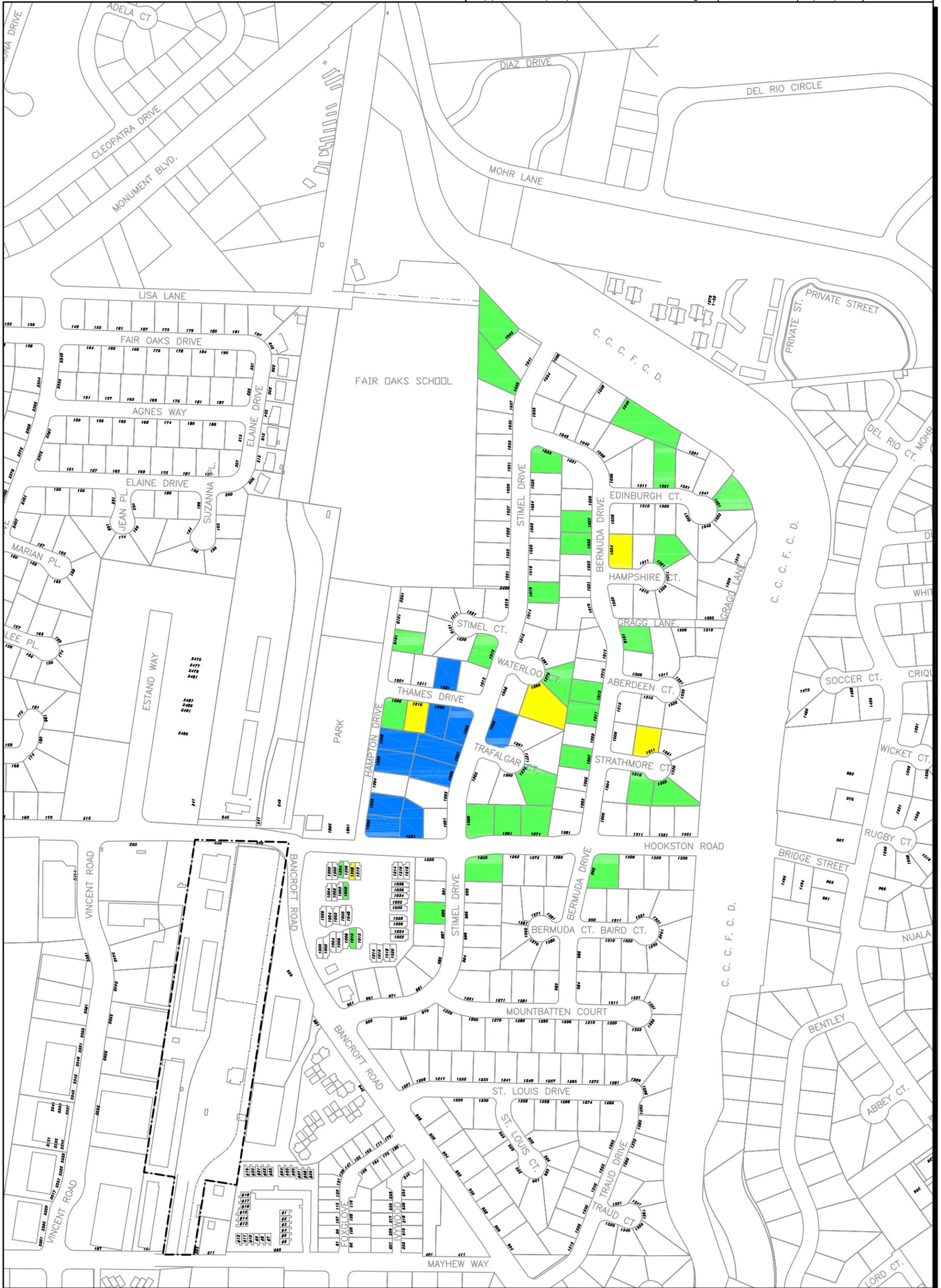


Figure 2-19
 Surface Water and Sediment Sample Locations
 Hookston Station
 Pleasant Hill, California



LEGEND

- Hookston Station Parcel Property Boundary
- TCE Not Detected in Indoor Air Above Laboratory Reporting Limit
- TCE Detected in Indoor Air At a Concentration Below 1.22 µg/m³ (Residential CHHSL)
- TCE Detected in Indoor Air At a Concentration of 1.22 µg/m³ or Greater (Residential CHHSL)

Note: For homes sampled more than once, figure is based on the maximum TCE concentrations detected in indoor air.

Note: Graphic depicts highest concentrations detected historically to show extent of impacts. Many homes have been fitted with vapor intrusion prevention systems which have reduced indoor air concentrations to below CHHSLs.

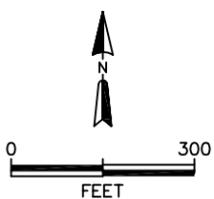
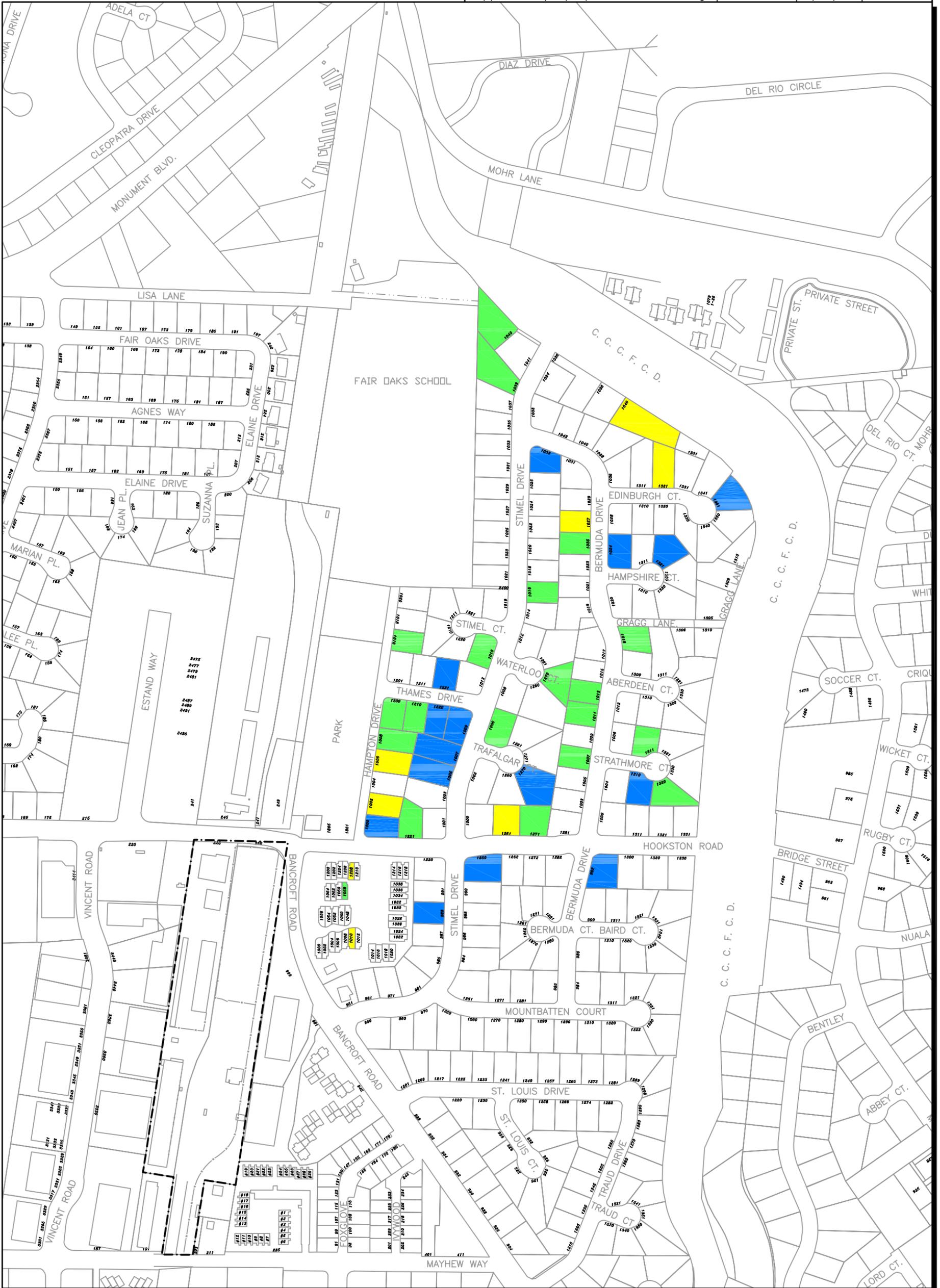


Figure 2-20
TCE in Residential Indoor Air (2004 - 2006)
Hookston Station
Pleasant Hill, California



LEGEND

- Hookston Station Parcel Property Boundary
- PCE Not Detected in Indoor Air Above Laboratory Reporting Limit
- PCE Detected in Indoor Air At a Concentration Below 0.412 µg/m³ (Residential CHHSL)
- PCE Detected in Indoor Air At a Concentration of 0.412 µg/m³ or Greater (Residential CHHSL)

Notes:

1. For homes sampled more than once, figure is based on the maximum PCE concentrations detected in indoor air.
2. Not all samples collected in 2004 were analyzed for PCE.

Note: Graphic depicts highest concentrations detected historically to show extent of impacts. Many homes have been fitted with vapor intrusion prevention systems which have reduced indoor air concentrations to below CHHSLs.

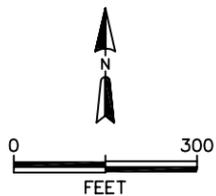
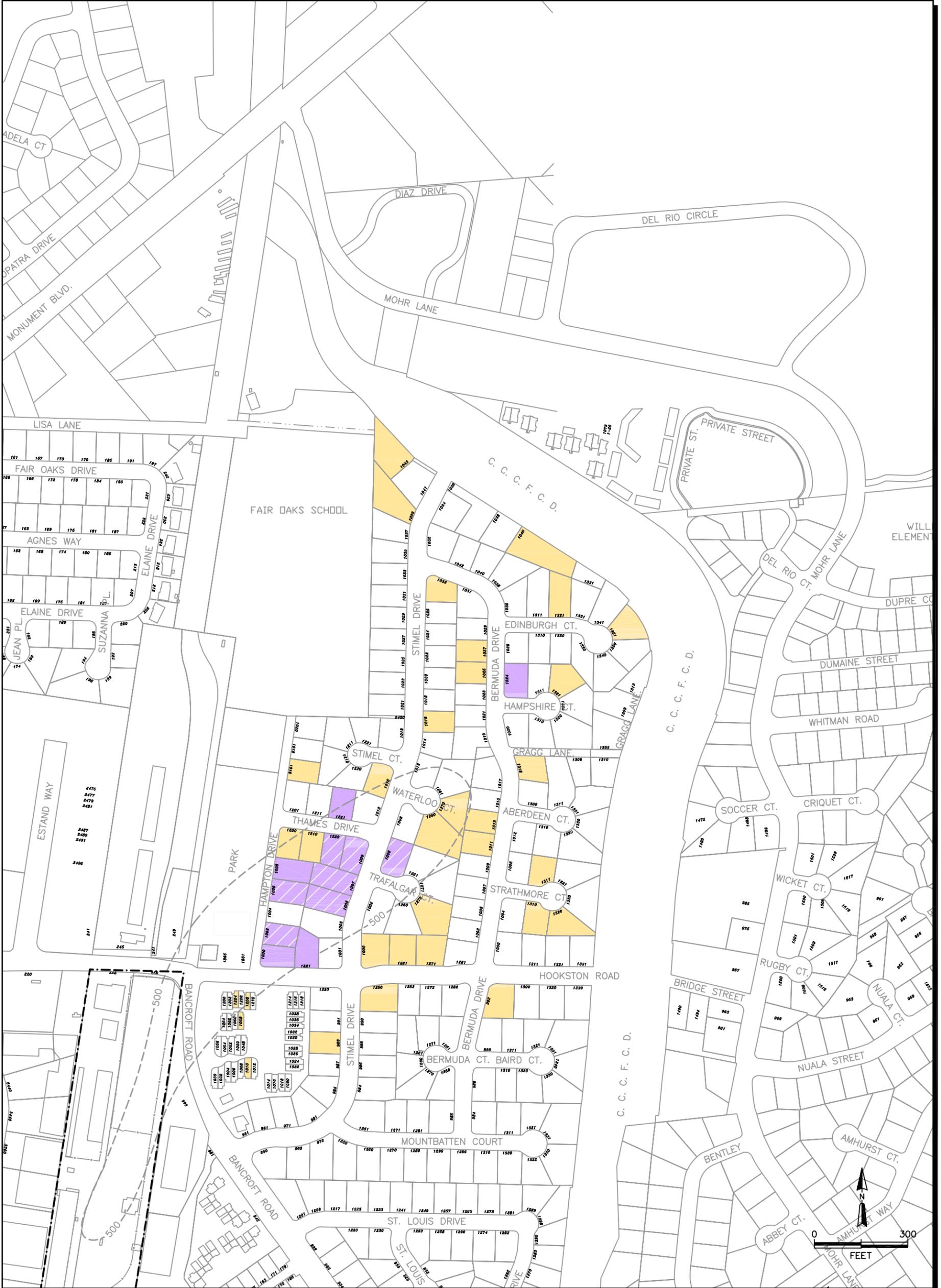


Figure 2-21
PCE in Residential Indoor Air (2004 - 2006)
 Hookston Station
 Pleasant Hill, California



LEGEND

-  Hookston Station Parcel Property Boundary
-  TCE Detected in Indoor Air At a Concentration of 0.96 $\mu\text{g}/\text{m}^3$ or Greater (risk-based cleanup goal)
-  TCE Detected in Indoor Air at Concentrations Below 0.96 $\mu\text{g}/\text{m}^3$, or Was Not Detected Above Laboratory Reporting Levels
-  Vapor Intrusion Prevention System Installed
-  500 TCE in A-Zone Ground Water Contour (500 $\mu\text{g}/\text{L}$), First Quarter 2006

Note: Figure is based on the maximum TCE concentrations detected in indoor air during 2004–2006.

Figure 4-1
Residential Indoor Air Relative to Risk-Based Cleanup Goal Hookston Station Pleasant Hill, California

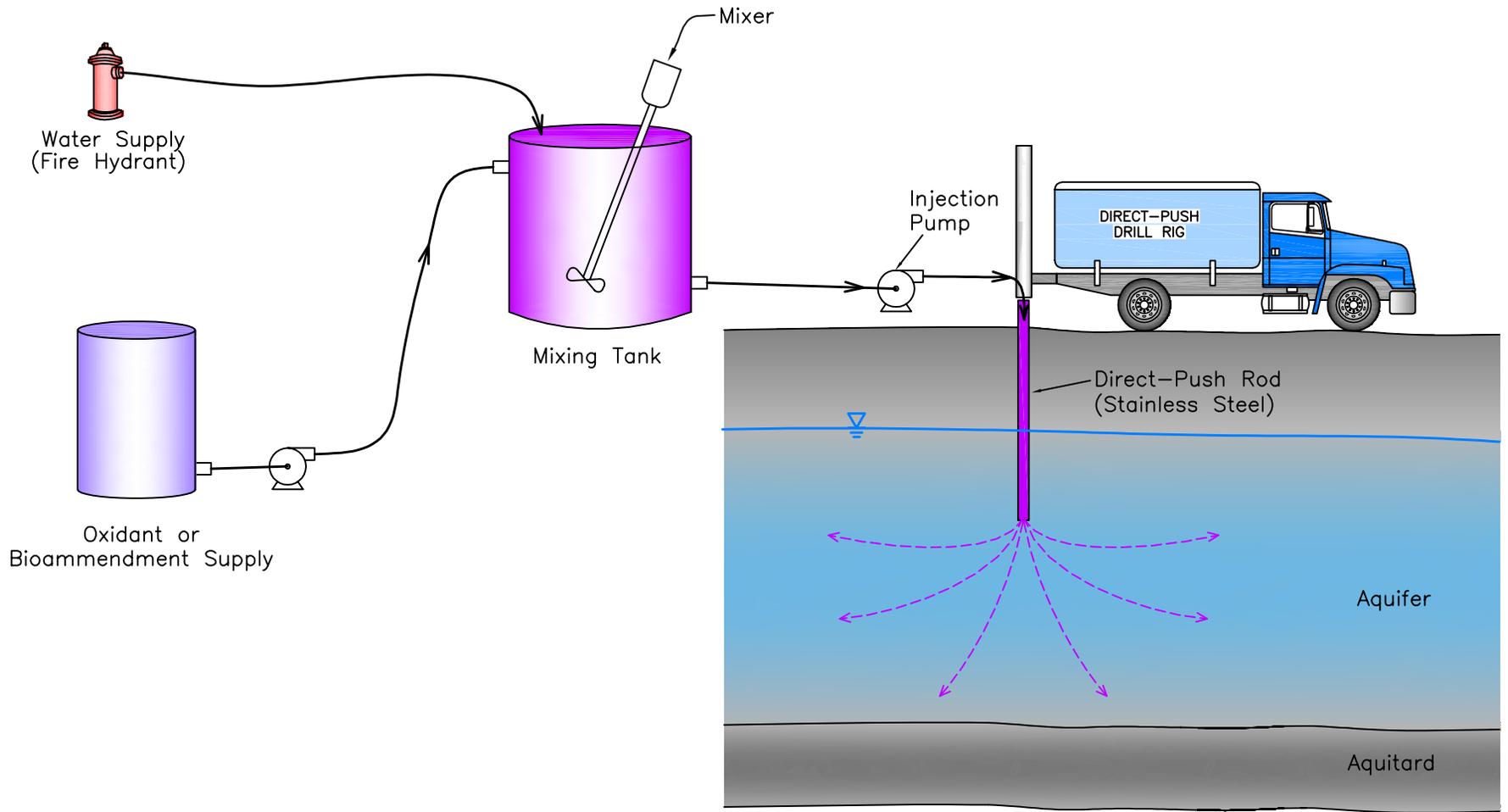
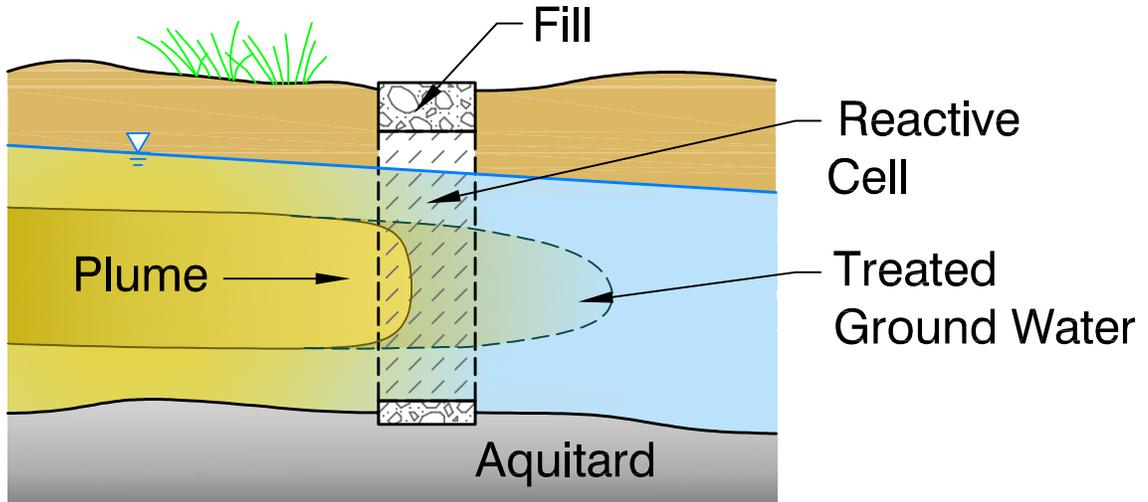
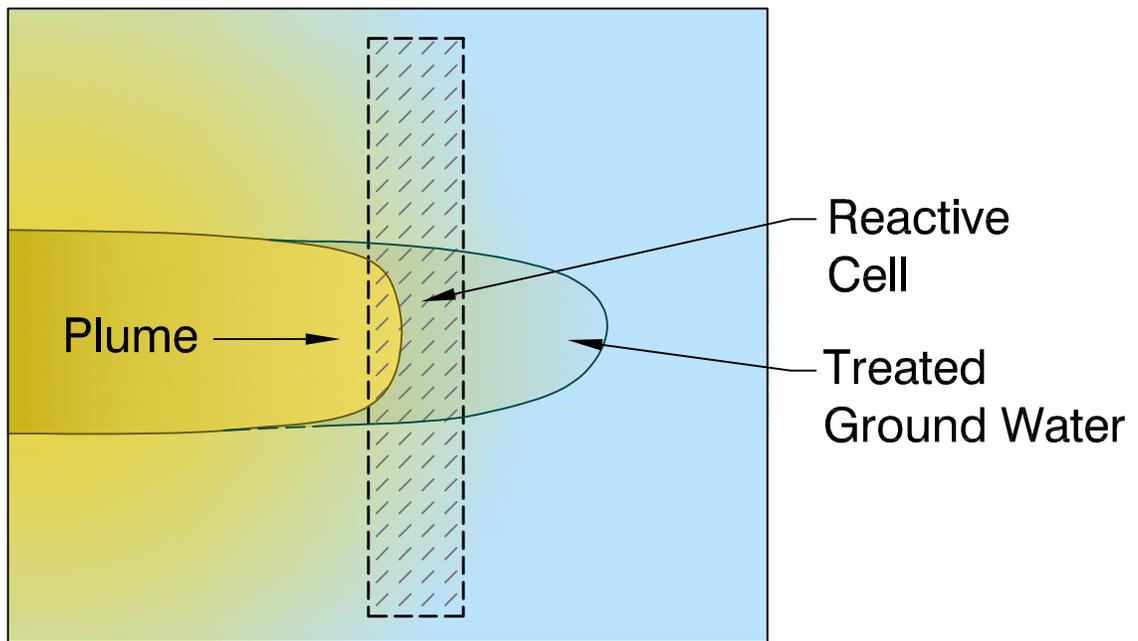


Figure 5-1
Conceptual View Direct-Push Injection System
Hookston Station
Pleasant Hill, California



Permeable Reactive Barrier (Elevation View)



Permeable Reactive Barrier (Plan View)

Figure 5-2
*Conceptual View Permeable Reactive Barrier Technology
Hookston Station
Pleasant Hill, California*

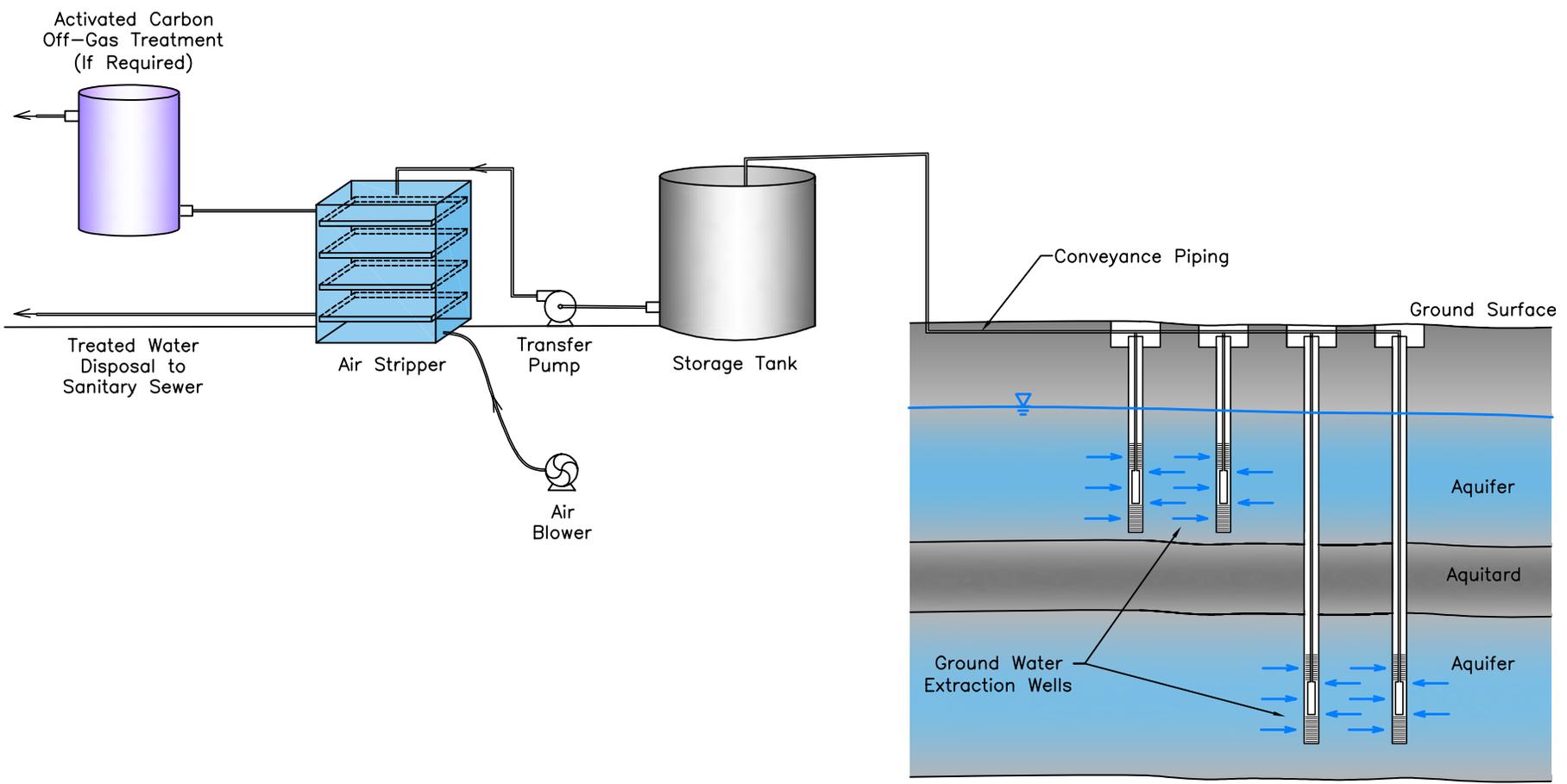
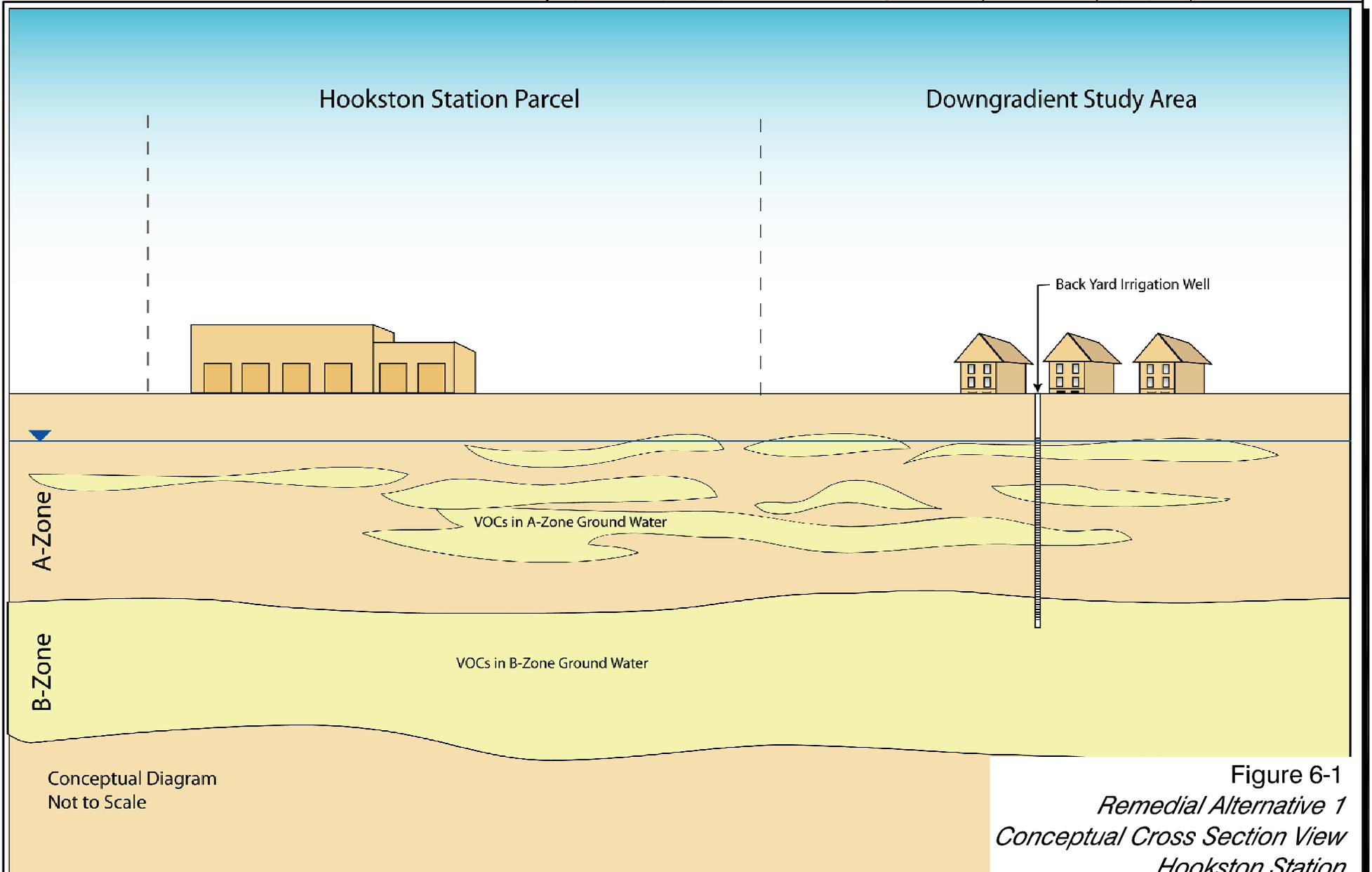


Figure 5-3
*Conceptual View Ground Water Extraction Treatment and Disposal
 Hookston Station
 Pleasant Hill, California*



Conceptual Diagram
Not to Scale

Figure 6-1
Remedial Alternative 1
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California

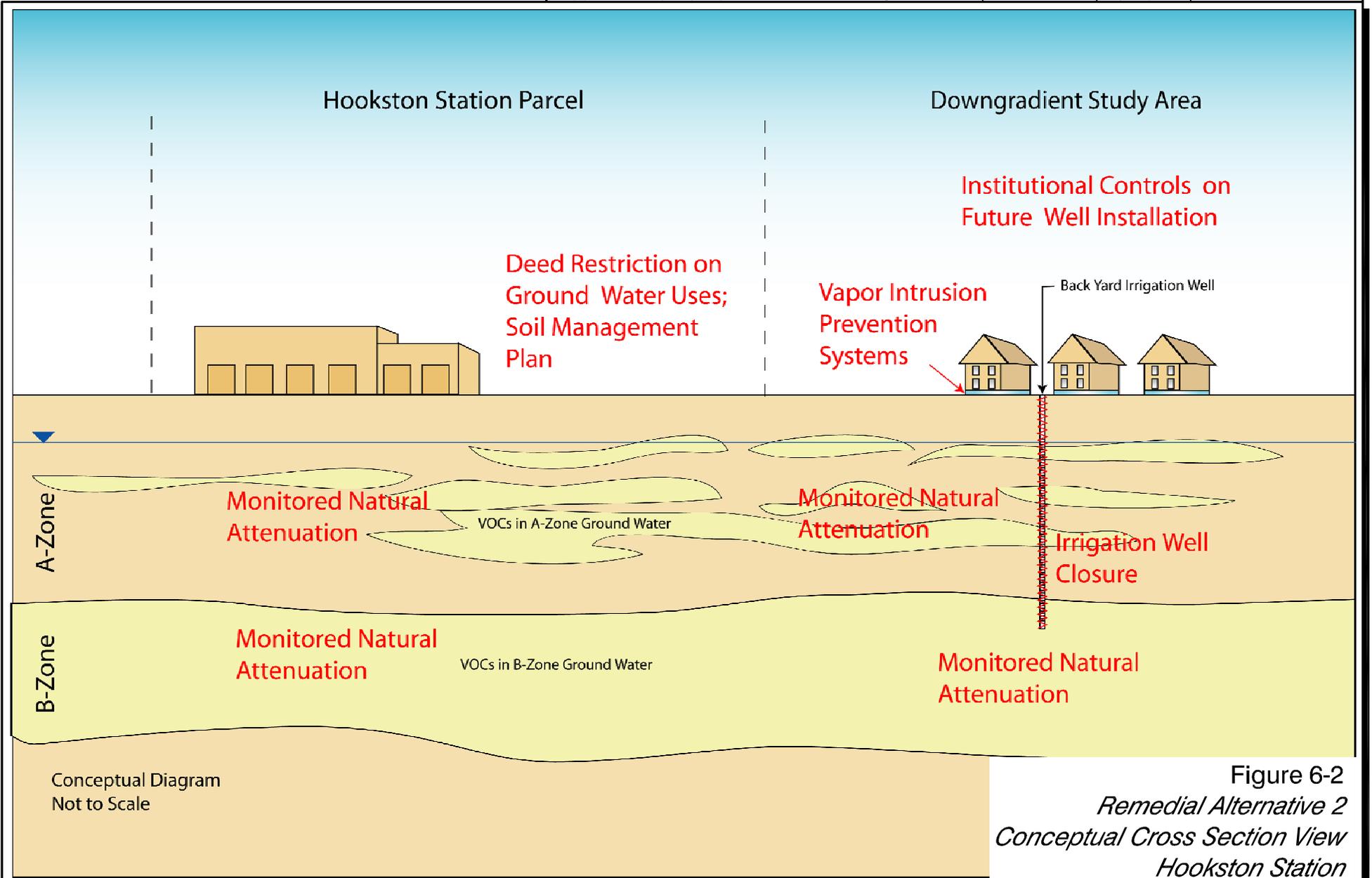
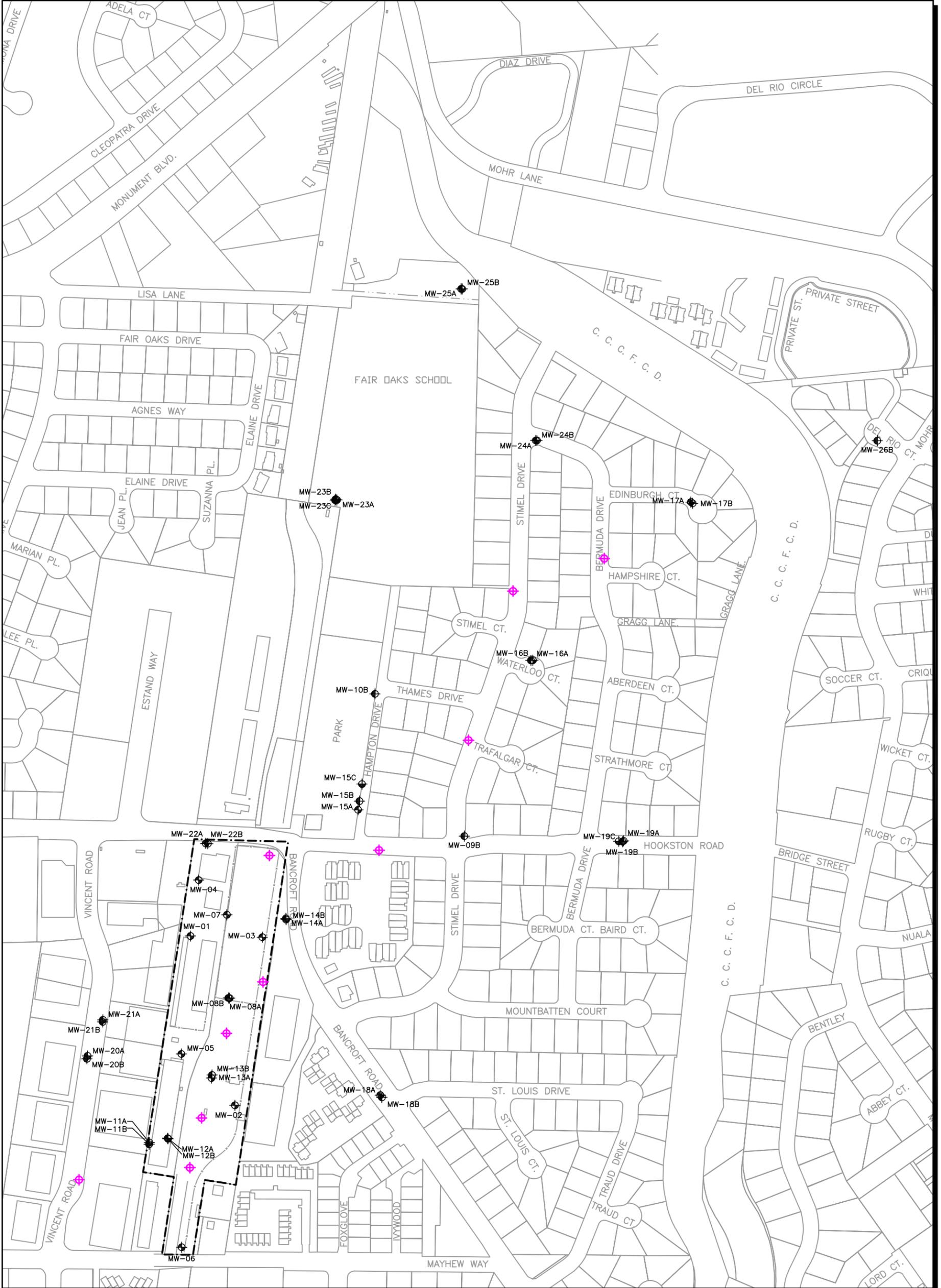


Figure 6-2
Remedial Alternative 2
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California



LEGEND

- ⊕ Existing A-Zone Monitoring Well
- ⊕ Existing B-Zone Monitoring Well
- ⊕ Existing C-Zone Monitoring Well
- ⊕ Proposed Paired A-Zone/B-Zone Monitoring Wells
- Hookston Station Parcel Property Boundary

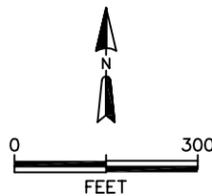


Figure 6-3
Remedial Alternative 2
Monitored Natural Attenuation
Hookston Station
Pleasant Hill, California

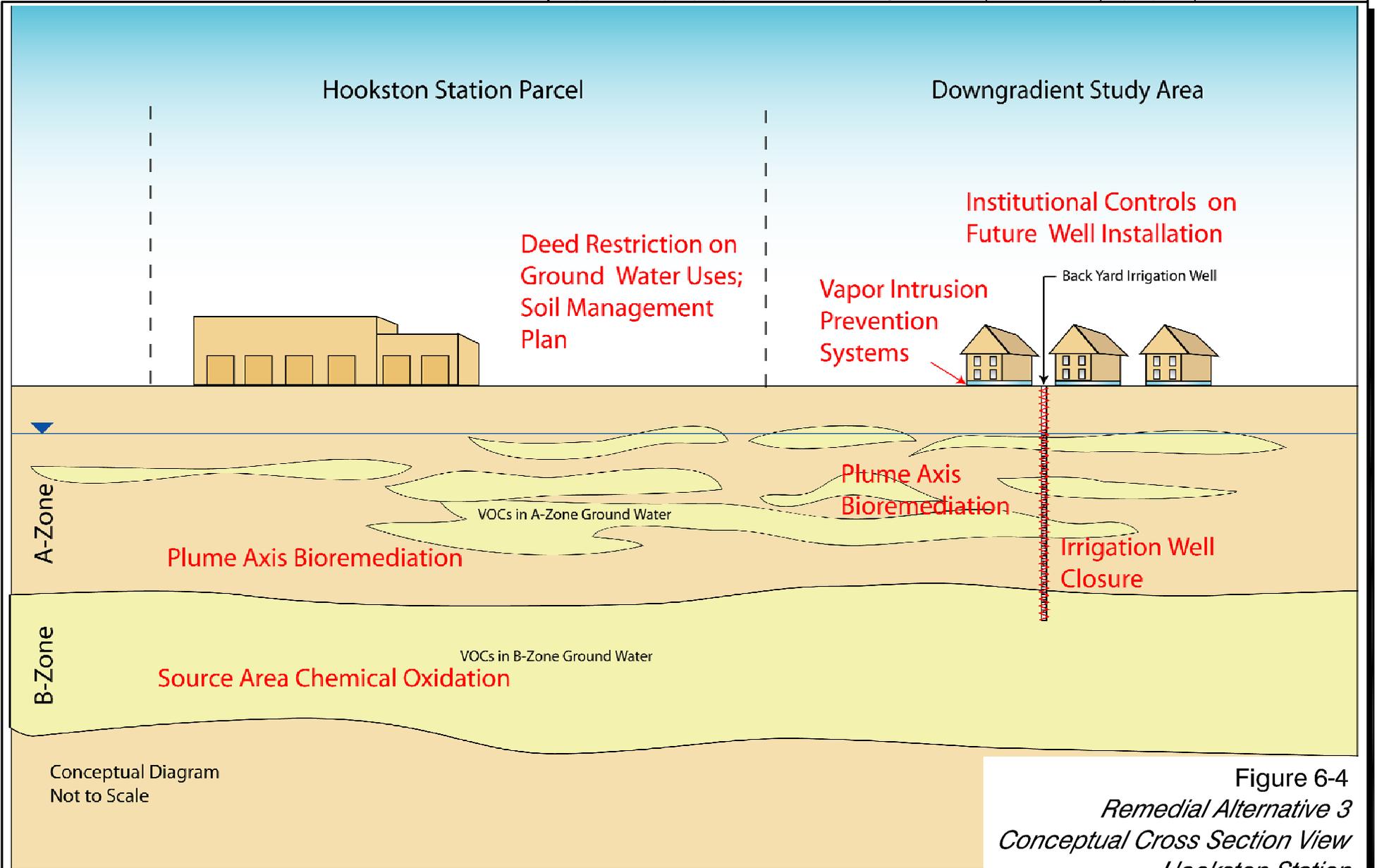
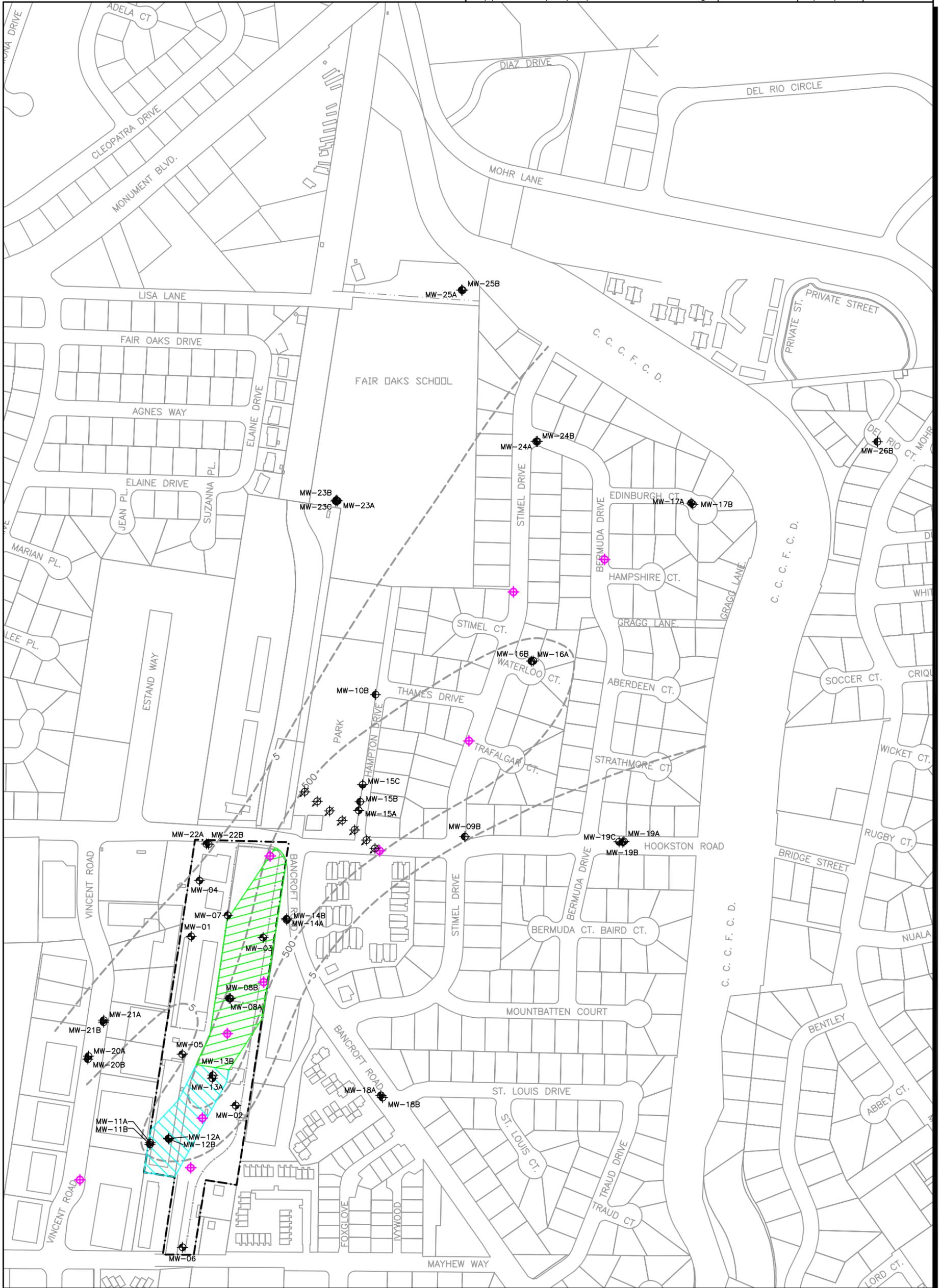


Figure 6-4
Remedial Alternative 3
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California



LEGEND	
	Existing A-Zone Monitoring Well
	Existing B-Zone Monitoring Well
	Existing C-Zone Monitoring Well
	Proposed A-Zone Injection Well
	Proposed Paired A-Zone/B-Zone Monitoring Wells
	Proposed Area of A-Zone Injection Points for Bioremediation Amendment
	Proposed Area of A-Zone Injection Points For Bioremediation Amendment and B-Zone Injection Points for Chemical Oxidation
	A-Zone Ground Water TCE Contour ($\mu\text{g/L}$), First Quarter 2006
	Hookston Station Parcel Property Boundary

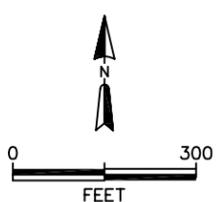
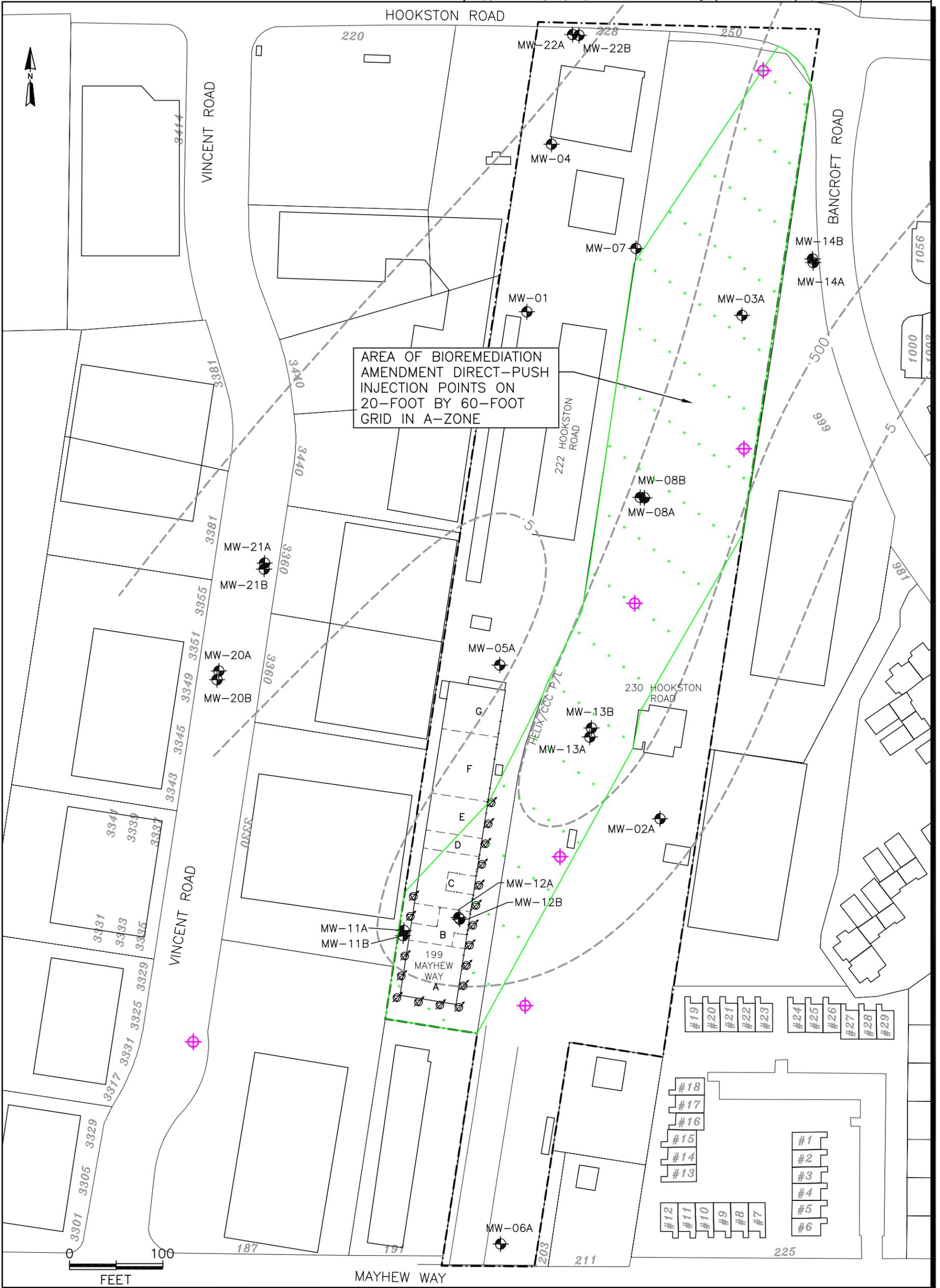


Figure 6-5
Remedial Alternative 3
Enhanced Anaerobic Bioremediation
Hookston Station
Pleasant Hill, California
 ERM 06/06

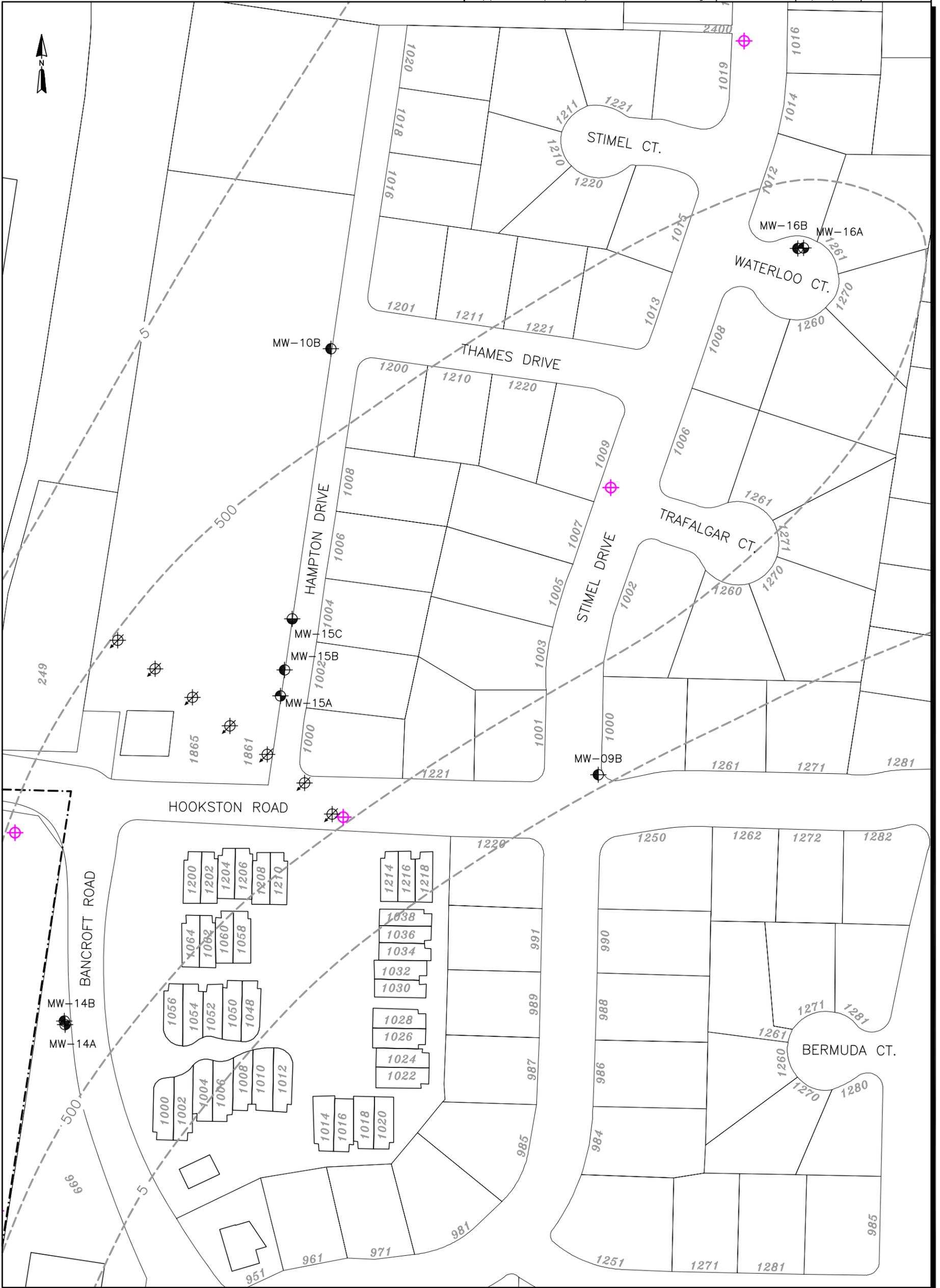


AREA OF BIOREMEDIATION
AMENDMENT DIRECT-PUSH
INJECTION POINTS ON
20-FOOT BY 60-FOOT
GRID IN A-ZONE

LEGEND

- Monitoring Well
- Proposed Paired A-Zone/B-Zone Monitoring Wells
- Proposed Angled Direct-Push Injection Point
- Proposed Direct-Push Injection Point
- A-Zone Ground Water TCE Contour ($\mu\text{g/L}$), First Quarter 2006
- Hookston Station Parcel Property Boundary

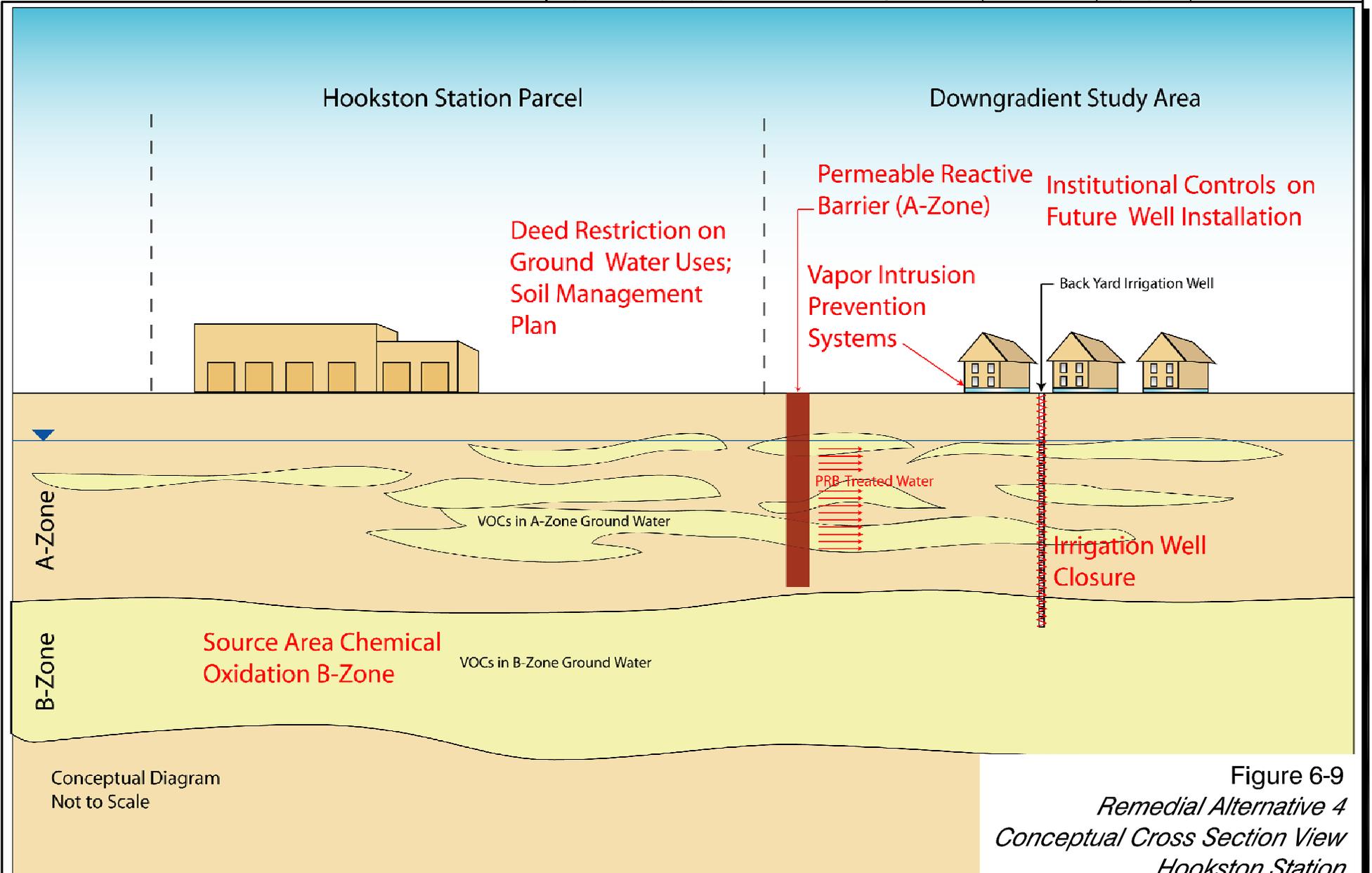
Figure 6-6
Remedial Alternative 3
A-Zone Detailed View - Hookston Station Parcel
Hookston Station
Pleasant Hill, California



LEGEND	
	Monitoring Well Location
	Proposed Paired A-Zone/B-Zone Monitoring Wells Location
	Proposed A-Zone Injection Well
	A-Zone Ground Water TCE Contour ($\mu\text{g/L}$), First Quarter 2006
	Hookston Station Parcel Property Boundary

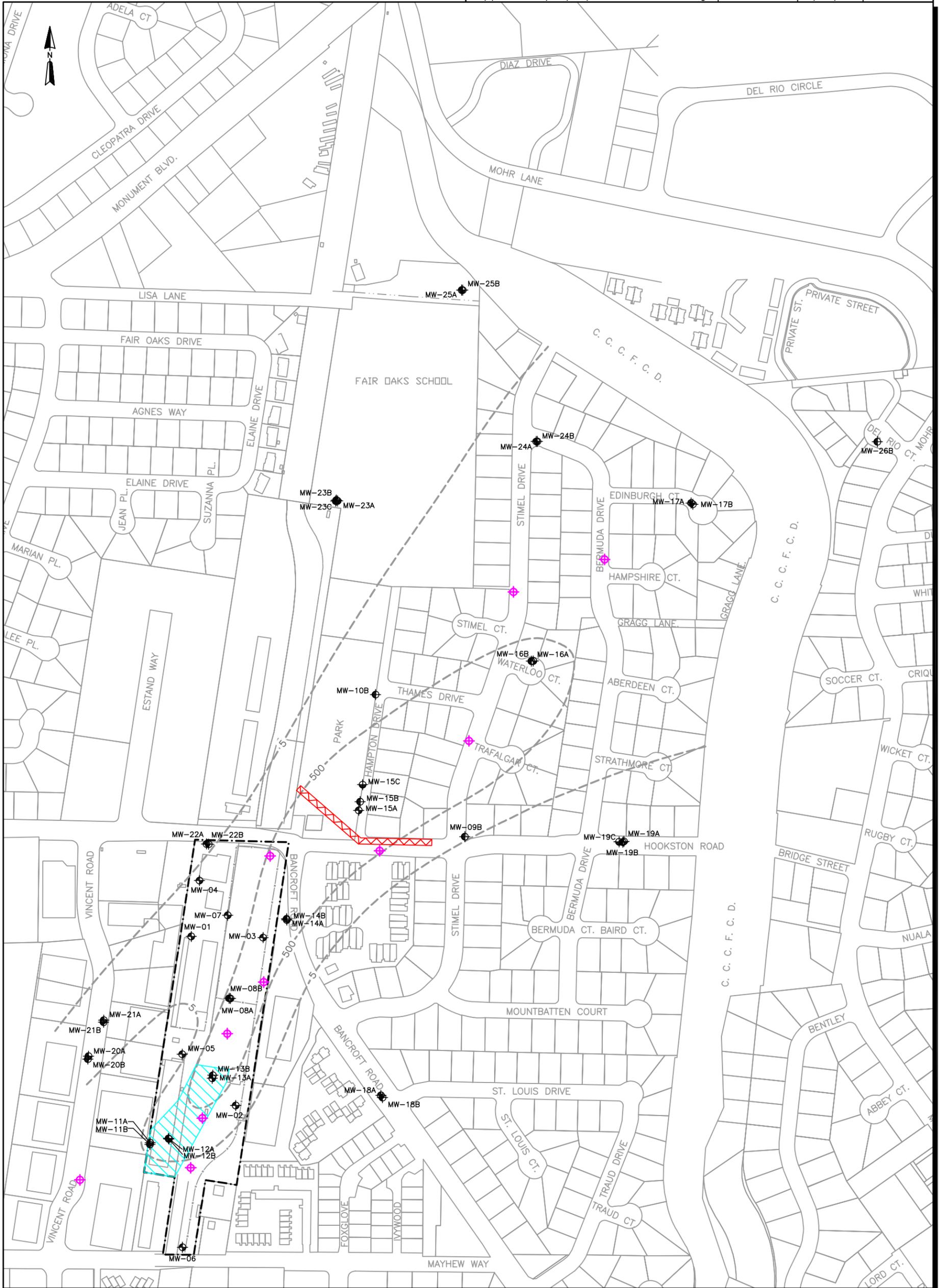


Figure 6-7
Remedial Alternative 3
A-Zone Detailed View - Downgradient Study Area
Hookston Station
Pleasant Hill, California



Conceptual Diagram
Not to Scale

Figure 6-9
Remedial Alternative 4
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California

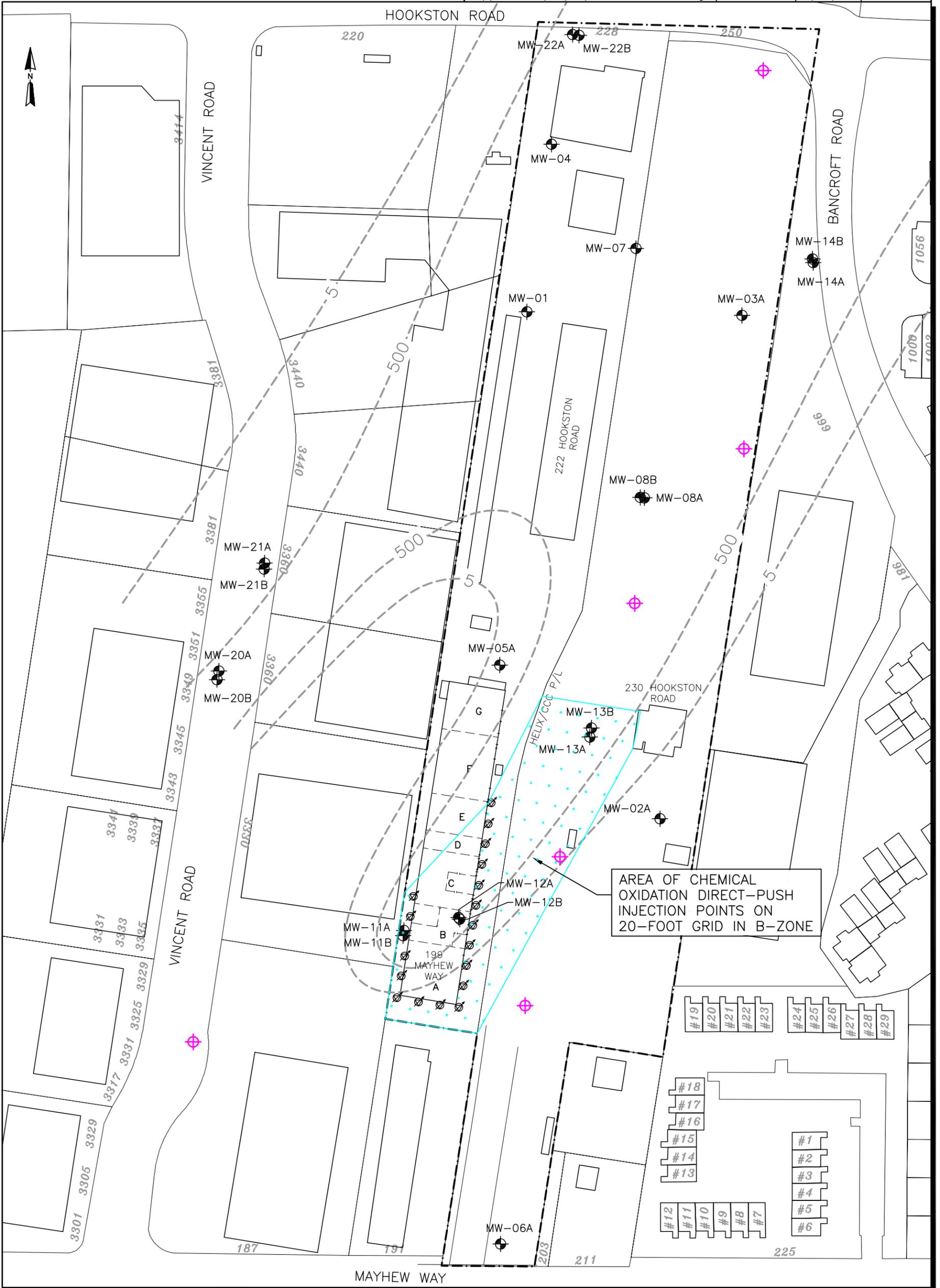


LEGEND

- Existing A-Zone Monitoring Well
- Existing B-Zone Monitoring Well
- Existing C-Zone Monitoring Well
- Proposed Paired Zone A-Zone/B-Zone Monitoring Wells
- Proposed Location of Zero-Valent Iron Permeable Reactive Barrier - A-Zone
- Proposed Area of B-Zone Injection Points for Chemical Oxidation
- A-Zone Ground Water TCE Contour ($\mu\text{g/L}$), First Quarter 2006
- Hookston Station Parcel Property Boundary

0 300
FEET

Figure 6-10
Remedial Alternative 4
Zero-Valent Iron Permeable Reactive Barrier
Hookston Station
Pleasant Hill, California



LEGEND

- Monitoring Well Location
- Proposed Paired A-Zone/B-Zone Monitoring Wells Location
- Proposed Angled Direct-Push Injection Point
- Proposed Direct-Push Injection Point
- B-Zone Ground Water TCE Contour ($\mu\text{g/L}$), First Quarter 2006
- Hookston Station Parcel Property Boundary



Figure 6-11
Remedial Alternative 4
Detailed View
Hookston Station
Pleasant Hill, California

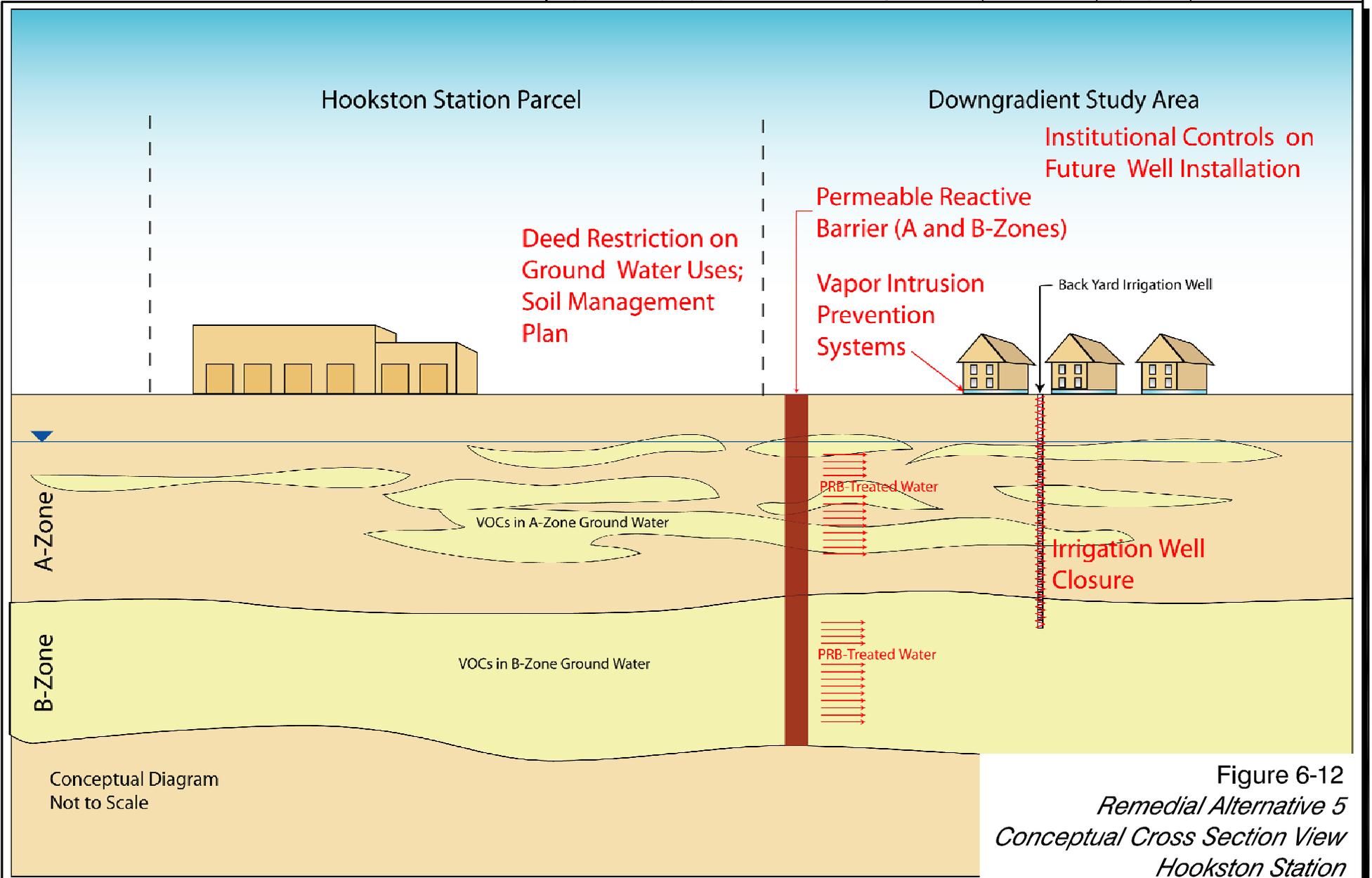
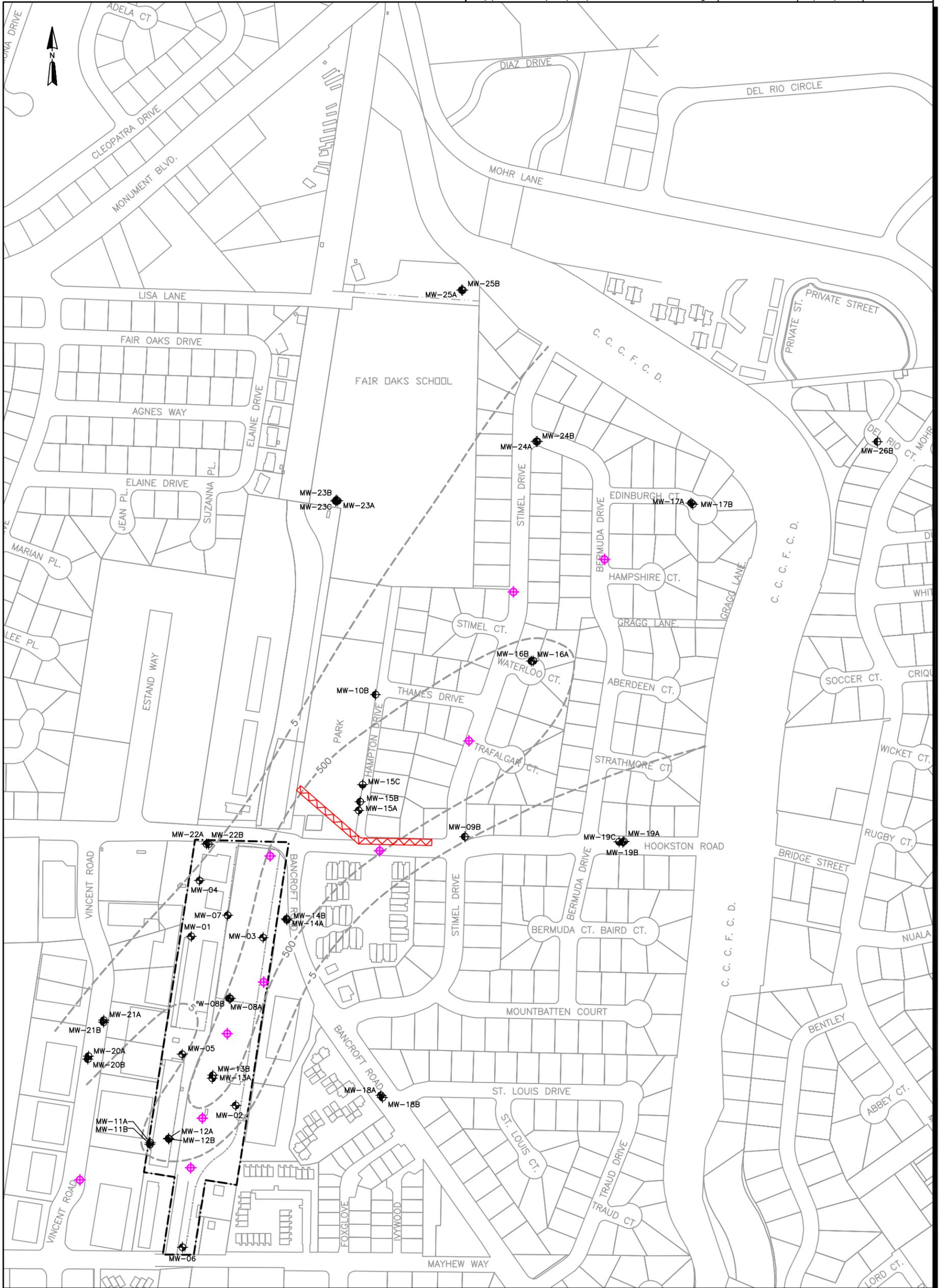


Figure 6-12
Remedial Alternative 5
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California



LEGEND

- ⊕ Existing A-Zone Monitoring Well
- ⊙ Existing B-Zone Monitoring Well
- ⊙ Existing C-Zone Monitoring Well
- ⊕ Proposed Paired A-Zone/B-Zone Monitoring Wells
-  Proposed Location of Zero-Valent Iron Permeable Reactive Barrier - A-Zone and B-Zone
- - - A-Zone Ground Water TCE Contour (µg/L), First Quarter 2006
- Hookston Station Parcel Property Boundary

0 300
FEET

Figure 6-13
Remedial Alternative 5
Zero-Valent Iron Permeable Reactive Barrier
Hookston Station
Pleasant Hill, California

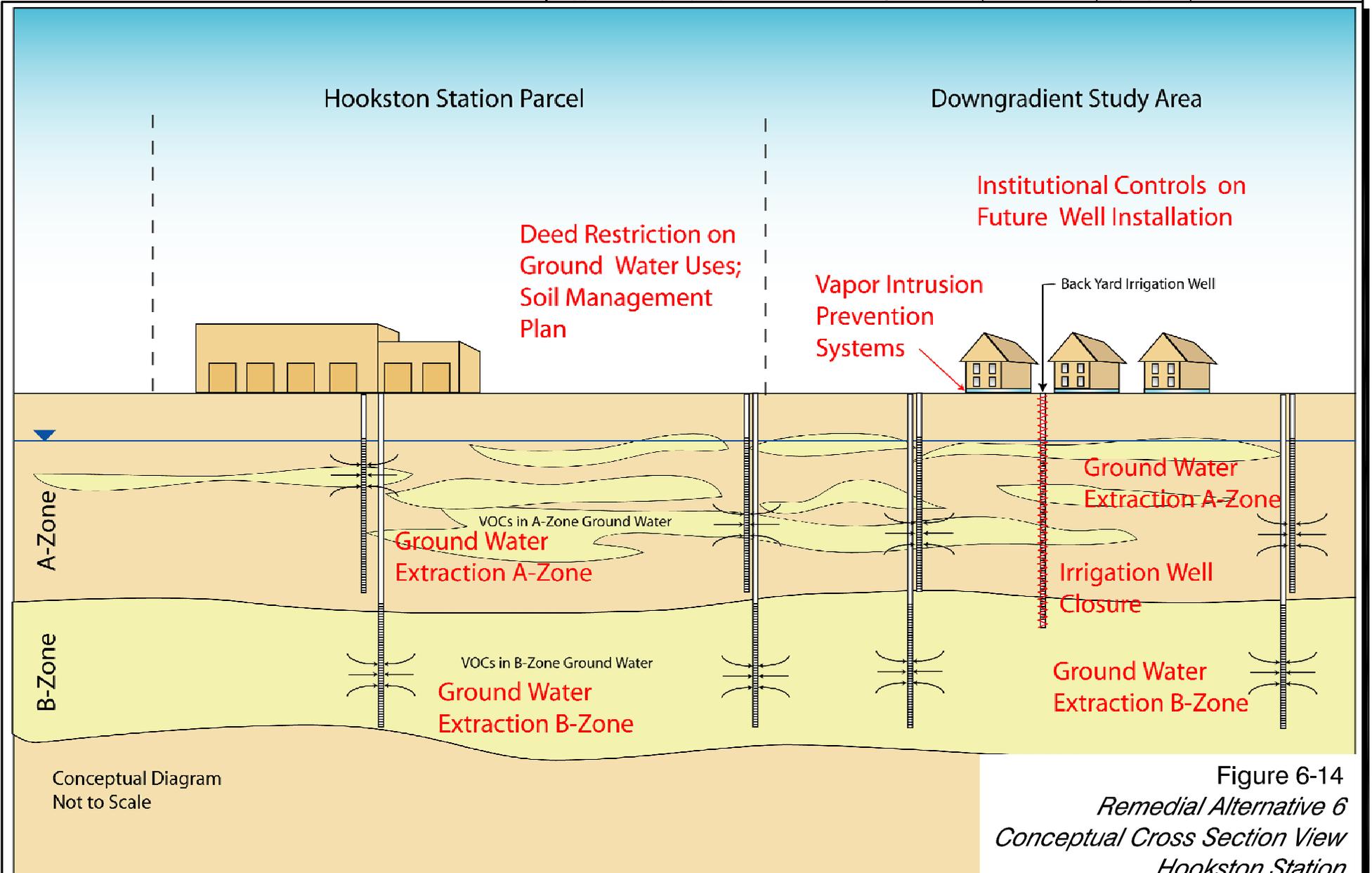
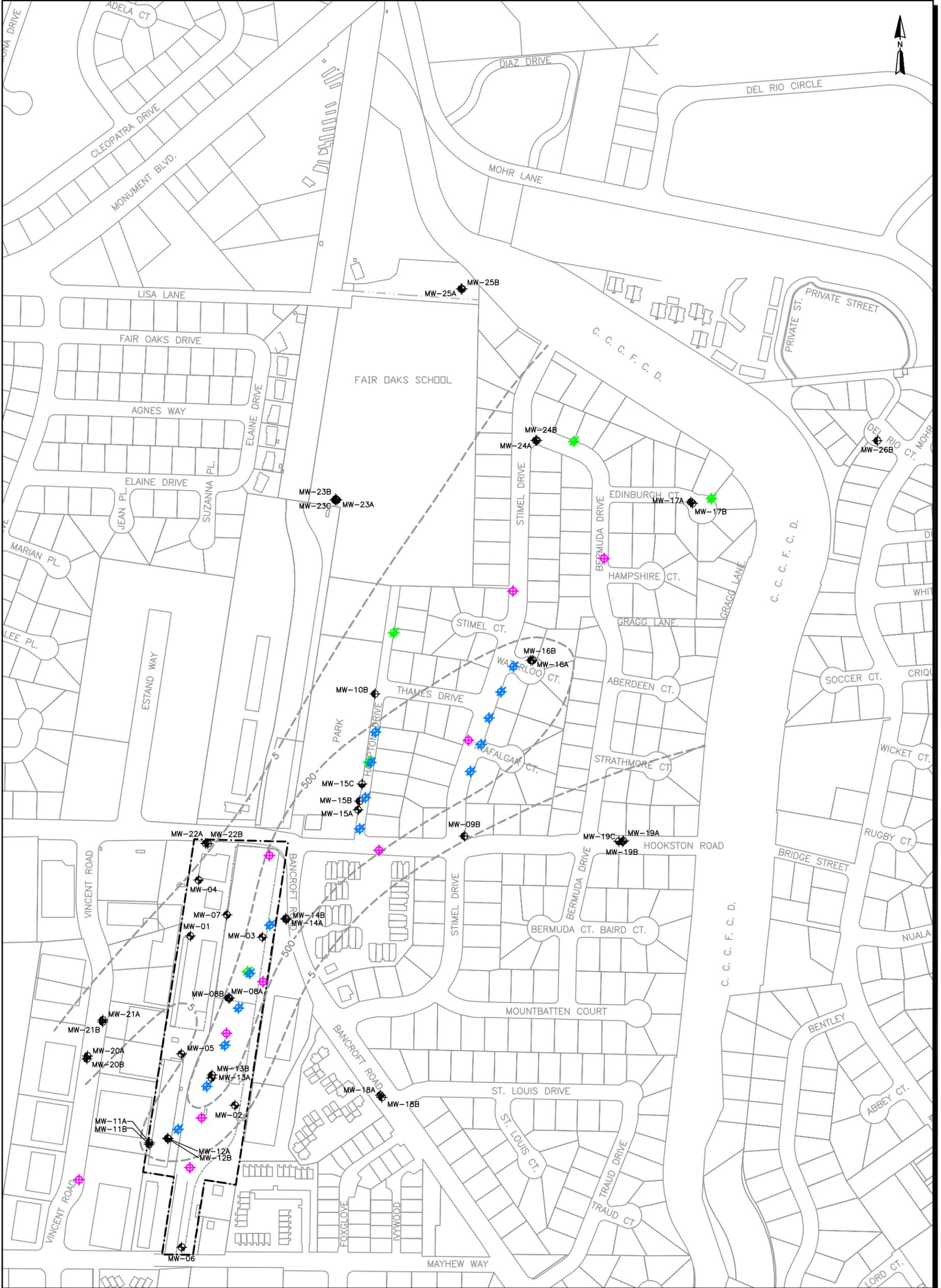


Figure 6-14
*Remedial Alternative 6
Conceptual Cross Section View
Hookston Station
Pleasant Hill, California*



LEGEND

● Existing A-Zone Monitoring Well	--- A-Zone Ground Water TCE Contour (µg/L), First Quarter 2006
● Existing B-Zone Monitoring Well	— Hookston Station Parcel Property Boundary
● Existing C-Zone Monitoring Well	
◆ Proposed Paired A-Zone/B-Zone Monitoring Wells	
★ Proposed A-Zone Extraction Well	0 300 FEET
★ Proposed B-Zone Extraction Well	

Figure 6-15
Remedial Alternative 6
Ground Water Extraction, Treatment, and Disposal
Hookston Station
Pleasant Hill, California

Tables

Table 2-1
Summary of Remedial Investigation Results
Hookston Station
Pleasant Hill, California

Location	Media	Sample Results Compared to MCLs, RWQCB ESLs, and CalEPA CHHSLs									
		TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	Non-Hookston VOCs	TPH	SVOCs	PCBs	Metals
Hookston Station Parcel	Shallow soil(≤9.8 ft)	above (6 of 117)	above (2 of 117)	below	nd	below	PCE (below)	above (14 of 47)	above (1 of 5)	below	above (10 of 18)
	Deep soil (>9.8 ft)	above (1 of 122)	below	below	below	nd	benzene and xylenes (above - 2 of 93); PCE (below)	below	ns	ns	ns
	Soil vapor*	above (1 of 2)	nd	nd	nd	nd	PCE, benzene, toluene, ethylbenzene, xylenes (below)	n/a	n/a	n/a	n/a
	Ground water	above (67 of 102)	above (33 of 102)	above (1 of 102)	above (33 of 102)	above (8 of 102)	PCE (15 of 102 above), benzene and MTBE(3 of 102 above)	above (5 of 8)	below	ns	above (8 of 17)
	Indoor air	above (2 of 5)	below	ns	nd	ns	ns	n/a	n/a	n/a	n/a
Outside the Hookston Station Parcel	Shallow soil(≤9.8 ft)	below	nd	nd	nd	nd	nd	nd	ns	ns	above (1 of 1)
	Deep soil (>9.8 ft)	below	nd	nd	nd	nd	nd	ns	ns	ns	ns
	Soil vapor*	above (8 of 23)	above (1 of 23)	below	below	above (3 of 23)	PCE (2 of 23 above), benzene and 1,1,1-TCA (1 of 23 above)	n/a	n/a	n/a	n/a
	Ground water	above (64 of 149)	above (28 of 149)	above (4 of 149)	above (41 of 149)	above (10 of 149)	PCE(10 of 149 above); benzene and MTBE(2 of 149 above)	above (2 of 8)	below	ns	above (18 of 23)
	Indoor air	above (9 of 47)	below	nd	below	above (1 of 42)	PCE (15 of 43 above), benzene (42 of 42 above), 1,2-DCA (8 of 42 above)	n/a	n/a	n/a	n/a
	Surface water	below	below	nd	nd	nd	MTBE (above); PCE and toluene (below)	ns	ns	ns	ns
	Sediment	nd	nd	nd	nd	nd	nd	ns	ns	ns	ns

Notes:

CalEPA CHHSL - CalEPA's California Human Health Screening Level (CalEPA DTSC 2005)
DCA = Dichloroethane
DCE = Dichloroethene
ft = feet
MCL = California Environmental Protection Agency (CalEPA) Maximum Contaminant Level for drinking water
MTBE = Methyl-tert-butyl ether
n/a - not applicable
nd - nondetect
ns - not sampled
PCB = Polychlorinated biphenyl
PCE = Tetrachloroethene
(6 of 100) - indicates frequency of detection above the MCL, ESL, or CHHSL

RWQCB ESL - San Francisco Bay Regional Water Quality Control Board Environmental Screening Level (RWQCB 2005)
SVOC = Semi-volatile organic compound
TCA = Trichloroethane
TCE = Trichloroethene
TPH = Total petroleum hydrocarbons
VOC = Volatile organic compounds
above - indicates compound was detected above the applicable MCL, RWQCB ESL, and/or CalEPA CHHSL
below - indicates compound was detected but at a concentration below the applicable MCL, RWQCB ESL, and/or CalEPA CHHSL
* Based on active soil vapor sampling results
Based on data collected during previous investigations, the remedial investigation, and quarterly monitoring events

Table 2-2
Summary of Risk Characterization for the Hookston Station Parcel
Hookston Station
Pleasant Hill, California

Source	Exposure Medium	Pathway	Receptor	Pathway Complete?	Exceeds Carcinogenic Risk Management Level for the Parcel (1 in 100,000)?	Exceeds Noncarcinogenic Risk Management Level (1)?	Primary Constituent Contributing to Risk Exceedance	Notes	Pathway Addressed in FS?
Ground water	Ground water	Ingestion and dermal contact with ground water used for drinking water purposes	Commercial/industrial worker, construction worker	No	-	-	-	Ground water is not used as a potable water supply.	No
		Inhalation of VOCs released from ground water used for tap or shower water	Commercial/industrial worker, construction worker	No	-	-	-	Ground water is not used as a potable water supply.	No
Ground water	Indoor air	Inhalation of VOCs migrating from shallow ground water	Commercial/industrial worker	Yes	No	No	None	Only TCE; cis-1,2-DCE; and 1,1-DCE were evaluated.	No
		Inhalation of VOCs migrating from shallow ground water	Construction worker	No	-	-	-	Construction workers are not expected to spend significant amounts of time indoors.	No
Ground water	Outdoor Air	Inhalation of VOCs migrating from shallow ground water	Commercial/industrial worker, construction worker	Yes	-	-	-	Additional risk characterization was not conducted because exposure pathway is minor due to rapid dilution in outdoor air.	No
	Indoor Air	Inhalation of VOCs migrating from shallow soil		Yes	No	No	None	Only TCE; cis-1,2-DCE; and 1,1-DCE were evaluated.	No
Soil	Soil	Ingestion	Commercial/industrial worker	Yes	No	No	None	Risk characterization based on the highest VOC, SVOC, and TPH detections reported in soil from 0 to 10 feet bgs, and highest metals concentration reported in surface soils (subsurface metals samples were not collected prior to the finalization of the Baseline Risk Assessment). Additional metals soil sampling conducted in June 2006 did not confirm the presence of elevated arsenic concentrations in surface soil but found elevated arsenic concentrations in subsurface soil (2 feet bgs). Therefore, this exposure pathway will not be addressed in this FS because commercial/industrial workers are not expected to have dermal contact subsurface soils.	No
	Soil	Dermal Contact		Yes	Yes	No	Arsenic		No (see notes)
	Outdoor air	Inhalation of chemicals migrating from shallow soil		Yes	No	No	None		No
	Indoor air	Inhalation of VOCs migrating from shallow soil		No	-	-	-	Construction workers are not expected to spend significant amounts of time indoors.	No
Soil	Soil	Ingestion	Construction worker	Yes	Yes	No	Arsenic	Risk characterization based on the highest VOC, SVOC, and TPH detections reported in soil from 0 to 10 feet bgs, and highest metals concentration reported in surface soils (subsurface metals samples were not collected prior to the finalization of the Baseline Risk Assessment). Additional soil sampling conducted in June 2006 did not confirm the presence of elevated arsenic concentrations in surface soil but found elevated arsenic concentrations in subsurface soil (2 feet bgs). Therefore, this exposure pathway will be addressed in this FS because construction workers may be exposed to subsurface soils.	Yes
	Soil	Dermal Contact		Yes	No	No	None		No
	Outdoor air	Inhalation of chemicals migrating from shallow soil		Yes	No	No	None		No

Notes:
VOC = Volatile organic compound
TCE = Trichloroethene
PCE = Tetrachloroethene
FS = Feasibility Study
ERM = ERM-West, Inc.
DCE = Dichloroethene
SVOC = Semi-volatile organic compound
bgs = below ground surface
TPH = Total petroleum hydrocarbons

Table 2-3
Summary of Risk Characterization for the Downgradient Study Area
Hookston Station
Pleasant Hill, California

Source	Exposure Medium	Pathway	Receptor	Pathway Complete?	Exceeds Carcinogenic Risk Management Level for Downgradient Study Area (1 in 1,000,000)?	Exceeds Noncarcinogenic Risk Management Level (1)?	Primary Constituent Contributing to Risk Exceedance	Notes	Pathway Addressed in FS?
Impacted ground water	Indoor Air	Inhalation of VOCs released from ground water used for tap or shower water	Downgradient resident	No	-	-	-	Downgradient private wells are not used for potable water supply.	No
		Inhalation of VOCs migrating from shallow ground water	Downgradient resident	Yes	Yes	Yes	Benzene, PCE	Risk characterization based on all VOCs detected in indoor air. Benzene and PCE are not chemicals of concern originating from Hookston Station, therefore, exposures to benzene and PCE will not be addressed in this FS.	No
		Inhalation of VOCs migrating from shallow ground water	Downgradient worker	Yes	Yes	No	TCE	Risk characterization based only on chemicals of concern originating from the Hookston Station Parcel (TCE and degradation compounds) detected in indoor air. Risk characterization does not include potential risks posed by PCE and benzene.	Yes
Impacted ground water	Ground water	Ingestion and dermal contact with ground water used for drinking water purposes	Downgradient resident	No	-	-	-	Downgradient private wells are not used for potable water supply.	No
Impacted ground water	Indoor and Outdoor Air	Inhalation of VOCs released from ground water during irrigation	Downgradient resident	Yes	No	No	None	Based on data collected from backyard irrigation wells. This exposure pathway is addressed in this FS, based on risk calculations for MW-14A.	Yes
				No - hypothetical pathway	Yes	No	TCE, vinyl chloride	Based on data collected from monitoring well MW-14A, which is only used for ground water monitoring purposes.	
Impacted ground water	Ground water	Ingestion of VOCs in ground water used to fill a backyard swimming pool	Downgradient child resident	Yes	No	No	None	Based on data collected from backyard irrigation wells.	Yes
				No - hypothetical pathway	Yes	Yes	None	Based on data collected from monitoring well MW-14A, which is upgradient of the residential neighborhood and is only used for ground water monitoring purposes.	
Impacted ground water	Ground water	Dermal contact with VOCs in ground water used to fill a backyard swimming pool	Downgradient child resident	Yes	No	No	None	Based on data collected from backyard irrigation wells.	Yes
				No - hypothetical pathway	Yes	Yes	None	Based on data collected from monitoring well MW-14A, which is upgradient of the residential neighborhood and is only used for ground water monitoring purposes.	
Impacted ground water	Outdoor air	Inhalation of VOCs in ground water used to fill a backyard swimming pool	Downgradient child resident	Yes	No	No	None	Based on data collected from backyard irrigation wells.	No (pathway addressed by default due to dermal and inhalation pathways)
				No - hypothetical pathway	No	No	None	Based on data collected from monitoring well MW-14A, which is upgradient of the residential neighborhood and is only used for ground water monitoring purposes.	
Impacted ground water migrating to surface water	Indoor and Outdoor Air	Inhalation of VOCs volatilizing from Walnut Creek Canal	Downgradient resident	Yes	Yes	No	PCE	PCE is not a chemical originating from the Hookston Station Parcel.	No
	Fish	Consumption of fish caught from Walnut Creek Canal	Downgradient resident	Yes	-	-	-	Screening level risk evaluation was conducted in the Preliminary Risk Assessment (ERM 2002). Surface water sample results were less than the National AWQC and California Inland Surface Waters Criteria; these criteria are promulgated under the federal Clean Water Act and the CTR respectively, and are developed to ensure protection of aquatic organisms and of human health via ingestion of aquatic organisms. Additional risk characterization was not warranted.	No

Notes:
VOC = Volatile organic compound
TCE = Trichloroethene
PCE = Tetrachloroethene
FS = Feasibility Study
ERM = ERM-West, Inc.
AWQC = Ambient Water Quality Criteria
CTR = California Toxics Rule
DCE = Dichloroethene
SVOC = Semi-volatile organic compound
bgs = below ground surface
TPH = Total petroleum hydrocarbons

Table 4-1
Chemical-Specific Applicable or Relevant and Appropriate Requirements
Hookston Station
Pleasant Hill, California

Chemical-Specific ARAR	Agency	Reference	Description	Comment
Safe Drinking Water Act - MCLs	USEPA	40 CFR 141.11 - 141.16; 141.60 - 141.62	National Primary Drinking Water Standards - enforceable standards for specified contaminants in drinking water.	Relevant and appropriate for setting water quality objectives for ground water. Lists water quality criteria for chemicals where an MCL is not established.
California Safe Drinking Water Act - MCLs	DHS	22 CCR 64444; 64473	California drinking water standards; primary and secondary MCLs for specified contaminants in drinking water.	Relevant and appropriate for setting water quality objectives for ground water, to the extent that state MCLs are more stringent than federal MCLs. Lists water quality criteria for chemicals where an MCL is not established.
Hazardous Waste - Identification	USEPA/DTSC	40 CFR 261/ 22 CCR 66261	Sets standards for classification of hazardous wastes. Establishes constituent levels for characteristic wastes and lists of wastes considered to be hazardous wastes.	All wastes generated during site activities must be evaluated to determine if they are hazardous.
Hazardous Waste - LDR	USEPA/DTSC	40 CFR 268/ 22 CCR 66268	Sets LDR constituent concentrations and treatment standards.	Hazardous wastes generated during site activities must meet LDR standards prior to land disposal.
San Francisco Bay Basin Water Quality Objectives	SFBRWQCB	Water Quality Control Plan for the San Francisco Bay Basin	Establishes water quality objectives, including narrative and numerical standards that protect the beneficial uses and water quality objectives of surface and ground water in the region.	Applicable portions of the basin plan include the beneficial uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated waters, must not result in actual water quality exceeding water quality objectives.
Safe Drinking Water and Toxics Enforcement Act (Proposition 65)	Health and Welfare Agency	22 CCR 12000 et seq.	Warning requirements/prohibition of discharge or release of any chemical listed by the state as a carcinogen or reproductive hazard to water or land, where the chemical will probably pass through a source of drinking water.	Several VOCs, including TCE, are on the list of chemicals. Relevant and appropriate for discharges that may impact a source of drinking water.

Notes:

ARAR = Applicable or relevant and appropriate requirement
CCR = California Code of Regulations
CFR = Code of Federal Regulations
DHS = Department of Health Services
DTSC = Department of Toxic Substances Control
LDR = Land Disposal Restriction
MCL = Maximum Contaminant Level
SFBRWQCB = San Francisco Bay Regional Water Quality Control Board
TCE = Trichloroethene
USEPA = United States Environmental Protection Agency
VOC = Volatile organic compound

Table 4-2
Action-Specific Applicable or Relevant and Appropriate Requirements
Hookston Station
Pleasant Hill, California

Action-Specific ARAR	Agency	Reference	Description	Comment
Air Resources Act	California Air Resources Board/ BAAQMD	Health & Safety Code, Div. 26, Sec. 39000 et seq.	Regulates both vehicular and nonvehicular sources of air contaminants in California. Defines relationship of California Air Resources Board and local or regional air pollution control districts. Establishes ambient air quality standards and permit procedures.	Applicable to air emission sources. The SMAQMD is the enforcement agency.
Air - Permits; exemptions	BAAQMD	Regulation 2, Rule 1	Specifies emissions units that are not required to obtain an Authority to Construct or a Permit to Operate.	Sources with emissions of any air contaminant that does not exceed 2 pounds in any 24-hour period are not required to obtain an authority to construct or permit to operate. Must maintain records to verify exemption.
Air - New Source Review of Toxic Air Contaminants	BAAQMD	Regulation 2, Rule 5	Requires review of new and modified sources of toxic air contaminant emissions in order to evaluate potential public exposure and health risk, to mitigate potentially significant health risks resulting from these exposures, and to provide net health risk benefits by improving the level of control when existing sources are modified or replaced.	Applicable to new or modified sources of toxic air contaminants that is required to have an authority to construct or permit to operate pursuant to Regulation 2, Rule 1.
Air - Organic Compounds - Air Stripping and Soil Vapor Extraction Operations	BAAQMD	Regulation 8, Rule 47	Limits emissions of organic compounds from contaminated ground water and soil.	Applicable to new and modified air stripping and soil vapor extraction equipment used for the treatment of ground water or soil contaminated with organic compounds.
Air - Opacity	BAAQMD	Regulation 6, Rule 301	Sets limits for opacity of emissions (Number 1 on the Ringelmann chart).	Applicable to emissions of visible air contaminants. Associated with dust-producing actions.
Air - Nuisance	BAAQMD	Regulation 6, Rule 305	Prohibits discharge of air contaminants in quantities that cause injury, detriment, or nuisance.	Applicable to emissions of air contaminants that may cause injury, detriment, nuisance or annoyance to any considerable number of persons or the public, or that endanger the comfort, health, or safety of any such persons or the public, or which cause or have natural tendency to cause injury or damage to business or property.
Air - Organic Compounds - Aeration of contaminated soil	BAAQMD	Regulation 8, Rule 40	Limits emissions of organic compounds from soil that has been contaminated by organic chemicals and specifies acceptable procedures for controlling emissions.	Applicable to excavation of soil impacted with organic compounds.
OSHA Hazardous Waste Operations and Emergency Response	Cal-OSHA	29 CFR 1910.120/8 CCR 5192	Worker training and health and safety plan requirements for site cleanup operations.	Applicable to on-site workers engaged in site cleanup operations.
OSHA Excavation Standards	Cal-OSHA	29 CFR 1926/8 CCR 1540 and 341	Includes requirements for benching, sloping, or shoring of excavations to prevent cave-ins; entry into any excavation deeper than 5 feet requires a permit.	Applicable to excavation activities.
OSHA Heavy Equipment Operation Standards	Cal-OSHA	29 CFR 1926/8 CCR 1590 and 3649	Requirements for safe operation of haulage, earthmoving, industrial trucks, and tractors.	Applicable to activities involving the use of heavy equipment.
OSHA Head, Eye, Face, and Hearing Protection Standards	Cal-OSHA	29 CFR 1926 Subpart E/8 CCR 3381, 3382, 5162, and 5097.	Specific details regarding PPE and noise levels for hearing protection for workers.	Applicable to activities where employees may encounter hazards requiring the use of PPE or hearing protection.
OSHA Worker Protection Programs	Cal-OSHA	29 CFR 1910.1200/8 CCR 5194 and 3203	Written program requirements include hazard communication, illness, and injury prevention plan.	Employees who may be exposed to hazardous substances must be informed of those hazards in accordance with hazard communication requirements. All employers must develop illness and injury prevention plan for providing information on safe and healthy work practices.
OSHA Worker Vinyl Chloride Exposure Standard	Cal-OSHA	29 CFR 1910.1017/8 CCR 5210	Specific standard for occupational exposure to vinyl chloride; includes requirements for monitoring, protective equipment, and decontamination. The PEL for vinyl chloride is currently 1 part per million for an 8-hour TWA.	If concentrations of vinyl chloride in air exceed the PEL, control measures will be required. This applies to actions that may encourage offgassing of volatile organic compounds.
OSHA Permissible Exposure Limits	Cal-OSHA	29 CFR 1910.1001/8 CCR 5155	Requirements for controlling employee exposure to airborne contamination during work operations; sets PELs for specified contaminants and workplace monitoring requirements.	If concentrations of any specified contaminant in air exceed the PEL, control measures (administrative or engineering controls, or personal protective equipment) will be required. This applies to dust-producing actions or actions that may encourage offgassing of volatile organic compounds.
Clean Water Act/Porter Cologne Water Quality Control Act - NPDES/Pretreatment Requirements	USEPA/ RWQCB	40 CFR 122 and 403; California Water Code 13370	Establishes permit and potential treatment requirements for any wastewater stream discharged to surface water. Standards may differ depending on whether water is discharged to a Publicly Owned Treatment Works or directly to a surface water body under an NPDES permit.	Applicable to discharge of any wastewater stream generated as part of an alternative.
Hazardous Waste	DTSC	27 CCR 66260	Provides definitions of terms used in the hazardous waste regulations under Title 22 of the CCR.	Applicable to activities generating wastes; wastes must be classified using generator knowledge or waste analysis.
Hazardous Waste Identification	USEPA/DTSC	40 CFR 261 / 22 CCR 66261	Sets standards for classification of RCRA hazardous wastes and California hazardous wastes and requirements for recycling and reclamation of RCRA and California hazardous wastes.	Wastes generated during site activities (including residues from treatment operations) must be evaluated to determine if hazardous.
Hazardous Waste Generator Standards	USEPA/DTSC	40 CFR 262 / 22 CCR 66262	Requirements for generation, on-site management, and off-site transportation of RCRA and non-RCRA hazardous waste.	Waste generated during site activities must be managed in accordance with these standards if determined to be a hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 265, 264 / 22 CCR 66265, 66264	Requirements for management/storage of hazardous waste in containers.	Applicable to any hazardous wastes accumulated or stored in containers.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart B / 22 CCR 66264 and 66265	General facility standards for on-site treatment, storage, or disposal of hazardous waste.	Applicable to alternatives involving the TSD of hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart C / 22 CCR 66264 and 66265	Preparedness and prevention requirements applicable to on-site TSD of hazardous waste. Applies to generators and TSDs.	Applicable to alternatives involving the TSD of hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart D / 22 CCR 66264 and 66265	Contingency Plan requirements applicable to on-site TSD of hazardous waste. Applies to generators and TSDs.	Applicable to alternatives involving the TSD of hazardous waste.

*Table 4-2
Action-Specific Applicable or Relevant and Appropriate Requirements
Hookston Station
Pleasant Hill, California*

Action-Specific ARAR	Agency	Reference	Description	Comment
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart E / 22 CCR 66264 and 66265	Manifesting, record keeping, and reporting requirements applicable to TSD facilities.	Applicable to alternatives involving the TSD of hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart F / 22 CCR 66264 and 66265	Establishes monitoring requirements for facilities that treat, store, or dispose of hazardous waste.	Applicable to alternatives involving the TSD of hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart G / 22 CCR 66264 and 66265	Closure and post-closure requirements for hazardous waste TSD in new on-site units.	Applicable to alternatives involving creation of new TSD units.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart K/ 22 CCR 66264 and 66265	Requirements for surface impoundment (waste pile) liner to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil or ground water.	Applicable to alternatives involving hazardous waste piles.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart L / 22 CCR 66264 and 66265	Requirements for storage of hazardous waste in a waste pile for greater than 90 days.	Applicable to alternatives in which hazardous waste is stored in a waste pile for greater than 90 days.
Hazardous Waste	USEPA/DTSC	40 CFR 264, 265 Subpart N / 22 CCR 66264 and 66265	Requirements for hazardous waste landfills.	Applicable to alternatives involving land disposal of hazardous waste.
Hazardous Waste	USEPA/DTSC	40 CFR 264 Subpart X/ 22 CCR 66264	Requirements for treatment in miscellaneous units.	Applicable to alternatives involving treatment in units classified as miscellaneous units.
Hazardous Waste	DTSC	Health and Safety Code 25200 et. seq	Establishes tiered permitting system for facilities involved in the treatment of certain non-RCRA hazardous wastes. Sets requirements applicable to facilities subject to tiered permitting.	Alternatives treating non-RCRA hazardous waste that meet specified waste stream and quantity limitations may be subject to tiered permitting.
Hazardous Waste	DTSC	Health and Safety Code 25123.3	Remediation waste staging requirements allowing the temporary accumulation of non-RCRA contaminated soil provided that certain conditions are met.	Applicable to activities that involve temporary accumulation of non-RCRA contaminated soil. Requires an impermeable surface, controls to prevent dispersion or runoff, inspections, and certification.
Hazardous Waste - Corrective Action Management Units and Temporary Units	USEPA	40 CFR 264 Subpart S	Requirements for the establishment of specialized units under the corrective action program that are applicable to site remediation activities.	Applicable to activities using corrective action management units or temporary units.
Hazardous Waste - LDR	USEPA/DTSC	40 CFR 268 / 22 CCR 66268	Establishes land disposal restrictions and treatment standards for hazardous wastes applicable to generators.	Any hazardous wastes generated as a result of on-site activities or by treatment systems must meet LDR requirements.
Hazardous Material/Hazardous Waste Transportation Requirements	USEPA / DOT / DTSC	40 CFR 262 / 49 CFR 172 / 22 CCR 66262	Requirements for packaging, labeling, placarding, and transporting hazardous waste.	Any hazardous wastes shipped off site for disposal must meet the requirements for hazardous waste shipping and transportation.
Discharge of Waste to Land	RWQCB	23 CCR Chapter 15 Division 3	Waste and site classifications of waste landfills, including allowable soluble constituent concentrations.	Applicable to on-site land disposal of wastes.
Land Use Controls	DTSC	CCC Section 1471	Allows an owner of land to make a covenant to restrict use of land for the benefit of a covenantee. The covenant runs with the land to bind successive owners.	In the event a remedy is selected that does not result in unrestricted use, a LUC between the City of Pleasant Hill and DTSC will be signed and recorded with Contra Costa County prior to DTSC certification that the removal action has been completed.
Land Use Controls	DTSC	CHSC 25222.1 and 25355.5	Authorizes DTSC to enter into an agreement with a land owner to restrict the present and future use of land.	
Land Use Controls	DTSC	CHSC 25233	Provides a process and criteria for requesting a variance from a land use restriction.	
Land Use Controls	DTSC	CHSC 25234	Provides a process and criteria for requesting the removal or termination of land use restrictions.	
Land Use Controls	DTSC	22 CCR 67391.1	Provides the requirements for land use covenants when contaminants will remain on land at levels that are not suitable for unrestricted use of land.	
Porter-Cologne Water Quality Control Act	RWQCB	California Water Code Sec. 13243	RWQCB may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.	Applicable to discharges that may affect water quality.
Porter-Cologne Water Quality Control Act	RWQCB	California Water Code Sec. 13263	RWQCB may issue waste discharge requirements to regulate discharges to protect ground and surface water quality.	Applicable to discharges that may affect water quality, including injection wells (e.g., in situ ground water treatment).
Porter-Cologne Water Quality Control Act	RWQCB	California Water Code Sec. 13267(b)	RWQCB may require any person suspected of discharging, or who proposes to discharge, waste to furnish technical or monitoring program reports.	Applicable to discharges that may affect water quality.
Porter-Cologne Water Quality Control Act	RWQCB	California Water Code Sec. 13304(a)	RWQCB may require any person who causes or permits any waste to be deposited or discharged where it is, or probably will be, discharged to waters of the state and create a condition of pollution or nuisance to clean up the waste or abate the effects of the waste.	Applicable to discharges that may affect water quality.
Porter-Cologne Water Quality Control Act/San Francisco Bay Basin Water Quality Objectives	RWQCB	RWQCB-Water Quality Control Plan for the San Francisco Bay Basin	Establishes water quality objectives that protect the beneficial uses and water quality objectives of surface and ground waters in the region. Describes implementation plans and other control measures designed to ensure compliance with statewide plans and policies and provide comprehensive water quality planning.	Applicable portions of the basin plan include the beneficial uses of affected water bodies and water quality objectives to protect those uses. Any activity, including, but not limited to, the discharge of contaminated waters must not result in actual water quality exceeding water quality objectives.
Porter-Cologne Water Quality Control Act	RWQCB	State Water Resources Control Board Resolution No. 92-49 (As amended October 2, 1996)	Establishes requirement for investigation and cleanup and abatement of discharges. Among other requirements, discharges must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of 23 CCR Division 3, Chapter 15 requirements to cleanups.	Applicable to all cleanups of discharges that may affect water quality.

Table 4-2
Action-Specific Applicable or Relevant and Appropriate Requirements
Hookston Station
Pleasant Hill, California

Action-Specific ARAR	Agency	Reference	Description	Comment
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2511(d)	Specifies that wastes removed from the immediate place of release must be discharged in accordance with the classification and siting requirements of Chapter 15. Waste contained or left in place must comply with Chapter 15 to the extent feasible.	Applies to actions taken by or at the direction of public agencies to clean up unintentional or unauthorized discharges of waste to the environment.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2550.4	Cleanup levels must be set at background concentration levels, or, if background levels are not technologically and economically feasible, then at the lowest levels that are economically and technologically achievable. Specific factors must be considered in setting cleanup levels above background levels. Cleanup levels above background levels shall be evaluated every 5 years. If the actual concentration of a constituent is lower than its associated cleanup level, the cleanup level shall be lowered to reflect existing water quality.	Applies in setting cleanup levels for ground water, surface water, and the unsaturated zone for all discharges of waste to land.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2550.6	Establishes compliance period for monitoring for waste management unit. Requires monitoring for compliance with remedial action objectives for 3 years from the date of achieving cleanup levels.	Applies to water quality monitoring for new waste management units and for corrective action activities.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2550.7	Requires general soil, surface water, and ground water monitoring.	Applies to all areas at which waste has been discharged to land.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2550.9	Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent.	Applies to areas at which monitoring results show statistically significant evidence of a release.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR 2550.10	Requires implementation of corrective action measures that ensure that cleanup levels are achieved throughout the zone affected by the release by removing the waste constituents or treating them in place. Source control may be required. Also requires monitoring to determine the effectiveness of the corrective actions.	Applies to cleanup activities in order to protect ground water.
Porter-Cologne Water Quality Control Act	RWQCB	23 CCR Chapter 15, 2550.2, 2550.3, 2550.4, 2550.5, 2550.6	Establishes water quality protection standards consisting of contaminants of concern, concentration limits, point of compliance and monitoring points.	SWRCB Resolution 92-49 requires actions to cleanup discharge of waste to comply with Chapter 15.
Safe Drinking Water and Toxic Enforcement Act (Prop. 65)	Health and Welfare Agency	California Health and Safety Code, Division 20	Warning requirements/discharge prohibitions of any chemical listed by state as carcinogen or reproductive hazard to water or land, where chemical will pass through a source of drinking water.	Chemicals and applicable regulatory levels are listed in Title 22, CCR 12000, et seq.
Clean Water Act - Storm Water	USEPA/RWQCB	40 CFR 122; California General Permit	Requires permits for storm water discharges associated with industrial activity. Construction activities on less than 5 acres are exempt.	Applicable to storm water discharges from activities involving material handling; hazardous waste treatment, storage, or disposal; or construction activities on 5 acres or more.
State Water Resources Control Board Non-Degradation Policy	SWRCB	Resolution 68-16 (as contained in the RWQCB's Water Quality Control Plan)	State Board Policy requiring maintenance of existing water quality unless demonstrated that the change is beneficial, will not unreasonably affect present or potential uses, and will not result in water quality less than what is prescribed by other state policies.	Applicable to discharges of waste to waters, including discharges that may affect surface or ground waters.
National Environmental Policy Act	United States Army Corps of Engineers	42 U.S.C. 4321-4370c	Requirements for preparation of an Environmental Impact Statement.	Applicable to major federal actions significantly affecting the environment.
CEQA	CalEPA	Public Resources Code 21000 et. seq.	Requires an analysis to determine whether a project will have a "significant" impact and proposed mitigation measures. Projects with potential significant impacts require an environmental impact evaluation.	CEQA requirements are conducted as part of the Remedial Action Plan process.

Notes:

ARAR = Applicable or relevant and appropriate requirement
BAAQMD = Bay Area Air Quality Management District
CalEPA = California Environmental Protection Agency
CCR = California Code of Regulations
CEQA = California Environmental Quality Act
CFR = Code of Federal Regulations
CHSC = California Health and Safety Code

NPDES = National Pollutant Discharge Elimination System
OSHA = Occupational Safety and Health Administration
PEL = Permissible exposure limit
PPE = Personal protective equipment
RCRA = Resource Conservation and Recovery Act
RWQCB = Regional Water Quality Control Board
SWRCB = State Water Resources Control Board

*Table 4-3
Location-Specific Applicable or Relevant and Appropriate Requirements
Hookston Station
Pleasant Hill, California*

Location-Specific ARAR	Agency	Reference	Description	Comment
Location Standards for Hazardous Waste Facilities - Floodplains	DTSC	27 CCR 66264.18	Requires that a facility located within a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste unless it can be demonstrated that the wastes can be removed safely before floodwaters can reach the facility.	Applicable to treatment, storage, or disposal facilities within a 100-year floodplain.
Location Standards for Hazardous Waste Facilities - Seismic Considerations	DTSC	27 CCR 66264.18	Specifies that portions of new facilities where transfer, treatment, storage, or disposal of hazardous waste will be conducted shall not be located within 200 feet (61 meters) of a fault that has had displacement in Holocene period.	Applicable to construction of any new treatment, storage, or disposal facilities.
Seismic Construction Standards	International Conference of Building Officials/ City of Pleasant Hill Community Development Department	California Uniform Building Code Part V, Chapter 23, Part III	Specifies requirements for earthquake-resistant design.	Any construction must be designed in accordance with these requirements.
Discharges of Waste to Land	RWQCB	23 CCR, Chapter 15	Waste management unit classification and siting and construction standards.	

Notes:

ARAR = Applicable or relevant and applicable requirement

CCR = California Code of Regulations

DTSC = Department of Toxic Substances Control

RWQCB = Regional Water Quality Control Board

Table 4-4
Chemical-Specific Requirements to be Considered
Hookston Station
Pleasant Hill, California

Chemical-Specific TBC	Agency	Reference	Description	Comment
PRGs	USEPA	PRG Table - October 2004	Sets a PRG for potential industrial and residential uses for a variety of compounds.	May be used for general risk screening purposes or to set initial cleanup goals.
Vapor Intrusion to Indoor Air from Soil and Ground Water	OSWER	Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Ground Water and Soils	Provides a tool for a screening level evaluation as to whether or not the vapor intrusion pathway is complete and whether it poses an unacceptable risk to human health.	May be used to evaluate indoor air quality.
Vapor Intrusion to Indoor Air from Soil and Ground Water	DTSC	Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air	Recommends an approach for evaluating vapor intrusion into buildings and its subsequent impact to indoor air quality.	May be used to evaluate indoor air quality.
Calderon-Sher Safe Drinking Water Act	OEHHA	PHG Tables - 6 March 2006	Requires OEHHA to adopt PHGs for drinking water based on health risk assessments using the most current scientific methods for the approximately 85 chemicals for which state MCLs are presently available.	May be used for general risk screening purposes.
ESLs	SFRWQCB	Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater, Interim Final, February 2005	Presents lookup tables of conservative ESLs for over 100 chemicals commonly found at sites with contaminated soil and ground water.	May be used for general risk screening purposes.
CHHSLs	Cal EPA	California Land Environmental Restoration and Reuse Act	CalEPA has developed "screening values" for 54 hazardous substances that are typically found at brownfields sites. These values serve as reference numbers to help developers and local governments estimate the costs and extent of cleanup of contaminated sites, providing valuable information in their development decisions.	May be used for general risk screening purposes.
Proposed Corrective Action Rule (40 CFR 264 Subpart S) Action Levels	USEPA	55 CFR 30798	Sets action levels for certain chemicals in soil; exceeding action levels may trigger requirements for additional investigation or remediation.	May be used in determining whether contamination poses potential threat to human health or the environment.
A Compilation of Water Quality Goals	RWQCB	CVRWQCB, August 2003 with updates through 25 May 2004	Defines a procedure for selection of appropriate concentrations of chemical constituents and water quality parameters used to determine compliance with the narrative water quality objectives contained in the Basin Plan.	

*Table 4-4
Chemical-Specific Requirements to be Considered
Hookston Station
Pleasant Hill, California*

Chemical-Specific TBC	Agency	Reference	Description	Comment
Health Advisories and Water Quality Advisories	USEPA	USEPA Office of Water	Short-term, long-term, and lifetime exposure health advisories for noncarcinogens and possible human carcinogens.	Incremental cancer risk estimates for known and probable human carcinogens are also included.
National Ambient Water Quality Criteria	USEPA/Clean Water Act	Quality Criteria for Water, 1986	Protects human health and welfare.	
Water Quality for Agriculture	Food and Agriculture Organization of the United Nations	Water Quality for Agriculture, 1985	Contains criteria protective of agricultural uses of water.	
Water Quality Criteria	SWRCB, 1963 and 1978	Water Quality Criteria, McKee and Wolf, 1963 and 1978	Contains criteria for human health and welfare, agricultural use, and industrial use.	

Notes:

CalEPA = California Environmental Protection Agency
 CFR = Code of Federal Regulations
 CHHSL = California Human Health Screening Level
 DTSC = Department of Toxic Substances Control
 ESL = Environmental Screening Level
 MCLs = Maximum contaminant levels
 OEHHA = Office of Environmental Health Hazard Assessment
 OSWER = Office of Solid Waste and Emergency Response
 PHGs = Public health goals
 PRG = Preliminary Remediation Goals
 RWQCB = Regional Water Quality Control Board
 SFRWQCB = San Francisco Regional Water Quality Control Board
 SWRCB = State Water Resources Control Board
 TBC = To be considered
 USEPA = United States Environmental Protection Agency

Table 4-5
Risk-Based Cleanup Goals
Hookston Station
Pleasant Hill, California

Receptor	Exposure Scenario	Reference	TCE		cis-1,2-DCE		trans-1,2-DCE		1,1-DCE		Vinyl Chloride		Arsenic	
			Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Theoretical Lifetime Excess Cancer Risk	Risk-Based Concentration for Selected Risk Management Threshold for Non-Cancer Risk
Soil	Construction Worker	Direct contact with on-site subsurface soil	Appendix H of the FS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	31.0 mg/kg	912 mg/kg
Ground Water	Residents	Inhalation of chemicals released from ground water during irrigation	Appendix H of the FS	1,890 µg/L	33,900 µg/L	nc	30,800 µg/L	nc	61,700 µg/L	nc	176,000 µg/L	49.2 µg/L	89,300 µg/L	n/a
Ground Water	Residents	Swimming contact with ground water used to fill a backyard pool	Appendix H of the FS	1,105 µg/L	815 µg/L	nc	42,700 µg/L	nc	85,500 µg/L	nc	155,000 µg/L	121 µg/L	19,600 µg/L	n/a
Indoor Air	Residents	Inhalation of off-site residential indoor air	Appendix H of the FS	0.96 µg/m ³	69 µg/m ³	nc	63 µg/m ³	nc	125 µg/m ³	nc	357 µg/m ³	0.025 µg/m ³	181 µg/m ³	n/a

California Maximum Contaminant Levels

Receptor	Exposure Scenario	Reference	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	Arsenic	
Ground Water	Human	Drinking Water	California MCLs for drinking water	5 µg/L	6 µg/L	10 µg/L	6 µg/L	0.5 µg/L	n/a

Final Cleanup Goals

	TCE	cis-1,2-DCE	trans-1,2-DCE	1,1-DCE	Vinyl Chloride	Arsenic
Soil	n/a	n/a	n/a	n/a	n/a	31 mg/kg
Ground Water	5 µg/L*	6 µg/L*	10 µg/L*	6 µg/L*	0.5 µg/L*	n/a
Indoor Air	0.96 µg/m ³	63 µg/m ³	125 µg/m ³	357 µg/m ³	0.025 µg/m ³	n/a

Notes:
 µg/L - microgram per liter
 µg/m³ - microgram per cubic meter
 DCE = Dichloroethene
 MCL - Maximum Contaminant Level
 mg/kg - milligram per kilogram
 n/a - not applicable - compound was nondetect or the detected concentrations represented risk levels below the Risk Management Thresholds (Section 2.3.3 of the FS); therefore risk-based cleanup goals were not calculated
 nc - noncarcinogenic
 TCE = Trichloroethene
 * MCLs have been selected as the final ground water cleanup goals. However, background ground water concentrations exceed the MCLs. Until background ground water is remediated to the MCLs by the appropriate Responsible Party(ies), background ground water concentrations will be utilized as the interim ground water cleanup goals for the downgradient study area.

Table 5-1
Soil Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but not acceptable to the general public or government agencies.	None	Required as a baseline for comparison by the National Contingency Plan. Retained.
Institutional Controls / Limited Action	Institutional Control	Deed Notification /Restriction	Implement deed notification to inform future owners of the presence of potentially hazardous substances at the Hookston Station Parcel and /or implement deed restriction to restrict future use of Hookston Station Parcel.	Effectiveness for protection of human health would depend on enforcement of and compliance with deed restrictions.	Technically implementable. Specific legal requirements and authority would need to be met.	Low capital	Potentially applicable in combination with other technologies. Retained.
	Access Control	Fencing /warning signage	Construct or maintain existing Hookston Station Parcel fencing and signage to control Hookston Station Parcel access by the general public thereby reducing potential exposure to contaminants.	Effective for reducing exposure risk to the general public provided fencing and signage is maintained in the long term.	Technically implementable but not consistent with current and future land use.	Low capital.	Not consistent with current and future land use. Not retained.
Containment	Capping	Surface Cap	Installation of surface cap over contaminated soil areas to prevent or reduce contaminant migration and to prevent exposure. Multiple-component cap may include asphalt or concrete paving, synthetic membranes, low permeability soil caps in landscaped areas, and existing or new buildings or structures.	Effective for preventing direct contact exposure (i.e. dermal contact or ingestion). Limits infiltration and leachate formation, but less effective than source removal options for protection of ground water.	Technically implementable. The selected capping technology must be consistent with proposed future land use.	Low capital. Negligible O&M.	Not applicable as arsenic-impacted soil requiring remediation is limited to the subsurface. Not retained.
In Situ Soil Treatment	Biological Treatment	Natural Attenuation	Natural processes such as volatilization, biodegradation, adsorption, and chemical reactions with soil materials can reduce contaminant concentrations to acceptable levels.	Generally not effective for reducing risk to human health. Not effective for metals.	Technically implementable. Generally not perceived as an acceptable response by the general public or government agencies.	Negligible capital. Low O&M. Low cost relative to other in situ options.	Not applicable for metals. Not Retained.
		Phytoremediation	Process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil.	Still in the demonstration phase. Potentially effective for metals, solvents, and petroleum hydrocarbons.	Technically implementable, but inconsistent with land use.	Low capital and O&M. Low cost relative to other in situ options.	Inconsistent with current and future land use. Not retained.
In Situ Soil Treatment	Physical/Chemical Treatment	Soil Flushing	The extraction of contaminants from soil with passage of aqueous solution through in-place soils using an injection or infiltration process. Extraction fluids must be recovered from underlying aquifer. Applicable for more soluble contaminants.	Applicable for VOCs and soluble inorganic chemicals. Presence of fine grained soils limits effectiveness.	Technically implementable. However, there has been little commercial application. Regulatory concerns over potential to wash contaminants beyond fluid capture zones and introduction of surfactants in to the subsurface make permitting difficult.	High capital and O&M. High cost relative to other in situ options.	Not effective for arsenic in soil. Not retained.
		Soil Vapor Extraction	Vacuum is applied through extraction pipes to create a pressure/concentration gradient in impacted areas, which induces gas-phase volatiles to diffuse through soil to extraction wells. The process includes a system for treating off-gas. Air flow also induces aerobic bioremediation of some contaminants. Generally applied to highly volatile contaminants.	Not effective for metals. Effective for VOCs, less effective for SVOCs.	Technically implementable, but not typically applied for metals-contaminated soil.	High capital. Moderate O&M.	Not effective for arsenic in soil. Not retained.
		In Situ Solidification/Stabilization	Contaminants are stabilized or solidified in situ, resulting in decreased mobility of the contaminant or the chemical conversion of the contaminant to a more stable form. Stabilization uses chemical processes to convert the contaminant, such as arsenic, to a more stable form or chemically fix the contaminant, resulting in a stable, low mobility form.	Stabilization would be effective for arsenic in vadose zone soil, provided the contaminant can be reached by injected stabilization chemicals.	Technically implementable. Would require significant infrastructure to address small volume of impacted soil.	High capital. Low O&M. High capital cost relative to level of risk.	Cost prohibitive relative to benefit. Extensive injection network required to achieve distribution. Not retained.
		In Situ Vitrification	Uses an electric current to melt soil at extremely high temperatures and thereby immobilize most inorganics and destroy organic pollutants by pyrolysis.	Effective for SVOCs and inorganic chemicals. Less effective for VOCs, and not effective for fuels.	Technically implementable. Resulting fused material in subsurface could interfere with land use. Would require significant infrastructure to address small volume of impacted soil.	Very high capital. Low O&M. High cost relative to other in situ options.	High cost relative to other in situ treatment options. Not retained.

Table 5-1
Soil Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
Removal	Removal/Off-Site Disposal	Excavation	Excavation of impacted material with disposal at an off-site location.	Effective for complete range of contaminant groups.	Implementable for areas of arsenic-impacted soils. Lack of lateral and vertical delineation results in difficult implementation for scale of contamination	High capital relative to risk associated with arsenic in soil. Negligible O&M.	Excavation too costly relative to risks associated with arsenic in soil. Not retained.
Off-site management	Land disposal	Landfill	Disposal of impacted soil at a permitted, off-site landfill	Effective for complete range of contaminant groups.	Technically implementable. Impacted soil must be profiled and meet land disposal restrictions. Pre-treatment may be required if material does not meet certain restrictions.	Moderate to high capital depending on types of waste present. Negligible O&M	Not applicable without use of excavation. Not retained.
Ex Situ Soil Treatment	Biological Treatment	Biopiles	Excavated soils are mixed with soil amendments and placed in an area that includes leachate collection systems and some form of aeration.	Solid-phase (soil) process is most effective for non-halogenated VOCs and fuel hydrocarbons. Not effective for some halogenated VOCs and SVOCs, and for metals.	Difficult to implement. May require complete enclosure. Addition of amendment material results in volumetric increase in treated material. Leachate and off-gas may require treatment.	Moderate capital and O&M. Moderate cost relative to other ex situ biological options.	Limited effectiveness for metals and difficult to implement. Not retained.
	Physical/Chemical Treatment	Chemical Reduction / Oxidation	Oxidizing/reducing agents are added to soils to convert hazardous contaminants to compounds that are less toxic, more stable, or inert.	Most effective for some inorganics. Less effective for arsenic and non-halogenated organic chemicals.	Technically implementable but difficult achieve sufficient distribution of oxidizing/reducing agents in heterogeneous soils.	High capital. Low O&M. High cost relative to other ex situ physical/chemical options.	Limited effectiveness for arsenic. Not retained.
		Soil Washing	Wash soil with water-based surfactants, detergents, acids, etc., to remove chemicals from soil particles. Treat or dispose of high chemical concentration residual fluids.	Most effective for inorganic chemicals, SVOCs and fuels. Less effective for VOCs. Removal of organics adsorbed to clay-sized particles may be difficult.	Difficult to implement for complex waste mixtures. Difficult to distribute washing fluids in heterogeneous soils. Residuals may be difficult to extract from matrix and may require additional treatment/disposal.	High capital and O&M. High cost relative to other ex situ physical/chemical options.	Difficult to implement. Difficult to formulate washing fluids for complex waste mixtures. Soils may remain toxic due to difficulty extracting residual fluids. Not retained.
		Solidification / Stabilization	Contaminants are physically bound or enclosed within a stabilized mass or chemical reactions are induced between stabilizing agent and contaminants to reduce their mobility.	Low temperature or cement stabilization effective for reducing the leachability of inorganic chemicals.	Technically implementable. However most processes result in significant increase in volume.	Moderate capital. Low O&M. Moderate cost relative to other ex situ physical/chemical options.	Not applicable without use of excavation. Not retained.
		Ex situ SVE	Excavated soils are placed in lined piles and vapor is extracted through vertical or horizontal wells/vents. Requires treatment to abate extracted vapors prior to release to atmosphere.	Effective for VOCs but not effective for metals.	Technically implementable but not applicable for metals.	Moderate capital and O&M. Moderate cost relative to other ex situ physical/chemical technologies, but high cost relative to competing in situ technologies (i.e. SVE).	Not applicable for metals. Not retained.

Notes:

Shading indicates Process Option not retained

O&M = operation and maintenance

SVE = Soil Vapor Extraction

SVOC = semivolatile organic compound

VOC = volatile organic compound

Table 5-2
Ground Water Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remediation Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
No Action	No Action	None	No institutional controls or treatment.	Not effective for protecting human health and environment.	Implementable but generally not acceptable to the general public or government agencies.	None.	Required as a baseline for comparison by the National Contingency Plan. Retained.
Institutional Controls/Limited Action	Institutional Control	Deed/Water Use Restriction or Notification	Implement deed restriction to restrict installation of new wells at the Hookston Station Parcel. Water use restrictions would be used to remove existing supply wells and prevent the installation of new supply wells within the downgradient study area.	Effectiveness for preventing exposure to impacted ground water would depend on enforcement of and compliance with deed restrictions and conditions of well permits.	Technically implementable. Specific legal requirements and authority would need to be met.	Low capital. Negligible O&M.	Potentially applicable in combination with other technologies. Retained.
	Long Term Monitoring	Ground Water Monitoring	Long term monitoring of the monitoring well network to assess plume stability and contaminant concentration trends over time.	Effective for tracking VOC distribution over time.	Technically implementable. Monitoring well network already established.	Negligible capital. Moderate O&M.	Potentially applicable in combination with other technologies. Retained.
	Engineering Controls	Irrigation Well Closure	Abandon existing irrigation wells within the downgradient study area and connect disconnected systems to existing public water supply.	Effective for removing risk pathway associated with extraction and use of contaminated groundwater in residential area.	Technically implementable. May require legal action to achieve cooperation with land owners. Would be implemented with water use restrictions to prevent installation of future wells.	Moderate capital. Low O&M.	Easily implemented method of eliminating risks associated with exposure ground water exposure pathways in the downgradient study area. Retained.
Containment	Physical Ground Water Barrier	Low Permeability Wall	Construction of a low-permeability vertical barrier to restrict ground water flow and contaminant migration in the downgradient direction. Long-term monitoring of containment structure required.	Effective for containing impacted ground water or providing a barrier for ground water treatment systems. Would need to be implemented in association with additional active treatment technologies to reduce contaminant mass.	Technically implementable in accessible areas.	High capital. Negligible O&M.	Narrow plume width. Not retained.
	Hydraulic Ground Water Barrier	Ground Water Pumping	Ground water pumping or injection to establish capture zone and restrict ground water flow and contaminant migration in the downgradient direction.	Effective for containing impacted ground water. Low-permeability soil within the A-Zone would require use of extensive well network to ensure adequate capture or maintenance of areas of concern. Will not achieve cleanup goals in area downgradient of barrier.	Technically implementable. Treatment of extracted ground water may be required depending on influent contaminant concentrations. Implementation in the downgradient study area would be difficult due to number of wells required. Maintenance of a hydraulic barrier requires extensive injection and extraction well network connected with significant conveyance piping.	High capital and O&M.	Not effective at reducing VOC concentrations downgradient from the extraction barrier. Not retained.
	Vapor Intrusion Barrier	Vapor Intrusion Prevention Systems	Systems using a combination of vapor barrier and/or vapor extraction prevents exposure to VOCs in soil and/or groundwater by blocking the migration pathway of VOCs into building basements/foundations. An impermeable barrier is installed either on the ground surface or underside of the floor under a crawlspace construction building. Can be combined with a vapor extraction system placed between the ground surface and the barrier that draws a low flow of vapor from the ground surface, providing additional mitigation.	Effective for preventing migration of VOCs into indoor air. Does not reduce VOC concentrations in primary medium, groundwater. Effectiveness compromised if not inspected and maintained regularly.	Relatively easily implementable for standard residential construction methods. Consistent with preservation of structures and current residential land use.	Low capital. Low O&M	Applicable for implementation at residences in the downgradient study area. Provides highly cost-effective reduction of risk associated with indoor air impacts from ground water. Retained.

Table 5-2
Ground Water Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remediation Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
		Soil Vapor Extraction	Vacuum is applied through extraction pipes to create a pressure/concentration gradient in impacted areas, which induces gas phase volatiles to diffuse through soil to extraction wells. The process includes a system for treating off-gas.	Effective in high permeability soils for extracting VOCs in soil and/or ground water. Less effective for removal of VOCs and hydrocarbons in low permeability soils where SVE is diffusion limited. Pilot testing has indicated insufficient radius of influence for effective application of vertical SVE wells within residential area.	Technically implementable. Would require placement of more expensive and difficult to install horizontal or angled SVE wells under residences to provide effective removal of VOCs in soil vapor prior to reaching indoor air. Location within the downgradient study area will require extensive infrastructure to convey vapors to central treatment system.	High capital. Moderate O&M. High capital cost due to use of horizontal and angled well systems and extensive infrastructure in the downgradient study area.	Cost prohibitive relative to benefit. Intrusive construction of systems near residences. Not retained.
In Situ Ground Water Treatment	Monitored Natural Attenuation	Intrinsic Bioremediation	Reduction of dissolved concentrations through naturally occurring processes such as dilution, volatilization, biodegradation, or adsorption. Sampling and analysis of ground water samples for indicators of natural attenuation is generally included.	Effective for VOCs, including TCE. Effectiveness evaluated through periodic monitoring of contaminant concentrations as well as indicators of attenuation byproducts. Reductive dechlorination of TCE has the potential to result in recalcitrant concentrations of dichloroethenes and vinyl chloride.	Technically implementable. Would require installation of more extensive network of monitoring wells to provide adequate performance monitoring.	Low capital. Moderate O&M. Low overall cost relative to active remediation options.	Potentially applicable to downgradient or post-treatment concentrations of VOCs in groundwater. Retained.
	Thermal Treatment	Steam Heating	Involves the installation of a series of steam injection wells. Steam is generated in a boiler that would be located at the Hookston Station Parcel and injected at the wells, which gradually raises the temperature of the ground water and soil, thereby enhancing the mobility and volatility of contaminants. This technology commonly uses an SVE system to control buildup of volatilized contaminants and non-condensable gases, as well as ground water extraction.	Typically effective for fuels and SVOCs and VOCs under correct conditions. The stratified nature and low permeability of A-Zone soil will likely inhibit proper flow and distribution of steam, reducing the effectiveness of this technology.	Technically implementable. SVE would be required to capture steam and vaporized contaminants. Consistent steam flow may be difficult to achieve in the low permeability and stratified A-Zone soils. High temperatures will require replacing existing ground water vapor and monitoring wells with heat resistant well materials. Presence of extensive subsurface utilities will require relocation of utilities.	High capital and O&M. High cost relative to other in situ options.	Costly alternative. Less effective for low permeability soils than electrically induced heating. Not retained.
		Electrically Induced Heating	Electrical current is generated between electrodes installed in the subsurface, which gradually raises the temperature of ground water, thereby enhancing the mobility and volatility of contaminants. This technology also requires an SVE system to control buildup of volatilized contaminants and non-condensable gases.	Effective for VOCs. More effective than steam heating in tight soils. Effective capture of VOCs requires implementation of SVE. Requires closely spaced wells to effectively capture soil vapor in low permeability soils.	Technically implementable, but difficult to implement in areas with surface features because closely spaced electrodes are required to implement this option. SVE would be required to capture steam and vaporized contaminants. High temperatures will require destruction of existing ground water vapor and monitoring wells and installation of heat resistant wells. Presence of extensive subsurface utilities will require relocation of utilities.	High capital and O&M. High cost relative to other in situ options.	Costly alternative. Not expected to be implementable in the downgradient study area. Not retained.
	Physical Treatment	In-Well Air Stripping	In-well aerators perform air stripping of ground water within the well. Ground water is not removed from the well, but is circulated between an upper and lower screen in the well. Volatile compounds enter the vapor phase and are recovered and treated by a vapor extraction system.	Effective for VOCs, SVOCs and fuels. Cost effective in areas with deep water tables because impacted ground water does not have to be pumped to surface. Relies on adequate groundwater flow within an induced recirculation cell, which may be prohibited by low permeability and layered nature of A-Zone soils.	Low permeability and layered nature of soils would significantly reduce radius of influence of this technology, increasing the number of recirculation wells required.	High capital. Moderate O&M.	Low effectiveness due to low permeability soil. Not retained.

Table 5-2
Ground Water Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remediation Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
		Air Sparging	Air is injected into the saturated zone to induce mechanical stripping and volatilization of contaminants. Introduction of oxygen also enhances aerobic biodegradation. SVE is required to capture vapor phase contaminants.	Effective for VOCs and fuels. Effective removal dependant on ability to sparge adequate air and to remove resultant vapor through SVE. Pilot testing would be required to determine effectiveness. Requires closely spaced SVE wells to effectively capture vapor phase contaminants. Biodegradation of TCE would not be enhanced, and could be hindered, by increase in oxygen concentration.	Technically implementable. Low permeability soils of the A-Zone would require close spacing of numerous sparge wells and associated SVE wells.	High capital. Low O&M. High cost relative to other in situ treatment options due to required number of wells, extent of equipment, and depth of impacts.	Not expected to be cost effective relative to other technologies. Not retained.
Chemical Treatment	Chemical Oxidation		Injection of a dilute solution of an oxidant such as potassium permanganate, sodium persulfate, or Fenton's Reagent, into the contaminated zone to directly oxidize VOCs.	Chemical oxidation is expected to be an effective method for mass reduction of contaminants of concern. Bench testing has indicated that oxidant demand is low in B-Zone soils and moderate in A-Zone soils. The low permeability, stratified soils within the A-Zone will limit effectiveness due to the low volume of solution capable of injection, and could inhibit distribution of oxidant to contaminants. However, the higher permeability and low soil oxidant demand of the B-Zone are conducive to effective oxidation.	Low permeability of A-Zone soil will impact ability to inject adequate volume of oxidant. However, B-Zone soil has a relatively higher permeability and a low oxidant demand (reducing the rate at which the oxidant is reacted), which help to reduce the treatment volume.	Moderate capital. Low O&M. Low cost relative to other in situ treatment options.	Low oxidant demand and relatively high permeability of B-Zone soil are conducive to chemical oxidation. Retained.
		Ozone Sparging	Sparging of gas-phase ozone to oxidize VOCs in situ. Implemented similarly to air sparging with the addition of ozone to the sparged air. Typically combined with soil vapor extraction. Typically most applicable for high concentration and recalcitrant contaminants.	Ozone can be effective at oxidizing VOCs in groundwater. Delivery of ozone may be prohibitive due to low-permeability of A-Zone soil. Short-lived ozone requires good distribution for adequate effectiveness.	Technology is implemented in a similar manner as air sparging, and has similar implementation issues. Pilot testing will be necessary to determine spacing of sparge wells and operation parameters. Low permeability soils of the A-Zone may require tight spacing of numerous sparge wells.	High capital. High O&M. High cost relative to other in situ treatment options due to required number of wells and extent of equipment.	Not expected to be cost effective relative to other technologies. Not retained.
		Zero-Valent Iron Permeable Reactive Barrier	Placement of zero-valent iron into the contaminated zone to destroy VOCs through chemically-mediated reductive dechlorination. The zero-valent iron is placed in the form of a reactive barrier wall perpendicular to ground water flow direction. Placement of the zero-valent iron may be performed using dug trenches or through high-pressure slurry injection.	Effective for complete destruction of halogenated VOCs.	Most commonly implemented as a reactive barrier wall, treating contaminants passing through wall. Trenching in the downgradient study area could present difficulties. Depth of the excavation would require shoring support or innovative trenching techniques. As a result, slurry injection could be more implementable.	Moderate to high capital. Negligible O&M. Moderate cost relative to some in situ treatment options.	Can be difficult and expensive to implement, but reliable treatment as a barrier. May be an effective barrier to prevent further migration of contaminants into the downgradient study area. Retained.
Biological Treatment	Enhanced Anaerobic Bioremediation		Injection of a carbon source (electron donor) material into the contaminated zone to stimulate degradation of polychlorinated VOCs through reductive dechlorination. Typical injectates include acetate, lactate, and food-grade oils. Can be supplemented with addition of specific degrading microbes to enhance overall effectiveness.	Effective for polychlorinated VOCs. However, daughter compounds such as dichloroethene and vinyl chloride are much more difficult to dechlorinate, which could be overcome with bioaugmentation.	Technically implementable. Most case studies indicate application requires a dense injection grid. Consequently, difficult to implement in developed portions of the downgradient study area. Bench testing would be required to evaluate biodegradation conditions.	Moderate capital. Low O&M. Moderate cost relative to other in situ treatment options.	May effectively completely dechlorinate TCE. Implementation can be relatively simple. Retained.

Table 5-2
Ground Water Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California

General Response Action	Remediation Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
		Enhanced Aerobic Bioremediation	Injection of oxygen or oxygen-releasing material into or upgradient of the contaminated zone to enhance degradation of organic compounds through aerobic respiration.	Effective for non-halogenated VOCs, SVOCs, and fuels. More effective for dichloroethene and vinyl chloride.	Technically implementable. Most case studies indicate application requires a dense injection grid. Consequently, difficult to implement in developed portions of the downgradient study area. Bench testing would be required to evaluate biodegradation conditions.	Moderate capital. Low O&M. High cost relative to other in situ treatment options	Not effective for primary contaminant, TCE. Not retained.
Collection/Ex Situ Treatment	Ground Water Pumping	Extraction Wells or Trenches	Ground water pumping using extraction wells or trenches. Objectives of ground water extraction include removal of dissolved contaminants from the subsurface and containment of contaminated ground water to prevent migration. Most applicable for contaminants which cannot be reliably treated in situ or where immediate containment is required.	Effective for plume containment and source area migration control. Can be implemented in combination with in situ technologies to increase influence of the in situ technology by creating regions of recirculation. Low permeability of A-Zone soil may limit effectiveness of extraction.	Technically implementable. Biological or iron fouling of extraction wells, conveyance piping and treatment systems is a common problem and severely limits system performance. Low permeability of A-Zone soils and large plume size will require extensive extraction network. Placement of extraction wells in the downgradient study area will require extensive infrastructure to develop conveyance and treatment system.	High capital. Moderate O&M.	Potentially applicable for contaminant mass removal in source areas and as an enhancement of other in situ technologies. Retained.
	Chemical/Physical Treatment	Air Stripping	Extracted water is passed downward against a stream of rising air. The countercurrent stream of air strips VOCs from the water. The resulting VOC-laden air is treated following removal from the vessel, if required.	Effective for removal of VOCs from extracted ground water.	Technically implementable. Treatment of off-gas may be required. Biological or iron fouling can severely limit system performance. Well established ex-situ technology readily provided by vendors.	Moderate capital. Moderate O&M. Moderate cost relative to other ex situ treatment options.	Applicable for treatment of VOCs dissolved in ground water. Retained.
		Liquid or Gas-Phase Carbon Adsorption	Extracted water or vapor is passed through vessels containing granular activated carbon. Organic compounds with an affinity for carbon are transferred from the aqueous or vapor phase to the solid phase by sorption to the carbon.	Most effective for hydrocarbons and SVOCs. Less effective for lower chlorinated VOCs.	Difficult to implement. Streams with high suspended solids (> 50 milligrams per liter) cause fouling and require frequent carbon change-out. Can be easily implemented as a point-of-use treatment for private irrigation wells.	Moderate capital. High O&M. High cost relative to other ex situ treatment options	Higher cost relative to other ex situ treatment options. Most effective for point-of-use applications in the downgradient study area. Retained.
		UV Oxidation /Reduction.	UV light and/or oxidizing chemicals (e.g., hydrogen peroxide) can be used to destroy organic constituents.	Effective for most organic compounds including petroleum hydrocarbons and halogenated VOCs. Chloroethanes may be stripped rather than destroyed requiring off-gas treatment with catalytic oxidation or carbon. Incomplete destruction is possible with some compounds.	Technically implementable. However, iron fouling is likely to affect UV units in the same manner as air strippers. O&M to address potential iron fouling is expected to be time consuming and costly for the UV units.	High capital and O&M.	Higher cost and O&M issues than other ex situ physical/chemical technologies. Not retained.

*Table 5-2
Ground Water Remedial Technologies and Process Options
Hookston Station
Pleasant Hill, California*

General Response Action	Remediation Technology	Process Option	Description	Effectiveness	Implementability	Cost	Summary of Screening
	Biological Treatment	Bioreactor Contact Beds	Water is passed through a reactor vessel that contains a fixed bacterial film. Contaminants are aerobically degraded by the bacteria as the water passes through the reactor vessel.	Effective for fuel hydrocarbons and SVOCs. Treatment of halogenated compounds may require addition of specially adapted cometabolite organisms.	Technically implementable. However, sustaining microbial populations can be difficult. Iron fouling is likely to affect bioreactors in the same manner as air strippers.	High capital and moderate O&M. Moderate cost relative to other ex situ treatment options	May be difficult to implement due to iron fouling. Higher cost than other ex situ technologies. Not retained.
Disposal	Off-site Disposal	Discharge to Publicly-Owned Treatment Works (POTW)	Discharge of extracted ground water to the sanitary sewer for conveyance to a local POTW for treatment and discharge.	Effective for disposal of extracted ground water.	Technically implementable. Requires sampling to ensure compliance with permit discharge standards. Pre-treatment may be required prior to discharge.	Low capital. Low O&M.	Potentially applicable for disposal of extracted ground water. Retained.
	Disposal at the Hookston Station Parcel	Injection Wells	Discharge of extracted ground water back into aquifer using injection wells	Effective for disposal of extracted ground water. May be used in cooperation with other in situ technologies to increase influence, such as in situ oxidation or enhanced bioremediation	Technically implementable. Permits can be difficult to obtain. Low permeability soils may require extensive injection network. Biofouling would be expected as a result of reinjecting extracted ground water.	Moderate capital. Moderate O&M.	More costly than POTW discharge, with low implementability. Not retained.

Notes:
 Shading indicates Process Option not retained
 DTSC = Department of Toxic Substances Control
 IRM = Interim Remedial Measure
 MCL = maximum contaminant level
 NPDES = National Pollution Discharge and Elimination System
 O&M = operation and maintenance
 POTW = Publically owned treatment works
 SVE = Soil Vapor Extraction
 SVOC = semivolatile organic compound
 UV = ultra violet
 VOC = volatile organic compound

Table 5-3
Summary of Screening - Retained Remedial Technologies
Hookston Station
Pleasant Hill, California

General Response Action	Remedial Technology	Process Option	Description
Soil Technologies			
No Action	No Action	None	No institutional controls or treatment.
Institutional Controls/Limited Action	Institutional Control	Deed Notification/Restriction	Implement deed notification to inform future owners of the presence of potentially hazardous substances at the Hookston Station Parcel and /or implement deed restriction to restrict future use of the Hookston Station Parcel.
Ground Water Technologies			
No Action	No Action	None	No institutional controls or treatment.
Institutional Controls/Limited Action	Institutional Control	Deed/Water Use Restriction or Notification	Implement deed restriction to restrict installation of wells and water usage on the Hookston Station Parcel. Implement water use restrictions to abandon existing wells and prevent installation of new wells within the downgradient study area.
	Long Term Monitoring	Ground Water Monitoring	Long term gauging and sampling of monitoring well network to assess plume stability and contaminant concentration trends over time.
	Engineering Controls	Irrigation Well Closure	Abandon existing extraction wells within the downgradient study area and reconnect systems to existing public water supply.
Containment	Vapor Intrusion Barrier	Vapor Intrusion Prevention Systems	Use of impermeable barrier installed below building floor to prevent crawl space or basement floor of residential buildings. Potentially combined with localized extraction of vapor under the barrier to enhance removal.
In Situ Ground Water Treatment	Monitored Natural Attenuation	Intrinsic Bioremediation	Reduction of dissolved concentrations through naturally occurring processes such as dilution, volatilization, biodegradation, or adsorption. Sampling and analysis of ground water sample for indicators of natural attenuation is generally included.
	Chemical Treatment	Chemical Oxidation	Injection of a dilute solution of an oxidant such as potassium permanganate, sodium persulfate, or Fenton's Reagent into the contaminated zone to directly oxidize VOCs.

Table 5-3
Summary of Screening - Retained Remedial Technologies
Hookston Station
Pleasant Hill, California

General Response Action	Remedial Technology	Process Option	Description
		Zero-Valent Iron Permeable Reactive Barrier	Placement of zero-valent iron into the contaminated zone to destroy VOCs through chemically-mediated reductive dechlorination.
	Biological Treatment	Enhanced Anaerobic Bioremediation	Injection of a carbon source (electron donor) material into the contaminated zone to stimulate degradation of polychlorinated VOCs through reductive dechlorination.
Collection/Ex Situ Treatment	Ground Water Pumping	Extraction Wells or Trenches	Ground water pumping using extraction wells or trenches. Objectives of ground water extraction include removal of dissolved contaminants from the subsurface and containment of contaminated ground water to prevent migration.
	Chemical/Physical Treatment	Air Stripping	Extracted water is passed downward against a stream of rising air. The countercurrent stream of air strips VOCs from the water. The resulting VOC laden air is treated following removal from the vessel, if required.
	Chemical/Physical Treatment	Liquid or Gas-Phase Carbon Adsorption	Extracted water or vapor is passed through vessels containing granular activated carbon. Organic compounds with an affinity for carbon are transferred from the aqueous or vapor phase to the solid phase by sorption to the carbon.
Disposal	Off-Site Disposal	Discharge to Publicly-Owned Treatment Works (POTW)	Discharge of extracted ground water to the sanitary sewer for conveyance to a local POTW for treatment and discharge.

Notes:

POTW = Publically owned treatment works

SVE = Soil Vapor Extraction

VOC = volatile organic compound

*Table 6-1
Remedial Alternative Summary
Hookston Station
Pleasant Hill, California*

Target Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Shallow Soil	No Action	Institutional Controls (soil management plan)	Institutional Controls (soil management plan)	Institutional Controls (soil management plan)	Institutional Controls (soil management plan)	Institutional Controls (soil management plan)
Residential Indoor Air	No Action	Indoor air vapor intrusion prevention systems	Indoor air vapor intrusion prevention systems	Indoor air vapor intrusion prevention systems	Indoor air vapor intrusion prevention systems	Indoor air vapor intrusion prevention systems
A-Zone Ground Water	No Action	Monitored natural attenuation, Private well removal	In situ enhanced anaerobic bioremediation, Private well removal	Zero-valent iron permeable reactive barrier, Private well removal	Zero-valent iron permeable reactive barrier, Private well removal	Ground water extraction with ex situ physical treatment, Private well removal
B-Zone Ground Water	No Action	Monitored natural attenuation, Private well removal	In situ chemical oxidation, Private well removal	In situ chemical oxidation, Private well removal	Zero-valent iron permeable reactive barrier, Private well removal	Ground water extraction with ex situ physical treatment, Private well removal

Table 7-1
Selected Components of Remedial Alternatives
Hookston Station
Pleasant Hill, California

Remedial Alternative	Description	O&M Duration	Direct and Indirect Capital Costs	Total O&M Costs (Undiscounted)	NPW of Total O&M Costs	Estimated Total Cost (NPV)
Alternative 1	No Action	NA	\$0	\$0	\$0	\$0
	Monitored Natural Attenuation - A-Zone and B-Zone Ground Water;	30 Years or greater	\$314,010	\$4,584,460	\$2,260,597	\$2,575,000
Alternative 2	Residential Vapor Intrusion Prevention Systems; Private Well Removal.	30 Years or greater NA				
	Enhanced Anaerobic Bioremediation - A-Zone Ground Water;	30 Years (10 years on Parcel)	\$3,013,987	\$3,000,155	\$1,915,610	\$4,930,000
Alternative 3	In Situ Chemical Oxidation - B-Zone Ground Water; Residential Vapor Intrusion Prevention Systems; Private Well Removal.	30 Years 6 Years NA				
	Zero-Valent Iron Permeable Reactive Barrier - A-Zone Ground Water;	30 Years	\$3,213,835	\$3,483,641	\$1,979,886	\$5,194,000
Alternative 4	In Situ Chemical Oxidation - B-Zone Ground Water; Residential Vapor Intrusion Prevention Systems; Private Well Removal.	30 Years 4 Years NA				
	Zero-Valent Iron Permeable Reactive Barrier - A-Zone and B-Zone Ground Water;	30 Years	\$7,067,510	\$2,884,073	\$1,670,940	\$8,739,000
Alternative 5	Residential Vapor Intrusion Prevention Systems; Private Well Removal.	4 Years NA				
	Ground Water Extraction, Treatment, and Disposal - A-Zone and B-Zone Ground Water;	30 Years	\$1,900,257	\$26,184,172	\$10,905,844	\$12,807,000
Alternative 6	Residential Vapor Intrusion Prevention Systems; Private Well Removal.	3 Years NA				

Notes:
O&M = Operation and Maintenance
NPV = Net Present Value, based on 7% discount rate
NA = Technology does not have an O&M component

Table 7-2
Summary of Detailed Analysis - Remedial Alternative 1
Hookston Station
Pleasant Hill, California

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	No actions are taken. Provides no protection of human health and the environment.	No
Compliance with applicable or relevant and appropriate requirements (ARARs)	Will not satisfy ARARs.	No
Balancing Criteria		
Long-term effectiveness and permanence	No actions are taken. Provides no long-term effectiveness or permanence.	0
Reduction of toxicity, mobility, or volume (TMV) through treatment	Provides no reduction in TMV through treatment.	0
Short-term effectiveness	As no actions are taken, there would be no short-term risk to workers. However protection from site risks would not be attained.	2
Implementability	As no actions are taken, this alternative is highly implementable.	5
Cost	No cost.	5
Balancing Criteria Score		12
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

Table 7-3
Summary of Detailed Analysis - Remedial Alternative 2
Hookston Station
Pleasant Hill, California

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	Immediate risks due to VOCs in ground water addressed through vapor mitigation and private well removal. MNA will be relied on to reduce overall concentrations of VOCs.	No
Compliance with applicable or relevant and appropriate requirements (ARARs)	While MNA may eventually be able to reduce VOCs from the Hookston Station to below ARARs in localized areas where conditions are favorable, this alternative is not expected to be able to reliably reach ARARs over the extent of the Hookston Station ground water plume in a reasonable period of time	No
Balancing Criteria		
Long-term effectiveness and permanence	In areas that are not conducive to biodegradation, intrinsic biodegradation may occur at very slow rates. Monitoring would ensure that geochemical conditions remain conducive to biodegradation throughout the attenuation period, and would be used to determine residual concentrations and/or the need to implement further treatment.	1
Reduction of toxicity, mobility, or volume (TMV) through treatment	No reduction in TMV of chemicals in soil and ground water through treatment. Vapor intrusion mitigation achieves a level of reduced toxicity, but slow ground water treatment may result in increased volume of impacted ground water	1
Short-term effectiveness	This alternative poses little risk to local receptors during implementation, and requires no additional implementation. However, MNA is a long-term process and therefore has only moderate short-term effectiveness.	3
Implementability	Materials and services needed to implement containment measures are readily available, and technologies are reliable and proven.	4
Cost	\$2,575,000	4
Balancing Criteria Score		13
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- TBD = To be determined
- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

Table 7-4
Summary of Detailed Analysis - Remedial Alternative 3
Hookston Station
Pleasant Hill, California

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	Immediate risks due to VOCs in ground water addressed through vapor mitigation and private well removal. Protective of human health and the environment, despite uncertainty of effectiveness of enhanced bioremediation.	Yes
Compliance with applicable or relevant and appropriate requirements (ARARs)	May be able to satisfy chemical, action, and location specific ARARs. B-Zone VOCs are expected to be treated to chemical-specific ARARs through source area treatment by oxidation.	Yes
Balancing Criteria		
Long-term effectiveness and permanence	Nearly immediate and permanent reduction of the most highly concentrated VOCs in A-Zone and B-Zone ground water is possible with this alternative. Complete effectiveness of bioremediation of VOCs in A-Zone is uncertain without completion of pilot-scale testing of this technology to ensure that residual concentrations of recalcitrant 1,2-DCE and/or vinyl chloride do not remain following treatment. Incomplete biodegradation could result in significant residual risk.	3
Reduction of toxicity, mobility, or volume (TMV) through treatment	Reduction of TMV of VOC-impacted ground water may be achieved through treatment by enhanced bioremediation (A-Zone) and chemical oxidation (B-Zone). The completeness of A-Zone bioremediation is uncertain, particularly within the downgradient study area, with potential for localized untreated areas as well as temporary or permanent residual concentrations of vinyl chloride as a result of incomplete reductive dechlorination.	2
Short-term effectiveness	This alternative presents minimal risk to the community. Workers performing the chemical oxidation injections will be in contact with potassium permanganate in solid and dissolved form. Immediate contaminant risks will be reduced through vapor mitigation systems and removal of private supply wells. However, the expected increased duration of bioremediation within the downgradient study area, due to the limited area over which this can be implemented, results in reduced short-term effectiveness.	3
Implementability	Materials and services needed for remedial action are readily available, and technologies are reliable and proven, with the exception of enhanced bioremediation for which reliability must be proven on a site-specific basis.	3
Cost	\$4,930,000	3
Balancing Criteria Score		14
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- TBD = To be determined
- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

Table 7-5
Summary of Detailed Analysis - Remedial Alternative 4
Hookston Station
Pleasant Hill, California

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	This alternative provides a high level of short-term and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment.	Yes
Compliance with applicable or relevant and appropriate requirements (ARARs)	This alternative is expected to be able to satisfy chemical, action, and location specific ARARs.	Yes
Balancing Criteria		
Long-term effectiveness and permanence	This alternative will be effective in the long-term for A-Zone ground water by providing immediate and permanent destruction of VOCs as ground water flows through the PRB. Nearly immediate and permanent reduction of the most highly concentrated VOCs in B-Zone ground water is expected with this alternative by chemical oxidation, providing for more complete downgradient reduction of VOCs natural processes.	5
Reduction of toxicity, mobility, or volume (TMV) through treatment	Significant reduction of TMV of VOC-impacted ground water is expected within the area and water-bearing zone with the greatest risk to receptors, A-Zone groundwater within the downgradient study area. The PRB is expected to immediately reduce the toxicity of A-Zone ground water as it passes through the PRB. Source area treatment of B-Zone groundwater by chemical	4
Short-term effectiveness	The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to be short, while achieving the ultimate cleanup goal of the MCL for ground water will take significantly longer, without posing immediate risks.	4
Implementability	Materials and services needed for remedial action are readily available, and technologies are reliable and proven. Installation of the PRB in the downgradient study area will require both innovative techniques and proper coordination with residences and city agencies. This would be true of either a trenched or injected PRB, with the trenched PRB presenting greater installation difficulties, due to potential presence of subsurface utilities. Installation of vapor intrusion mitigation systems and decommissioning of private wells will require cooperation with residents.	3
Cost	\$5,194,000	3
Balancing Criteria Score		19
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- TBD = To be determined
- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

*Table 7-6
Summary of Detailed Analysis - Remedial Alternative 5
Hookston Station
Pleasant Hill, California*

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	This alternative provides a moderately high level of short-term and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment.	Yes
Compliance with applicable or relevant and appropriate requirements (ARARs)	This alternative is expected to satisfy chemical, action, and location specific ARARs within a reasonable time frame, as ground water is treated as it passes through the A-Zone and B-Zone PRBs. However, ground water within the Hookston Station Parcel will take a significantly longer duration to reach ARARs, while not posing an immediate risk to receptors.	Yes
Balancing Criteria		
Long-term effectiveness and permanence	This alternative will be effective in the long-term for A-Zone and B-Zone ground water by providing immediate and permanent destruction of VOCs as ground water flows past the PRB. Ground water within the Hookston Station Parcel is expected to reduce in the long-term through natural degradation processes, but this may result in residual contamination due to the high concentrations of VOCs present in the source area, particularly in B-Zone ground water.	4
Reduction of toxicity, mobility, or volume (TMV) through treatment	Significant reduction of TMV of VOC-impacted ground water is expected within the area and water-bearing zone with the greatest risk to receptors, A-Zone groundwater within the downgradient study area. The PRB is expected to immediately reduce the toxicity of ground water. The TMV of ground water within the Hookston Station Parcel is expected to eventually reduce as a result of natural degradation processes, but this is expected to take a significant amount of time.	3
Short-term effectiveness	The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to be short, while achieving the ultimate cleanup goal of the MCL for ground water will take significantly longer without posing immediate risks. The duration to achieve MCLs in the B-Zone is expected to take a significant time frame.	4
Implementability	Materials and services needed for remedial action are readily available, and technologies are reliable and proven. Installation of the PRB in the downgradient study area will be difficult and require both innovative techniques and proper coordination with residences and city agencies. The deeper A-Zone and B-Zone placement of the PRB will require a greater time frame and the use of innovative injected PRB methods. Installation of vapor intrusion mitigation systems and decommissioning of private wells will require cooperation with residents.	3
Cost	\$8,739,000	2
Balancing Criteria Score		16
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- TBD = To be determined
- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

*Table 7-7
Summary of Detailed Analysis - Alternative 6
Hookston Station
Pleasant Hill, California*

Evaluation Criteria	Detailed Analysis Summary	Score
Threshold Criteria		
Overall protection of human health and the environment	This alternative provides a moderately high level of short-term and long-term effectiveness and is expected to meet risk-based RAOs and therefore is considered protective of human health and the environment.	Yes
Compliance with applicable or relevant and appropriate requirements (ARARs)	This alternative is expected to satisfy chemical- specific ARARs for ground water, but over a significantly longer time frame than with alternatives consisting of more aggressive in situ technologies.	Yes
Balancing Criteria		
Long-term effectiveness and permanence	Plume-wide ground water extraction is expected to provide effective and relatively fast reduction of A-Zone TCE to concentrations reducing associated risks associated with migration to indoor air. However, this alternative relies on long-term operation and maintenance of an extraction and treatment system to achieve MCLs in A-Zone and B-Zone ground water, which may be unreliable.	4
Reduction of toxicity, mobility, or volume (TMV) through treatment	Reduction of TMV is expected with this alternative, through extraction of TCE-impacted ground water. However, the contaminants are simply removed from ground water, rather than being destroyed in situ. Contaminants are transferred between media at several stages of the treatment process. In addition, the low reliability of extraction to be able to capture all impacted ground water may result in localized untreated zones and higher residual TMV.	3
Short-term effectiveness	This alternative will require significant infrastructure associated with the treatment. The long duration of system operation and maintenance for this alternative reduces the level of short-term effectiveness. The expected time frame to achieve treatment to the level at which indoor air risks are reduced is expected to be short, while achieving the ultimate cleanup goal of the MCL for ground water will take significantly longer without posing immediate risks.	4
Implementability	This alternative requires construction, operation, and maintenance of significant infrastructure to implement P&T. However, the construction methods and equipment are readily available.	2
Cost	\$12,807,000	1
Balancing Criteria Score		14
Modifying Criteria		
State and community acceptance	State and community acceptance will be evaluated following public review of the FS	TBD

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- TBD = To be determined
- NR = Not ranked
- 0 = No/none
- 1 = Low
- 2 = Low-moderate
- 3 = Moderate
- 4 = Moderate-high
- 5 = High

*Table 7-8
Summary of Comparative Analysis of Alternatives
Hookston Station
Pleasant Hill, California*

Remedial Alternative	Threshold Criteria (Yes/No)		Balancing Criteria (Ranked 1-5)					Total Score ¹		Modifying Criteria (Yes/No) ²	RANK ³
	Protection of Human Health and the Environment	Compliance with ARARs	Long Term Effectiveness	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (including ranking)			State and Community Acceptance	
<u>Alternative 1</u>	N	N	0	0	2	5	\$0	5	12	TBD	6
<u>Alternative 2</u>	N	N	1	1	3	4	\$2,575,000	4	13	TBD	5
<u>Alternative 3</u>	Y	Y	3	2	3	3	\$4,930,000	3	14	TBD	4
<u>Alternative 4</u>	Y	Y	5	4	4	3	\$5,194,000	3	19	TBD	1
<u>Alternative 5</u>	Y	Y	4	3	4	3	\$8,739,000	2	16	TBD	2
<u>Alternative 6</u>	Y	Y	4	3	4	2	\$12,807,000	1	14	TBD	3

Notes:
1 = Total Score is sum of ranking for Balancing Criteria
2 = State and Community Acceptance is typically evaluated following review and comment and is expected to be more completely evaluated in later versions of this FS.
3 = Rank of Alternatives in order of preference, based on evaluation criteria. This evaluation includes the total score of the Balancing Criteria, as well as whether the threshold criteria are met.
TBD = To be determined. The modifying criteria of State and Community Acceptance will be evaluated following review of the FS.

Each alternative's performance against the criteria is initially ranked on a scale of 0 to 5. The ranking scores are not intended to be quantitative, but rather are only summary indicators of the alternative's performance against the CERCLA evaluation criteria. The rankings equate to the following qualifiers:

- NR = Not Ranked
- 0 = No/None
- 1= Low
- 2 = Low-Moderate
- 3 = Moderate
- 4 = Moderate-High
- 5 = High

*Table 8-1
Preliminary Implementation Schedule
Hookston Station
Pleasant Hill, California*

Task #	Task Description	Anticipated Duration	Months from Final Approval of Feasibility Study and Remedy Selection																							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Final RWQCB Approval of Feasibility Study and Implementation Plan	Milestone	◇																							
2	Implementation of Vapor Intrusion Prevention Systems and Well Abandonments	90 days																								
3	SMP Development and Submittal	60 days																								
4	Pre-Design Investigation Work Plan Development and Submittal	60 days																								
5	Pre-Design Investigation Work Plan RWQCB Review and Approval	60 days																								
6	Pre-Design Investigation Implementation and Reporting	90 days																								
7	Remedial Design	90 days																								
8	RWQCB Review and Final Approval of Remedial Design	60 days																								
9	Permitting, Utility Clearance, Procurement	60 days																								
10	Remedy Implementation	180 days																								

Notes:
Anticipated Durations are estimates shown in calendar days.

Tasks 5 and 8 estimate a 60-day period for RWQCB review and final approval of the submittals under Tasks 4 and 7, respectively. If the period required for RWQCB approval of those submittals exceeds 60 days, the schedule for commencement of subsequent tasks dependent upon those approvals will be delayed.

Appendix A
Additional Soil Arsenic Sampling

APPENDIX A - ADDITIONAL SOIL ARSENIC SAMPLING

Additional soil sampling activities were conducted in May and June 2006 to support remedial alternative evaluations for the Hookston Station Feasibility Study (FS). This appendix describes the field activities and presents the results of the soil sampling activities.

SCOPE OF WORK

In May and June 2006, 17 soil samples for arsenic analysis were collected in the immediate vicinities of previous sampling locations B-69, B-84, and S-09. Surface soil samples previously collected at B-69 and B-84 reported arsenic concentrations of 211 and 75.8 milligrams per kilogram (mg/kg), respectively. Arsenic was not detected in surface soil at S-09 above a laboratory reporting level of 500 mg/kg. The purpose of the sampling activities was to confirm the absence or presence of elevated soil arsenic concentrations in each of these areas.

On 31 May 2006, soil samples were collected from eight soil borings, B-69A to B-69D and B-84A to B-84D. Borings B-69A and B-84A were advanced in the same locations as borings B-69 and B-84. Borings B-69B to B-69D were advanced within 10 feet of B-69A and borings B-84B to B-84D were located in a similar fashion around B-84A. On 7 June 2006, one soil sample was collected from boring S-09A, located in the same location as S-09. Sample locations are shown on Figure 2-6 of the FS.

Soil samples were collected in 6-inch brass liners with a manual slide hammer. Samples from B-69A/B/C/D and B-84A/B/C/D were collected from 0.5 and 2.0 feet below ground surface. Boring logs prepared for these locations are included in Attachment A. One soil sample was collected from S-09A at 0.5 feet below ground surface. Soil samples were submitted to Severn Trent Laboratories in Sacramento, California, for arsenic analysis by United States Environmental Protection Agency Method 6020.

ARSENIC SOIL SAMPLE RESULTS

Arsenic was detected in each of the soil samples collected in May and June 2006, as described below:

- B-69 Area: surface soil samples reported arsenic concentrations from 0.56 to 23.4 mg/kg. Subsurface soil samples reported arsenic concentrations between 9.7 and 252 mg/kg.
- B-84 Area: arsenic was detected at concentrations up to 16.6 mg/kg in surface soils and 17.3 mg/kg in subsurface soils.
- S-09 Area: arsenic was detected in surface soil at a concentration of 4.2 mg/kg.

Figure A-1 and Table A-1 present the results, along with historical soil arsenic results. The laboratory analytical report is included in Attachment B. ERM conducted a data quality review of the soil results. As noted in that review, which is also included in Attachment B, no data required qualification or rejection.

The soil results were compared with the shallow soil Environmental Screening Level (ESL) for commercial/industrial land use (Regional Water Quality Control Board [RWQCB] 2005). As stated in the ESL document (RWQCB 2005), background arsenic concentrations in Bay Area soils often exceed health-based direct-contact goals for arsenic; therefore, the soil ESL of 5.5 mg/kg arsenic is based on an assumed background concentration of 5.5 mg/kg arsenic. Table A-2 provides a range of background metals values derived from nine publicly available studies performed on Bay Area sites, representing over 850 background soil samples. From these studies, a range of typical background values was generated, including an arsenic background range of 1.2 to 31 mg/kg. These values are considered representative of background conditions in East Bay soils and will be used as risk management thresholds for the FS rather than the arsenic soil ESL.

Based on the Bay Area soil background ranges, three of the four subsurface soil samples collected near B-69 contain soil arsenic concentrations above background levels.

REFERENCES

Regional Water Quality Control Board. 2005. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, Volume 1: Summary Tier 1 Lookup Tables*. Interim Final February 2005.

Figure

Tables

Table A-1
Arsenic Detected in Soil Samples
Hookston Station
Pleasant Hill, California

Sample Location	Date	Sample Depth (feet)	Analytical Laboratory	Arsenic (mg/kg)
RWQCB Commercial/Industrial (≤ 9.8 feet) ESL				5.5
CA Background ¹				1.2-31
S-01	10/27/1989	0.5	MTA	10
S-02	10/27/1989	0.5	MTA	4.8
S-04	10/27/1989	0.5	MTA	3.2
S-05	10/27/1989	0.5	MTA	5
S-06	10/27/1989	0.5	MTA	3.4
S-07	10/27/1989	0.5	MTA	2.6
S-08	10/27/1989	0.5	MTA	3.4
S-09	10/27/1989	0.5	MTA	< 500 u
S-09A	6/7/2006	0.5	STLSAC	4.2
B-59	9/16/2003	0.5	STLSEA	3.8
B-65	10/1/2003	0.5	STLSEA	5.11
B-69	9/17/2003	0.5	STLSEA	211
B-69A	5/11/2006	0.5	STLSAC	0.94
B-69A	5/11/2006	2.0	STLSAC	252
B-69B	5/11/2006	0.5	STLSAC	23.4
B-69B	5/11/2006	2.0	STLSAC	37.2
B-69C	5/11/2006	0.5	STLSAC	0.56
B-69C	5/11/2006	2.0	STLSAC	171
B-69D	5/11/2006	0.5	STLSAC	5.4
B-69D	5/11/2006	2.0	STLSAC	9.7
B-70	9/17/2003	0.5	STLSEA	2.78
B-73	9/29/2003	0.5	STLSEA	1.09
B-75	9/22/2003	0.5	STLSEA	4.14
B-83	9/17/2003	0.5	STLSEA	9.57
B-84	9/23/2003	0.5	STLSEA	75.8
B-84A	5/11/2006	0.5	STLSAC	2.7
B-84A	5/11/2006	2.0	STLSAC	5.5
B-84B	5/11/2006	0.5	STLSAC	16.6
B-84B	5/11/2006	2.0	STLSAC	8.5
B-84C	5/11/2006	0.5	STLSAC	12.3
B-84C	5/11/2006	2.0	STLSAC	17.3
B-84D	5/11/2006	0.5	STLSAC	9.7
B-84D	5/11/2006	2.0	STLSAC	15.3
B-94	9/29/2003	0.5	STLSEA	6.13
B-95	9/29/2003	0.5	STLSEA	5.57
MW-13A	9/30/2003	0.5	STLSEA	4.5

Notes:

ESL = Environmental Screening Level

mg/kg = milligrams per kilogram

RWQCB = Regional Water Quality Control Board

u = Compound was analyzed for but not detected. Analyte result was below the Reporting Type Limit.

< = Not Detected

¹ = Refer to Table A-2 for additional information.

Laboratories:

MTA = MED-TOX Associates, Inc.

STLSEA = Severn Trent Laboratories, Seattle

STLSAC = Severn Trent Laboratories, Sacramento

Table A-2
Comparison of Background Concentrations of Metals in Bay Area Soils
Hookston Station
Pleasant Hill, California

Study	Number of Samples	Formation	Calculation	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
LBNL, 1995	498	--	95% UCL	5.5	19.1	323.6	1.0	2.7	99.6	22.2	69.4	16.1	0.4	7.4	119.8	5.6	1.8	27.1	74.3	106.1
	97	Colluvium & Fill	95% UCL	5.9	14	358.8	0.9	1.5	91.4	22	59.6	14.5	0.3	3.2	120.2	5.6	1.7	42.5	78.2	91.5
	97	Great Valley Group	95% UCL	6.3	31	248.5	1.0	3.2	59	25.5	99.7	21.5	0.6	3.8	69.7	4.8	2.2	8.7	69.3	135.9
	101	Moraga Formation	95% UCL	6.1	9.3	154.1	0.8	2.6	142.2	23.1	54.1	8.9	0.3	3.8	100.4	4.7	2.0	38.9	90.1	84.7
	184	Orinda Formation	95% UCL	5.2	17.8	411.2	1.1	3.3	95.2	20.6	66.9	14.8	0.3	11.4	144.3	7.0	1.9	19.8	69.3	98.3
	13	San Pablo Group	95% UCL	7.1	15.7	280	0.8	2.9	78.6	22	40.9	10.3	0.4	3.7	125.9	4.9	1.5	10.9	36.2	97.7
BMWC, 1994	< 150	Fill	Geometric mean	1.98	4.32	40.6	0.29	0.43	16.32	6.45	5.44	4.79	0.07	0.76	42.85	1.36	0.35	--	22.19	32.90
		Fill	Geometric std. dev.	1.74	1.83	1.62	1.47	2.05	9.38	1.71	6.62	2.93	1.76	1.98	1.50	2.93	1.57	--	1.54	1.54
Scott, 1991	~150	Alluvium	Arithmetic mean	--	2.86	--	0.88	--	51.28	--	35.63	11.43	--	--	73.53	--	--	--	--	65.27
			Std. dev.	--	2.61	--	0.55	--	20.77	--	11.85	4.66	--	--	27.15	--	--	--	--	17.55
MLH, 1991	--	Off-Site Background (2 Rounds)	Arithmetic mean	--	8.3	--	--	1.0	10.0	--	22	32.4	0.14	--	16	--	--	--	--	65
	23		--	< 4.1	--	--	--	< 0.9	16.4	--	7.2	61	< 0.11	--	18	--	--	--	--	67.2
D&M, 1989a	4	Upgradient	Arithmetic mean	--	5.15	115	--	--	42.5	10	17.5	13.3	0.5	--	42.5	--	--	--	35	37.5
D&M, 1989b	26	Upgradient	Arithmetic mean	--	1.9	127.3	--	--	44.6	11.5	17.7	< 10	0.2	--	45.4	--	--	--	36.2	41.9
SECD, 1992	5	Clay / Loam	Arithmetic mean	2.5	8.48	228	0.5	0.83	72.6	9.53	37	65	0.14	1.74	43	< 0.25	< 0.25	< 0.25	46.9	281.6
PRC, 1996	20	Fill	95% UCL	1.5	8.4	145	0.72	0.27	95	16	72	59	0.6	0.33	96	--	0.2	--	70	152
Author Unknown	10	Background Soil	Arithmetic mean	--	1.2	125	0.35	--	33.4	8.8	22.7	7.4	--	--	22.5	--	--	--	27.8	39.9
			Std. dev.	--	1.8	145	0.17	--	6.5	3.1	16.7	2.1	--	--	15.7	--	--	--	6.3	16.4
Background Concentration Ranges				1.5 - 7.1	1.2 - 31	41 - 411	0.29 - 1.1	0.27 - 3.3	10 - 142	6.5 - 25.5	5.4 - 100	4.8 - 65	0.07 - 0.6	0.33 - 11.4	16 - 144	<0.25 - 7	0.2 - 2.2	<0.25 - 42.5	22 - 90	33 - 282

References:

- Author Unknown. *Results of Chemical Testing on Background Soil Samples, Area 2 Investigation Completion Report, Roberts Landing Development Site, San Leandro, California.* 1994
- BMWC = Burns and McDonnell Waste Consultants, Inc. *San Francisco International Airport Background Metals Concentrations in Soil.* December 1994.
- D&M = Dames and Moore, Inc. *Report - Phase II Remedial Investigation, 1455 Factor Avenue Site, San Leandro, California.* 3 August 1989.
- D&M = Dames and Moore, Inc. *Report - Phase II Remedial Investigation, 750 139th Avenue Site, San Leandro, California.* 13 October 1989.
- LBNL = Lawrence Berkeley National Laboratory, University of California, Environmental Restoration Program. *Protocol for Determining Background Concentrations of Metals in Soil at Lawrence Berkeley National Laboratory.* August 1995.
- MLH = McLaren-Hart. *Remedial Investigation Report - Hercules Properties, Inc., Hercules, California.* 15 March 1991.
- PRC = PRC Environmental Management. *Final Remedial Investigation Report - Fleet and Industrial Supply Center Oakland, Alameda Facility / Alameda Annex Site, Alameda California.* January 1996.
- Scott = Scott, Christina Marie. *Background Metals Concentrations in Northern Santa Clara County, California. Master's Thesis, University of San Francisco.* December 1991.
- SECD = SEC Donahue Environment and Infrastructure. *Sitewide Remedial Investigation, Pacific States Steel Corporation, Union City, California.* 3 December 1992.
- UCL = Upper confidence level

Attachment A
Soil Boring Logs



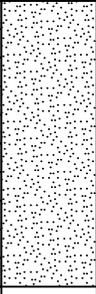
ERM
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 Suite 200
 Walnut Creek, California 94596
 (925) 946-0455

BOREHOLE LOG

Site Id: B-69A
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
1		SP		B-69A-0.5		SAND (SP): tan, gravelly, dry.
2		SP		B-69A-2.0		SAND (SP): as above.
3						SAND (SP): as above, less gravel, silty.
4						Total Depth - 2.0' bgs
5						
6						
7						



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BOREHOLE LOG

Site Id: B-69B
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
1		SP		B-69B-0.5		SAND (SP): tan, gravelly, dry.
2		ML		B-69B-2.0		SAND (SP): as above. SILT (ML): dark gray, clayey, stiff, dry.
3						Total Depth - 2.0' bgs
4						
5						
6						
7						



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BOREHOLE LOG

Site Id: B-69C
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
0 - 1.5		SP		B-69C-0.5		SAND (SP): tan, gravelly, dry.
1.5 - 2.0		ML		B-69C-2.0		SAND (SP): as above, brown. SILT (ML): dark gray, clayey, stiff, dry.
2.0 - 2.0						Total Depth - 2.0' bgs



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BOREHOLE LOG

Site Id: B-69D
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
0 - 1.5		SP		B-69D-0.5		SAND (SP): tan, gravelly, dry.
1.5 - 2.0		ML		B-69D-2.0		SAND (SP): as above, brown. SILT (ML): dark gray, clayey, stiff, dry.
2.0 - 2.0						Total Depth - 2.0' bgs



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BOREHOLE LOG

Site Id: B-84A
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: Hand Augered/Slide Hammer
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
0 - 1.5		SP		B-84A-0.5		SAND (SP): tan, gravelly, dry.
1.5 - 2.0		ML		B-84A-2.0		SAND (SP): as above SILT (ML): tan, sandy, gravelly, dry.
2.0 - 2.0						Total Depth - 2.0' bgs
3						
4						
5						
6						
7						



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BOREHOLE LOG

Site Id: B-84B
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: Hand Augered/Slide Hammer/DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
0 - 1.5		SP		B-84B-0.5		SAND (SP): tan, gravelly, dry.
1.5 - 2.0		ML		B-84B-2.0		SAND (SP): as above. SILT (ML): dark gray, clayey, dry.
2.0 - 2.0						Total Depth - 2.0' bgs



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BOREHOLE LOG

Site Id: B-84C
 Page 1 of 1

Project Number: 0020557.10

Total Depth: 2.00'

Project Name: UP Hookston Station

Borehole Dia.: 2.00in

Location: Pleasant Hill, California

Initial Water Level: NA

Contractor: Vironex

X-Coordinate: NA

Drilling Method: DirectPush

Y-Coordinate: NA

Logged By: D. Moberg

Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
1		SP		B-84C-0.5		SAND (SP): tan, gravelly, dry.
2		ML		B-84C-2.0		SAND (SP): as above, brick fragments. SILT (ML): dark gray, clayey, stiff, dry. Total Depth - 2.0' bgs
3						
4						
5						
6						
7						



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BOREHOLE LOG

Site Id: B-84D
 Page 1 of 1

Project Number: 0020557.10
 Project Name: UP Hookston Station
 Location: Pleasant Hill, California
 Contractor: Vironex
 Drilling Method: DirectPush
 Logged By: D. Moberg

Total Depth: 2.00'
 Borehole Dia.: 2.00in
 Initial Water Level: NA
 X-Coordinate: NA
 Y-Coordinate: NA
 Date(s): 05/11/06

Depth (ft)	Graphic Log	USCS Code	Sample Recovery	Sample No.	PID (ppm)	Soil Description and Observations
0 - 1.5		SP		B-84D-0.5		SAND (SP): tan, gravelly, dry.
1.5 - 2.0		ML		B-84D-2.0		SAND (SP): as above, brick fragments. SILT (ML): dark gray, clayey, stiff, dry.
2.0 - 2.0						Total Depth - 2.0' bgs

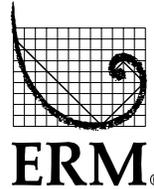
Attachment B
Laboratory Analytical Reports
and Data Quality Review

Memorandum

**Environmental
Resources
Management**

To: Kimberly Lake
From: Jackie Luta
Date: 20 June 2006
Subject: Data Review of UPRR Hookston Station Samples
Collected 11 May 2006
Project Number: 0020557.10
Data Package: STL-Sacramento Data Packages G6E130187 and
G6F090417

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Walnut Creek, CA 94596
(925) 946-0455
(925) 946-9968 (fax)



The quality of the data was assessed and any necessary qualifiers were applied following the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, July 2002.

HOLDING TIME AND PRESERVATION EVALUATION

The samples were prepared and analyzed within the method prescribed time period from the date of collection. The sample shipment was received at the laboratory at 8 degrees Celsius (°C), out of the recommended temperature requirement of from 2 to 6 °C. However, the samples were not analyzed for organic constituents and the temperature exceedance is not determined to be significant. None of the data were qualified based on holding time or temperature preservation exceedances.

BLANK EVALUATION

The method blank sample results were nondetected for the target analyte. No data required qualification based on method blank results.

BLANK SPIKE EVALUATION

The laboratory control sample percent recoveries were within the laboratory's limits of acceptance. The laboratory control sample recoveries indicate acceptable laboratory accuracy and precision.

MATRIX SPIKE EVALUATION

The matrix spike/matrix spike duplicate recoveries were within the laboratory's limits of acceptance. The matrix spike/matrix spike duplicate recoveries indicate acceptable laboratory accuracy and precision and minimal matrix interference.

OVERALL ASSESSMENT

No data required qualification or rejection. All of the data can be used for decision-making purposes. The quality of the data generated during this investigation is acceptable for the preparation of technically defensible documents.

STL Sacramento
880 Riverside Parkway
West Sacramento, CA 95605

Tel: 916 373 5600 Fax: 916 372 1059
www.stl-inc.com

June 20, 2006

STL SACRAMENTO PROJECT NUMBER: G6F090417
PO/CONTRACT:

Kimberly Lake
Environmental Resources Mgmt.
1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596

Dear Ms. Lake,

This report contains the analytical results for the sample received under chain of custody by STL Sacramento on June 9, 2006. This sample is associated with your 0020557.10 project.

The test results in this report meet all NELAC requirements for parameters that accreditation is required or available. Any exceptions to NELAC requirements are noted in the case narrative. The case narrative is an integral part of this report.

If you have any questions, please feel free to call me at (916) 374-4442.

Sincerely,



Pravani Pillay
Project Manager

CASE NARRATIVE

STL SACRAMENTO PROJECT NUMBER G6F090417

There were no anomalies associated with this project.

STL Sacramento Certifications/Accreditations

Certifying State	Certificate #	Certifying State	Certificate #
Alaska	UST-055	Oregon*	CA 200005
Arizona	AZ0616	Pennsylvania	68-1272
Arkansas	04-067-0	South Carolina	87014002
California*	01119CA	Texas	TX 270-2004A
Colorado	NA	Utah*	QUAN1
Connecticut	PH-0691	Virginia	00178
Florida*	E87570	Washington	C087
Georgia	960	West Virginia	9930C, 334
Hawaii	NA	Wisconsin	998204680
Louisiana*	01944	NFESC	NA
Michigan	9947	USACE	NA
Nevada	CA44	USDA Foreign Plant	37-82605
New Jersey*	CA005	USDA Foreign Soil	S-46613
New York*	11666		

*NELAP accredited. A more detailed parameter list is available upon request. Updated 1/27/05

QC Parameter Definitions

QC Batch: The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards at the same time.

Method Blank: An analytical control consisting of all reagents, which may include internal standards and surrogates, and is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination.

Laboratory Control Sample and Laboratory Control Sample Duplicate (LCS/LCSD): An aliquot of blank matrix spiked with known amounts of representative target analytes. The LCS (and LCSD as required) is carried through the entire analytical process and is used to monitor the accuracy of the analytical process independent of potential matrix effects. If an LCSD is performed, it may also used to evaluate the precision of the process.

Duplicate Sample (DU): Different aliquots of the same sample are analyzed to evaluate the precision of an analysis.

Surrogates: Organic compounds not expected to be detected in field samples, which behave similarly to target analytes. These are added to every sample within a batch at a known concentration to determine the efficiency of the sample preparation and analytical process.

Matrix Spike and Matrix Spike Duplicate (MS/MSD): An MS is an aliquot of a matrix fortified with known quantities of specific compounds and subjected to an entire analytical procedure in order to indicate the appropriateness of the method for a particular matrix. The percent recovery for the respective compound(s) is then calculated. The MSD is a second aliquot of the same matrix as the matrix spike, also spiked, in order to determine the precision of the method.

Isotope Dilution: For isotope dilution methods, isotopically labeled analogs (internal standards) of the native target analytes are spiked into the sample at time of extraction. These internal standards are used for quantitation, and monitor and correct for matrix effects. Since matrix effects on method performance can be judged by the recovery of these analogs, there is little added benefit of performing MS/MSD for these methods. MS/MSD are only performed for client or QAPP requirements.

Control Limits: The reported control limits are either based on laboratory historical data, method requirements, or project data quality objectives. The control limits represent the estimated uncertainty of the test results.

SAMPLE SUMMARY

G6F090417

<u>WO #</u>	<u>SAMPLE#</u>	<u>CLIENT</u>	<u>SAMPLE ID</u>	<u>SAMPLED</u> <u>DATE</u>	<u>SAMP</u> <u>TIME</u>
H66AD	001	S-09A		06/07/06	10:10

NOTE(S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

CHAIN OF CUSTODY RECORD

NO: 4541

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Page 1 of 1

PROJECT #	PROJECT NAME	RECEIVING LABORATORY		# OF CONTAINERS		MATRIX	REQUESTED PARAMETERS
0020557.10	UP Hookstein	STL-Sacramento (916) 373-5600		1		SOIL	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> RECEIVED IN GOOD CONDITION NUMBER 100 JUN - 9 2006 INT. CW </div>
SAMPLER: (PRINT NAME) D. Ludlow	(SIGNATURE) <i>D. Ludlow</i>	COMP	SAMPLING METHOD	PRESERVATIVE	FOR	WATER	
SAMPLE I.D. S-09A	DATE 6/7/06 1070	GRAB	6/7/06 1255	N/A	2x4	ASSENIC ICP/MS	
RELINQUISHED BY (SIGNATURE) <i>D. Ludlow</i>	DATE 6/7/06 1070	RECEIVED BY	DATE 6/7/06 1255	RECEIVED BY	DATE 6/9/06 1315	TIME	FIELD REMARKS Rush analysis required - Contact Kimberly Lake 925-279-3207
RELINQUISHED BY (SIGNATURE)	DATE	RECEIVED BY	DATE	RECEIVED BY	DATE	TIME	
RELINQUISHED BY (SIGNATURE)	DATE	RECEIVED BY	DATE	RECEIVED BY	DATE	TIME	
REMARKS ON SAMPLE RECEIPT <input type="checkbox"/> BOTTLE INTACT <input type="checkbox"/> CUSTODY SEALS <input type="checkbox"/> CHILLED <input type="checkbox"/> PRESERVED <input type="checkbox"/> SEALS INTACT <input type="checkbox"/> SEE REMARKS							
ERM REMARKS							SEND REPORT TO: <i>Kimberly Lake</i>



STL

LOT RECEIPT CHECKLIST STL Sacramento

CLIENT ERM PM ff LOG # 39347

LOT# (QUANTIMS ID) G6F090417 QUOTE# 48416 LOCATION W26D

DATE RECEIVED 6/9/06 TIME RECEIVED 1315 Initials CV Date 6/9/06

- DELIVERED BY
- FEDEX
 - AIRBORNE
 - UPS
 - STL COURIER
 - OTHER
 - CA OVERNIGHT
 - GOLDENSTATE
 - BAX GLOBAL
 - COURIERS ON DEMAND
 - CLIENT
 - DHL
 - GO-GETTERS

CUSTODY SEAL STATUS INTACT BROKEN N/A

CUSTODY SEAL #(S) _____

SHIPPING CONTAINER(S) STL CLIENT N/A

TEMPERATURE RECORD (IN °C) IR 1 3 OTHER _____

COC #(S) 4541

TEMPERATURE BLANK Observed: NA Corrected: _____

SAMPLE TEMPERATURE

Observed: 3 Average: 3 Corrected Average: 4

COLLECTOR'S NAME: Verified from COC Not on COC

pH MEASURED YES ANOMALY N/A

LABELED BY.....

LABELS CHECKED BY.....

PEER REVIEW NA

SHORT HOLD TEST NOTIFICATION

SAMPLE RECEIVING

WETCHEM N/A

VOA-ENCORES N/A

METALS NOTIFIED OF FILTER/PRESERVE VIA VERBAL & EMAIL N/A

COMPLETE SHIPMENT RECEIVED IN GOOD CONDITION WITH APPROPRIATE TEMPERATURES, CONTAINERS, PRESERVATIVES N/A

Clouseau TEMPERATURE EXCEEDED (2 °C - 6 °C)*1 N/A

WET ICE BLUE ICE GEL PACK NO COOLING AGENTS USED PM NOTIFIED

Notes: _____

Lot ID: G6F090417

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
VOA*	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
VOAh*	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
AGB																				
AGBs																				
250AGB																				
250AGBs																				
250AGBn																				
500AGB																				
___AGJ																				
500AGJ																				
250AGJ																				
125AGJ																				
___CGJ																				
500CGJ																				
250CGJ																				
125CGJ																				
PJ																				
PJn																				
500PJ																				
500PJn																				
500PJna																				
500PJzn/na																				
250PJ																				
250PJn																				
250PJna																				
250PJzn/na																				
Acetate Tube																				
<u>4</u> "CT	1																			
Encore																				
Folder/filter																				
PUF																				
Petri/Filter																				
XAD Trap																				
Ziploc																				

h = hydrochloric acid s = sulfuric acid na = sodium hydroxide n = nitric acid zn = zinc acetate

Number of VOAs with air bubbles present / total number of VOA's

ERM-West

Client Sample ID: S-09A

TOTAL Metals

Lot-Sample #...: G6F090417-001

Matrix.....: WG

Date Sampled...: 06/07/06

Date Received...: 06/09/06

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6165168						
Arsenic	4.2	0.20	mg/kg	SW846 6020	06/14/06	H66AD1AA
		Dilution Factor: 1		MDL.....: 0.010		

QC DATA ASSOCIATION SUMMARY

G6F090417

Sample Preparation and Analysis Control Numbers

<u>SAMPLE#</u>	<u>MATRIX</u>	<u>ANALYTICAL METHOD</u>	<u>LEACH BATCH #</u>	<u>PREP BATCH #</u>	<u>MS RUN#</u>
001	WG	SW846 6020		6165168	6165068

METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: G6F090417

Matrix.....: SOLID

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
MB Lot-Sample #: G6F140000-168				Prep Batch #...: 6165168		
Arsenic	ND	0.20	mg/kg	SW846 6020	06/14/06	H7CJF1AA
		Dilution Factor: 1				

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: G6F090417

Matrix.....: SOLID

<u>PARAMETER</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
LCS Lot-Sample#:	G6F140000-168	Prep Batch #...:	6165168		
Arsenic	91	(76 - 110)	SW846 6020	06/14/06	H7CJF1AC
		Dilution Factor: 1			

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE DATA REPORT

TOTAL Metals

Client Lot #...: G6F090417

Matrix.....: SOLID

<u>PARAMETER</u>	<u>SPIKE</u> <u>AMOUNT</u>	<u>MEASURED</u> <u>AMOUNT</u>	<u>UNITS</u>	<u>PERCNT</u> <u>RECVRY</u>	<u>METHOD</u>	<u>PREPARATION-</u> <u>ANALYSIS DATE</u>	<u>WORK</u> <u>ORDER #</u>
------------------	-------------------------------	----------------------------------	--------------	--------------------------------	---------------	---	-------------------------------

LCS Lot-Sample#: G6F140000-168 Prep Batch #...: 6165168

Arsenic	20.0	18.2	mg/kg	91	SW846 6020	06/14/06	H7CJF1AC
---------	------	------	-------	----	------------	----------	----------

Dilution Factor: 1

NOTE(S) :

Calculations are performed before rounding to avoid round-off errors in calculated results.

MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: G6F090417

Matrix.....: WG

Date Sampled...: 06/07/06

Date Received...: 06/09/06

<u>PARAMETER</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>	<u>RPD</u>	<u>RPD LIMITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
------------------	-------------------------	------------------------	------------	-------------------	---------------	-----------------------------------	---------------------

MS Lot-Sample #: G6F090417-001 Prep Batch #...: 6165168

Arsenic	85	(76 - 110)			SW846 6020	06/14/06	H66AD1AC
	82	(76 - 110)	6.7	(0-20)	SW846 6020	06/14/06	H66AD1AD

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Results and reporting limits have been adjusted for dry weight.

MATRIX SPIKE SAMPLE DATA REPORT

TOTAL Metals

Client Lot #...: G6F090417

Matrix.....: WG

Date Sampled...: 06/07/06

Date Received...: 06/09/06

<u>PARAMETER</u>	<u>AMOUNT</u>	<u>SAMPLE SPIKE AMT</u>	<u>MEASRD AMOUNT</u>	<u>UNITS</u>	<u>PERCNT RECVRY</u>	<u>RPD</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
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MS Lot-Sample #: G6F090417-001 Prep Batch #...: 6165168

Arsenic

4.2	20.0	21.2	mg/kg	85			SW846 6020	06/14/06	H66AD1AC
4.2	19.0	19.9	mg/kg	82	6.7		SW846 6020	06/14/06	H66AD1AD

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.
Results and reporting limits have been adjusted for dry weight.



STL

STL Sacramento
880 Riverside Parkway
West Sacramento, CA 95605

Tel: 916 373 5600 Fax: 916 372 1059
www.stl-inc.com

May 26, 2006

STL SACRAMENTO PROJECT NUMBER: G6E130187
PO/CONTRACT:

Brian Bjorklund
Environmental Resources Mgmt.
1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596

Dear Mr. Bjorklund,

This report contains the analytical results for the samples received under chain of custody by STL Sacramento on May 12, 2006. These samples are associated with your 0020557.10 Hookston Station project.

The test results in this report meet all NELAC requirements for parameters that accreditation is required or available. Any exceptions to NELAC requirements are noted in the case narrative. The case narrative is an integral part of this report.

If you have any questions, please feel free to call me at (916) 374-4442.

Sincerely,

Pravani Pillay
Project Manager

CASE NARRATIVE

STL SACRAMENTO PROJECT NUMBER G6E130187

General Comments

The samples were received at 8°C. The collection time for B-69D-2.0 states 15:54 on the chain of custody (COC), the label indicates 15:55. The sample was logged in according to the COC.

There were no other anomalies associated with this project.

STL Sacramento Certifications/Accreditations

Certifying State	Certificate #	Certifying State	Certificate #
Alaska	UST-055	Oregon*	CA 200005
Arizona	AZ0616	Pennsylvania	68-1272
Arkansas	04-067-0	South Carolina	87014002
California*	01119CA	Texas	TX 270-2004A
Colorado	NA	Utah*	QUAN1
Connecticut	PEI-0691	Virginia	00178
Florida*	E87570	Washington	C087
Georgia	960	West Virginia	9930C, 334
Hawaii	NA	Wisconsin	998204680
Louisiana*	01944	NFESC	NA
Michigan	9947	USACE	NA
Nevada	CA44	USDA Foreign Plant	37-82605
New Jersey*	CA005	USDA Foreign Soil	S-46613
New York*	11666		

*NELAP accredited. A more detailed parameter list is available upon request. Updated 1/27/05

QC Parameter Definitions

QC Batch: The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards at the same time.

Method Blank: An analytical control consisting of all reagents, which may include internal standards and surrogates, and is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination.

Laboratory Control Sample and Laboratory Control Sample Duplicate (LCS/LCSD): An aliquot of blank matrix spiked with known amounts of representative target analytes. The LCS (and LCSD as required) is carried through the entire analytical process and is used to monitor the accuracy of the analytical process independent of potential matrix effects. If an LCSD is performed, it may also be used to evaluate the precision of the process.

Duplicate Sample (DU): Different aliquots of the same sample are analyzed to evaluate the precision of an analysis.

Surrogates: Organic compounds not expected to be detected in field samples, which behave similarly to target analytes. These are added to every sample within a batch at a known concentration to determine the efficiency of the sample preparation and analytical process.

Matrix Spike and Matrix Spike Duplicate (MS/MSD): An MS is an aliquot of a matrix fortified with known quantities of specific compounds and subjected to an entire analytical procedure in order to indicate the appropriateness of the method for a particular matrix. The percent recovery for the respective compound(s) is then calculated. The MSD is a second aliquot of the same matrix as the matrix spike, also spiked, in order to determine the precision of the method.

Isotope Dilution: For isotope dilution methods, isotopically labeled analogs (internal standards) of the native target analytes are spiked into the sample at time of extraction. These internal standards are used for quantitation, and monitor and correct for matrix effects. Since matrix effects on method performance can be judged by the recovery of these analogs, there is little added benefit of performing MS/MSD for these methods. MS/MSD are only performed for client or QAPP requirements.

Control Limits: The reported control limits are either based on laboratory historical data, method requirements, or project data quality objectives. The control limits represent the estimated uncertainty of the test results.

SAMPLE SUMMARY

G6E130187

<u>WO #</u>	<u>SAMPLE#</u>	<u>CLIENT SAMPLE ID</u>	<u>SAMPLED DATE</u>	<u>SAMP TIME</u>
H5DEX	001	B-84A-0.5	05/11/06	10:05
H5DE1	002	B-84A-2.0	05/11/06	10:50
H5DE2	003	B-84B-0.5	05/11/06	11:10
H5DE3	004	B-84B-2.0	05/11/06	14:00
H5DE4	005	B-84C-0.5	05/11/06	14:15
H5DE5	006	B-84D-2.0	05/11/06	14:45
H5DE6	007	B-84D-0.5	05/11/06	14:50
H5DE7	008	B-84C-2.0	05/11/06	15:10
H5DE8	009	B-69A-0.5	05/11/06	15:35
H5DE9	010	B-69A-2.0	05/11/06	15:40
H5DFA	011	B-69C-0.5	05/11/06	15:45
H5DFC	012	B-69C-2.0	05/11/06	15:47
H5DFE	013	B-69D-0.5	05/11/06	15:52
H5DFF	014	B-69D-2.0	05/11/06	15:54
H5DFG	015	B-69B-0.5	05/11/06	16:05
H5DFH	016	B-69B-2.0	05/11/06	16:10

NOTE (S) :

- The analytical results of the samples listed above are presented on the following pages.
- All calculations are performed before rounding to avoid round-off errors in calculated results.
- Results noted as "ND" were not detected at or above the stated limit.
- This report must not be reproduced, except in full, without the written approval of the laboratory.
- Results for the following parameters are never reported on a dry weight basis: color, corrosivity, density, flashpoint, ignitability, layers, odor, paint filter test, pH, porosity pressure, reactivity, redox potential, specific gravity, spot tests, solids, solubility, temperature, viscosity, and weight.

PROJECT #	PROJECT NAME	# OF CONTAINERS		MATRIX	REQUESTED PARAMETERS							
0070557-10	Hockley Station	1	1	SOIL	Asbestos PCBMS							
SAMPLER: (PRINT NAME) (SIGNATURE) Doug Mcberg		1	1	WATER								
RECEIVING LABORATORY SCL - Sacramento		1	1	GAS								
SAMPLE I.D.	DATE	TIME	COMP	GRAB	SAMPLING METHOD	PRESERVE	Y/N	SAMPLING VOLUME	RECEIVED BY	DATE	TIME	FIELD REMARKS
B-246-0.5	5/19/06	1005		X	Hand	-	Y	200ml	Cheng Xue	5/26/06	1205	UPRR Project Manager Mike Grant.
B-246-2.0		1050		X	↓	-	Y					
B-246-0.5		1110		X	↓	-	Y					
B-246-2.0		1140		X	↓	-	Y					
B-246-0.5		1145		Y	↓	-	Y					
B-246-2.0		1145		Y	↓	-	Y					
B-246-0.5		1250		Y	↓	-	Y					
B-246-2.0		1510		Y	↓	-	Y					
B-246-0.5		1535		Y	↓	-	Y					
B-246-2.0		1740		Y	↓	-	Y					
RELINQUISHED BY (SIGNATURE)		DATE	TIME	RECEIVED BY		DATE	TIME	FIELD REMARKS				
Doug Mcberg		5/19/06	1740	Cheng Xue		5/26/06	1205	UPRR Project Manager Mike Grant. Dined Bill				
RELINQUISHED BY (SIGNATURE)		DATE	TIME	RECEIVED BY		DATE	TIME	FIELD REMARKS				
RELINQUISHED BY (SIGNATURE)		DATE	TIME	RECEIVED BY		DATE	TIME	FIELD REMARKS				
REMARKS ON SAMPLE RECEIPT												
<input checked="" type="checkbox"/> BOTTLE INTACT <input type="checkbox"/> CUSTODY SEALS <input type="checkbox"/> CHILLED <input type="checkbox"/> PRESERVED <input type="checkbox"/> SEALS INTACT <input type="checkbox"/> SEE REMARKS												
SEND REPORT TO: Orion Gumbel												

CHAIN OF CUSTODY RECORD

1777 Botelho Drive, Suite 260 • Walnut Creek, CA • 94596 • (925) 946-0455 • FAX (925) 946-9968

NO: 3988

Page 2 of 2

PROJECT #	PROJECT NAME	# OF CONTAINERS	MATRIX	REQUESTED PARAMETERS	DATE	TIME	DATE	TIME	DATE	TIME	FIELD REMARKS	
0905710	Hood's Station	1	SOIL	Asbestos	5/16/06	12:05						
SAMPLER: (PRINT NAME) (SIGNATURE)		RECEIVING LABORATORY										
Doug Moberg		STL Sacramento										
SAMPLE ID	DATE	TIME	CON	PC	CS	SAMPLING METHOD	DATE	TIME	DATE	TIME	FIELD REMARKS	
B-670-01	5/16/06	15:15	✓	✓	✓	Hand	5/16/06	12:05				
B-670-02	5/16/06	15:17	✓	✓	✓	Hand						
B-670-03	5/16/06	15:22	✓	✓	✓	Hand						
B-670-04	5/16/06	15:24	✓	✓	✓	Hand						
B-670-05	5/16/06	16:05	✓	✓	✓	Hand						
B-670-06	5/16/06	16:10	✓	✓	✓	Hand						
RELINQUISHED BY (SIGNATURE)		RECEIVED BY										
Doug Moberg		Cheng He										
RELINQUISHED BY (SIGNATURE)		RECEIVED BY										
RELINQUISHED BY (SIGNATURE)		RECEIVED BY										

REMARKS ON SAMPLE RECEIPT

BOTTLE INTACT
 CUSTODY SEALS
 CHILLED
 PRESERVED
 SEALS INTACT
 SEE REMARKS

SEND REPORT TO: *Review by Lab Lead*

CANARY - FIELD COPY
 PINK - DATABASE MANAGER
 GOLD - PROJECT FILE

** Rec'd labeled @ 1555 - on 5/16/06*

Lot ID: G6E130187

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
VOA*	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
VOAh*	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
AGB																				
AGBs																				
250AGB																				
250AGBs																				
250AGBn																				
500AGB																				
___AGJ																				
500AGJ																				
250AGJ																				
125AGJ																				
___CGJ																				
500CGJ																				
250CGJ																				
125CGJ																				
PJ																				
PJn																				
500PJ																				
500PJn																				
500PJna																				
500PJzn/na																				
250PJ																				
250PJn																				
250PJna																				
250PJzn/na																				
Acetate Tube				/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
<u>6</u> "CT	/	/	/																	
Encore																				
Folder/filter																				
PUF																				
Petri/Filter																				
XAD Trap																				
Ziploc																				

h = hydrochloric acid s = sulfuric acid na = sodium hydroxide n = nitric acid zn = zinc acetate

Number of VOAs with air bubbles present / total number of VOA's

ERM-West

Client Sample ID: B-84A-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-001

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 2.4

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	2.7	0.20	mg/kg	SW846 6020	05/18-05/22/06	H5DEX1AC
		Dilution Factor: 1		MDL.....: 0.051		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84A-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-002

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 4.5

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING</u>		<u>METHOD</u>	<u>PREPARATION-</u>	<u>WORK</u>
		<u>LIMIT</u>	<u>UNITS</u>		<u>ANALYSIS DATE</u>	<u>ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	5.5	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DE11AC
		Dilution Factor: 1		MDL.....: 0.052		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84B-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-003

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 2.5

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	16.6	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DE21AC
		Dilution Factor: 1		MDL.....: 0.051		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84B-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-004
Date Sampled...: 05/11/06
% Moisture.....: 15

Date Received...: 05/12/06

Matrix.....: SO

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	8.5	0.23	mg/kg	SW846 6020	05/18-05/22/06	H5DE31AC
		Dilution Factor: 1		MDL.....: 0.058		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84C-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-005

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 5.6

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	12.3	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DE41AC
		Dilution Factor: 1		MDL.....: 0.053		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84D-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-006

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 18

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	15.3	0.24	mg/kg	SW846 6020	05/18-05/22/06	H5DE51AC
		Dilution Factor: 1		MDL.....: 0.060		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84D-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-007

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 6.7

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	9.7	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DE61AC
		Dilution Factor: 1		MDL.....: 0.053		

NOTE (S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-84C-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-008

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 18

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	17.3	0.24	mg/kg	SW846 6020	05/18-05/22/06	H5DE71AC
		Dilution Factor: 1		MDL.....: 0.060		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69A-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-009

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 1.8

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	0.94	0.20	mg/kg	SW846 6020	05/18-05/22/06	H5DE81AC
		Dilution Factor: 1		MDL.....: 0.051		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69A-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-010

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 3.5

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	252	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DE91AC
		Dilution Factor: 1		MDL.....: 0.052		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69C-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-011

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 2.4

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	0.56	0.20	mg/kg	SW846 6020	05/18-05/22/06	H5DFALAC
		Dilution Factor: 1		MDL.....: 0.051		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69C-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-012

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 9.4

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	171	0.22	mg/kg	SW846 6020	05/18-05/22/06	H5DFC1AC
		Dilution Factor: 1		MDL.....: 0.055		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69D-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-013

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 4.0

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	5.4	0.21	mg/kg	SW846 6020	05/18-05/22/06	H5DFE1AC
		Dilution Factor: 1		MDL.....: 0.052		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69D-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-014
Date Sampled...: 05/11/06
% Moisture.....: 17

Date Received...: 05/12/06

Matrix.....: SO

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	9.7	0.24	mg/kg	SW846 6020	05/18-05/22/06	H5DFFLAC
		Dilution Factor: 1		MDL.....: 0.060		

NOTE(S):

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69B-0.5

TOTAL Metals

Lot-Sample #...: G6E130187-015

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 1.9

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	23.4	0.20	mg/kg	SW846 6020	05/18-05/22/06	H5DFG1AC
		Dilution Factor: 1		MDL.....: 0.051		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

ERM-West

Client Sample ID: B-69B-2.0

TOTAL Metals

Lot-Sample #...: G6E130187-016

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

% Moisture.....: 17

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
Prep Batch #...: 6137337						
Arsenic	37.2	0.24	mg/kg	SW846 6020	05/18-05/22/06	H5DFHLAC
		Dilution Factor: 1		MDL.....: 0.060		

NOTE(S) :

Results and reporting limits have been adjusted for dry weight.

QC DATA ASSOCIATION SUMMARY

G6E130187

Sample Preparation and Analysis Control Numbers

<u>SAMPLE#</u>	<u>MATRIX</u>	<u>ANALYTICAL METHOD</u>	<u>LEACH BATCH #</u>	<u>PREP BATCH #</u>	<u>MS RUN#</u>
001	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
002	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
003	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
004	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
005	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
006	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
007	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
008	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
009	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
010	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
011	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
012	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
013	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
014	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213

(Continued on next page)

QC DATA ASSOCIATION SUMMARY

G6E130187

Sample Preparation and Analysis Control Numbers

<u>SAMPLE#</u>	<u>MATRIX</u>	<u>ANALYTICAL METHOD</u>	<u>LEACH BATCH #</u>	<u>PREP BATCH #</u>	<u>MS RUN#</u>
015	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213
016	SO	SW846 6020		6137337	6137196
	SO	ASTM D 2216-90		6142403	6142213

METHOD BLANK REPORT

TOTAL Metals

Client Lot #...: G6E130187

Matrix.....: SOLID

<u>PARAMETER</u>	<u>RESULT</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
MB Lot-Sample #: G6E170000-337				Prep Batch #...: 6137337		
Arsenic	ND	0.20	mg/kg	SW846 6020	05/18-05/22/06	H5JWV1AA
		Dilution Factor: 1				

NOTE(S) :

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: G6E130187

Matrix.....: SOLID

<u>PARAMETER</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
------------------	-----------------------------	----------------------------	---------------	---------------------------------------	---------------------

LCS Lot-Sample#: G6E170000-337 Prep Batch #...: 6137337

Arsenic	92	(79 - 110)	SW846 6020	05/18-05/22/06	H5JWV1AC
---------	----	------------	------------	----------------	----------

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE DATA REPORT

TOTAL Metals

Client Lot #...: G6E130187

Matrix.....: SOLID

<u>PARAMETER</u>	<u>SPIKE</u> <u>AMOUNT</u>	<u>MEASURED</u> <u>AMOUNT</u>	<u>UNITS</u>	<u>PERCNT</u> <u>RECVRY</u>	<u>METHOD</u>	<u>PREPARATION-</u> <u>ANALYSIS DATE</u>	<u>WORK</u> <u>ORDER #</u>
------------------	-------------------------------	----------------------------------	--------------	--------------------------------	---------------	---	-------------------------------

LCS Lot-Sample#: G6E170000-337 Prep Batch #...: 6137337

Arsenic	20.0	18.4	mg/kg	92	SW846 6020	05/18-05/22/06	H5JWV1AC
---------	------	------	-------	----	------------	----------------	----------

Dilution Factor: 1

NOTE(S) :

Calculations are performed before rounding to avoid round-off errors in calculated results.

MATRIX SPIKE SAMPLE EVALUATION REPORT

TOTAL Metals

Client Lot #...: G6E130187

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

<u>PARAMETER</u>	<u>PERCENT RECOVERY</u>	<u>RECOVERY LIMITS</u>	<u>RPD</u>	<u>RPD LIMITS</u>	<u>METHOD</u>	<u>PREPARATION- ANALYSIS DATE</u>	<u>WORK ORDER #</u>
MS Lot-Sample #: G6E130187-001 Prep Batch #...: 6137337							
Arsenic	85	(79 - 110)			SW846 6020	05/18-05/22/06	H5DEX1AD
	85	(79 - 110)	0.08	(0-20)	SW846 6020	05/18-05/22/06	H5DEX1AE
			Dilution Factor: 1				

NOTE(S) :

Calculations are performed before rounding to avoid round-off errors in calculated results.

Results and reporting limits have been adjusted for dry weight.

MATRIX SPIKE SAMPLE DATA REPORT

TOTAL Metals

Client Lot #...: G6E130187

Matrix.....: SO

Date Sampled...: 05/11/06

Date Received...: 05/12/06

PARAMETER	AMOUNT	SAMPLE SPIKE AMT	MEASRD AMOUNT	UNITS	PERCNT RECVRY	RPD	METHOD	PREPARATION- ANALYSIS DATE	WORK ORDER #
-----------	--------	------------------	---------------	-------	---------------	-----	--------	----------------------------	--------------

MS Lot-Sample #: G6E130187-001 Prep Batch #...: 6137337

Arsenic

2.7	20.3	20.0	mg/kg	85			SW846 6020	05/18-05/22/06	H5DEX1AD
2.7	20.3	20.0	mg/kg	85	0.08		SW846 6020	05/18-05/22/06	H5DEX1AE

Dilution Factor: 1

NOTE(S):

Calculations are performed before rounding to avoid round-off errors in calculated results.

Results and reporting limits have been adjusted for dry weight.

Appendix B
Soil Vapor Sampling

APPENDIX B - SOIL VAPOR SAMPLING

Additional soil vapor sampling activities were conducted in June 2006 to support remedial alternative evaluations for the Feasibility Study. This appendix describes the field activities and presents the results of the soil vapor sampling activities.

SCOPE OF WORK

Active soil vapor sampling was completed at three locations (ASV-13 to ASV-15) on 1 June 2006. One ambient air sample was also collected during this time. The active soil vapor sampling points were located within the downgradient portion of the Colony Park residential neighborhood, generally beyond the high concentration trichloroethylene (TCE) impacts (>500 micrograms per liter TCE in groundwater) but along the plume axis. Based on previous data, a good correlation between soil vapor concentrations and indoor air impacts has generally been observed. This study was conducted to refine our understanding of the potential downgradient area of indoor air impacts. These data will supplement the previous soil vapor sampling data and indoor air data collected in the neighborhood. Sampling locations of ASV-13 through ASV-15, as well as previous sampling locations (ASV-1 through ASV-14) and the 10 permanent soil vapor probes (SVP-1 through SVP-10) are shown on Figure B-1.

The active soil vapor samples were collected with the use of a direct-push sampling rig equipped with 1-inch diameter steel vapor probes with 1/8-inch flexible nylon tubing. At each location, the vapor probe was advanced to 5 feet below ground surface and then slightly withdrawn to open the sampling tip and expose the vapor sampling port. To minimize ambient air leakage within the sampling system, bentonite seals were placed at the ground surface along the outside of the sampling rods, and at the top of the sampling rods where the sample tubing is located. Soil vapor was then withdrawn from the tubing using a graduated syringe. Prior to soil vapor sample collection at each location, a vacuum check was performed, the syringe was leak-checked, and the tubing was purged to fill it with soil vapor. Samples were collected into a 6-liter Summa canister using a 200 milliliter per minute flow controller. During sampling, leak tests were performed using isopropyl alcohol (2-propanol).

The soil vapor and ambient air samples were analyzed for volatile organic compounds (VOCs) by Method TO-15 at Air Toxics, Ltd., in Sacramento, California.

Soil vapor sampling activities were conducted in accordance with the 15 December 2005 (revised 7 February 2005) *Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* and the *Advisory - Active Soil Gas Investigations* (28 January 2003) documents developed by the Department of Toxic Substances Control and the California Environmental Protection Agency.

SOIL VAPOR SAMPLE RESULTS

Chlorinated VOCs, including TCE and associated degradation compounds, were not detected in the soil vapor samples. However, low levels of 20 different VOCs that do not originate from the Hookston Station Parcel were detected in one or more of the soil vapor samples. These VOCs are mostly petroleum-related compounds, and include benzene, toluene, ethylbenzene, xylenes, and 1,2,4-trimethylbenzene. The sample results are summarized on Table B-1, and the laboratory analytical report is included as Attachment A to this appendix. ERM conducted a data quality review of the soil vapor results. As noted in that review, which is also included in Attachment A, no data required qualification or rejection.

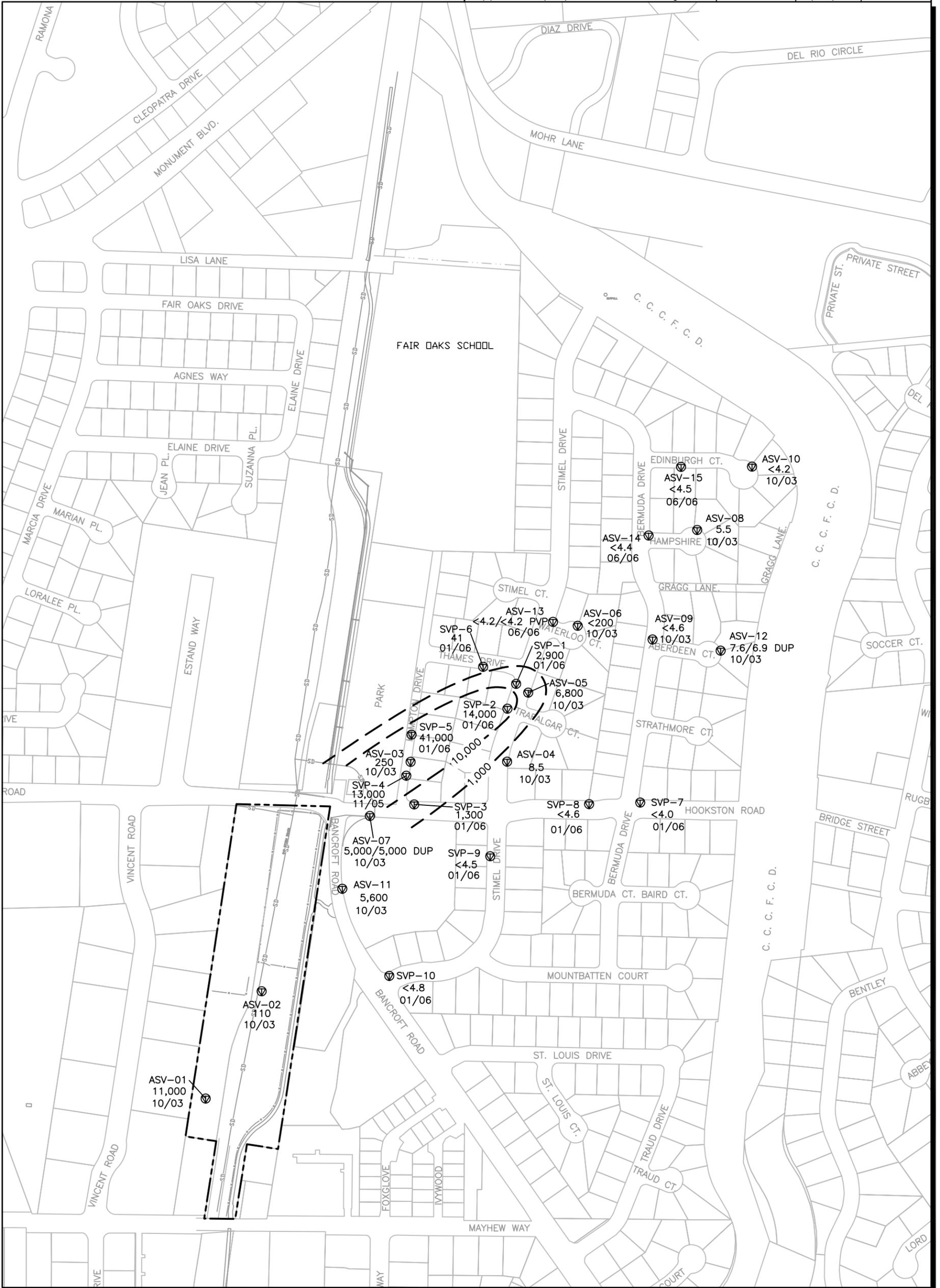
The results were compared with the soil vapor Environmental Screening Levels (ESLs)(Regional Water Quality Control Board 2005) and the California Human Health Screening Levels (CHHSLs)(California Environmental Protection Agency 2005) for residential land use scenarios. VOCs detected during the June 2006 soil vapor sampling activities did not exceed the ESLs or CHHSLs.

REFERENCES

California Environmental Protection Agency. 2005. *Use of California Human Health Screening Levels in Evaluation of Contaminated Properties*. January 2005.

Regional Water Quality Control Board. 2005. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, Volume 1: Summary Tier 1 Lookup Tables*. Interim Final February 2005.

Figure



LEGEND	
	Soil Vapor Monitoring Probe Location
	Hookston Station Parcel Property Boundary
100	TCE Soil Vapor Concentration Contour ($\mu\text{g}/\text{m}^3$)
190	TCE Soil Vapor Concentration ($\mu\text{g}/\text{m}^3$)
DUP	Duplicate
NS	Not Sampled

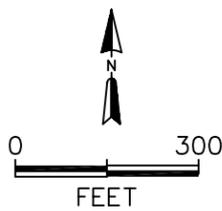


Figure B-1
*TCE in Active Soil Vapor Samples
 October 2003 - June 2006
 Hookston Station
 Pleasant Hill, California*

Table

Table B-1
June 2006 Active Soil Gas Sampling Results
Hookston Station
Pleasant Hill, California

Location	Date	Depth (feet)	Laboratory	Analytical Method	PCE (µg/m ³)	TCE (µg/m ³)	cis-1,2-DCE (µg/m ³)	trans-1,2-DCE (µg/m ³)	1,1-DCE (µg/m ³)	1,3-butadiene (µg/m ³)	Hexane (µg/m ³)	Cyclohexane (µg/m ³)	Heptane (µg/m ³)	CDS (µg/m ³)	Acetone (µg/m ³)	Benzene (µg/m ³)	2-Butanone (µg/m ³)	Ethyl Benzene (µg/m ³)
Residential Land Use Samples																		
				<i>RWQCB Residential ESL</i>	410	1,200	7,300	15,000	42,000	-	-	-	-	-	73,000	84	2,400	2,200
				<i>California Residential CHHSL</i>	180	528	15,900	31,900	-	-	-	-	-	-	-	36.2	-	-
ASV-13	6/1/2006	5	ATL	TO-15	<5.4	<4.2	<3.1	<3.1	<3.1	<1.7	<2.8	<2.7	<3.2	<2.5	<7.5	<2.5	<2.3	<3.4
ASV-13 Dup	6/1/2006	5	ATL	TO-15	<5.4	<4.2	<3.1	<3.1	<3.1	<1.7	<2.8	<2.7	<3.2	<2.5	<7.5	<2.5	<2.3	<3.4
ASV-14	6/1/2006	5	ATL	TO-15	<5.6	<4.4	<3.2	<3.2	<3.2	15	26	3.0	6.2	3.0	120	7.2	29	9.7
ASV-15	6/1/2006	5	ATL	TO-15	<5.7	<4.5	<3.3	<3.3	<3.3	6.2	28	<2.9	<3.4	<2.6	34	<2.7	4.2	13
Ambient Air Samples																		
Ambient Air	6/1/2006	ambient air	ATL	TO-15	<5.9	<4.7	<3.5	<3.5	<3.5	<1.9	<3.1	<3.0	<3.6	<2.7	<8.3	<2.8	<2.6	<3.8

Notes:

ATL = Air Toxics, Ltd.
 CalEPA = California Environmental Protection Agency
 CDS = carbon disulfide
 CHHSL = CalEPA Human Health Screening Level for soil vapor (CalEPA 2005)
 DCE = Dichloroethene
 Dup = duplicate sample
 ESL = Environmental Screening Level for soil vapor (RWQCB 2005)
 PCE = Tetrachloroethene
 RWQCB = Regional Water Quality Control Board
 TCE = Trichloroethene
 TMB = Trimethylbenzene
 U = Qualified as non-detect. Common laboratory contaminants at concentrations less than 10 times the practical quantitation limit.
 µg/m³ = micrograms per cubic meter
 2-Propanol was used for detecting leaks within the sampling system.

Table B-1
June 2006 Active Soil Gas Sampling Results
Hookston Station
Pleasant Hill, California

Location	Date	Depth (feet)	Laboratory	Analytical Method	4-ethyltoluene (µg/m ³)	Toluene (µg/m ³)	m-&p-Xylenes (µg/m ³)	o-Xylene (µg/m ³)	Ethanol (µg/m ³)	2-Propanol (µg/m ³)	Tetrahydrofuran (µg/m ³)	4-methyl-2-pentanone (µg/m ³)	Propylbenzene (µg/m ³)	1,3,5-TMB (µg/m ³)	1,2,4-TMB (µg/m ³)
Residential Land Use Samples															
				<i>RWQCB Residential ESL</i>	-	83,000	-	-	19,000,000	-	-	-	-	-	-
				<i>California Residential CHHSL</i>	-	135,000	317,000	315,000	-	-	-	-	-	-	-
ASV-13	6/1/2006	5	ATL	TO-15	9.5	<3.0	9.7	4.5	<6.0	250	<2.3	<3.2	<3.9	4.7	18
ASV-13 Dup	6/1/2006	5	ATL	TO-15	10	<3.0	9.6	4.5	<6.0	250	<2.3	<3.2	<3.9	4.8	18
ASV-14	6/1/2006	5	ATL	TO-15	30	11	47	23	21	28	3.1	3.7	4.9	17	59
ASV-15	6/1/2006	5	ATL	TO-15	52	8.6	80	38	9.3	30	<2.5	<3.4	9.1	22	71
Ambient Air Samples															
Ambient Air	6/1/2006	ambient air	ATL	TO-15	<4.3	<3.3	<3.8	<3.8	<6.6	<8.6	<2.6	<3.6	<4.3	<4.3	<4.3

Notes:

ATL = Air Toxics, Ltd.
 CalEPA = California Environmental Protection Agency
 CDS = carbon disulfide
 CHHSL = CalEPA Human Health Screening Level for soil vapor (CalEPA 2005)
 DCE = Dichloroethene
 Dup = duplicate sample
 ESL = Environmental Screening Level for soil vapor (RWQCB 2005)
 PCE = Tetrachloroethene
 RWQCB = Regional Water Quality Control Board
 TCE = Trichloroethene
 TMB = Trimethylbenzene
 U = Qualified as non-detect. Common laboratory contaminants at concentrations less than 10 times the practical quantitation limit.
 µg/m³ = micrograms per cubic meter
 2-Propanol was used for detecting leaks within the sampling system.

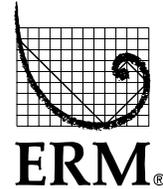
Attachment A
Soil Vapor Laboratory Analytical Report
and Data Quality Review

Memorandum

Environmental
Resources
Management

To: Kimberly Lake
From: Jackie Luta
Date: 21 June 2006
Subject: Data Review of UPRR Hookston Station Samples
Collected 01 June 2006
Project Number: 0020557.10
Data Package: Air Toxics Data Package 0606023

1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596
(925) 946-0455
(925) 946-9968 (fax)



The quality of the data was assessed and any necessary qualifiers were applied following the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, October 1999.

HOLDING TIME AND PRESERVATION EVALUATION

The samples were prepared and analyzed within the method prescribed time period from the date of collection. None of the data were qualified based on holding time exceedances.

BLANK EVALUATION

The method blank and trip blank sample results were nondetected for each of the target analytes. The ambient air sample had no detections of target analytes. No data required qualification based on blank results.

BLANK SPIKE EVALUATION

The laboratory control sample (LCS) percent recoveries (%R) were within the laboratory's limits of acceptance. No data required qualification based on LCS recoveries.

SURROGATE SPIKE EVALUATION

The surrogate recoveries were within acceptable limits. No qualifications to the data were made. The surrogate recoveries indicate minimal matrix interference in the samples.

FIELD DUPLICATE EVALUATION

One field duplicate sample was collected and submitted for analysis. ERM calculated the RPDs between detected results. The USEPA has not established control criteria for duplicate samples; therefore, sample data are not qualified on the basis of duplicate imprecision. The RPDs were less than 10 percent, indicating sample homogeneity. These RPDs are presented in Table 1.

OVERALL ASSESSMENT

No data required qualification or rejection. All of the data can be used for decision-making purposes. The quality of the data generated during this investigation is acceptable for the preparation of technically defensible documents.

Table 1
Field Duplicate Results and Calculated Relative Percent Differences
Hookston Station
Pleasant Hill, California

Lab Package	Sample ID	Compound	Concentration		Report	Units	RPD (%)
			Sample	Duplicate	Limit		
0606023	ASV-13	2-Propanol	250	250	7.8	µg/m ³	0
0606023	ASV-13	m,p-Xylene	9.7	9.6	3.4	µg/m ³	1.0
0606023	ASV-13	o-Xylene	4.5	4.5	3.4	µg/m ³	0
0606023	ASV-13	4-Ethyltoluene	9.5	10	3.9	µg/m ³	5.1
0606023	ASV-13	1,3,5-Trimethylbenzene	4.7	4.8	3.9	µg/m ³	2.1
0606023	ASV-13	1,2,4-Trimethylbenzene	18	18	3.9	µg/m ³	0

Key:

NC = Not calculated, one result was detected and the other result was nondetected

µg/m³ = Micrograms per cubic meter

RPD = Relative percent difference

Air Toxics Ltd. Introduces the Electronic Report

Thank you for choosing Air Toxics Ltd. To better serve our customers, we are providing your report by e-mail. This document is provided in Portable Document Format which can be viewed with Acrobat Reader by Adobe.

This electronic report includes the following:

- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

WORK ORDER #: 0606023

Work Order Summary

CLIENT: Ms. Kimberly Lake
ERM-West
1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596

BILL TO: Mr. Alan Nye
Center for Toxicology and Environmental
Health
615 West Markham Street
Little Rock, AR 72201

PHONE: 925-946-0455

FAX: 925-946-9968

DATE RECEIVED: 06/02/2006

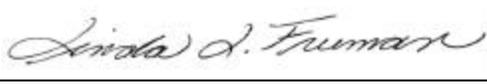
DATE COMPLETED: 06/05/2006

P.O. # 0020557.10

PROJECT # 0020557.10 Hookston Station

CONTACT: Nicole Danbacher

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>RECEIPT VAC./PRES.</u>
01A	ASV-14	Modified TO-15	5.5 "Hg
02A	Ambient Air 6-1-06	Modified TO-15	7.0 "Hg
02AA	Ambient Air 6-1-06 Duplicate	Modified TO-15	7.0 "Hg
03A	ASV-15	Modified TO-15	6.0 "Hg
04A	ASV-13	Modified TO-15	4.5 "Hg
05A	ASV-13-DUP	Modified TO-15	4.5 "Hg
06A	Lab Blank	Modified TO-15	NA
07A	CCV	Modified TO-15	NA
08A	LCS	Modified TO-15	NA

CERTIFIED BY: 

DATE: 06/05/06

Laboratory Director

Certification numbers: CA NELAP - 02110CA, LA NELAP/LELAP- AI 30763, NJ NELAP - CA004
NY NELAP - 11291, UT NELAP - 9166389892

Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/05, Expiration date: 06/30/06
Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

This report shall not be reproduced, except in full, without the written approval of Air Toxics Ltd.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Modified TO-15
ERM-West
Workorder# 0606023

Five 6 Liter Summa Canister samples were received on June 02, 2006. The laboratory performed analysis via modified EPA Method TO-15 using GC/MS in the full scan mode. The method involves concentrating up to 0.2 liters of air. The concentrated aliquot is then flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passes directly into the GC/MS for analysis.

Method modifications taken to run these samples are summarized in the below table. Specific project requirements may over-ride the ATL modifications.

<i>Requirement</i>	<i>TO-15</i>	<i>ATL Modifications</i>
Daily CCV	+/- 30% Difference	<=/= 30% Difference with two allowed out up to <=/=40%.; flag and narrate outliers
Sample collection media	Summa canister	ATL recommends use of summa canisters to insure data defensibility, but will report results from Tedlar bags at client request
Method Detection Limit	Follow 40CFR Pt.136 App. B	The MDL met all relevant requirements in Method TO-15 (statistical MDL less than the LOQ). The concentration of the spiked replicate may have exceeded 10X the calculated MDL in some cases

Receiving Notes

The Chain of Custody was not relinquished properly. The discrepancy was noted in the Sample Receipt Confirmation email/fax.

Analytical Notes

The reported LCS for each daily batch has been derived from more than one analytical file.

Definition of Data Qualifying Flags

Eight qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

UJ- Non-detected compound associated with low bias in the CCV

N - The identification is based on presumptive evidence.



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File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue



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Summary of Detected Compounds MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

Client Sample ID: ASV-14

Lab ID#: 0606023-01A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,3-Butadiene	0.82	6.8	1.8	15
Ethanol	3.3	11	6.2	21
Acetone	3.3	52	7.8	120
2-Propanol	3.3	11	8.1	28
Carbon Disulfide	0.82	0.95	2.6	3.0
Hexane	0.82	7.4	2.9	26
2-Butanone (Methyl Ethyl Ketone)	0.82	9.8	2.4	29
Tetrahydrofuran	0.82	1.0	2.4	3.1
Cyclohexane	0.82	0.89	2.8	3.0
Benzene	0.82	2.2	2.6	7.2
Heptane	0.82	1.5	3.4	6.2
4-Methyl-2-pentanone	0.82	0.90	3.4	3.7
Toluene	0.82	2.9	3.1	11
Ethyl Benzene	0.82	2.2	3.6	9.7
m,p-Xylene	0.82	11	3.6	47
o-Xylene	0.82	5.4	3.6	23
Propylbenzene	0.82	0.99	4.0	4.9
4-Ethyltoluene	0.82	6.0	4.0	30
1,3,5-Trimethylbenzene	0.82	3.4	4.0	17
1,2,4-Trimethylbenzene	0.82	12	4.0	59

Client Sample ID: Ambient Air 6-1-06

Lab ID#: 0606023-02A

No Detections Were Found.

Client Sample ID: Ambient Air 6-1-06 Duplicate

Lab ID#: 0606023-02AA

No Detections Were Found.

Client Sample ID: ASV-15

Lab ID#: 0606023-03A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,3-Butadiene	0.84	2.8	1.8	6.2
Ethanol	3.4	4.9	6.3	9.3



AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

Summary of Detected Compounds MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

Client Sample ID: ASV-15

Lab ID#: 0606023-03A

Acetone	3.4	14	8.0	34
2-Propanol	3.4	12	8.2	30
Hexane	0.84	8.0	3.0	28
2-Butanone (Methyl Ethyl Ketone)	0.84	1.4	2.5	4.2
Toluene	0.84	2.3	3.2	8.6
Ethyl Benzene	0.84	2.9	3.6	13
m,p-Xylene	0.84	18	3.6	80
o-Xylene	0.84	8.9	3.6	38
Propylbenzene	0.84	1.8	4.1	9.1
4-Ethyltoluene	0.84	11	4.1	52
1,3,5-Trimethylbenzene	0.84	4.4	4.1	22
1,2,4-Trimethylbenzene	0.84	14	4.1	71

Client Sample ID: ASV-13

Lab ID#: 0606023-04A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
2-Propanol	3.2	100	7.8	250
m,p-Xylene	0.79	2.2	3.4	9.7
o-Xylene	0.79	1.0	3.4	4.5
4-Ethyltoluene	0.79	1.9	3.9	9.5
1,3,5-Trimethylbenzene	0.79	0.95	3.9	4.7
1,2,4-Trimethylbenzene	0.79	3.6	3.9	18

Client Sample ID: ASV-13-DUP

Lab ID#: 0606023-05A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
2-Propanol	3.2	100	7.8	250
m,p-Xylene	0.79	2.2	3.4	9.6
o-Xylene	0.79	1.0	3.4	4.5
4-Ethyltoluene	0.79	2.0	3.9	10
1,3,5-Trimethylbenzene	0.79	0.98	3.9	4.8
1,2,4-Trimethylbenzene	0.79	3.8	3.9	18



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-14

Lab ID#: 0606023-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060411	Date of Collection:	6/1/06
Dil. Factor:	1.64	Date of Analysis:	6/4/06 04:29 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.82	Not Detected	4.0	Not Detected
Freon 114	0.82	Not Detected	5.7	Not Detected
Chloromethane	3.3	Not Detected	6.8	Not Detected
Vinyl Chloride	0.82	Not Detected	2.1	Not Detected
1,3-Butadiene	0.82	6.8	1.8	15
Bromomethane	0.82	Not Detected	3.2	Not Detected
Chloroethane	0.82	Not Detected	2.2	Not Detected
Freon 11	0.82	Not Detected	4.6	Not Detected
Ethanol	3.3	11	6.2	21
Freon 113	0.82	Not Detected	6.3	Not Detected
1,1-Dichloroethene	0.82	Not Detected	3.2	Not Detected
Acetone	3.3	52	7.8	120
2-Propanol	3.3	11	8.1	28
Carbon Disulfide	0.82	0.95	2.6	3.0
3-Chloropropene	3.3	Not Detected	10	Not Detected
Methylene Chloride	0.82	Not Detected	2.8	Not Detected
Methyl tert-butyl ether	0.82	Not Detected	3.0	Not Detected
trans-1,2-Dichloroethene	0.82	Not Detected	3.2	Not Detected
Hexane	0.82	7.4	2.9	26
1,1-Dichloroethane	0.82	Not Detected	3.3	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.82	9.8	2.4	29
cis-1,2-Dichloroethene	0.82	Not Detected	3.2	Not Detected
Tetrahydrofuran	0.82	1.0	2.4	3.1
Chloroform	0.82	Not Detected	4.0	Not Detected
1,1,1-Trichloroethane	0.82	Not Detected	4.5	Not Detected
Cyclohexane	0.82	0.89	2.8	3.0
Carbon Tetrachloride	0.82	Not Detected	5.2	Not Detected
2,2,4-Trimethylpentane	0.82	Not Detected	3.8	Not Detected
Benzene	0.82	2.2	2.6	7.2
1,2-Dichloroethane	0.82	Not Detected	3.3	Not Detected
Heptane	0.82	1.5	3.4	6.2
Trichloroethene	0.82	Not Detected	4.4	Not Detected
1,2-Dichloropropane	0.82	Not Detected	3.8	Not Detected
1,4-Dioxane	3.3	Not Detected	12	Not Detected
Bromodichloromethane	0.82	Not Detected	5.5	Not Detected
cis-1,3-Dichloropropene	0.82	Not Detected	3.7	Not Detected
4-Methyl-2-pentanone	0.82	0.90	3.4	3.7
Toluene	0.82	2.9	3.1	11
trans-1,3-Dichloropropene	0.82	Not Detected	3.7	Not Detected
1,1,2-Trichloroethane	0.82	Not Detected	4.5	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-14

Lab ID#: 0606023-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060411	Date of Collection:	6/1/06
Dil. Factor:	1.64	Date of Analysis:	6/4/06 04:29 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.82	Not Detected	5.6	Not Detected
2-Hexanone	3.3	Not Detected	13	Not Detected
Dibromochloromethane	0.82	Not Detected	7.0	Not Detected
1,2-Dibromoethane (EDB)	0.82	Not Detected	6.3	Not Detected
Chlorobenzene	0.82	Not Detected	3.8	Not Detected
Ethyl Benzene	0.82	2.2	3.6	9.7
m,p-Xylene	0.82	11	3.6	47
o-Xylene	0.82	5.4	3.6	23
Styrene	0.82	Not Detected	3.5	Not Detected
Bromoform	0.82	Not Detected	8.5	Not Detected
Cumene	0.82	Not Detected	4.0	Not Detected
1,1,2,2-Tetrachloroethane	0.82	Not Detected	5.6	Not Detected
Propylbenzene	0.82	0.99	4.0	4.9
4-Ethyltoluene	0.82	6.0	4.0	30
1,3,5-Trimethylbenzene	0.82	3.4	4.0	17
1,2,4-Trimethylbenzene	0.82	12	4.0	59
1,3-Dichlorobenzene	0.82	Not Detected	4.9	Not Detected
1,4-Dichlorobenzene	0.82	Not Detected	4.9	Not Detected
alpha-Chlorotoluene	0.82	Not Detected	4.2	Not Detected
1,2-Dichlorobenzene	0.82	Not Detected	4.9	Not Detected
1,2,4-Trichlorobenzene	3.3	Not Detected	24	Not Detected
Hexachlorobutadiene	3.3	Not Detected	35	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	87	70-130
1,2-Dichloroethane-d4	100	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Ambient Air 6-1-06

Lab ID#: 0606023-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060413	Date of Collection:	6/1/06
Dil. Factor:	1.75	Date of Analysis:	6/4/06 06:20 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.88	Not Detected	4.3	Not Detected
Freon 114	0.88	Not Detected	6.1	Not Detected
Chloromethane	3.5	Not Detected	7.2	Not Detected
Vinyl Chloride	0.88	Not Detected	2.2	Not Detected
1,3-Butadiene	0.88	Not Detected	1.9	Not Detected
Bromomethane	0.88	Not Detected	3.4	Not Detected
Chloroethane	0.88	Not Detected	2.3	Not Detected
Freon 11	0.88	Not Detected	4.9	Not Detected
Ethanol	3.5	Not Detected	6.6	Not Detected
Freon 113	0.88	Not Detected	6.7	Not Detected
1,1-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Acetone	3.5	Not Detected	8.3	Not Detected
2-Propanol	3.5	Not Detected	8.6	Not Detected
Carbon Disulfide	0.88	Not Detected	2.7	Not Detected
3-Chloropropene	3.5	Not Detected	11	Not Detected
Methylene Chloride	0.88	Not Detected	3.0	Not Detected
Methyl tert-butyl ether	0.88	Not Detected	3.2	Not Detected
trans-1,2-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Hexane	0.88	Not Detected	3.1	Not Detected
1,1-Dichloroethane	0.88	Not Detected	3.5	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.88	Not Detected	2.6	Not Detected
cis-1,2-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Tetrahydrofuran	0.88	Not Detected	2.6	Not Detected
Chloroform	0.88	Not Detected	4.3	Not Detected
1,1,1-Trichloroethane	0.88	Not Detected	4.8	Not Detected
Cyclohexane	0.88	Not Detected	3.0	Not Detected
Carbon Tetrachloride	0.88	Not Detected	5.5	Not Detected
2,2,4-Trimethylpentane	0.88	Not Detected	4.1	Not Detected
Benzene	0.88	Not Detected	2.8	Not Detected
1,2-Dichloroethane	0.88	Not Detected	3.5	Not Detected
Heptane	0.88	Not Detected	3.6	Not Detected
Trichloroethene	0.88	Not Detected	4.7	Not Detected
1,2-Dichloropropane	0.88	Not Detected	4.0	Not Detected
1,4-Dioxane	3.5	Not Detected	13	Not Detected
Bromodichloromethane	0.88	Not Detected	5.9	Not Detected
cis-1,3-Dichloropropene	0.88	Not Detected	4.0	Not Detected
4-Methyl-2-pentanone	0.88	Not Detected	3.6	Not Detected
Toluene	0.88	Not Detected	3.3	Not Detected
trans-1,3-Dichloropropene	0.88	Not Detected	4.0	Not Detected
1,1,2-Trichloroethane	0.88	Not Detected	4.8	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Ambient Air 6-1-06

Lab ID#: 0606023-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060413	Date of Collection:	6/1/06
Dil. Factor:	1.75	Date of Analysis:	6/4/06 06:20 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.88	Not Detected	5.9	Not Detected
2-Hexanone	3.5	Not Detected	14	Not Detected
Dibromochloromethane	0.88	Not Detected	7.4	Not Detected
1,2-Dibromoethane (EDB)	0.88	Not Detected	6.7	Not Detected
Chlorobenzene	0.88	Not Detected	4.0	Not Detected
Ethyl Benzene	0.88	Not Detected	3.8	Not Detected
m,p-Xylene	0.88	Not Detected	3.8	Not Detected
o-Xylene	0.88	Not Detected	3.8	Not Detected
Styrene	0.88	Not Detected	3.7	Not Detected
Bromoform	0.88	Not Detected	9.0	Not Detected
Cumene	0.88	Not Detected	4.3	Not Detected
1,1,2,2-Tetrachloroethane	0.88	Not Detected	6.0	Not Detected
Propylbenzene	0.88	Not Detected	4.3	Not Detected
4-Ethyltoluene	0.88	Not Detected	4.3	Not Detected
1,3,5-Trimethylbenzene	0.88	Not Detected	4.3	Not Detected
1,2,4-Trimethylbenzene	0.88	Not Detected	4.3	Not Detected
1,3-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
1,4-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
alpha-Chlorotoluene	0.88	Not Detected	4.5	Not Detected
1,2-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
1,2,4-Trichlorobenzene	3.5	Not Detected	26	Not Detected
Hexachlorobutadiene	3.5	Not Detected	37	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	86	70-130
1,2-Dichloroethane-d4	103	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Ambient Air 6-1-06 Duplicate

Lab ID#: 0606023-02AA

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060417	Date of Collection:	6/1/06
Dil. Factor:	1.75	Date of Analysis:	6/4/06 09:04 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.88	Not Detected	4.3	Not Detected
Freon 114	0.88	Not Detected	6.1	Not Detected
Chloromethane	3.5	Not Detected	7.2	Not Detected
Vinyl Chloride	0.88	Not Detected	2.2	Not Detected
1,3-Butadiene	0.88	Not Detected	1.9	Not Detected
Bromomethane	0.88	Not Detected	3.4	Not Detected
Chloroethane	0.88	Not Detected	2.3	Not Detected
Freon 11	0.88	Not Detected	4.9	Not Detected
Ethanol	3.5	Not Detected	6.6	Not Detected
Freon 113	0.88	Not Detected	6.7	Not Detected
1,1-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Acetone	3.5	Not Detected	8.3	Not Detected
2-Propanol	3.5	Not Detected	8.6	Not Detected
Carbon Disulfide	0.88	Not Detected	2.7	Not Detected
3-Chloropropene	3.5	Not Detected	11	Not Detected
Methylene Chloride	0.88	Not Detected	3.0	Not Detected
Methyl tert-butyl ether	0.88	Not Detected	3.2	Not Detected
trans-1,2-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Hexane	0.88	Not Detected	3.1	Not Detected
1,1-Dichloroethane	0.88	Not Detected	3.5	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.88	Not Detected	2.6	Not Detected
cis-1,2-Dichloroethene	0.88	Not Detected	3.5	Not Detected
Tetrahydrofuran	0.88	Not Detected	2.6	Not Detected
Chloroform	0.88	Not Detected	4.3	Not Detected
1,1,1-Trichloroethane	0.88	Not Detected	4.8	Not Detected
Cyclohexane	0.88	Not Detected	3.0	Not Detected
Carbon Tetrachloride	0.88	Not Detected	5.5	Not Detected
2,2,4-Trimethylpentane	0.88	Not Detected	4.1	Not Detected
Benzene	0.88	Not Detected	2.8	Not Detected
1,2-Dichloroethane	0.88	Not Detected	3.5	Not Detected
Heptane	0.88	Not Detected	3.6	Not Detected
Trichloroethene	0.88	Not Detected	4.7	Not Detected
1,2-Dichloropropane	0.88	Not Detected	4.0	Not Detected
1,4-Dioxane	3.5	Not Detected	13	Not Detected
Bromodichloromethane	0.88	Not Detected	5.9	Not Detected
cis-1,3-Dichloropropene	0.88	Not Detected	4.0	Not Detected
4-Methyl-2-pentanone	0.88	Not Detected	3.6	Not Detected
Toluene	0.88	Not Detected	3.3	Not Detected
trans-1,3-Dichloropropene	0.88	Not Detected	4.0	Not Detected
1,1,2-Trichloroethane	0.88	Not Detected	4.8	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Ambient Air 6-1-06 Duplicate

Lab ID#: 0606023-02AA

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060417	Date of Collection:	6/1/06
Dil. Factor:	1.75	Date of Analysis:	6/4/06 09:04 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.88	Not Detected	5.9	Not Detected
2-Hexanone	3.5	Not Detected	14	Not Detected
Dibromochloromethane	0.88	Not Detected	7.4	Not Detected
1,2-Dibromoethane (EDB)	0.88	Not Detected	6.7	Not Detected
Chlorobenzene	0.88	Not Detected	4.0	Not Detected
Ethyl Benzene	0.88	Not Detected	3.8	Not Detected
m,p-Xylene	0.88	Not Detected	3.8	Not Detected
o-Xylene	0.88	Not Detected	3.8	Not Detected
Styrene	0.88	Not Detected	3.7	Not Detected
Bromoform	0.88	Not Detected	9.0	Not Detected
Cumene	0.88	Not Detected	4.3	Not Detected
1,1,2,2-Tetrachloroethane	0.88	Not Detected	6.0	Not Detected
Propylbenzene	0.88	Not Detected	4.3	Not Detected
4-Ethyltoluene	0.88	Not Detected	4.3	Not Detected
1,3,5-Trimethylbenzene	0.88	Not Detected	4.3	Not Detected
1,2,4-Trimethylbenzene	0.88	Not Detected	4.3	Not Detected
1,3-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
1,4-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
alpha-Chlorotoluene	0.88	Not Detected	4.5	Not Detected
1,2-Dichlorobenzene	0.88	Not Detected	5.3	Not Detected
1,2,4-Trichlorobenzene	3.5	Not Detected	26	Not Detected
Hexachlorobutadiene	3.5	Not Detected	37	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	85	70-130
1,2-Dichloroethane-d4	100	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-15

Lab ID#: 0606023-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060414	Date of Collection:	6/1/06
Dil. Factor:	1.68	Date of Analysis:	6/4/06 07:00 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.84	Not Detected	4.2	Not Detected
Freon 114	0.84	Not Detected	5.9	Not Detected
Chloromethane	3.4	Not Detected	6.9	Not Detected
Vinyl Chloride	0.84	Not Detected	2.1	Not Detected
1,3-Butadiene	0.84	2.8	1.8	6.2
Bromomethane	0.84	Not Detected	3.3	Not Detected
Chloroethane	0.84	Not Detected	2.2	Not Detected
Freon 11	0.84	Not Detected	4.7	Not Detected
Ethanol	3.4	4.9	6.3	9.3
Freon 113	0.84	Not Detected	6.4	Not Detected
1,1-Dichloroethene	0.84	Not Detected	3.3	Not Detected
Acetone	3.4	14	8.0	34
2-Propanol	3.4	12	8.2	30
Carbon Disulfide	0.84	Not Detected	2.6	Not Detected
3-Chloropropene	3.4	Not Detected	10	Not Detected
Methylene Chloride	0.84	Not Detected	2.9	Not Detected
Methyl tert-butyl ether	0.84	Not Detected	3.0	Not Detected
trans-1,2-Dichloroethene	0.84	Not Detected	3.3	Not Detected
Hexane	0.84	8.0	3.0	28
1,1-Dichloroethane	0.84	Not Detected	3.4	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.84	1.4	2.5	4.2
cis-1,2-Dichloroethene	0.84	Not Detected	3.3	Not Detected
Tetrahydrofuran	0.84	Not Detected	2.5	Not Detected
Chloroform	0.84	Not Detected	4.1	Not Detected
1,1,1-Trichloroethane	0.84	Not Detected	4.6	Not Detected
Cyclohexane	0.84	Not Detected	2.9	Not Detected
Carbon Tetrachloride	0.84	Not Detected	5.3	Not Detected
2,2,4-Trimethylpentane	0.84	Not Detected	3.9	Not Detected
Benzene	0.84	Not Detected	2.7	Not Detected
1,2-Dichloroethane	0.84	Not Detected	3.4	Not Detected
Heptane	0.84	Not Detected	3.4	Not Detected
Trichloroethene	0.84	Not Detected	4.5	Not Detected
1,2-Dichloropropane	0.84	Not Detected	3.9	Not Detected
1,4-Dioxane	3.4	Not Detected	12	Not Detected
Bromodichloromethane	0.84	Not Detected	5.6	Not Detected
cis-1,3-Dichloropropene	0.84	Not Detected	3.8	Not Detected
4-Methyl-2-pentanone	0.84	Not Detected	3.4	Not Detected
Toluene	0.84	2.3	3.2	8.6
trans-1,3-Dichloropropene	0.84	Not Detected	3.8	Not Detected
1,1,2-Trichloroethane	0.84	Not Detected	4.6	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-15

Lab ID#: 0606023-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060414	Date of Collection:	6/1/06
Dil. Factor:	1.68	Date of Analysis:	6/4/06 07:00 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.84	Not Detected	5.7	Not Detected
2-Hexanone	3.4	Not Detected	14	Not Detected
Dibromochloromethane	0.84	Not Detected	7.2	Not Detected
1,2-Dibromoethane (EDB)	0.84	Not Detected	6.4	Not Detected
Chlorobenzene	0.84	Not Detected	3.9	Not Detected
Ethyl Benzene	0.84	2.9	3.6	13
m,p-Xylene	0.84	18	3.6	80
o-Xylene	0.84	8.9	3.6	38
Styrene	0.84	Not Detected	3.6	Not Detected
Bromoform	0.84	Not Detected	8.7	Not Detected
Cumene	0.84	Not Detected	4.1	Not Detected
1,1,2,2-Tetrachloroethane	0.84	Not Detected	5.8	Not Detected
Propylbenzene	0.84	1.8	4.1	9.1
4-Ethyltoluene	0.84	11	4.1	52
1,3,5-Trimethylbenzene	0.84	4.4	4.1	22
1,2,4-Trimethylbenzene	0.84	14	4.1	71
1,3-Dichlorobenzene	0.84	Not Detected	5.0	Not Detected
1,4-Dichlorobenzene	0.84	Not Detected	5.0	Not Detected
alpha-Chlorotoluene	0.84	Not Detected	4.3	Not Detected
1,2-Dichlorobenzene	0.84	Not Detected	5.0	Not Detected
1,2,4-Trichlorobenzene	3.4	Not Detected	25	Not Detected
Hexachlorobutadiene	3.4	Not Detected	36	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	85	70-130
1,2-Dichloroethane-d4	103	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-13

Lab ID#: 0606023-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060415	Date of Collection:	6/1/06
Dil. Factor:	1.58	Date of Analysis:	6/4/06 07:43 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.79	Not Detected	3.9	Not Detected
Freon 114	0.79	Not Detected	5.5	Not Detected
Chloromethane	3.2	Not Detected	6.5	Not Detected
Vinyl Chloride	0.79	Not Detected	2.0	Not Detected
1,3-Butadiene	0.79	Not Detected	1.7	Not Detected
Bromomethane	0.79	Not Detected	3.1	Not Detected
Chloroethane	0.79	Not Detected	2.1	Not Detected
Freon 11	0.79	Not Detected	4.4	Not Detected
Ethanol	3.2	Not Detected	6.0	Not Detected
Freon 113	0.79	Not Detected	6.0	Not Detected
1,1-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Acetone	3.2	Not Detected	7.5	Not Detected
2-Propanol	3.2	100	7.8	250
Carbon Disulfide	0.79	Not Detected	2.5	Not Detected
3-Chloropropene	3.2	Not Detected	9.9	Not Detected
Methylene Chloride	0.79	Not Detected	2.7	Not Detected
Methyl tert-butyl ether	0.79	Not Detected	2.8	Not Detected
trans-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Hexane	0.79	Not Detected	2.8	Not Detected
1,1-Dichloroethane	0.79	Not Detected	3.2	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.79	Not Detected	2.3	Not Detected
cis-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Tetrahydrofuran	0.79	Not Detected	2.3	Not Detected
Chloroform	0.79	Not Detected	3.8	Not Detected
1,1,1-Trichloroethane	0.79	Not Detected	4.3	Not Detected
Cyclohexane	0.79	Not Detected	2.7	Not Detected
Carbon Tetrachloride	0.79	Not Detected	5.0	Not Detected
2,2,4-Trimethylpentane	0.79	Not Detected	3.7	Not Detected
Benzene	0.79	Not Detected	2.5	Not Detected
1,2-Dichloroethane	0.79	Not Detected	3.2	Not Detected
Heptane	0.79	Not Detected	3.2	Not Detected
Trichloroethene	0.79	Not Detected	4.2	Not Detected
1,2-Dichloropropane	0.79	Not Detected	3.6	Not Detected
1,4-Dioxane	3.2	Not Detected	11	Not Detected
Bromodichloromethane	0.79	Not Detected	5.3	Not Detected
cis-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected
4-Methyl-2-pentanone	0.79	Not Detected	3.2	Not Detected
Toluene	0.79	Not Detected	3.0	Not Detected
trans-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected
1,1,2-Trichloroethane	0.79	Not Detected	4.3	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-13

Lab ID#: 0606023-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060415	Date of Collection:	6/1/06
Dil. Factor:	1.58	Date of Analysis:	6/4/06 07:43 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.79	Not Detected	5.4	Not Detected
2-Hexanone	3.2	Not Detected	13	Not Detected
Dibromochloromethane	0.79	Not Detected	6.7	Not Detected
1,2-Dibromoethane (EDB)	0.79	Not Detected	6.1	Not Detected
Chlorobenzene	0.79	Not Detected	3.6	Not Detected
Ethyl Benzene	0.79	Not Detected	3.4	Not Detected
m,p-Xylene	0.79	2.2	3.4	9.7
o-Xylene	0.79	1.0	3.4	4.5
Styrene	0.79	Not Detected	3.4	Not Detected
Bromoform	0.79	Not Detected	8.2	Not Detected
Cumene	0.79	Not Detected	3.9	Not Detected
1,1,2,2-Tetrachloroethane	0.79	Not Detected	5.4	Not Detected
Propylbenzene	0.79	Not Detected	3.9	Not Detected
4-Ethyltoluene	0.79	1.9	3.9	9.5
1,3,5-Trimethylbenzene	0.79	0.95	3.9	4.7
1,2,4-Trimethylbenzene	0.79	3.6	3.9	18
1,3-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
1,4-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
alpha-Chlorotoluene	0.79	Not Detected	4.1	Not Detected
1,2-Dichlorobenzene	0.79	Not Detected	4.7	Not Detected
1,2,4-Trichlorobenzene	3.2	Not Detected	23	Not Detected
Hexachlorobutadiene	3.2	Not Detected	34	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	84	70-130
1,2-Dichloroethane-d4	102	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-13-DUP

Lab ID#: 0606023-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060416	Date of Collection:	6/1/06
Dil. Factor:	1.58	Date of Analysis:	6/4/06 08:22 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.79	Not Detected	3.9	Not Detected
Freon 114	0.79	Not Detected	5.5	Not Detected
Chloromethane	3.2	Not Detected	6.5	Not Detected
Vinyl Chloride	0.79	Not Detected	2.0	Not Detected
1,3-Butadiene	0.79	Not Detected	1.7	Not Detected
Bromomethane	0.79	Not Detected	3.1	Not Detected
Chloroethane	0.79	Not Detected	2.1	Not Detected
Freon 11	0.79	Not Detected	4.4	Not Detected
Ethanol	3.2	Not Detected	6.0	Not Detected
Freon 113	0.79	Not Detected	6.0	Not Detected
1,1-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Acetone	3.2	Not Detected	7.5	Not Detected
2-Propanol	3.2	100	7.8	250
Carbon Disulfide	0.79	Not Detected	2.5	Not Detected
3-Chloropropene	3.2	Not Detected	9.9	Not Detected
Methylene Chloride	0.79	Not Detected	2.7	Not Detected
Methyl tert-butyl ether	0.79	Not Detected	2.8	Not Detected
trans-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Hexane	0.79	Not Detected	2.8	Not Detected
1,1-Dichloroethane	0.79	Not Detected	3.2	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.79	Not Detected	2.3	Not Detected
cis-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Tetrahydrofuran	0.79	Not Detected	2.3	Not Detected
Chloroform	0.79	Not Detected	3.8	Not Detected
1,1,1-Trichloroethane	0.79	Not Detected	4.3	Not Detected
Cyclohexane	0.79	Not Detected	2.7	Not Detected
Carbon Tetrachloride	0.79	Not Detected	5.0	Not Detected
2,2,4-Trimethylpentane	0.79	Not Detected	3.7	Not Detected
Benzene	0.79	Not Detected	2.5	Not Detected
1,2-Dichloroethane	0.79	Not Detected	3.2	Not Detected
Heptane	0.79	Not Detected	3.2	Not Detected
Trichloroethene	0.79	Not Detected	4.2	Not Detected
1,2-Dichloropropane	0.79	Not Detected	3.6	Not Detected
1,4-Dioxane	3.2	Not Detected	11	Not Detected
Bromodichloromethane	0.79	Not Detected	5.3	Not Detected
cis-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected
4-Methyl-2-pentanone	0.79	Not Detected	3.2	Not Detected
Toluene	0.79	Not Detected	3.0	Not Detected
trans-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected
1,1,2-Trichloroethane	0.79	Not Detected	4.3	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: ASV-13-DUP

Lab ID#: 0606023-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060416	Date of Collection:	6/1/06
Dil. Factor:	1.58	Date of Analysis:	6/4/06 08:22 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.79	Not Detected	5.4	Not Detected
2-Hexanone	3.2	Not Detected	13	Not Detected
Dibromochloromethane	0.79	Not Detected	6.7	Not Detected
1,2-Dibromoethane (EDB)	0.79	Not Detected	6.1	Not Detected
Chlorobenzene	0.79	Not Detected	3.6	Not Detected
Ethyl Benzene	0.79	Not Detected	3.4	Not Detected
m,p-Xylene	0.79	2.2	3.4	9.6
o-Xylene	0.79	1.0	3.4	4.5
Styrene	0.79	Not Detected	3.4	Not Detected
Bromoform	0.79	Not Detected	8.2	Not Detected
Cumene	0.79	Not Detected	3.9	Not Detected
1,1,2,2-Tetrachloroethane	0.79	Not Detected	5.4	Not Detected
Propylbenzene	0.79	Not Detected	3.9	Not Detected
4-Ethyltoluene	0.79	2.0	3.9	10
1,3,5-Trimethylbenzene	0.79	0.98	3.9	4.8
1,2,4-Trimethylbenzene	0.79	3.8	3.9	18
1,3-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
1,4-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
alpha-Chlorotoluene	0.79	Not Detected	4.1	Not Detected
1,2-Dichlorobenzene	0.79	Not Detected	4.7	Not Detected
1,2,4-Trichlorobenzene	3.2	Not Detected	23	Not Detected
Hexachlorobutadiene	3.2	Not Detected	34	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	85	70-130
1,2-Dichloroethane-d4	101	70-130
4-Bromofluorobenzene	101	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0606023-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060405	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	6/4/06 12:01 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.50	Not Detected	2.5	Not Detected
Freon 114	0.50	Not Detected	3.5	Not Detected
Chloromethane	2.0	Not Detected	4.1	Not Detected
Vinyl Chloride	0.50	Not Detected	1.3	Not Detected
1,3-Butadiene	0.50	Not Detected	1.1	Not Detected
Bromomethane	0.50	Not Detected	1.9	Not Detected
Chloroethane	0.50	Not Detected	1.3	Not Detected
Freon 11	0.50	Not Detected	2.8	Not Detected
Ethanol	2.0	Not Detected	3.8	Not Detected
Freon 113	0.50	Not Detected	3.8	Not Detected
1,1-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Acetone	2.0	Not Detected	4.8	Not Detected
2-Propanol	2.0	Not Detected	4.9	Not Detected
Carbon Disulfide	0.50	Not Detected	1.6	Not Detected
3-Chloropropene	2.0	Not Detected	6.3	Not Detected
Methylene Chloride	0.50	Not Detected	1.7	Not Detected
Methyl tert-butyl ether	0.50	Not Detected	1.8	Not Detected
trans-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Hexane	0.50	Not Detected	1.8	Not Detected
1,1-Dichloroethane	0.50	Not Detected	2.0	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.50	Not Detected	1.5	Not Detected
cis-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Tetrahydrofuran	0.50	Not Detected	1.5	Not Detected
Chloroform	0.50	Not Detected	2.4	Not Detected
1,1,1-Trichloroethane	0.50	Not Detected	2.7	Not Detected
Cyclohexane	0.50	Not Detected	1.7	Not Detected
Carbon Tetrachloride	0.50	Not Detected	3.1	Not Detected
2,2,4-Trimethylpentane	0.50	Not Detected	2.3	Not Detected
Benzene	0.50	Not Detected	1.6	Not Detected
1,2-Dichloroethane	0.50	Not Detected	2.0	Not Detected
Heptane	0.50	Not Detected	2.0	Not Detected
Trichloroethene	0.50	Not Detected	2.7	Not Detected
1,2-Dichloropropane	0.50	Not Detected	2.3	Not Detected
1,4-Dioxane	2.0	Not Detected	7.2	Not Detected
Bromodichloromethane	0.50	Not Detected	3.4	Not Detected
cis-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
4-Methyl-2-pentanone	0.50	Not Detected	2.0	Not Detected
Toluene	0.50	Not Detected	1.9	Not Detected
trans-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
1,1,2-Trichloroethane	0.50	Not Detected	2.7	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0606023-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060405	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	6/4/06 12:01 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.50	Not Detected	3.4	Not Detected
2-Hexanone	2.0	Not Detected	8.2	Not Detected
Dibromochloromethane	0.50	Not Detected	4.2	Not Detected
1,2-Dibromoethane (EDB)	0.50	Not Detected	3.8	Not Detected
Chlorobenzene	0.50	Not Detected	2.3	Not Detected
Ethyl Benzene	0.50	Not Detected	2.2	Not Detected
m,p-Xylene	0.50	Not Detected	2.2	Not Detected
o-Xylene	0.50	Not Detected	2.2	Not Detected
Styrene	0.50	Not Detected	2.1	Not Detected
Bromoform	0.50	Not Detected	5.2	Not Detected
Cumene	0.50	Not Detected	2.4	Not Detected
1,1,2,2-Tetrachloroethane	0.50	Not Detected	3.4	Not Detected
Propylbenzene	0.50	Not Detected	2.4	Not Detected
4-Ethyltoluene	0.50	Not Detected	2.4	Not Detected
1,3,5-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,2,4-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,3-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,4-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
alpha-Chlorotoluene	0.50	Not Detected	2.6	Not Detected
1,2-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,2,4-Trichlorobenzene	2.0	Not Detected	15	Not Detected
Hexachlorobutadiene	2.0	Not Detected	21	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	86	70-130
1,2-Dichloroethane-d4	102	70-130
4-Bromofluorobenzene	102	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0606023-07A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 6/4/06 09:47 AM

Compound	%Recovery
Freon 12	112
Freon 114	114
Chloromethane	128
Vinyl Chloride	105
1,3-Butadiene	100
Bromomethane	114
Chloroethane	107
Freon 11	113
Ethanol	104
Freon 113	108
1,1-Dichloroethene	105
Acetone	96
2-Propanol	107
Carbon Disulfide	101
3-Chloropropene	98
Methylene Chloride	108
Methyl tert-butyl ether	99
trans-1,2-Dichloroethene	102
Hexane	99
1,1-Dichloroethane	104
2-Butanone (Methyl Ethyl Ketone)	103
cis-1,2-Dichloroethene	105
Tetrahydrofuran	112
Chloroform	114
1,1,1-Trichloroethane	107
Cyclohexane	99
Carbon Tetrachloride	113
2,2,4-Trimethylpentane	102
Benzene	94
1,2-Dichloroethane	114
Heptane	104
Trichloroethene	108
1,2-Dichloropropane	102
1,4-Dioxane	99
Bromodichloromethane	110
cis-1,3-Dichloropropene	101
4-Methyl-2-pentanone	101
Toluene	98
trans-1,3-Dichloropropene	111
1,1,2-Trichloroethane	109



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0606023-07A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 6/4/06 09:47 AM

Compound	%Recovery
Tetrachloroethene	112
2-Hexanone	108
Dibromochloromethane	120
1,2-Dibromoethane (EDB)	111
Chlorobenzene	110
Ethyl Benzene	106
m,p-Xylene	113
o-Xylene	105
Styrene	109
Bromoform	127
Cumene	114
1,1,2,2-Tetrachloroethane	107
Propylbenzene	108
4-Ethyltoluene	109
1,3,5-Trimethylbenzene	106
1,2,4-Trimethylbenzene	106
1,3-Dichlorobenzene	109
1,4-Dichlorobenzene	110
alpha-Chlorotoluene	109
1,2-Dichlorobenzene	110
1,2,4-Trichlorobenzene	95
Hexachlorobutadiene	105

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	92	70-130
1,2-Dichloroethane-d4	105	70-130
4-Bromofluorobenzene	103	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0606023-08A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060403	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 6/4/06 10:30 AM

Compound	%Recovery
Freon 12	104
Freon 114	109
Chloromethane	122
Vinyl Chloride	98
1,3-Butadiene	97
Bromomethane	112
Chloroethane	104
Freon 11	109
Ethanol	101
Freon 113	103
1,1-Dichloroethene	101
Acetone	93
2-Propanol	100
Carbon Disulfide	103
3-Chloropropene	107
Methylene Chloride	105
Methyl tert-butyl ether	93
trans-1,2-Dichloroethene	99
Hexane	97
1,1-Dichloroethane	100
2-Butanone (Methyl Ethyl Ketone)	96
cis-1,2-Dichloroethene	101
Tetrahydrofuran	102
Chloroform	109
1,1,1-Trichloroethane	101
Cyclohexane	94
Carbon Tetrachloride	106
2,2,4-Trimethylpentane	108
Benzene	93
1,2-Dichloroethane	111
Heptane	100
Trichloroethene	107
1,2-Dichloropropane	101
1,4-Dioxane	96
Bromodichloromethane	99
cis-1,3-Dichloropropene	80
4-Methyl-2-pentanone	94
Toluene	95
trans-1,3-Dichloropropene	109
1,1,2-Trichloroethane	107



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0606023-08A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	f060403	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 6/4/06 10:30 AM

Compound	%Recovery
Tetrachloroethene	111
2-Hexanone	101
Dibromochloromethane	109
1,2-Dibromoethane (EDB)	108
Chlorobenzene	107
Ethyl Benzene	110
m,p-Xylene	105
o-Xylene	91
Styrene	113
Bromoform	109
Cumene	118
1,1,2,2-Tetrachloroethane	106
Propylbenzene	114
4-Ethyltoluene	111
1,3,5-Trimethylbenzene	94
1,2,4-Trimethylbenzene	75
1,3-Dichlorobenzene	110
1,4-Dichlorobenzene	112
alpha-Chlorotoluene	109
1,2-Dichlorobenzene	112
1,2,4-Trichlorobenzene	115
Hexachlorobutadiene	113

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	93	70-130
1,2-Dichloroethane-d4	104	70-130
4-Bromofluorobenzene	100	70-130



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 AN ENVIRONMENTAL ANALYTICAL LABORATORY

CHAIN-OF-CUSTODY RECORD

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Page 1 of 1

Contact Person: Bridon Bjorklund
 Company: ERWA Email: bridon.bjorklund@erwa.com
 Address: 17779 Botello Dr #220 Walnut Creek CA 94596
 Phone: 925-946-0455 Fax: 925-946-9968
 Collected by: (Signature) Ganni Yi

Project Info:
 P.O. # 0020557.10
 Project # 0020557.10
 Project Name Hoodston Station

Turn Around Time: 3 Normal
 Flush 24 hr
 Date: 12/10/06
 Pressurization Gas: He

Lab I.D.	Field Sample I.D. (Location)	Can#	Date	Time	Analyses Requested	Canister Pressure/Vacuum		
						Initial	Final	Reel/Pr. Final
01A	ASV-14	2266	6-1-06	0922	TD-15 VOCs	-23	-1	5.5 MPa
02A	Ambient Air 6-1-06	94303	6-1-06	0926	TD-15 VOCs	-23	-1.5	1.0 MPa
03A	ASV-15	12911	6-1-06	1142	TD-15 VOCs	-24.5	-0.5	6.0 MPa
04A	ASV-13	94191	6-1-06	1333	TD-15 VOCs	-23.5	-0.5	4.5 MPa
05A	ASV-13-DUP	1852	6-1-06	1333	TD-15 VOCs	-23.5	-0.5	4.5 MPa

Relinquished by: (signature) Ganni Yi Date/Time _____
 Received by: (signature) [Signature] Date/Time 6/12/06 0830
 Notes: Used separate pressure gauge to measure Initial/Final Vacuum from the canister gauges.

Relinquished by: (signature) _____ Date/Time _____
 Received by: (signature) _____ Date/Time _____
 Shipper Name: _____ Air Bill # _____ Temp (°C) 44 Condition good
 Customer Seals Intact? Yes No None Work Order # 0606023

Appendix C
Chemical Oxidation Treatability Study

Memorandum

Environmental Resources Management

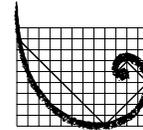
To: Project File

From: Arun Chemburkar

Date: 31 May 2006

Subject: Chemical Oxidation Treatability Study for
UPRR/Helix, Pleasant Hill, California

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This memorandum is intended to accompany and summarize the 22 December 2003 letter report *Chemical Oxidation Treatability Study for UPRR/Helix, Pleasant Hill, California* produced by ERM's Remediation Technology Center (RTC) in Lawrenceville, New Jersey.

To evaluate the effectiveness of chemical oxidation using permanganate and persulfate in treating site soils, RTC analyzed two composite samples (designated "shallow" and "deep"), in late 2003. Specifically the bench-scale tests evaluated the soil permanganate demand and the amount of persulfate consumed by the samples. A sample of each of the composites was also sent to Severn Trent Laboratories in West Sacramento, California for total organic carbon and volatile organic compound analyses.

The shallow soil composite, collected from depths representative of the A-Zone aquifer, exhibited a "moderate" total permanganate demand (4 to 7 pounds per cubic yard [lb/yd³]). The shallow soil composite consumed only 15 to 17%, (5X and 20X concentrations, respectively), of the initial persulfate concentrations during the 14-day test. This relates to a persulfate demand of 6 to 27 lb/yd³.

The deep soil composite, collected from depths representative of the B-Zone aquifer, exhibited a "low" total permanganate demand, (0.5 to 1 lb/yd³). As with the shallow sample, the deep soil composite consumed only 15 to 17% of the initial persulfate concentrations during the 14-day test. This consumption rate relates to a persulfate demand of 6 to 28 lb/yd³.

Based on the significantly greater amount necessary to treat a given soil volume and the increased cost per pound of persulfate, permanganate is the preferred oxidant for implementing a chemical oxidation remediation for ground water treatment at the site.

22 December 2003

Reference: 0011397

Mr. Arun Chemburkar
ERM-West, Inc.
1777 Botelho Drive, Suite 260
Walnut Creek, CA 94596



Re: Chemical Oxidation Treatability Study for UPRR/Helix,
Pleasant Hill, California

Dear Mr. Chemburkar,

This letter report presents the findings of the recent chemical oxidation treatability study performed on VOC-contaminated soils collected from the Hookston Station Site in Pleasant Hill, California. The study was designed to evaluate the total soil permanganate demand and the amount of persulfate consumed by each of two soil samples.

SUPPLY OF SITE SOILS

Site soil samples arrived at ERM's Remediation Technology Center (RTC) in Lawrenceville, New Jersey on 3 October 2003. Five soil samples arrived in good condition, were logged in, and were designated as follows:

- 08190-01: B-68-17.5-18.5;
- 08190-02: MW-13B-23;
- 08190-03: B-68-53;
- 08190-04: MW-12B-18.5; and
- 08190-05: MW-12B-53.

All samples were stored refrigerated until used.

TREATABILITY STUDY

The study consisted of three phases of work as described in the sections that follow.

Phase I: Initial Characterization

The five soil samples were combined into two separate composites, designated as "shallow" and "deep." The shallow composite was made up from B-68-17.5-18.5, MW-13B-23, and MW-12B-18.5. The deep composite was made up from B-68-53 and MW-12B-53.

Each of the composite soils was constructed by adding the individual soils to a large bucket, mixing them together by hand until they appeared homogeneous, and then removing any large debris that was present. A sample from each of the composite soils was submitted to Severn Trent Laboratories (STL) in West Sacramento, California, for Total Organic Carbon (TOC) and VOC analyses. The results of these tests are shown in Table 1.

The VOC concentrations were needed to determine the stoichiometric demand of the chlorinated solvents present in each soil composite for persulfate treatment. Because no VOCs were detected in either composite soil, an "assumed" total VOC concentration of 75 mg/kg was used to calculate the mass of persulfate to add in the Persulfate Soil Consumption Test. The ERM-West project manager discussed and approved this assumed total VOC concentration.

Phase II: Total Soil Permanganate Demand

In addition to reacting with many hazardous chemicals, permanganate will react with many organic and inorganic materials naturally present in site soils. If the concentrations of these non-target oxidizable materials are very high, large amounts of oxidant will be required for field treatment, resulting in high full-scale implementation costs. The soil demand test is designed to evaluate the oxidant demand exerted by site soils.

The test was individually performed on each composite soil by adding 25 grams of wet-weight processed soil to each of ten 50-ml centrifuge tubes. Increasing volumes (20 μ L to 10 mL) of a stock 5% potassium permanganate solution and distilled water were added to each tube to bring the total liquid volume in each tube to approximately 40 mL. The ten tubes made up a concentration series ranging from 1 to 500 mg of potassium permanganate per tube; each tube in the series contained twice the permanganate concentration of the preceding tube. In addition, a "Control" tube was constructed containing only soil and distilled water. All tubes were incubated at room temperature (approximately 20°C) in the laboratory.

All centrifuge tubes were manually mixed over the 15-day reaction period (18 November to 3 December 2003). At that time, the color of the liquid in each tube was visually determined and recorded. For each composite, the pH and ORP of the tubes which bracketed the tube with the lowest residual concentration of permanganate were also measured and recorded.

Solutions containing residual permanganate were pink to purple in color, while solutions in which the starting mass of permanganate had been essentially depleted were colorless. The actual total soil permanganate demand concentration lies between the tube with highest concentration of exhausted permanganate and the tube with the lowest concentration of residual permanganate. The results of the permanganate demand tests for the composite soils are shown in Table 2.

Shallow Composite: The soil permanganate demand is between 1.4 and 2.6 g/kg. Based on comparisons with similar oxidant demand tests, this soil would be considered to exhibit a “moderate” total permanganate demand. This result is consistent with the relatively moderate TOC concentration of the processed soil.

Scaled up, the permanganate demand would theoretically correspond to the need for approximately 4 to 7 pounds of permanganate per cubic yard of soil treated. These calculations were made assuming a soil porosity of 30% and a bulk density of 2,700 lb/yd³.

Deep Composite: The soil permanganate demand is between 0.17 and 0.35 g/kg. Based on comparisons with similar oxidant demand tests, this soil would be considered to exhibit a “low” total permanganate demand. This result is consistent with the low TOC concentration of the processed soil.

Scaled up, the permanganate demand would theoretically correspond to the need for approximately 0.5 to 1 pound of permanganate per cubic yard of soil treated. These calculations were made assuming a soil porosity of 30% and a bulk density of 2,700 lb/yd³.

Phase III: Persulfate Soil Consumption Test

The test was individually performed on each of the two composites by adding 200 g of wet-weight processed soil to each of three 500-mL centrifuge bottles. The Control bottle then received 300 mL of distilled water, was sealed, and shaken by hand to mix. One reaction bottle then received 3 g of sodium persulfate to achieve an oxidant mass equal to five

times the stoichiometric demand of the “assumed concentration” of contaminants. The second reaction bottle received 12 g of sodium persulfate to achieve a 20 times excess mass of oxidant. Each of these two reaction bottles then received an iron catalyst at 100 mg/Kg. The bottles were then filled with 300 mL of distilled water, capped, and shaken by hand to mix.

The six bottles were placed on a shaker table to mix over the 14-day reaction period (19 November to 3 December 2003). After seven days of treatment (26 November 2003), the bottles were removed from the shaker table, and the slurries were analyzed for pH, ORP, and residual persulfate. The bottles were then returned to the shaker table to complete the reaction period. On Day 14 (03 December 2003), the six bottles were again removed from the shaker table and the slurries were analyzed for pH, ORP, and residual persulfate. Results from this test are shown in Table 3.

Shallow Composite: After a 14-day reaction period, residual persulfate was detected in both the 5X and 20X excess reaction samples. The percent loss of the 5X excess reaction sample was 14.94%, and the 20X excess reaction showed a 16.52% loss. On a mass consumed per mass of soil treated basis, the 5X composite exhibited a total demand of approximately 2 grams of persulfate per kilogram of wet-weight soil, while the 20X composite exhibited a total demand of approximately 10 grams per kilogram.

These rates of persulfate loss were deemed to be relatively “low,” and indicate that a significant concentration of residual persulfate would be expected to exist in site soils after a contact time of two weeks. The residual persulfate would be available for continued chemical oxidation of such soils and/or provide oxidation potential as the oxidant is diluted and moves down gradient with the groundwater flow.

Deep Composite: After a 14-day reaction period, residual persulfate was detected in both the 5X and 20X excess reaction samples. The percent loss of the 5X excess reaction sample was 14.94%, and the 20X excess reaction showed a 17.31% loss. On a mass consumed per mass of soil treated basis, the 5X composite exhibited a total demand of approximately 2 grams of persulfate per kilogram of wet-weight soil, while the 20X composite exhibited a total demand of approximately 10.5 grams per kilogram.

These rates of persulfate loss were deemed to be relatively “low,” and indicate that a significant concentration of residual persulfate would be

expected to exist in site soils after a contact time of two weeks. The residual persulfate would be available for continued chemical oxidation of such soils and/or provide oxidation potential as the oxidant is diluted and moves down gradient with the groundwater flow.

CONCLUSIONS

The following conclusions can be drawn from the results of this treatability study:

- The “Shallow” soil composite exhibited a total permanganate demand of 1.4 to 2.6 g/kg, a range considered to be “moderate” based on the results of many such tests;
- The “Shallow” soil composite consumed a relatively low percentage of the starting persulfate concentration during the two week test (15 to 17%, respectively, with a 5X and 20X stoichiometric excess). The 5X and 20X composite soils exhibited a total demand of approximately 2 and 10 grams of persulfate per kilogram of wet-weight soil, respectively;
- The “Deep” soil composite exhibited a total permanganate demand of 0.17 to 0.35 g/kg, a range considered to be “low;” and
- The “Deep” soil composite consumed a relatively low percentage of the starting persulfate concentration during the two week test (15 to 17%, respectively, with a 5X and 20X stoichiometric excess). The 5X and 20X composite soils exhibited a total demand of approximately 2 and 10.5 grams of persulfate per kilogram of wet-weight soil, respectively

The representativeness of the soil samples supplied for use in the demand tests should be carefully considered when interpreting the laboratory results. This is especially true when composite, rather than discrete samples are tested. Results from soils not “typical” of those at the site to be treated can result in significant under or over statement of the true soil oxidant demands. Field pilot testing can be used to verify the bench-scale results and to provide data valid for process scale-up.

Since both permanganate and persulfate are successful in oxidizing chloroethenes, the choice between the oxidants typically centers around two key issues: (1) economics of use, and (2) ease of implementation. For economics of use, the total oxidant demand numbers can be compared to provide an initial evaluation of cost-effectiveness. For ease of implementation, permanganate treatment is in general superior to persulfate oxidation because permanganate solutions are chemically stable,

react without the need for catalysts, and the pink to purple color of these solutions is helpful in easily determining whether the oxidant is present or not.

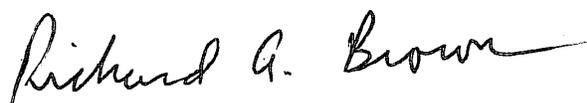
The shallow composite soils exhibited an extrapolated total permanganate demand of 4 to 7 pounds of permanganate per cubic yard of soil treated, while the total persulfate demand ranged from approximately 6 pounds of persulfate per cubic yard at 5X stoichiometry to 27 pounds of persulfate per cubic yard at 20X stoichiometry. Assuming that these demand numbers are accurate, permanganate treatment is cheaper than persulfate treatment on chemical cost per cubic yard of treated soil basis.

The deep composite soils exhibited an extrapolated total permanganate demand of only 0.5 to 1 pound of permanganate per cubic yard of soil treated, while the total persulfate demand ranged from approximately 6 pounds of persulfate per cubic yard at 5X stoichiometry to 28 pounds of persulfate per cubic yard at 20X stoichiometry. Assuming that these demand numbers are accurate, permanganate treatment is cheaper than persulfate treatment on chemical cost per cubic yard of treated soil basis.

In addition to the favorable reagent cost, permanganate treatment is both simpler to implement and more likely to behave in a predictable manner in the field.

Should you have any questions about the study or need additional information, please feel free to contact me at 609-895-0050.

Sincerely,

A handwritten signature in cursive script that reads "Richard A. Brown". The signature is written in black ink and is positioned above the printed name.

Richard A. Brown

Table 1. Initial Characterization Results
Hookston Station
Pleasant Hill, CA
 16-Dec-03

1-A. Shallow Composite

Analyte	Concentration (mg/kg)
Total Organic Carbon (TOC)	1,720
VOCs	ND*

*Not detected

1-B. Deep Composite

Analyte	Concentration (mg/kg)
Total Organic Carbon (TOC)	455
VOCs	ND*

*Not detected

Table 2. Total Soil Permanganate Demand
Hookston Station
Pleasant Hill, CA
 16-Dec-03

2-A. Shallow Composite

Theoretical Permanganate Load (mg/kg of wet-weight soil)	Actual Permanganate Load (mg/kg of wet-weight soil)	Observed Supernatant Color	Observed ORP (mV)	Observed pH	Permanganate Demand (g/kg of wet weight soil)	Permanganate Demand (lbs/yd ³ soil)*
20,000	21,054	Purple	NA**	NA	< 21	< 57
10,000	10,523	Purple	NA	NA	< 11	< 28
5,000	5,266	Purple	659.2	7.5	< 5	< 14
2,500	2,570	Pink	582.5	7.9	< 2.6	< 6.9
1,250	1,397	Clear	534.3	8.6	> 1.4	> 3.8
625	714	Clear	NA	NA	> 0.71	> 1.9
313	351	Clear	NA	NA	> 0.35	> 0.95
156	157	Clear	NA	NA	> 0.16	> 0.42
78	81	Clear	NA	NA	> 0.081	> 0.22
39	52	Clear	NA	NA	> 0.052	> 0.14

*Assumes a 30% porosity and a soil bulk density of 100 lbs/ft³

**NA = Not Analyzed

2-B. Deep Composite

Theoretical Permanganate Load (mg/kg of wet-weight soil)	Actual Permanganate Load (mg/kg of wet-weight soil)	Observed Supernatant Color	Observed ORP (mV)	Observed pH	Permanganate Demand (g/kg of wet weight soil)	Permanganate Demand (lbs/yd ³ soil)*
20,000	20,974	Purple	NA**	NA	< 21	< 57
10,000	10,539	Purple	NA	NA	< 11	< 28
5,000	5,261	Purple	NA	NA	< 5	< 14
2,500	2,583	Purple	NA	NA	< 2.6	< 7.0
1,250	1,402	Purple	627.5	7.9	< 1.4	< 3.8
625	695	Purple	586.1	8.3	< 0.70	< 1.9
313	354	Lt. Pink	542.3	8.5	< 0.35	< 0.96
156	165	Clear	598.5	8.8	> 0.17	> 0.45
78	77	Clear	NA	NA	> 0.077	> 0.21
39	40	Clear	NA	NA	> 0.040	> 0.11

*Assumes a 30% porosity and a soil bulk density of 100 lbs/ft³

**NA = Not Analyzed

Table 3. Persulfate Soil Consumption Test
Hookston Station
Pleasant Hill, CA
 16-Dec-03

3-A. "Time = 7 Days" Results

Sample	pH	ORP	Initial Oxidant (mg/L)	Residual Oxidant (mg/L)	Percent Loss	Persulfate Demand (g/kg)*	Persulfate Demand (lb/yd ³ soil)**
Shallow Composite 5X	7.4	602.1	10,000	8,821	11.8	1.8	4.8
Deep Composite 5X	7.6	611.3	10,000	8,506	14.9	2.2	6.1
Shallow Composite 20X	7.2	691.7	40,000	33,392	16.5	9.9	26.8
Deep Composite 20X	7.0	690.4	40,000	34,337	14.2	8.5	22.9

*Wet-weight soil

**Assumes a 30% porosity and a soil bulk density of 100 lbs/ft³

3-B. "Time = 14 Days" Results

Sample	pH	ORP	Initial Oxidant (mg/L)	Residual Oxidant (mg/L)	Percent Loss	Persulfate Demand (g/kg)*	Persulfate Demand (lb/yd ³ soil)**
Shallow Composite 5X	7.5	613.0	10,000	8,506	14.9	2.2	6.1
Deep Composite 5X	7.5	642.4	10,000	8,506	14.9	2.2	6.1
Shallow Composite 20X	7.2	652.1	40,000	33,392	16.5	9.9	26.8
Deep Composite 20X	7.0	666.9	40,000	33,077	17.3	10.4	28.0

*Wet-weight soil

**Assumes a 30% porosity and a soil bulk density of 100 lbs/ft³

Appendix D
Fate and Transport Evaluation

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LIST OF ATTACHMENTS

- A Time Estimate for Operating Vapor Intrusion Prevention Systems*
- B Polymerase Chain Reaction Assay Results*

LIST OF ACRONYMS

DCE	dichloroethene
DHE	dehalococcoides ethenogenes
CVOC	Chlorinated volatile organic compound
ft/day	Feet per day
PCE	tetrachloroethene
TCE	trichloroethene
VC	vinyl chloride

The Hookston Station Feasibility Study provides analyses of a broad range of remedial alternatives. The effectiveness of these alternatives depends on a variety of physical and chemical characteristics of the site, such as the geologic and hydrogeologic characteristics of the aquifer, the physical and chemical properties of the soil, and the metabolic capabilities of native microbes. This appendix provides the results of the contaminant fate and transport analysis conducted for Hookston Station. One of the primary objectives of this analysis is to provide attenuation rate constants for ground water modeling of the various remedial alternatives.

There are four major processes affecting dissolved contaminant fate and transport:

- **Advection** – The transport of solutes by the bulk movement of ground water;
- **Dispersion** – The longitudinal and transverse spreading of a solute plume, caused by both molecular diffusion and mechanical dispersion;
- **Sorption** – The process in which molecules become fixed (sorbed) to the aquifer matrix;
- **Volatilization** – The process in which molecules transfer from a liquid state (in ground water) to a vapor state (in soil gas); and
- **Degradation** – Includes both biological and abiotic breakdown of volatile organic compounds.

In order for a solute transport model to quantitatively estimate the concentration of a plume and its rate of travel, the above processes must be quantified within the framework of the model. This memorandum presents the parameter calculation methods and results, using site-specific data where appropriate.

The Section 2 of this appendix describes these attenuation mechanisms in detail. Section 3 describes site-specific evidence of plume degradation. Section 4 provides the attenuation calculations that are used for solute transport modeling, and Section 5 provides conclusions from this analysis.

The following section provides a description of the various contaminant fate and transport mechanisms that were evaluated for Hookston Station.

2.1

ADVECTION

Ground water gradient and flow direction information is well documented within existing quarterly ground water monitoring reports and other site investigation reports. In general, ground water flows from the south of the study area toward the north to northeast at an average hydraulic gradient of 0.004 feet vertically per foot horizontally (feet/foot) (gradients are generally similar among the various aquifer units). The advective (linear) ground water flow velocity can be estimated using the following formula:

$$v_x = \frac{K}{n_e} \frac{dH}{dL}$$

where,

- v_x = Advective ground water velocity [L/T]
- K = Hydraulic conductivity [L/T]
- n_e = Effective porosity [L³/L³]
- dH/dL = Hydraulic gradient [L/L]

Based on a representative hydraulic conductivity of 5 feet per day (ft/day) for the A-Zone and 50 ft/day for the B-Zone (Appendix G), an average hydraulic gradient of 0.004 feet/foot, and a measured effective porosity of 0.21 for the aquifer sands (Appendix F), the average advective ground water flow velocity is approximately 40 feet per year in the A-Zone and 300 feet per year in the B-Zone. It should be noted that the hydraulic conductivity calculations provided in Appendix G range from 2 to 40 ft/day in the A-Zone, and from 4 to 153 ft/day in the B-Zone (based on different individual well tests), so although the values described above are believed to be representative of the Hookston Station Parcel and downgradient study area, a range of potential seepage velocities are expected within this flow system. Detailed three-dimensional ground water flow directions, gradients, and velocities are simulated with the ground water flow model (Appendix I). A more detailed evaluation of ground water flow rates will, therefore, not be addressed within this memorandum. The estimated seepage velocity estimates are provided

herein because they are used in the calculation of degradation rate as described further below.

2.2 *DISPERSION*

Longitudinal dispersivity (α_x), which is a measure of the “spread” of the plume, was estimated based on a formula developed by Xu and Eckstein (1995) that uses a weighted best fit of field data, with the units of L_p and α_x adjusted from meters to feet¹:

$$\alpha_x = 3.28 \times 0.83 \left(\log \frac{L_p}{3.28} \right)^{2.412}$$

where:

- α_x = Longitudinal dispersivity [L (ft)]
- L_p = Plume length [L (ft)]

As shown in Table D-5, a longitudinal dispersivity of 15.9 feet was calculated for the A-Zone, and a longitudinal dispersivity of 16.5 feet was calculated for the B-Zone. Transverse dispersivities are assumed to be one third of the longitudinal dispersivity (American Society for Testing and Materials 1995; United States Environmental Protection Agency [USEPA] 1986) and vertical dispersivities are assumed to be one tenth of longitudinal dispersivity (USEPA 1986).

2.3 *SORPTION*

Sorption is an important component to a solute transport model, as it causes slowing (or “retardation”) of organic compounds relative to the advective ground water flow velocity. Organic carbon and clay mineral fractions generally act as sites of adsorption, and therefore, the more organic carbon and clay minerals in an aquifer, the slower an organic compound plume will travel relative to the advective ground water velocity.

¹ Xu, M., and Eckstein, Y., 1995, *Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Field Scale*, Ground Water, November 1995.

Sorption is quantified as a coefficient of retardation (R), which can be expressed as a function of the distribution of an organic compound between the aquifer matrix and the aqueous phase:

$$R = 1 + \left(\frac{\rho_b \cdot K_d}{n} \right)$$

where:

- R = Coefficient of retardation
- ρ_b = Bulk density of the aquifer matrix [M/L³]
- K_d = Distribution coefficient [L³/M] [= sorbed concentration/dissolved concentration]
- n = Porosity [L³/L³]

The distribution coefficient (K_d) can also be expressed as:

$$K_d = K_{oc} \cdot f_{oc}$$

where:

- K_d = Distribution coefficient [L³/M]
- K_{oc} = Soil sorption coefficient [L³/M]
- f_{oc} = Fraction of organic carbon (milligram [mg] of organic carbon/mg of soil)

As shown in the above equation, sorption is proportional to the amount of organic carbon within the aquifer. As described in Appendix F, site-specific testing of aquifer sands identified that generally low to non-detectable levels of organic carbon were present. As a conservative assumption, no retardation via sorption was applied to the modeled plume.

2.4 VOLATILIZATION

Because of the fine-grained nature of the vadose zone, a significant mass transfer out of the ground water system through volatilization is not expected. However, the migration of volatile organic compounds through the vadose zone is relevant to the cleanup duration timeframe estimates, as vapor intrusion is one of the complete exposure pathways. In theory, once ground water cleanup has occurred, a lag time will occur between this cleanup time and the time in which those effects will be observed at the ground surface, where vapor intrusion into indoor air has been

observed. Attachment A presents the results of vadose zone calculations, which shows that there will be an approximate 1 year lag between when ground water concentrations reach acceptably low levels (below 530 micrograms per liter, the ground water Environmental Screening Level for protection of indoor air for vapor intrusion concerns) and when indoor air concentrations would be reduced to acceptable levels. For the purpose of the solute transport model, no loss of mass is assumed through volatilization of the plume.

2.5 DEGRADATION OF CVOCS

Chlorinated volatile organic compounds (CVOCs) may undergo biodegradation by three different methods: use as electron acceptors, use as electron donors, or through cometabolism. Although one or more of these processes may occur at a site at any given time, natural conditions appear to favor the use of CVOCs as electron acceptors. This process, also known as reductive dechlorination, provides energy for the growth of the microorganisms facilitating the electron transfer. In this case, biodegradation of CVOCs is likely an electron-donor-limited process. The three methods by which biodegradation of CVOCs can occur are discussed in the following sections.

Chlorinated solvents such as PCE are known to undergo a variety of microbially mediated biodegradation reactions (Mohn and Tiedje 1992). In anaerobic environments, PCE can undergo reductive dechlorination, whereby PCE is reduced to TCE, TCE to cis-1,2-DCE, cis-1,2-DCE to VC, and VC to benign end products such as ethene, carbon dioxide, water and chloride (Figure D-1). A variety of microorganisms reduce the highly chlorinated compounds PCE and TCE to cis-1,2-DCE. However, *complete dechlorination* is defined as reduction of these parent compounds to ethene, and these reactions require specific halo-respiring bacteria.

A number of anaerobic, halo-respiring bacteria have been identified in the environment that will degrade TCE to cis-1,2-DCE. But only one type of bacteria, *dehalococcoides ethenogenes* (or DHE), is reported to catalyze the dechlorination of cis-1,2-DCE to VC. Because DHE is not always present in the subsurface environment, samples from the site were analyzed for the presence of various dehalogenating microbes, including DHE.

Chlorinated solvents can also be abiotically degraded by naturally occurring reduced iron minerals. A brief description of abiotic degradation pathways is provided at the end of this section.

2.5.1 *CVOCs as Electron Acceptors*

In general, reductive dechlorination of chlorinated ethenes occurs by dechlorination from tetrachloroethene (PCE) to trichloroethene (TCE) to dichloroethene (DCE) to vinyl chloride (VC) to ethene as chlorine atoms are removed and replaced with hydrogen atoms (Figure D-1).

Unfavorable environmental conditions for reductive dechlorination may interrupt this sequence, allowing other biological processes to act on the daughter products. Reductive dechlorination of CVOCs results in the accumulation of sequential daughter products along with an increase in chloride ion concentrations. The most susceptible compounds to reductive dechlorination are those that are most highly chlorinated or most oxidized. Of the chlorinated ethenes, PCE is the most susceptible to reductive dechlorination and VC is the least susceptible. During reductive dechlorination, all three isomers of DCE (cis-1,2-DCE; trans-1,2-DCE; and 1,1-DCE) can theoretically be produced; however, when they are daughter products, cis-1,2-DCE is more prevalent than trans-1,2-DCE, and 1,1-DCE is the least prevalent of the three isomers. Since the chlorinated hydrocarbon is used as an electron acceptor during reductive dechlorination, rather than as a carbon source, an alternate source of carbon is required for this process to occur. Potential sources of carbon include native organic matter or other organic sources such as petroleum hydrocarbons.

2.5.2 *CVOCs as Electron Donors*

Although PCE and TCE are not typically used as electron donors, under aerobic and some anaerobic conditions, the less oxidized CVOCs, such as VC, can be used by microorganisms as primary substrates, or sources of both energy and organic carbon. Evidence exists of the mineralization of VC under iron-reducing conditions, provided that sufficient bioavailable iron (III) is present. Aerobic biodegradation of VC may be characterized by a loss of VC mass and a decreasing ratio of moles of VC to moles of other CVOCs.

2.5.3 *Biodegradation by Cometabolism*

When CVOCs undergo biodegradation through cometabolism, the compounds are degraded by enzymes fortuitously produced by microorganisms for other purposes. The organism does not use the CVOCs as sources of carbon or energy. It has been reported that under aerobic and anaerobic conditions, chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation.

2.5.4

Abiotic Degradation of CVOCs

At sites with naturally occurring reduced iron (i.e., magnetite) or at sites with iron-rich mineralogy and strong reducing conditions, ferrous iron minerals are present and can degrade chlorinated solvents without the corresponding production of common biological daughter products such as 1,1-dichloroethane from 1,1,1-trichloroethane or cis-DCE and vinyl chloride from PCE and TCE. The chemical reaction is similar to that produced by zero-valent iron, which is commonly used in permeable reactive barriers to treat chlorinated solvents.

3.0 EVIDENCE OF PLUME DEGRADATION

3.1 GEOCHEMICAL INDICATORS FOR BIODEGRADATION OF CVOCS

The geochemical ground water data collected from A- and B-Zone monitoring wells indicate that biodegradation has advanced to different degrees throughout the ground water plumes, depending on the availability of electron donor, carbon source, and the geochemistry of the ground water.

Based on the presence and distribution of *cis*-1,2-DCE and 1,1-DCE (byproducts of biodegradation of PCE and TCE), biodegradation has developed to some degree in both the A- and B-Zone ground water. Biodegradation appears to be more developed in A-Zone ground water in the northwestern portion of the site where a man-made carbon source (petroleum hydrocarbons from the adjacent gasoline station) is present. Biodegradation is less developed in the B-Zone and in other areas of the A-Zone where man-made carbon sources have not been identified.

Ground water samples that were collected in April 2004 were analyzed for monitored natural attenuation parameters (e.g., sulfate, nitrate, chloride, iron, etc.) (Table D-1). Additional field data were collected in June 2006 (oxidation reduction potential, pH, dissolved oxygen, temperature, and specific conductivity) (Table D-2). Based on these recent data, conditions in both ground water zones appeared to be mildly oxidizing to mildly reducing (with an overall average of mildly reducing), with highly reducing conditions in select areas. These results are typical of mature ground water plumes undergoing some degree of biodegradation.

3.2 BIOLOGICAL INDICATORS FOR BIODEGRADATION OF CVOCS

Soil samples collected from one boring (TW-1) located in the northern portion of the site were analyzed to evaluate the presence and activity of the dehalogenating microbes responsible for each step of the sequential dechlorination of TCE to ethene. The laboratory results for this analysis are provided in Attachment B. The duplicate samples, A and B, contained 1,700 and 6,300 gene copies of DHE per gram. In the sample with the lower DHE count, the genes responsible for production of the reductive enzyme (reductase) of TCE and VC were absent. In the sample B, moderate levels of the TCE reductase and higher levels of VC reductase were found. This suggests that a dehalogenating population of microbes that are capable of complete reductive dechlorination is present in this portion of the site and, based upon the current population density, is active.

The following approaches were used to quantify the rate of attenuation and the extent of biodegradation:

- The first approach involves calculation of a bulk attenuation rate which allows for the estimation of a first-order rate constant for biodegradation alone, after accounting for the effects of non-destructive processes such as volatilization, dilution, dispersion, and sorption; and
- The second approach includes estimation of a mass loss rate from a calculation of the difference in contaminant mass flux across two parallel transects, one in the source, and one at the downgradient edge of the plume. This approach provides an estimate of the mass lost through attenuation of the plume.

These calculation methods and results are discussed in greater detail in the subsequent subsections.

4.1

BULK ATTENUATION AND FIRST ORDER RATE CONSTANTS

To predict plume chemodynamics and to determine biochemical reaction rate characteristics for CVOCs, it is often necessary to calculate site-specific biodegradation rates. Typically, degradation along flow paths approximates a first-order process.

This method uses an empirical relationship to calculate approximate first-order biodegradation rate constants for steady-state plumes. This method involves coupling the regression of contaminant concentration (plotted on a logarithmic scale) versus distance downgradient (plotted on a linear scale) to an analytical solution for one-dimensional, steady-state contaminant transport that includes advection, dispersion, sorption, and biodegradation. The effects of volatilization on the dissolved CVOC plume are assumed to be negligible. For a steady-state plume, the first-order biological decay rate is given by (Buscheck and Alcantar 1995):

$$\lambda = \frac{v_c}{4\alpha_x} \left(\left(1 + 2\alpha_x \left(\frac{k}{v_x} \right) \right)^2 - 1 \right)$$

where:

k/v_x = Negative slope of line formed by making a log-linear plot of contaminant concentration versus distance downgradient along the flow path (feet⁻¹)

α_x = Longitudinal dispersivity (feet)

Longitudinal dispersivity is given by (Xu and Eckstein 1995):

$$\alpha_x = 3.28 * 0.83 \left(\text{Log} \left(\frac{L_p}{3.28} \right) \right)^{2.414}$$

where:

L_p = Length of plume (feet)

The log-linear plots of contaminant concentration versus distance downgradient along the flow paths for the A- and B-Zones are provided in Tables D-3 and D-4, respectively.

An estimate of the bulk attenuation rate for the the A-Zone was performed. CVOC concentrations versus distance downgradient from a selected location are plotted to evaluate bulk attenuation rates. The calculated attenuation rate for TCE was 1E-04 day⁻¹ for the A-Zone and 2.4E-04 day⁻¹ for the B-Zone (Table D-5). Using the Buscheck and Alcantar equation, biodegradation rate half-lives were calculated to be 19 years for TCE in the A-Zone and 4 years for TCE in the B-Zone. These values were used for biodegradation rates within the solute transport model.

4.2 *MASS LOSS RATE*

This approach estimates the intrinsic capacity for degradation of CVOCs by estimating the mass loss rate based solely on mass balance calculations. For a stable plume (where plume dimensions do not change with time), the difference in chemical flux across lines drawn perpendicular to the ground water flow direction, located in the source area and near the downgradient plume margin, provides quantification of net chemical loss from destructive (microbial degradation) and non-destructive (volatilization, dilution, dispersion, and sorption) processes. Mass loss calculations are performed as follows:

1. Draw chemical isoconcentration contours for chemicals of concern;
2. Draw lines perpendicular to the flow direction in the source area and in the downgradient area of the plume;

3. Using aquifer thickness, plume width, and contaminant velocity and concentration, estimate the mass of chemicals traveling across each line; and
4. Compare the mass flux calculations to estimate the chemical mass lost due to both destructive and non-destructive processes;

4.2.1 *Mass Loss Calculation Results - A-Zone*

The overall mass loss across the A-Zone plume was also calculated between transects established across the Hookston Station source area (Transect I), the on-site portion of the Vincent Road source area plume (Transect II), and the downgradient edge of the 500 micrograms per liter TCE A-Zone contour (Transect III). The locations of these transects are shown on Figure D-2. Based on this calculation, the mass lost across the transects is 12 pounds per year (lbs/yr) ([Transect I flux + Transect II flux] - Transect III flux) (Table D-6). The total mass flux from the A-Zone Hookston Station and the Vincent Road source areas was estimated to be 20 lbs/yr. This indicates that 62 percent of the original mass flux from the two source areas is attenuated (through a variety of chemical, physical, and biological processes) during downgradient migration.

4.2.2 *Mass Loss Calculation Results - B-Zone*

The overall mass loss across the B-Zone plume was calculated between transects established across the on-site source area and the downgradient portion of the B-Zone plume; the locations of the transects are included on Figure D-3. The total mass flux from the on-site B-Zone source area was estimated to be 300 lbs/yr. The mass lost calculated between the two transects was calculated to be 60 lbs/yr, indicating that approximately 20 percent of the original mass flux from the on-site B-Zone source area is attenuated during downgradient migration (Table D-7). Mass contributions to the B-Zone plume from the off-site Vincent Road source area were not accounted for in this analysis due to the scarcity of data from for that source. The absence of data from this area would therefore produce an underestimate of the mass lost through natural attenuation processes, as this analysis did not include this potential supplemental source. Additional investigations into this off-site source area by the responsible parties will better define the impacts of this source to the overall ground water plume.

The conclusions of the fate and transport analysis are summarized below:

- Ground water seepage velocities range from approximately 40 to 300 feet per year within the study area, although localized areas of higher or lower flow velocities are present. Contaminant velocities are typically lower than ground water seepage velocities due to a number of attenuation mechanisms.
- Reductive dechlorination is occurring within the A- and B-Zone ground water plumes. It is most notably observed in the A-Zone in the northwestern portion of the site. The dechlorination is likely due to favorable geochemistry and the presence of microbial population (the presence of which was confirmed with site-specific microbial analyses).
- Calculations using A-Zone plume data indicate that 61 percent of the original mass flux from the Hookston Station and Vincent Road source areas is attenuated during downgradient migration.
- Calculations using B-Zone plume data indicate that approximately 20 percent of the original mass from the Hookston Station source area is attenuated during downgradient migration. This evaluation may underestimate the total amount of mass loss through attenuation, as sufficient data regarding B-Zone impacts from the Vincent Road source area and other potential source areas are not currently available.
- Based on bulk attenuation rates using site-specific data, the solute transport model (Appendix I) will apply a biodegradation half-life of 19 years for TCE in the A-Zone and 4 years for TCE in the B-Zone. The modeling will also include dispersion based on site-specific data, but will not include retardation due to sorption or mass loss due to volatilization.

Buschek, T.E. and Alcantar, C.M. 1995. Regression techniques and analytical solutions to demonstrate intrinsic bioremediation, *In Proceedings of the 1995 Battelle International Conference on In-Situ and On Site Bioremediation*. April 1995.

United States Environmental Protection Agency (USEPA). *Anaerobic Biodegradation Rates of Organic Chemicals in Ground water: A Summary of Field and Laboratory Studies*. June 1999.

USEPA. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*. USEPA/600/R-98/128. September 1998.

Mohn, W.W. and J.M. Tiedje. 1992. Microbial Reductive Dehalogenation. *Microbiol. Rev.* 56,482-507.

Figures

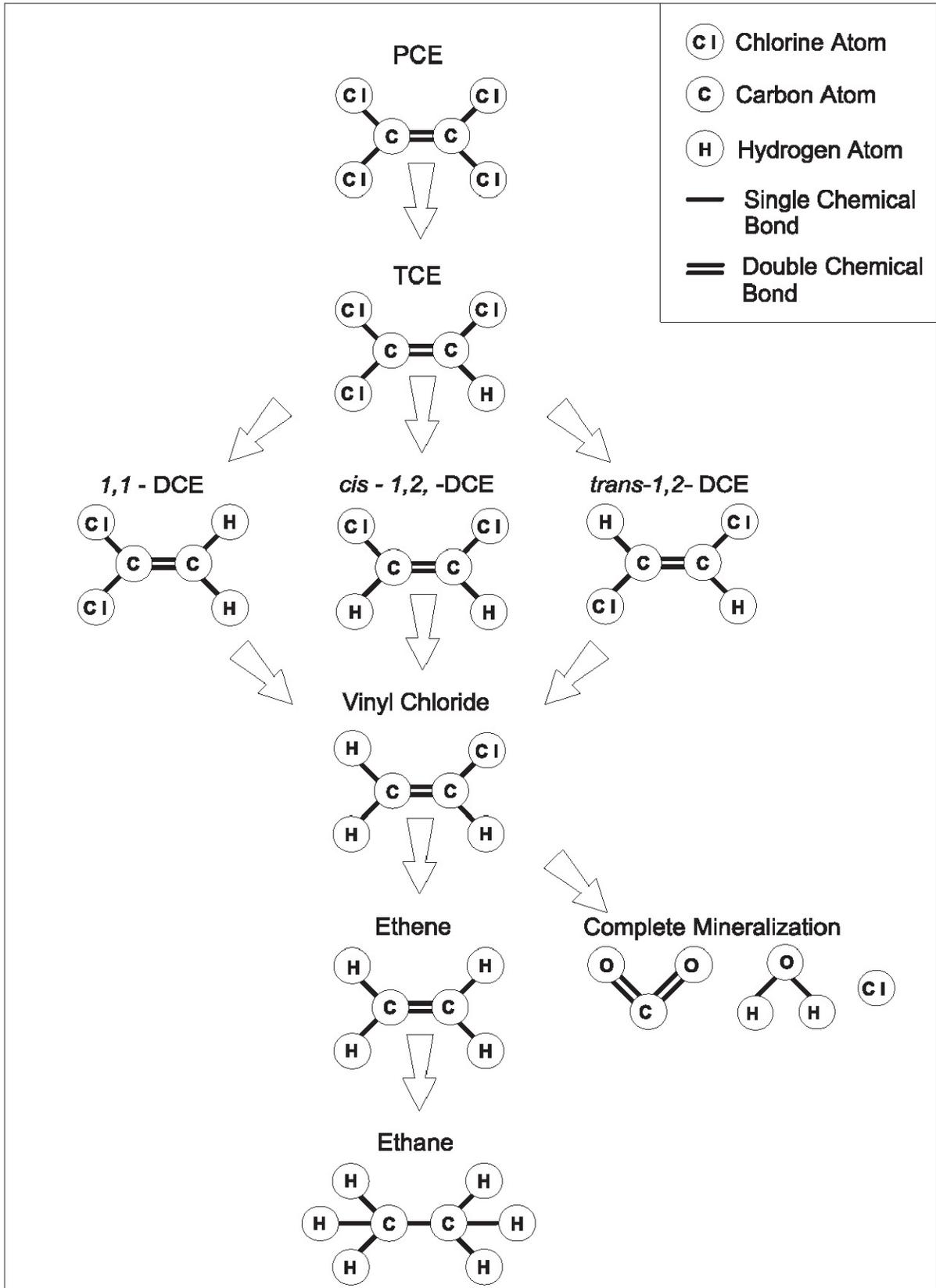
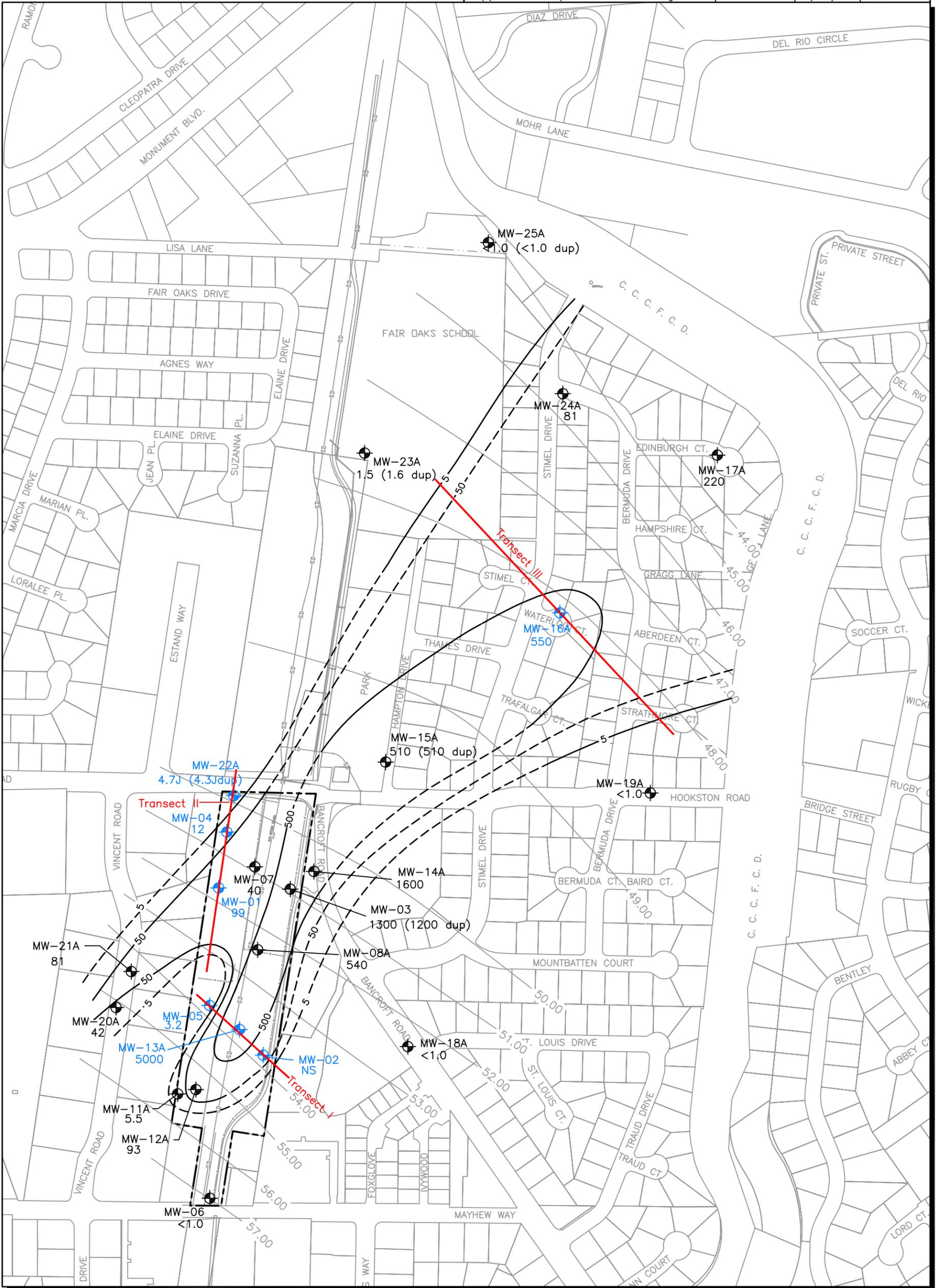


Figure D-1
Reductive Dechlorination of PCE
Hookston Station
Pleasant Hill, California

Source: T.H. Weidemeier, M.A. Swanson, D.E. Montoux, E.K. Gordon, J.T. Wilson, B.H. Wilson, D.H. Kampbell, P.E. Haas, R.N. Miller, J.E. Hansen, and F.H. Chappelle. 1998. "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water."



LEGEND

- ⊙ Monitoring Well Location
- ⊕ Indicates Well Included in Mass-Flux Analysis
- 5.5 TCE Concentration ($\mu\text{g/L}$)
- 50 TCE in Ground Water Contour, Solid Based on First Quarter 2006 Monitoring Well Data, Dashed Where Inferred from Off-Site Investigation Data or Historical Grab Ground Water Sampling.
- 53.00 Ground Water Elevation Contour, A-Zone, January 2006 (feet above mean sea level)
- J Estimated Values
- NS Not Sampled
- * Not Used for Contouring Based on Historical Data

The Maximum Contaminant Level For TCE in Drinking Water is $5 \mu\text{g/L}$.
 Note: MW-07 Data Not Used for Contouring Purposes.

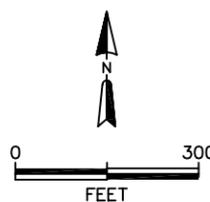
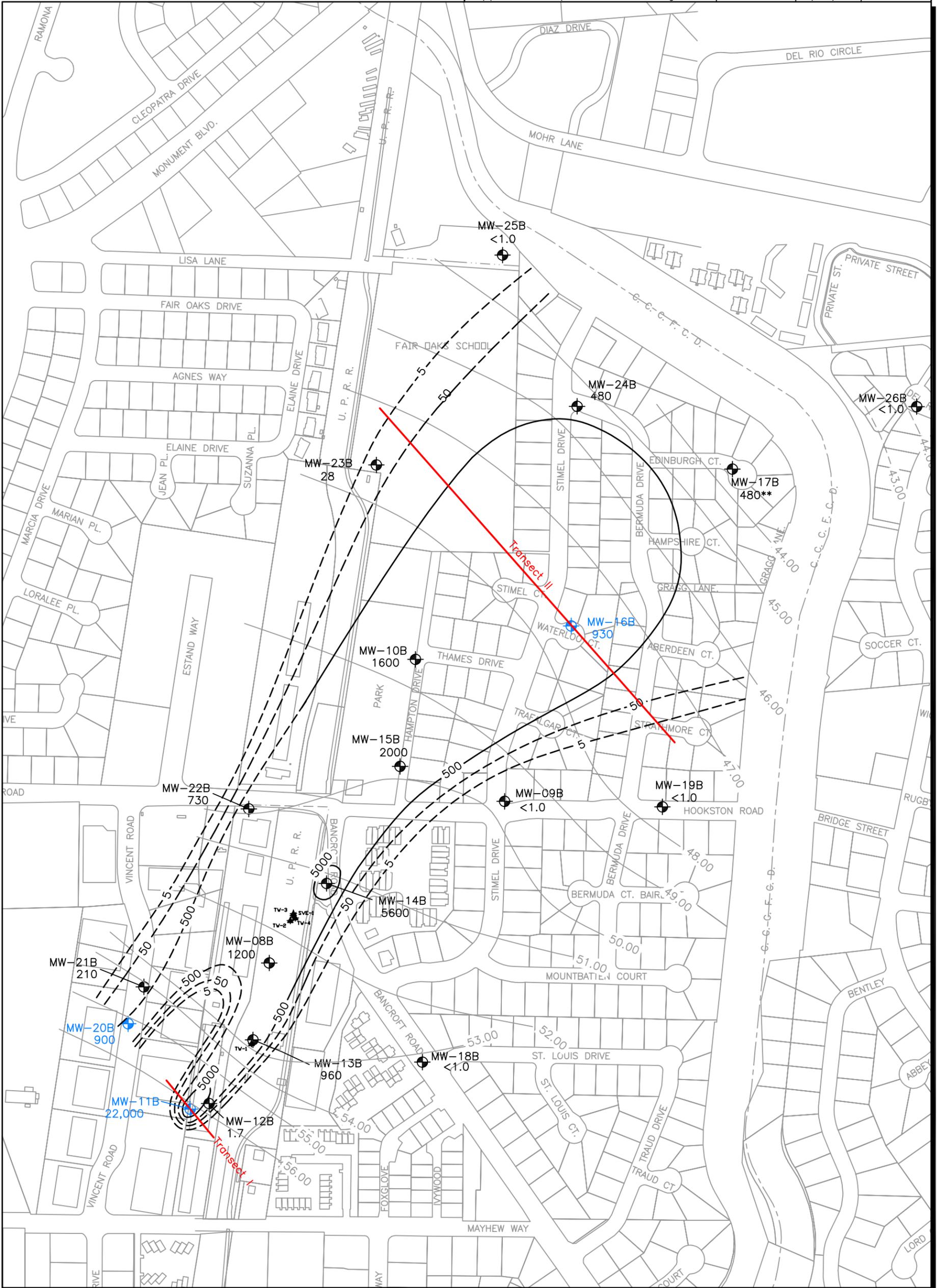


Figure D-2
 Mass-Flux Analysis Transects
 A Zone Ground Water
 First Quarter 2006
 Hookston Station
 Pleasant Hill, California



LEGEND

- Monitoring Well Location
- Indicates Well Included in Mass-Flux Analysis
- 59 TCE Concentration ($\mu\text{g/L}$)
- 50 TCE in Ground Water Contour, Solid Based on First Quarter 2006 Monitoring Well Data, Dashed Where Inferred from Off-Site Investigation Data or Historical Grab Ground Water Sampling.
- 51.00 Ground Water Elevation Contour, B-Zone, January 2006 (feet above mean sea level)
- ** Multiple Samples Were Collected at Various Depths Within the Well Screen. The Highest Result is Posted

The maximum contaminant level for TCE in drinking water is $5 \mu\text{g/L}$

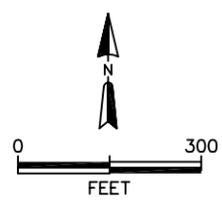


Figure D-3
Mass-Flux Analysis Transects
B Zone Ground Water
First Quarter 2006
Hookston Station
Pleasant Hill, California

Tables

Table D-1
General Minerals, Water Quality, and Natural Attenuation Parameters in Ground Water
Hookston Station
Pleasant Hill, California

Sample Location	Date	Sample Depth	Analytical Laboratory	Preparation Fraction	ALKALINITY,	CHLORIDE	HARDNESS	POTASSIUM	TOC	IRON	MANGANESE	NITRATE,	SULFATE	CARBON	ETHANE	ETHENE	METHANE	
					TOTAL AS CAC03 (mg/L) MCAWW 310.1	(mg/L) MCAWW 300.0	(mg/L) SM18 2340B	(mg/L) SW846 6010B	(mg/L) MCAWW 415.1	(mg/L) SW846 6010B	(mg/L) SW846 6010B	NITROGEN (mg/L) MCAWW 300.0	(mg/L) MCAWW 300.0	DIOXIDE (mg/L) RSK 175	(µg/L) RSK 175	(µg/L) RSK 175	(mg/L) RSK 175	
MW-01	4/20/2004	10-20	STL Sac	Total	553	72.2	q	746	10.4	3.6			1.5	135	q			
MW-03	4/20/2004	10-20	STL Sac	Total	719	177	q	1720	21.4	4	0.27	0.0072	2.2	190	q	82	NS	
MW-04	4/21/2004	11-21	STL Sac	Total	737	212	q	893	9.0	4.4			1.6	184	q			
MW-04 Duplicate	4/21/2004	11-21	STL Sac	Total	750	218	q	863	8.4	4.8			1.5	183	q			
MW-05	4/20/2004	10-30	STL Sac	Total	785	129	q	1010	8.9	3			2.4	235	q			
MW-06	4/20/2004	15-35	STL Sac	Total	783	197	q	1020	6.3	3.2	NS		2.5	251	q			
MW-07	4/20/2004	15-35	STL Sac	Total	751	155	q	874	3.7	2.6			0.83	262	q			
MW-08A	4/21/2004	10-25	STL Sac	Total	786	195	q	869	1.5	3	0.06	b	0.095	1.7	289	q	110	
MW-08B (previously MW-01D)	4/20/2004	45-60	STL Sac	Total	64.8	62.4	q	198	2.3	2.5	0.064	b	0.0042	0.52	22.8	q	0.68	
MW-08B dup (previously MW-01D)	4/20/2004	45-60	STL Sac	Total	67.0	61.8	q	195	2.3	2.5	0.074	b	0.0065	0.54	22.2	q	0.65	
MW-09B (previously MW-02D)	4/27/2004	50.5-60.5	STL Sac	Total	369	110	Qj	507	4.8	2			0.97	< 10	uq			
MW-10B (previously MW-03D)	4/26/2004	40-50	STL Sac	Total	153	29.2	q	155	21.1	17.2			4.0	qJ	33.8	QjJ		
MW-10B dup (previously MW-03D)	4/26/2004	40-50	STL Sac	Total	160	31.5	q	143	21.0	16.7			4.1	qJ	35.0	QjJ		
MW-11A	4/27/2004	10-25	STL Sac	Total	743	158	qJ	746	2.0	3.6	0.36		0.12	< 0.5	u	198	qJ	97
MW-11B	4/27/2004	40-50	STL Sac	Total	536	347	qJ	672	1.3	2	0.093	b	2.5	< 0.5	u	124	qJ	61
MW-12A	4/27/2004	10-25	STL Sac	Total	601	109	qJ	667	2.2	2.4	< 0.1	u	0.077	5.2	q	171	qJ	88
MW-12B	4/27/2004	50-60	STL Sac	Total	498	277	qJ	602	1.3	2.4	0.11		1	< 0.5	u	82.6	qJ	60
MW-13A	4/21/2004	18-33	STL Sac	Total		135	q	640	1.1	3.2	0.019	b	1	1.1	q	152	q	77
MW-13B	4/22/2004	45-55	STL Sac	Total	644	168	q	626	1.9	4.6	j < 0.1	u	0.94	0.48	bj	198	q	57
MW-14A	4/28/2004	29-34	STL Sac	Total	462	223	qJ	881	10.3	5.9	j 0.075	b	0.87	< 0.5	u	160	qJ	25
MW-14B	4/28/2004	40-50	STL Sac	Total	382	180	qJ	312	9.8	1.9	j < 0.1	u	0.01	1.4	u	120	qJ	4
MW-15A	4/22/2004	14.5-24.5	STL Sac	Total	781	228	q	1250	19.9	4.1	j < 0.1	u	0.11	2.1	qJ	227	q	110
MW-15B	4/23/2004	49-59	STL Sac	Total	538	216	q	535	5.7	14.8	j < 0.1	u	0.17	0.56	j	162	q	35
MW-15C	4/22/2004	90-95	STL Sac	Total	373	156	q	402	2.7	2.1	j NS		< 0.5	uR	61.7	q		
MW-16A	4/27/2004	15-25	STL Sac	Total	472	160	qJ	877	12.5	4.1	0.035	b	0.19	1.8	q	164	qJ	7.9
MW-16B	4/26/2004	35-45	STL Sac	Total	150	174	q	181	16.1	5.4	< 0.1	u	0.0015	0.56	j	169	qJ	< 0.17
MW-17A	4/27/2004	20.7-30.7	STL Sac	Total	575	169	qJ	930	11.5	2.5	0.094	b	0.031	16.3	q	135	qJ	110
MW-17B	4/27/2004	44-54	STL Sac	Total	450	160	qJ	571	2.9	2.1	< 0.1	u	0.023	3.0	q	119	qJ	25
MW-18A	4/28/2004	14.7-24.7	STL Sac	Total	904	178	qJ	1060	14.7	3.1	j		3.5	q	213	qJ		
MW-18B	4/28/2004	32-42	STL Sac	Total	672	179	qJ	788	2.1	4	j		1.6	q	206	qJ		
MW-19A	4/28/2004	14-24	STL Sac	Total	655	111	qJ	866	18.1	2.2	j		< 1	uq	139	qJ		
MW-19B	4/28/2004	29-39	STL Sac	Total	618	193	qJ	799	4.9	2.4	j		5.1	q	179	qJ		
MW-19C	4/28/2004	70-80	STL Sac	Total	370	166	qJ	402	2.4	3.4	j		< 0.5	u	58.7	qJ		
MW-19C Duplicate	4/28/2004	70-80	STL Sac	Total	376	159	qJ	399	2.3	3.3	j		< 0.5	u	56.0	qJ		
MW-20A	4/22/2004	10-20	STL Sac	Total	469	121	q	1090	20.5	2.4	j		2.0	qJ	135	q		
MW-20B	4/22/2004	30.5-40.5	STL Sac	Total	428	97.2	q	557	4.8	2.5	j		< 0.5	uR	196	q		
MW-21A	4/21/2004	10-20	STL Sac	Total	710	175	q	1770	g 34.4	g 3.9			2.2	q	224	q		
MW-21B	4/21/2004	29-39	STL Sac	Total		135	q	742	6.8	2.5			1.4	q	222	q		
MW-22A	4/21/2004	15-25	STL Sac	Total	1020	175	q	1590	24.4	6.1			< 0.05	u	89.4	q		
MW-22B	4/21/2004	40-50	STL Sac	Total	716	240	q	980	7.8	5			< 0.05	u	243	q		
MW-24A	4/27/2004	19.5-29.5	STL Sac	Total	598	126	qJ	888	13.2	2.6			3.3	q	149	qJ		
MW-24B	4/27/2004	39.5-49.5	STL Sac	Total	610	230	qJ	789	5.2	6.7			< 0.5	u	219	qJ		
MW-26B	4/28/2004	40-50	STL Sac	Total	472	79.5	qJ	638	6.9	13	j 0.017	b	0.076	7.2	q	187	qJ	53

Notes:

- # = Maximum of multiple analytical results
 - u = Compound was analyzed for but not detected. Analyte result was below the Reporting Type Limit.
 - d = Result from an analysis at a secondary dilution factor.
 - b = ORG: Compound is found in the associated blank as well as in the sample. INORG: Value less than contract required detection limit but greater than or equal to instrument detection limit.
 - g = Elevated reporting limit due to matrix interference
 - j = Estimated Value
 - q = Elevated reporting limit due to high analyte levels
 - NS = Not Sampled
 - < = Not Detected
- Bicarbonate, carbonate, and hydroxide alkalinity were also analyzed during 1st Quarter 2001 but are not reported on this table.

Laboratories:

- CTBERK = Curtis&Thompkins Berkley
- STL Sac = Severn Trent Laboratory, Sacramento

Abbreviation Chemical

TOC = TOTAL ORGANIC CARBON

Table D-2
Field Parameter Data
Hookston Station
Pleasant Hill, California

Well ID	Date Sampled	Screen Interval (ft bgs)	Gallons Removed	Temp °C	pH	Conductivity (µg/cm)	ORP mV	DO mg/L
A-Zone								
MW-1	9 Jun 06	10-25	0.7	19.38	7.87	956	-81.8	0.13
MW-3	9 Jun 06	10-20	0.7	23.61	6.64	1954	-11.7	0.57
MW-4	9 Jun 06	11-21	0.6	17.36	7.37	1565	-136.7	0.16
MW-5	9 Jun 06	10-30	0.5	25.86	7.27	1569	87.9	0.26
MW-6	9 Jun 06	15-35	0.6	26.22	7.20	2185	13.5	0.20
MW-7	9 Jun 06	15-35	0.5	21.64	7.07	1500	-68.9	0.14
MW-8A	9 Jun 06	10-25	0.6	19.88	7.97	1606	6.2	0.20
MW-11A	8 Jun 06	10-25	0.6	20	7.10	1409	9.6	0.39
MW-12A	8 Jun 06	10-25	0.5	19.78	7.66	1189	-99.1	0.34
MW-13A	9 Jun 06	18-33	0.6	24.9	6.86	1347	-13.2	0.62
MW-14A	8 Jun 06	29-34	0.5	21.59	7.11	1603	-46.5	0.15
MW-15A	8 Jun 06	15-25	1.3	21.36	6.86	1841	-1.0	0.25
MW-16A	8 Jun 06	15-25	0.4	18.51	7.11	1056	-37.8	0.44
MW-17A	7 Jun 06	20.7-30.7	0.5	26.57	6.60	1710	60.3	1.42
MW-18A	7 Jun 06	15-25	0.6	21.52	6.70	1732	-30.2	0.25
MW-20A	8 Jun 06	10-20	0.5	25.36	6.90	1876	-36.6	0.19
MW-21A	8 Jun 06	10-20	0.6	24.79	6.80	1856	-52.2	0.09
MW-22A	9 Jun 06	15-25	0.5	20.75	7.09	1703	-45.3	0.20
MW-25A	7 Jun 06	18-28	0.7	20.44	6.69	1775	26.0	0.21
Average			0.6	22.08	7.10	1602	-24.1	0.33
B-Zone								
MW-8B	9 Jun 06	45-60	0.5	20.02	7.51	1561	-7.7	0.14
MW-11B	8 Jun 06	40-50	0.8	21.26	7.00	1722	-51.1	0.14
MW-12B	8 Jun 06	50-60	0.4	19.36	7.47	1529	-131.7	0.27
MW-13B	9 Jun 06	45-55	0.6	20.74	8.29	1356	-45.3	0.20
MW-14B	8 Jun 06	40-50	0.7	23.41	7.24	1573	-114.0	0.14
MW-15B	8 Jun 06	49-59	2.0	19.52	7.13	1462	-0.2	0.23
MW-16B	8 Jun 06	35-45	2.0	19.09	6.71	1605	98.0	0.22
MW-17B	7 Jun 06	44-54	0.9	21.12	6.92	1141	20.1	0.15
MW-18B	7 Jun 06	32-42	0.3	21.92	6.66	1750	38.2	0.34
MW-20B	8 Jun 06	30.5-40.5	0.7	25.6	7.25	1403	-123.8	0.15
MW-21B	8 Jun 06	29-39	0.6	23.84	7.06	1732	-26.0	0.23
MW-22B	9 Jun 06	40-50	0.6	19.5	7.15	1609	75.3	0.20
MW-25B	7 Jun 06	48-58	0.6	25.16	6.92	1800	46.9	0.97
Average			0.8	21.58	7.18	1557	-17.0	0.26

Notes:

ft bgs = feet below ground surface
 °C = degrees Celsius
 mS/cm = microsiemens per centimeter
 mV = millivolt

Table D-3
A-Zone Bulk Attenuation Rate Calculation
Hookston Station
Pleasant Hill, California

Well ID	x (ft)	PCE (µg/L)	TCE (µg/L)	cDCE (µg/L)	tDCE (µg/L)	VC (µg/L)
MW-13A	0	45	5,000	380	50	50
MW-08	234.78	5.0	540	42	4.1	5.0
MW-14A	553.04	50	1,600	5,800	21	1,400
MW-15A	965.22	5.0	510	75	2.0	5.0
MW-16A	1,695.7	5.0	550	49	5.0	5.0
MW-17A	2,400.0	2.5	220	0.99	2.5	2.5

Notes:

Shaded/italicized values are non-detects reported as one-half the method detection limit.
 Groundwater data from January 2006 monitoring round.

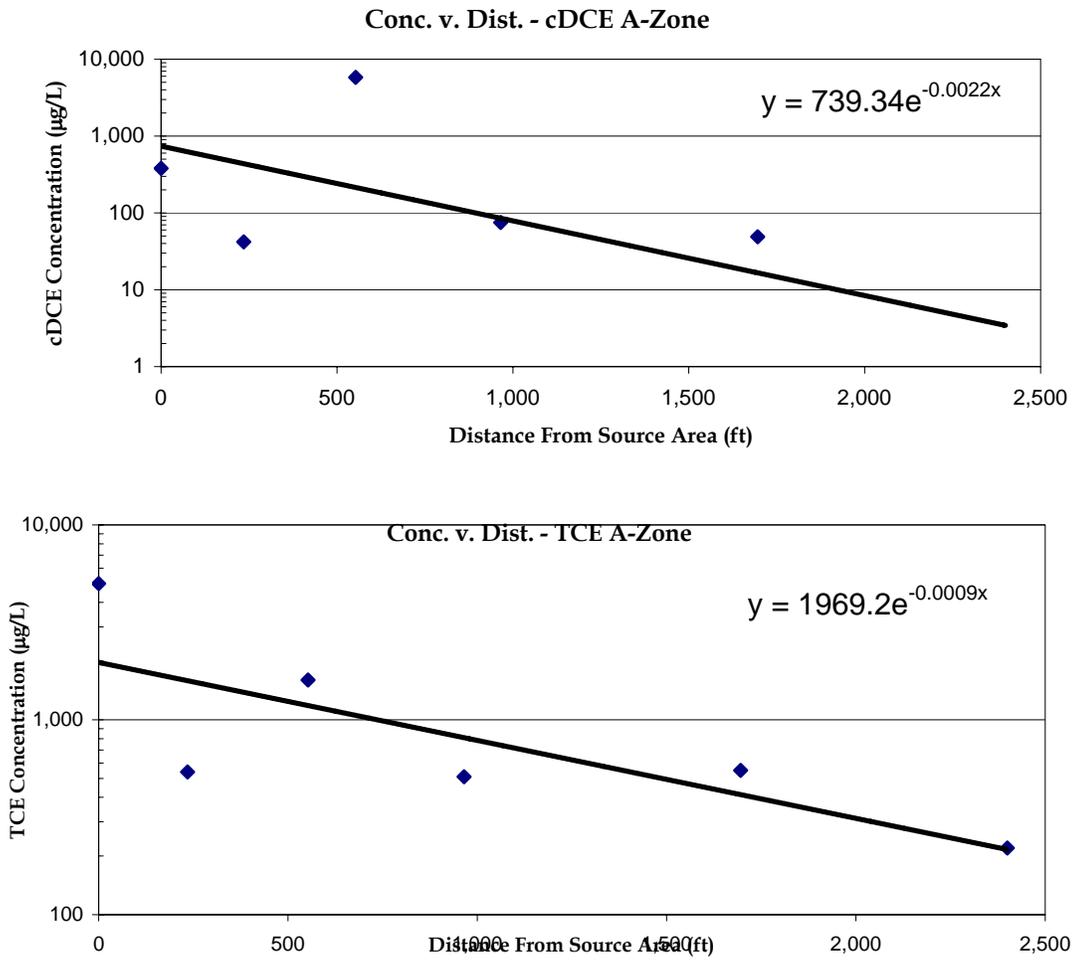


Table D-4
B-Zone Bulk Attenuation Rate Calculation
Hookston Station
Pleasant Hill, California

Well ID	x (ft)	PCE (µg/L)	TCE (µg/L)	cDCE (µg/L)	tDCE (µg/L)	VC (µg/L)
MW-11B	0	250	22,000	2,500	250	250
MW-13B	297.4	10	960	73	10	10
MW-08B	532.2	10	1,200	31	10	10
MW-14B	850.4	50	5,600	50	50	50
MW-15B	1,262.6	25	2,000	340	25	25
MW-16B	1,993.1	10	930	24	10	10
MW-17B	2,697.4	5.0	480	1.0	5.0	5.0

Notes:

Shaded/italicized values are non-detects reported as one-half the method detection limit.
 Groundwater data from January 2006 monitoring round.

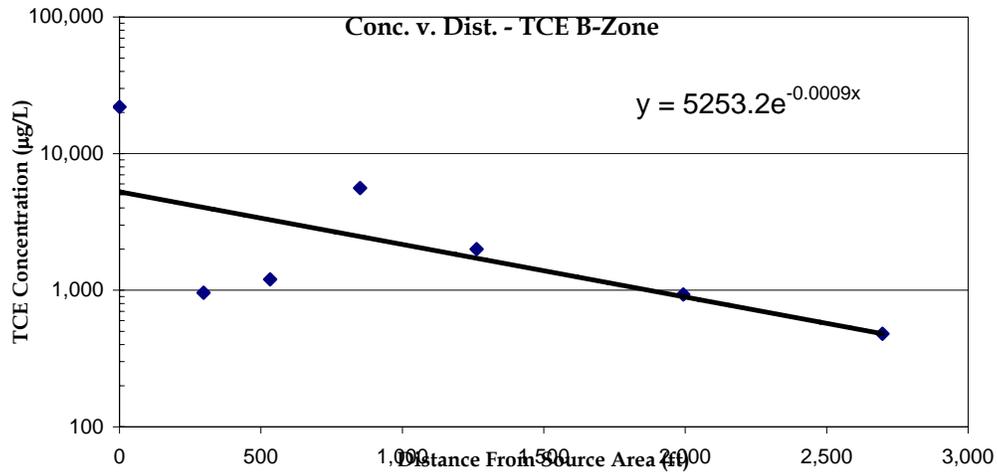
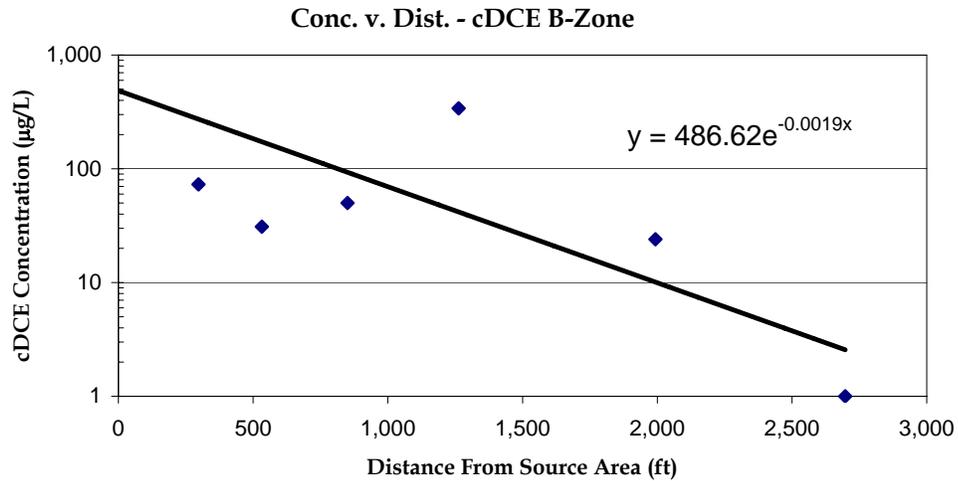


Table D-5
First-Order Degradation Rate Constants
Hookston Station
Pleasant Hill, California

	A-Zone Calculations				B-Zone Calculations			
	k/v_x (ft ⁻¹)	k (day ⁻¹)	Calculated λ^1 (day ⁻¹)	Half-life (year)	k/v_x (ft ⁻¹)	k (day ⁻¹)	Calculated λ^1 (day ⁻¹)	Half-life (year)
TCE	-0.0009	0.00010	-0.000098	19	-0.0009	0.00047	-0.00046	4
cis-1,2-DCE	-0.0022	0.00024	-0.000234	8	-0.0019	0.00099	-0.00096	2

Notes:

k = First order rate constant, all degradation processes.

¹ = Calculated as follows:

$$\alpha_x = 0.83(\text{Log}_{10} L_p)^{2.414} \quad \lambda = \frac{v_c}{4\alpha_x} \left(\left[1 + 2\alpha_x \left(\frac{k}{v_x} \right) \right]^2 - 1 \right) \quad \text{half-life (years)} = \frac{\ln(2)}{\lambda \cdot 365}$$

Where:

Symbol	Description	A-Zone	B-Zone	Units	Source
α_x	Longitudinal dispersivity				
	TCE	15.9	16.5	ft	Calculated
	cis-1,2-DCE	14.7	16.5	ft	Calculated
L_p	Plume length				Site data
	TCE	2,500	2,800	ft	
	cis-1,2-DCE	1,950	2,800	ft	
λ	1 st -order biological rate constant	See Above	See Above		Calculated
v_c	Retarded contaminant velocity	0.110	0.520	ft/day	Seepage velocity, assumed no retardation due to sorption
k/v_x	Slope of trend line	See Above	See Above		Semi-log Concentration v. Distance plot, from Tables D-3 and D-4

*Table D-6
A-Zone Mass Flux Calculation
Hookston Station
Pleasant Hill, California*

Transect	Contaminant Velocity (ft/day)	Depth of Aquifer (feet)	Width of Section (feet)	Average Concentration (µg/L)	Conversion Factor ¹	Mass Rate Through Transect (lb/yr)
I	0.110	16	60	27.5	2.28E-05	0.0661
	0.110	16	110	275	2.28E-05	1.213
	0.110	16	120	3,192	2.28E-05	15.35
						16.63
II	0.110	16	140	27.5	2.28E-05	0.1543
	0.110	16	270	310	2.28E-05	3.350
						3.504
Total Transect I and II mass rate (lb/yr) =						20.13
III	0.110	10	120	27.5	2.28E-05	0.0827
	0.110	10	615	275	2.28E-05	4.24
	0.110	10	235	567	2.28E-05	3.338
						7.66
Total Transect III mass rate (lb/yr) =						7.66
Mass rate difference (lb/yr) =						12.48
Mass Loss =						62%

Notes:

Transect I = Mass from Hookston Station source area.

Transect II = Mass entering Hookston Station's western property boundary.

Transect III = Mass flowing through downgradient study area.

¹ = Converts (ft³/day)*(µg/L) to lb/yr.

µg/L = micrograms per liter.

lb/yr = pounds (mass) per year.

Table D-7
B-Zone Mass Flux Calculation
Hookston Station
Pleasant Hill, California

Transect	Contaminant Velocity (ft/day) ¹	Depth of Aquifer (feet)	Width of Section (feet)	Average Concentration (µg/L)	Conversion Factor ¹	Mass Rate Through Transect (lb/yr)
I	0.520	30	32	27.5	2.28E-05	0.313
	0.520	30	26	275	2.28E-05	2.54
	0.520	30	32	2,750	2.28E-05	31.3
	0.520	30	47	16,150	2.28E-05	270
Total Transect I and II mass rate (lb/yr) =						304
II	0.520	30	200	27.5	2.28E-05	1.954
	0.520	30	300	275	2.28E-05	29.3
	0.520	30	785	761	2.28E-05	212.1
Total Transect II mass rate (lb/yr) =						243.4
Mass rate difference (lb/yr) =						60.4
Mass Loss =						20%

Notes:

Transect I = Mass from Hookston Station source area.

Transect II = Mass flowing through downgradient study area.

¹ = Converts (ft³/day)*(µg/L) to lb/yr.

µg/L = micrograms per liter.

lb/yr = pounds (mass) per year.

Attachment A
Time Estimate for Operating
Vapor Intrusion Prevention
Systems

Memorandum

**Environmental
Resources
Management**

To: Project File

From: Arthur Taylor, Arun Chemburkar, P.E.

Date: 8 June 2006

Subject: Time Estimate for Operating Vapor Intrusion
Prevention Systems

1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596
(925) 946-0455
(925) 946-9968 (fax)



Calculations were made for the downgradient study area to estimate incremental operation time for vapor intrusion prevention systems after the ground water remediation efforts have been reduced to concentrations that no longer warrant concern for vapor intrusion into indoor air. This memorandum describes the calculation method, assumptions made in creating the conceptual model, and the resulting durations for the residual TCE in the vadose zone (comprised of TCE mass in the pore vapor, dissolved in soil moisture and sorbed to the soil) to attenuate to levels that pose no adverse effect to human health.

INTRODUCTION

The primary chemicals of concern is trichloroethene (TCE), and will be the focus of this exercise to estimate the lag time between attaining the ground water Environmental Screening Level (ESL) of 530 µg/L and the time after which the TCE in vadose soils are expected to no longer pose a TCE vapor intrusion risk to the residents in the area of interest.

ASSUMPTIONS

For this exercise, as an overlying assumption, several soil characteristics are assumed to be homogeneous throughout the vadose zone.

Fourteen soil samples were analyzed during a geotechnical study performed on the Hookston Station Parcel. The average porosity of these samples was 43% (0.43) with a standard deviation of only 3.3%. Of these samples, six were considered to be part of the vadose zone. These samples had an average porosity and standard deviation of 42.55% and 1.93, respectively. The comparable porosities led to the decision to utilize the observed mean porosity for all the samples as the porosity for the model. The average bulk density of the same samples was 1.55 g/cm³, with a standard deviation of 0.086 g/cm³. Ground water depths were measured in 48 monitoring wells, some of which were installed as early as 1990. The ground water depth records for these

wells yielded and average groundwater depth of 16.67 ft, with a standard deviation of 2.60 ft. A ground water depth of 16.7 ft was used to model the subsurface.

Based on the above characteristics, the following assumptions regarding the physical characteristics of the subsurface were used in the calculations:

- Homogeneous Soil Porosity = 0.43
- Homogeneous Soil Density = 1.55 kg/L
- Uniform groundwater depth = 16.7 ft.
- Volumetric water content within soil volume = 0.33
- Volumetric air content within soil volume = 0.1

Several assumptions were also made regarding the physical interactions between the groundwater, soil, and pore vapor and the interactions of their geochemical constituents. These assumptions are as follows:

- The TCE concentration is uniform in the pore vapor and soil moisture; and,
- The TCE sorbed to soil particles is capable of desorbing at a rate that is not limiting beyond the compensation factors discussed below.

To achieve a conservative estimate of the time required for the pore vapor in the vadose zone to reach clean-up concentrations, efficiency factors are incorporated into the calculations. One such factor relates to the ability of the vapor intrusion prevention system (RadonAway™ fan systems are used in the downgradient study area) to extract air from the vadose zone. We estimate that only 75% of the available airflow contains extracted air from the vadose zone and the remainder of the air estimated to have leaked in from the ground surface immediately surrounding the footprint of the home. In addition, an efficiency factor of 30% is applied when calculating the TCE concentration in the vent gas of the vapor extraction process to account for the possible decrease in TCE concentration in the pore vapor, as the migration of TCE contaminated vapor up through the soil column is likely diffusion limited.

To make this exercise straightforward, we have assumed that the beneficial effect of operation of vapor intrusion prevention systems during the ground water remedy implementation were ignored to add conservatism as well as calculation simplicity to the duration estimate.

CALCULATIONS

TCE Concentrations

Henry's Law is utilized to determine the TCE pore vapor concentration in equilibrium with the groundwater clean up goal concentration (530 µg/L or part per billion [ppb]).

$$C_{AIR} = K_h \times C_{WATER} \quad (1)$$

where K_h is the dimensionless Henry's Law constant (0.379 for TCE). The TCE concentration in the soil vapor can thus be determined ($C_{AIR} = 201$ ppbv). Using the DiGiulio Method (DiGiulio, 1992) the following equation can be derived to determine the total fraction of TCE in the soil (in pore vapor, soil moisture and sorbed to the soil particles):

$$C_{SOIL} = C_{AIR} * (a * K_d / K_h + b / K_h + c)$$

where

a = bulk density (kg/L)

b = Volumetric water content within soil volume (dimensionless)

c = Volumetric air content within soil volume (dimensionless)

K_d = Distribution coefficient (L/kg)

K_h = Henry's Law constant (dimensionless)

Using the values discussed in the assumptions section above the TCE concentration sorbed to the soil can be calculated ($C_{SOIL} = 223$ ppb).

The portion of the downgradient study area exceeding indoor air risk is estimated to be approximately 256,000 ft². This number was derived from the 500 µg/L TCE in the groundwater concentration contour line, as shown in Figure 6 of the *First Quarter 2006 Monitoring Report and April 2006 Monthly Status Report*, prepared by ERM on 1 May 2006. Using the assumptions that the distance to ground water is constant and that C_{SOIL} is uniform the total mass of the TCE in the vadose zone is estimated to be 4.19×10^4 g.

TCE Flux

ERM conducted a preliminary risk evaluation of the vapor intrusion threat to the residential units in the area of interest (ERM, 2002). During this study a flux chamber was used to determine VOC fluxes both indoors and outdoors. The outdoor sampling effort yielded a TCE flux of $0.085 \mu\text{g}\cdot\text{m}^{-2}\cdot\text{min}^{-1}$.

For the purpose of this study, approximately 20 of the homes, with footprints of 2,000 ft² each, in the downgradient study area will be equipped with RadonAway™ pumping systems below the house to evacuate VOCs vapors and preventing them from entering the home. A conservative estimate of the extraction rates of these pumps is 100 cubic feet per minute (CFM). An efficiency factor of 75% is used to make allowance for the possibility of air leakage from the surface. Thus, only 75 CFM of vented gas is anticipated to be drawn in from the vadose zone. As mentioned above, the TCE concentration in the pore vapor (C_{AIR}) is assumed constant throughout the soil column, and was estimated using Henry's Law to be 201 ppbv. However, an efficiency factor of 30% is applied to this to account for the diffusion limited transport of the TCE vapor up from the water table, as discussed in the assumptions section above.

The TCE flux attributed to the RadonAway™ systems can be estimated using the following equation:

$$\frac{m}{\text{day}} = Q_v \times \frac{mw}{V} \times C_{\text{ppmv}} \times 1440(\text{min}/\text{day})$$

where

Q_v = Volumetric Flux of vent gas

mw = molecular weight

C_{ppmv} = Concentration of contaminant in venting gas

resulting in a flux of $2.22 \times 10^{-3} \text{ lb}/\text{day}$, which incorporates the efficiency factors discussed above in both Q_v and C_{ppmv} . The TCE flux for the remainder of the surface is estimated using the TCE surface flux measured during the *Preliminary Risk Evaluation* to be $5.43 \times 10^{-3} \text{ lb}/\text{day}$.

Acceptable Levels of TCE in the subsurface

The indoor air cleanup goal, representing a 1E-06 theoretical lifetime excess cancer risk (or a Hazard Index of 1 for non-carcinogens) for residential inhalation, assuming elevated breathing rates in accordance with Water Board requirements, is 0.96 µg/m³ for TCE. This value represents a calculated one-in-a-million lifetime excess cancer risk number that was calculated within the Baseline Risk Assessment (CTEH, 2006). Using a conservative attenuation factor of 1E-03 (concentration in indoor air/concentration in subsurface soil vapor), the concentration allowable in indoor air (0.960 µg/m³) translates to 960 µg/m³ of TCE allowed in the pore vapor. Using the DiGiulio Method and following similar calculations as above results in a total of 3.35 x 10⁴ g TCE allowed in the subsurface under consideration.

Clean-up Time Estimation

Applying a first order rate equation to determine the time required to vent the TCE from the subsurface:

$$(TCE_1 - TCE_{ALLOWABLE}) / (F_R + F_S) = t$$

where:

TCE₁ = Estimated starting mass of TCE in the vadose zone

TCE_{ALLOWABLE} = Acceptable TCE mass in vadose zone, as discussed above.

t = time

F_R = TCE flux attributed to RadonAway™ systems

F_S = TCE flux rate of open surfaces

This equation yields an estimated clean-up lag time of approximately 368 days. This calculation neglects the impact of pavement outside the houses (e.g., roads, driveways and sidewalks). If the neighborhood is assumed to be 40% pavement and that the flux through that pavement is zero, the clean-up lag time changes by 30 days, to 398 days.

CONCLUSIONS

It is estimated that operation of vapor intrusion prevention systems (rated for 100 scfm) from 20 locations for approximately one year, will reduce TCE levels to below regulatory standards, after the groundwater remediation effort has achieved its clean-up goal.

REFERENCES

ERM, 2002. *Preliminary Risk Evaluation: Hookston Station Project, Pleasant Hill, California*. 22 October 2002.

DiGiulio, Dominic C., 1992. *Evaluation of Soil Venting Application*. Ground Water Issue, April 1992. EPA/540/S-92/004.

Attachment B
Polymerase Chain Reaction
Assay Results



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Phone: (865) 573-8188
Fax: (865) 573-8133
Email: info@microbe.com

Analysis Report

Client: Mike Lee
Terra Systems, Inc.
1035 Philadelphia Pike
Suite E
Wilmington, DE 19809

Phone: (302) 798-9553

Fax: (302) 798-9554

MI Identifier: 031DD

Date Rec: 04/19/2006

Report Date: 04/20/2006

Client Project #:

Client Project Name: Hookston ANG

Purchase Order #:

Analysis Requested: CENSUS (final), Chain of Custody

Comments:

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

Reported By:

Reviewed By:

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

MICROBIAL INSIGHTS, INC.

2340 Stock Creek Blvd. Rockford, TN 37853-3044
Tel: (865) 573-8188; Fax: (865) 573-8133

Q Potential (DNA)

Client: Terra Systems, Inc.
Project: Hookston ANG

MI Project Number: 031DD
Date Received: 04/19/2006

Sample Information

Client Sample ID:	A	B
Sample Date:	04/18/2006	04/18/2006
Units:	cells/g	cells/g

Dechlorinating Bacteria

Dehalococcoides spp (1)	DHC	1.68E+03	6.34E+03
-------------------------	-----	----------	----------

Functional Genes

TCE R-Dase (1)	TCE	<9.47E+02	4.43E+00 (J)
VC R-Dase	VCR	<9.47E+02	9.03E+02 (J)

Legend:

NA = Not Analyzed NS = Not Sampled J = Estimated gene copies below PQL but above LQL I = Inhibited
< = Result not detected

Notes:

1 Bio-Dechlor Census technology was developed by Dr. Loeffler and colleagues at Georgia Institute of Technology and was licensed for use through Regeneration.

REPORT TO:

Reports will be provided to the contact(s) listed below. Parties other than the contact(s) listed below will require prior approval.

Name: Mike Lee
 Company: Terra Systems Inc
 Address: 1035 Philadelphia Pike
Suite E
Wilmington DE 19809
 email: mlee@terrasystems.net
 Phone: (302) 798 9553
 Fax: (302) 798 9554
 Project Manager: Mike Lee
 Project Name: Hockston AVG
 Project No.: _____

INVOICE TO:

For Invoices paid by a third party it is imperative that contact information & corresponding reference No. be provided.

Name: Same
 Company: _____
 Address: _____
 email: _____
 Phone: () _____
 Fax: () _____
 Purchase Order No. _____
 Subcontract No. _____



2340 Stock Creek Blvd.
 Rockford, TN 37853-3044
 phone (865) 573-8188
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 email: info@microbe.com
 www.microbe.com

Please Check One:

More Samples to Follow
 No Additional Samples

Please contact us prior to submitting samples regarding questions about the analyses you are requesting at (865) 573-8188 (8:00 am to 5:00 pm M-F). After these hours please call (865) 300-8053.

Sample Information					qPCR Targets																									
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Matrix	Contaminant (BTEX, TCE, etc.)	PLFA	VFA	W/E/E	POC-CO ₂	POC-SSE	qSBAAC (Total)	qSRB/RSS	qMGN (methanogens)	qMCR (methanotrophs)	qDNF (Denitrifying)	qAOB (ammonia oxidizing)	qDHC (Dehalococoides)	qTCE-P-Dase	qBAPV-VCF-Ease	qTBE (Dehalobacter)	qDSM (Desulforomnis)	qPMI (MTBE aerobic)	qTOD (Total PAHs aerobic)	qCAT (Intermediate PAHs aerobic)	qBSS (Toluene/Xylene Anaerobic)	qNAH (Naphthalene aerobic)	qBIC (qPCR)	Other	Other	Other	
031 DD 1	A	4/18/06	S	TCE																										
2	B	4/18/06	S	TCE																										

Relinquished by: Michael Lee Date: 4/18/06 16:25 Received by: _____

Sample(s) Received: 04.19.06 ^{Felix} Time: 10:10
 COC sent: Y N Bottle ID match: Y N
 Temp.: 17°C All intact? ✓
 No. of damaged/missing samples: 0

Sample Analyses Requested
 CUL Y DNA Y IAQ PLFA VFA Other: _____

Set #: 031 DD Signed: _____

In order for analysis to be completed correctly, it is vital that chain of custody is filled out correctly & that all relative information is provided. Failure to information may result in delays for which MI will not be liable.

Appendix E
Soil Vapor Extraction Pilot Test

APPENDIX E – SOIL VAPOR EXTRACTION PILOT TEST

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- E-2** *SVE Performance Test - Vacuum Readings versus Time*
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LIST OF ATTACHMENTS

- A** *Well Construction Logs*
- B** *Field Sheets*
- C** *Soil Vapor Analytical Report*
- D** *Data Evaluation Computations*

1.0

INTRODUCTION

On behalf of Union Pacific Railroad Company and Daniel C. Helix (on behalf of himself, Mary Lou Helix, Elizabeth Young, John V. Hook, Steven Pucell, Nancy Ellicock, and the Contra Costa Redevelopment Agency), ERM-West, Inc. (ERM) has prepared this *Soil Vapor Extraction Pilot Study Summary Report* for the Hookston Station site in Pleasant Hill, California (the "site"). In order to evaluate soil vapor extraction (SVE) as a potential remedial alternative for the site, a pilot test was conducted on 11 April 2006.

SVE involves the application of a vacuum to wells screened in the unsaturated zone of contaminated soils. The vacuum, which is applied using an aboveground blower, induces vapor flow through impacted soils. The volatile organic compounds (VOCs) within the soil are removed through evaporation, volatilization, and desorption through the extraction wells. The extracted vapors are typically treated with granular activated carbon or with a thermal or catalytic oxidizer prior to discharge to the atmosphere.

The pilot test focused on obtaining the following system design parameters:

- A vapor flow rate system curve (vacuum versus vapor flow curve);
- Air permeability of unsaturated soils;
- Vacuum influence, radius of influence (ROI) and directional variations of the extraction well;
- Chemical constituents and concentrations in extracted soil vapor;
- Mass removal rates; and
- Water generation rates.

1.1

PILOT STUDY LOCATION

In order to maximize mass removal rates, demonstrate the capabilities of soil vapor extraction (SVE) as a remediation alternative, and to simulate system design conditions, the pilot study wells were located along the groundwater plume source area where the subsurface conditions were

thought to be fairly representative of the site as a whole (Figure E-1). This location also allows for accurate mass removal estimations for the design of vapor abatement equipment, as well as allowing for eventual scale up of the SVE system. To facilitate implementation of the SVE pilot study, one extraction well and three monitoring wells were installed. Well locations are shown on Figure E-1. Boring logs for the wells are provided in Attachment A. A detailed discussion of the activities completed during the installation of the SVE wells is provided in the following subsection.

1.2 SVE WELL INSTALLATION

One SVE well (SVE-1) and three test wells (TW-2, TW-3, and TW-4) were installed as a part of the SVE pilot test (Figure E-1). Prior to installing the wells, the following activities were completed:

- A well installation permit was obtained from the Contra Costa County Environmental Health Department;
- Underground Service Alert was notified; and
- ForeSite Engineering Services, a private utility locating service, was retained to clear the drilling location.

Gregg Drilling and Testing, Inc., a drilling subcontractor from Martinez, California, was retained to perform the well installations. A hollow-stem auger drill rig was used to conduct the drilling, sampling, and well installation activities on 7 and 10 April 2006. The drilling locations were hand-cleared to 5 feet below ground surface (bgs) to minimize the potential for encountering underground utilities during drilling activities.

Monitoring well SVE-1 was advanced to a total depth of 12 feet bgs and wells TW-2 through TW-4 were advanced to a total depth of 25 feet bgs with 6-inch diameter hollow stem augers.

Soil samples were collected continuously using 18- and 24-inch California-modified split spoon samplers. Boring logs, prepared in the field by ERM geologists using the Unified Soil Classification System, are included in Attachment A. The geologist recorded vertical changes in soil lithology, color, moisture content, grain size, and texture, as well as any observations of staining or odors.

Soil samples were collected for geotechnical analysis from the unsaturated zone and the A-Zone aquifer at each well location. The samples were collected in shelly tubes, labeled, and sent under proper chain-of-custody procedure to Cooper Testing Labs in Palo Alto, California, for the following analysis:

- Grain size distribution (American Society for Testing and Materials [ASTM] D422);
- Dry bulk density, total porosity, effective porosity, air-filled porosity, water-filled porosity, and moisture content (API RP40 and ASTM D2325m);
- Specific gravity (ASTM D854m);
- Percent saturation (ASTM D5084); and
- Total organic content (Walkley-Black).

Once the total depth of the boring was reached and the samples were collected, the boring was then over-drilled with using 10-inch (SVE-1) or 8-inch (TW-2 through TW-4) diameter hollow stem augers in order to accommodate the installation of the well materials. SVE-1 was then constructed with 4-inch-diameter polyvinyl chloride screen (0.020-inch machine-slotted) from 5 to 12 feet bgs and blank riser pipe to the ground surface. Wells TW-2 through TW-4 were constructed with 2-inch diameter polyvinyl chloride screen (0.020-inch machine-slotted) from 5 to 25 feet bgs and blank riser pipe to the ground surface. For each well, a filter pack of #2/12 sand was placed within the annular space to approximately 6 inches above the top of the screen interval. The transition seal consisted of 2 feet of bentonite chips hydrated with potable water approximately 30 minutes prior to placement of the cement-bentonite seal. SVE-1 and TW-2 through TW-4 were completed at the ground surface with a flush-mounted well vault, watertight expansion cap, and secured with a lock.

Wells TW-2 through TW-4 were developed on 13 April 2006 using a dedicated disposable bailer for each well. Approximately 18 gallons (roughly 10 well volumes) were removed from each well. The wells were also surged during development to remove any sediment that entered during installation. Stabilization parameters (acidity/alkalinity, specific conductance, turbidity, and temperature) were monitored and recorded during development. Copies of the well logs are provided in Attachment A and the geotechnical analytical results are included in Appendix F of the Feasibility Study.

1.3

SOIL VAPOR EXTRACTION PILOT TEST EQUIPMENT

The SVE pilot test equipment consisted of a generator, a vacuum blower, a liquid knockout vessel, a liquid transfer pump, a thermal oxidizer, a recovered-liquids containment tank, and conveyance piping. The generator, vacuum blower, knockout vessel, and transfer pump were installed on a trailer. Vapor effluent from the blower was routed through the thermal oxidizer for treatment prior to discharge to the atmosphere. Other equipment used for the pilot test included a thermal anemometer, vacuum gauges, a vacuum pump, and a photoionization detector.

2.0 *PILOT TEST PROCEDURES*

The purpose of the pilot test was to obtain the design parameters that are necessary for evaluating SVE as a remedial alternative for the site. Two field tests were conducted to collect the SVE design data. The first was a step test designed to measure the vapor flow versus vacuum applied to the extraction well. Following the step test, a short-term pilot test was conducted to determine the soil air permeability, ROI, extracted vapor concentrations, and mass removal rates. Prior to the start of the pilot test, the Bay Area Air Quality Monitoring Board was notified as per Regulation 8 Rule 47 specifications.

2.1 *INITIAL WELL MEASUREMENTS*

Prior to startup of the pilot tests, baseline measurements of groundwater elevations, wellhead VOC readings, and wellhead vacuum readings were collected under static conditions from the test wells. These measurements are included in Attachment B.

2.2 *SYSTEM PERFORMANCE STEP TEST*

Following collection of the baseline data, the SVE system was started. A system performance step test was conducted to collect data on flow rate versus applied vacuum.

The test began with the air dilution valve at the blower completely open. The dilution valve was then closed to achieve an initial vacuum of 10 inches of water (in H₂O). The resulting vapor flow rate was allowed to stabilize, measured with a hot-wire anemometer, and recorded. This procedure was repeated in seven increments of increasing vacuum until the valve had been sufficiently closed to achieve the maximum operating vacuum of the pump (roughly 340 in H₂O). The readings collected during the step test are presented in Attachment B.

The flow rate versus applied vacuum data was plotted and this data was used to determine the most efficient operating vacuum for the system. Based on this data, it was determined that the maximum flow rate occurred when a vacuum of roughly 100 in H₂O was applied to the

extraction well. As a result, further testing of the SVE system was conducted while operating at an applied vacuum of about 100 in H₂O.

2.3 *SHORT-TERM PILOT TEST*

Once the SVE system step test was completed, the SVE system was shut down to allow the area to return to baseline conditions. Data loggers designed to continuously measure and record air pressure were placed in the monitoring wells (TW-2, TW-3, and TW-4). In addition, specialized well caps were fitted to the test wells to allow for collection of manual pressure readings.

Once all equipment was in place, the SVE system was started and operated at an initial vacuum of 100 in H₂O. The vacuum was adjusted throughout the test to attempt to maintain a constant flow rate of approximately 145 standard cubic feet per minute (scfm). Since the first few minutes of the pilot test are critical for data collection, as the rate of change is usually greatest during this period, extraction well vacuum readings, photoionization detector readings, extracted vapor flow rate, and induced vacuum readings at the monitoring wells were collected as quickly as possible for the first 30 minutes and every 10 minutes for the next 40 minutes. After 10 and 20 minutes, vapor samples were collected for laboratory analysis. Subsequent readings were generally collected every 30 minutes over the remaining duration of the 6-hour test. Prior to completion of the test, final readings were recorded and a third vapor sample was collected for laboratory analysis. The field data is provided in Attachment B.

The three extracted vapor samples collected for laboratory analysis were submitted to Air Toxics, Ltd., in Folsom, California, for analysis of chlorinated VOCs using United States Environmental Protection Agency Method TO-14. The laboratory analytical results are provided in Attachment C.

3.0 DATA EVALUATION AND RESULTS

This section provides a summary of the data obtained, observations made and evaluations conducted as they relate to designing a technically and economically feasible full-scale SVE system. The field data logs, analytical data, and calculations are provided in Attachments B, C, and D, respectively.

3.1 SYSTEM PERFORMANCE STEP TESTING

Figure E-2 presents a vacuum versus flow performance curve for the site. A maximum flow rate of approximately 154 scfm was observed at a vacuum of 100 in H₂O. The flow rate decreased as the applied vacuum to the extraction well increased beyond 100 in H₂O. This decrease in flow at increasing vacuum is likely due to a reduction in unsaturated media available for vapor flow caused by groundwater mounding. The most efficient operating conditions of the SVE system occurred while applying a vacuum of about 100 in H₂O.

3.2 PERMEABILITY TESTING

The soil permeability with respect to air was calculated under transient conditions and using a steady state approach. Under transient conditions, the Cooper-Jacob approximation of the Johnson, Kemblowski, and Colthart (United States Army Corps of Engineers [USACE] 2002) solution for transient radial two-dimensional flow was used to calculate the soil air permeability. Vacuum measurements from each monitoring well were plotted with respect to time on a log scale (Figure E-3). A linear fit was applied to each plot and the slope of this line was used to calculate the soil air permeability. These calculations are included in Attachment D-2.

Using this approach, the following soil air permeabilities were calculated:

$$K_{TW-2} = 201 \text{ darcy}$$

$$K_{TW-3} = 57 \text{ darcy}$$

$$K_{TW-4} = 304 \text{ darcy}$$

The soil air permeability was also calculated based on an equation for one-dimensional radial flow (USACE 2002). With this method, the soil air permeability is calculated using the vacuum measurements from monitoring points at varying distances from the extraction well after the system has reached a steady state. These calculations are included in Attachment D-3. Using this steady state approach, the following soil air permeabilities were calculated:

$$K_{TW-2/TW-3} = 62 \text{ darcy}$$

$$K_{TW-3/TW-4} = 27 \text{ darcy}$$

The soil air permeability values calculated using the steady state approach were very similar to the value calculated for TW-3 under transient conditions. For the purpose of this evaluation, it was assumed that these values most accurately represent the average soil air permeability at the site. As a result, the value for soil air permeability that is assumed to be representative of the site is estimated at 60 darcy.

3.3

VACUUM INFLUENCE AND RADIUS OF INFLUENCE

Figure E-4 shows the relationship between the vacuums observed in the monitoring wells versus their distance from the extraction well. As shown in this figure, the observed vacuum influence was greater in TW-2, located approximately 20 feet from the extraction well, than in TW-4, which is located approximately 10 feet from the extraction well. This indicates that vacuum influence is not radial and that the actual vacuum influence for a SVE well would likely vary due to heterogeneity of soils across the site.

The system ROI was calculated using the steady state equation for one-dimensional radial flow (USACE 2002). Using the values observed during the test at TW-3, the radial distance from the extraction well that would produce a vacuum measurement of 0.01 in H₂O was calculated to be roughly 26 feet. ROI calculations are provided in Attachment D.

The USACE recommends that minimum pore gas velocity of 3 to 30 feet per day be used for the design criteria when determining the ROI. Using darcy's law, it was determined that the pore gas velocity at a radial distance of 26 feet under a vacuum of 0.01 in H₂O was 15 feet per day, which falls within the USACE guidelines (Attachment D).

3.4 *EXTRACTED VAPOR CONCENTRATIONS*

Three vapor samples were collected and submitted for laboratory analysis during the pilot test. Although several VOCs were detected in the samples, the primary constituents of concern were 1,1-dichloroethene (DCE), *cis*-1,2-DCE, trichloroethene (TCE), and tetrachloroethene (PCE). The vapor sampling showed:

- Total VOC concentrations ranging from 9.1 to 77.6 micrograms per liter (ug/L);
- 1,1-DCE concentrations ranging from 0.10 to 0.95 ug/L;
- *cis*-1,2-DCE concentrations ranging from 0.034 to 0.32 ug/L;
- TCE concentrations ranging from 8.9 to 76.0 ug/L; and
- PCE concentrations ranging from 0.048 to 0.37 ug/L.

These data show increasing VOC concentrations over the duration of the pilot test, with final concentrations over 8 times greater than the initial readings. Analytical results are provided in Attachment C.

3.5 *MASS REMOVAL RATES*

Based on the concentrations and extracted flow rates observed, the mass removal rates for the pilot test ranged from 0.12 to 1.01 pounds per day (lbs/day), with TCE accounting for over 97 percent of the total. Over the duration of the 6-hour test, <0.01 lbs of 1,1-DCE, <0.01 lbs of *cis*-1,2-DCE, 0.13 lbs of TCE, and <0.01 lbs of PCE were extracted from the subsurface. Mass removal calculations are presented in Attachment D-5.

3.6 *WATER GENERATION RATES*

Measurable amounts of water were not observed during the SVE pilot study. It is likely that long-term operation, especially during winter months, could produce condensation, but water generation is anticipated to be minimal.

This section provides the conclusions developed as part of the SVE pilot test:

- The optimal vacuum for SVE operation was determined to be 100 in H₂O.
- Substantial vapor flow (150 scfm) can be achieved from a shallow extraction well with a short well screen (7 feet);
- Groundwater mounding in the extraction well appears to occur at vacuums in excess of 100 in H₂O;
- Soil permeabilities are calculated at 60 darcy;
- Vacuum influence and ROI calculations indicate a well spacing of 40 to 50 feet would be appropriate for an effective zone of influence;
- The SVE treatment area may be variable due to lithological heterogeneity of vadoze zone soils and surface covers (i.e., paving);
- The primary extracted contaminant, TCE, accounts for over 97 percent of the material expected to be extracted;
- Mass removal rates of less than 1 lb per day can be expected from the extraction wells; and
- Significant water production is not expected when operating the system at 100 in H₂O.

5.0

REFERENCES

United States Army Corps of Engineers. 2002. *Soil Vapor Extraction and Bioventing*. EM 1110-1-4001.

Figures

CAD File: G:\0020557\10\FS-002055710FS-54.dwg
Drawn By: J. Estrada
Date: 07/01/06
Project No. 0020557.10



- LEGEND**
- ▲ TEST WELL
 - ⊗ SOIL VAPOR EXTRACTION WELL

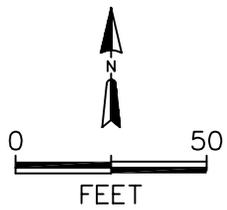


Figure E-1
SVE Pilot Test Locations Map
Hookston Station
Pleasant Hill, California

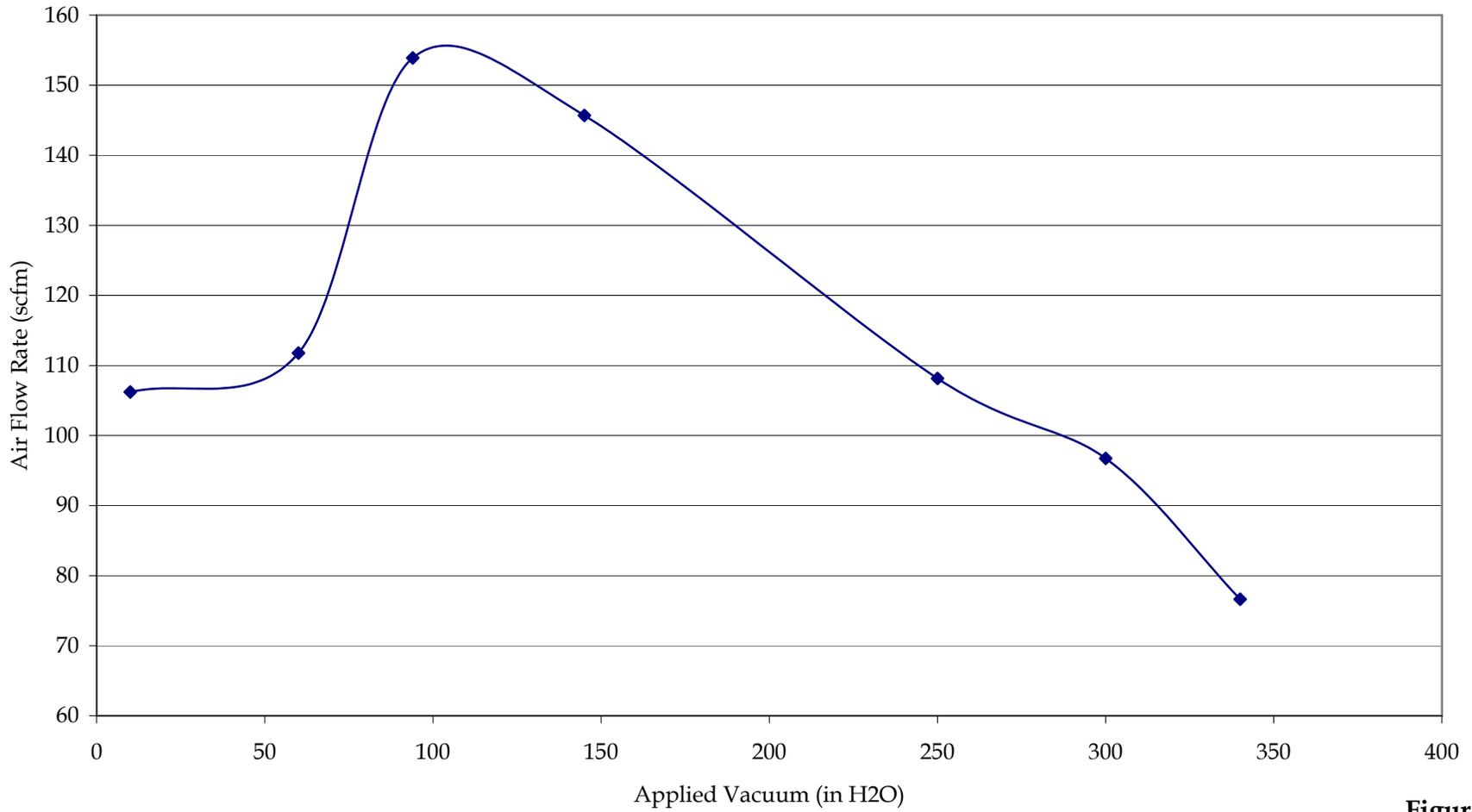


Figure E-2
SVE Performance Test
Vacuum Readings versus Time
Hookston Station
Pleasant Hill, California

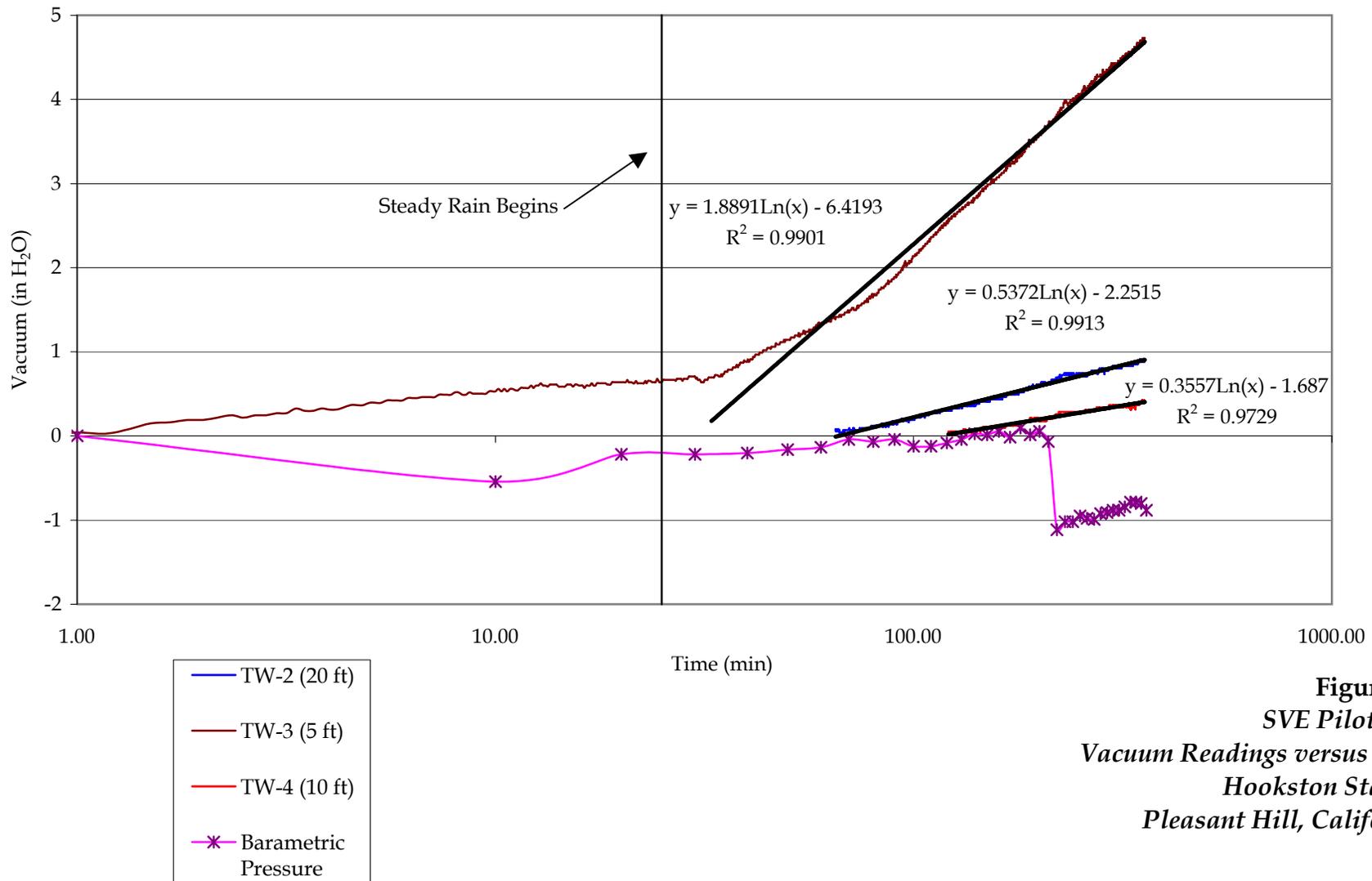


Figure E-3
SVE Pilot Test
Vacuum Readings versus Time
Hookston Station
Pleasant Hill, California

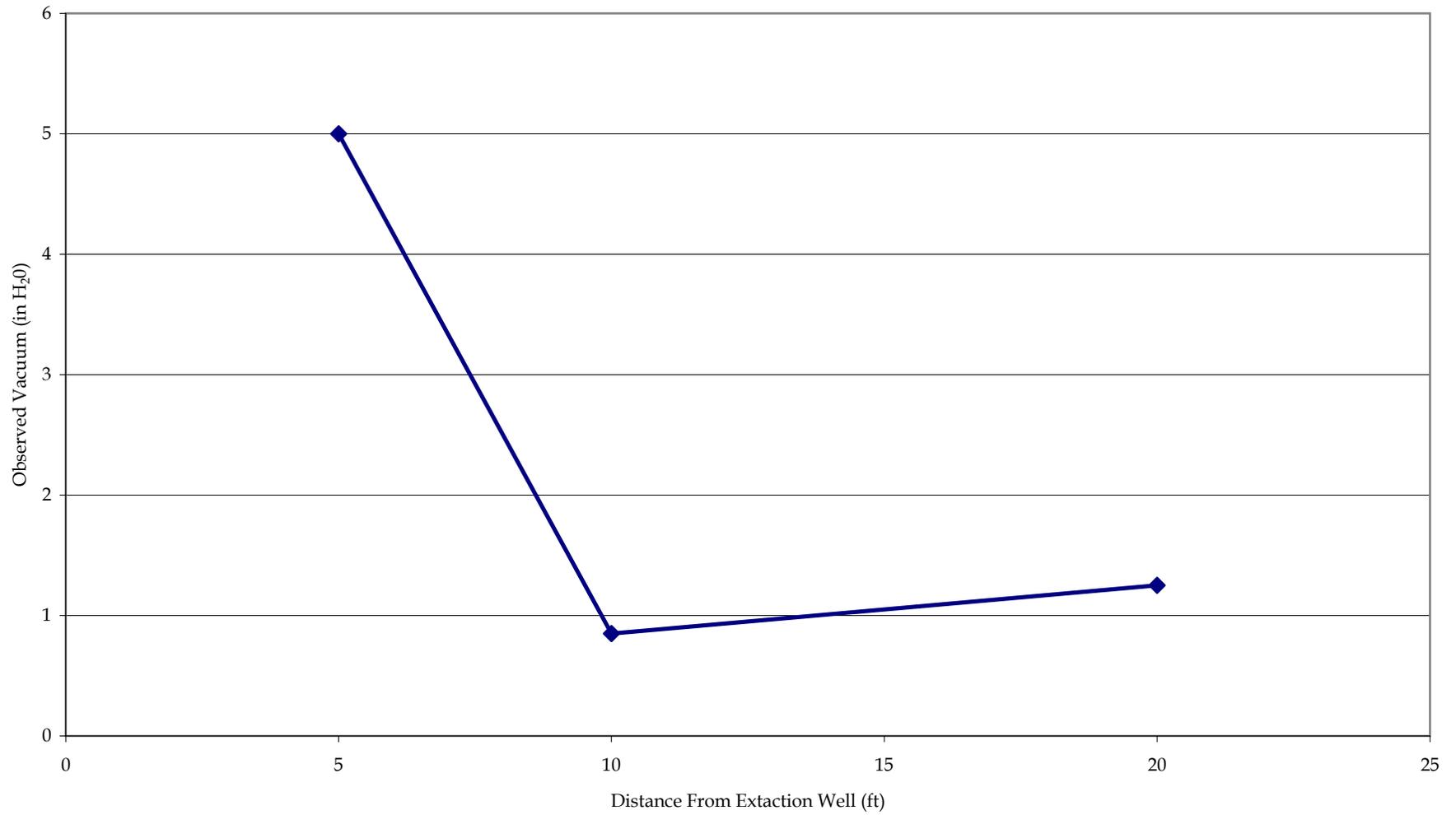


Figure E-4
SVE Pilot Test
Vacuum versus Distance
Hookston Station
Pleasant Hill, California

Attachment A
Well Construction Logs

Attachment B
Field Sheets

Project Hookston Station Project No. _____ Sheet _____ of _____
 Subject SUE Pilot Test Field Log By _____ Date _____
 Chkd. by _____ Date _____

Monday 4-10-06

11:00 On site to set up SUE system

11:30 Mako On site with SUE skid.
 Greg is still working on wells will need to wait for them to leave before we can set up SUE system.

12:30 Gregg Drilling finished installing the extraction well. Will not be able to extract from the well today because the grout needs to finish setting

13:00 Set up SUE unit. Fire up generator and blower and Thermal oxidizer.

14:30 All components are working fine. Walk through operating instructions with Mako
 *Liquid propane is used for generator and gas for Thermal Oxidizer.

15:30 Arun and Doug on site. Propane Tanks will need to be secured can not leave out over night. Also it is decided that SUE skid needs to be put in a more secure location.

16:00 Arun and Doug off site. Move propane tanks to fenced in yard ^{used} ~~used~~ by Jack's Auto body

17:00 off site

Environmental Resources Management

1777 Botelho Drive, Suite 260 • Walnut Creek, CA 94596
(925) 946-0455 • Fax (925) 946-9968

Project Hookston Station Project No. _____ Sheet _____ of _____
Subject SUE Pilot Test Field Log By _____ Date _____
Chkd. by _____ Date _____

Tuesday 4-11-06

- 7:45 On-site, move SUE skid to Pilot location
- 8:30 Chris on-site with SUE manifold, set up manifold. Take Baseline Readings
- 9:30 Starts to lightly rain. Begin system curve testing (see system curve notes)
- 10:30 Stop system curve test. From system test it is determined that max flow occurs at a vacuum of ≈ 100 in H₂O or 7" Hg
- 11:00 Reset data loggers and place in monitoring wells. Parametric pressure will be recorded on baratrod that Rachel and Chimi are using for pump test.
- 12:06 Start SUE Pilot Test (see notes)
- 12:30 Starts to rain steadily. Ann on-site
- 13:30 Ann off site
- 15:00 Head to office meet w/ Brian and Ann. Decide SUE Testing will continue until 18:00.
- 17:00 Back on site
- 18:00 Finish SUE Testing. Shut down systems. disconnect and move to the corner of the lot.
- 19:30 off site.



SVE Pilot Test
Soil Vapor Permeability Test
Field Data
Hookston Station

ERM Personnel:
Date and Arrival Time:
Ambient Temperature:

260 CAL6 Signatures: _____
4-11-06 9:00
Rainy 60°F



Time	Extraction Well Readings				Monitoring Well Vacuum Readings (in H ₂ O)		
	Applied Vacuum in H ₂ O	Temperature (F)	Flow Velocity (fpm)	Influent PID Reading	TW-2	TW-3	TW-4
12:07	100 in H ₂ O	63.6	709	31	NM	NM	NM
12:10	105	63.4	945	16	Ø	0.5	Ø
12:13	120	64.2	837	24	NM	NM	NM
10min 12:16	110	64.5	856	18	0.25	0.5	Ø
12:20	110	64.3	825	17	0.25	0.5	Ø
70min 12:26	110	63.8	850	19	0.20	0.55	Ø
12:36	110	NM	NM	31	0.10	0.6	Ø
12:46	110	NM	NM	21	0.10	0.6	Ø
12:56	110	NM	NM	22	0.10 NM	NM	NM
60min 13:06	110	NM	NM	18	0.15	1.4	0.10
70min 13:16	110	62.4	996	18	NM	NM	NM
90min 13:36	110	58.9	945	23	0.25	1.9	0.20
120min 14:06	105	59.1	1266	19	0.60	3.0	0.40
15:06	100	59.8	831	22	0.75	3.5	0.50
15:30	90	58.6	835	20.4	0.80	3.8	0.5
16:00	90	59.1	845	3.2	1.0	4.0	0.65
16:30	90	59.1	822	27	1.0	4.45	0.75
17:00	90	58.9	823	26.6	1.20	4.6	0.75
17:30	90	NM	NM	26.2	1.20	4.8	0.80
18:00	90	NM	NM	21.7	1.25	5.0	0.85

Comments

- Start Time = 12:06
- Thermal anemometer gets wet and stops working @ 12:36
Chris gets new anemometer @ 13:16
- Tedlar bag samples taken @ 12:16 12:26 and 17:30
- Rain becomes heavy @ about 13:00 lasts for duration
- NM = not measured
- Thermal oxidizer stopped working @ 17:30

Attachment C
Soil Vapor Analytical Report

Air Toxics Ltd. Introduces the Electronic Report

Thank you for choosing Air Toxics Ltd. To better serve our customers, we are providing your report by e-mail. This document is provided in Portable Document Format which can be viewed with Acrobat Reader by Adobe.

This electronic report includes the following:

- Work order Summary;
- Laboratory Narrative;
- Results; and
- Chain of Custody (copy).

WORK ORDER #: 0604225R1

Work Order Summary

CLIENT: Ms. Kimberly Lake
ERM-West
1777 Botelho Drive
Suite 260
Walnut Creek, CA 94596

BILL TO: Mr. Alan Nye
Center for Toxicology and Environmental
Health
615 West Markham Street
Little Rock, AR 72201

PHONE: 925-946-0455

FAX: 925-946-9968

DATE RECEIVED: 04/13/2006

DATE COMPLETED: 04/19/2006

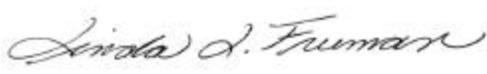
DATE REISSUED: 04/24/2006

P.O. #

PROJECT # 20577.10 Hookston Station

CONTACT: Nicole Danbacher

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>RECEIPT VAC./PRES.</u>
01A	SVE T1	Modified TO-15	Tedlar Bag
02A	SVE T2	Modified TO-15	Tedlar Bag
03A	SVE T3	Modified TO-15	Tedlar Bag
04A	Lab Blank	Modified TO-15	NA
04B	Lab Blank	Modified TO-15	NA
05A	CCV	Modified TO-15	NA
05B	CCV	Modified TO-15	NA
06A	LCS	Modified TO-15	NA
06B	LCS	Modified TO-15	NA

CERTIFIED BY: 

DATE: 04/26/06

Laboratory Director

Certification numbers: CA NELAP - 02110CA, LA NELAP/LELAP- AI 30763, NJ NELAP - CA004
NY NELAP - 11291, UT NELAP - 9166389892

Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/05, Expiration date: 06/30/06
Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

This report shall not be reproduced, except in full, without the written approval of Air Toxics Ltd.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Modified TO-15
ERM-West
Workorder# 0604225R1

Three 1 Liter Tedlar Bag samples were received on April 13, 2006. The laboratory performed analysis via modified EPA Method TO-15 using GC/MS in the full scan mode. The method involves concentrating up to 0.2 liters of air. The concentrated aliquot is then flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passes directly into the GC/MS for analysis.

Method modifications taken to run these samples are summarized in the below table. Specific project requirements may over-ride the ATL modifications.

<i>Requirement</i>	<i>TO-15</i>	<i>ATL Modifications</i>
Daily CCV	+/- 30% Difference	<= 30% Difference with two allowed out up to <=40%.; flag and narrate outliers
Sample collection media	Summa canister	ATL recommends use of summa canisters to insure data defensibility, but will report results from Tedlar bags at client request
Method Detection Limit	Follow 40CFR Pt.136 App. B	The MDL met all relevant requirements in Method TO-15 (statistical MDL less than the LOQ). The concentration of the spiked replicate may have exceeded 10X the calculated MDL in some cases

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

The reported LCS for each daily batch has been derived from more than one analytical file.

THE WORKORDER WAS REISSUED ON 4/25/06 TO REPORT RESULTS IN PPBV AS WELL AS UG/M3.

Definition of Data Qualifying Flags

Eight qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

UJ- Non-detected compound associated with low bias in the CCV

N - The identification is based on presumptive evidence.



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File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue



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Summary of Detected Compounds MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

Client Sample ID: SVE T1

Lab ID#: 0604225R1-01A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Ethanol	20	57	38	110
1,1-Dichloroethene	5.0	26	20	100
Acetone	20	24	48	57
2-Butanone (Methyl Ethyl Ketone)	5.0	5.7	15	17
cis-1,2-Dichloroethene	5.0	8.5	20	34
Tetrahydrofuran	5.0	22	15	64
Trichloroethene	5.0	1600	27	8900
Tetrachloroethene	5.0	7.1	34	48
1,4-Dichlorobenzene	5.0	6.4	30	39

Client Sample ID: SVE T2

Lab ID#: 0604225R1-02A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,1-Dichloroethene	20	140	79	540
cis-1,2-Dichloroethene	20	39	79	150
Tetrahydrofuran	20	56	59	160
Trichloroethene	20	7300	110	39000
Tetrachloroethene	20	26	140	180

Client Sample ID: SVE T3

Lab ID#: 0604225R1-03A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,1-Dichloroethene	50	240	200	950
cis-1,2-Dichloroethene	50	81	200	320
Trichloroethene	50	14000	270	76000
Tetrachloroethene	50	54	340	370



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Client Sample ID: SVE T1

Lab ID#: 0604225R1-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041407	Date of Collection:	4/11/06
Dil. Factor:	10.0	Date of Analysis:	4/14/06 02:46 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	5.0	Not Detected	25	Not Detected
Freon 114	5.0	Not Detected	35	Not Detected
Chloromethane	20	Not Detected	41	Not Detected
Vinyl Chloride	5.0	Not Detected	13	Not Detected
1,3-Butadiene	5.0	Not Detected	11	Not Detected
Bromomethane	5.0	Not Detected	19	Not Detected
Chloroethane	5.0	Not Detected	13	Not Detected
Freon 11	5.0	Not Detected	28	Not Detected
Ethanol	20	57	38	110
Freon 113	5.0	Not Detected	38	Not Detected
1,1-Dichloroethene	5.0	26	20	100
Acetone	20	24	48	57
2-Propanol	20	Not Detected	49	Not Detected
Carbon Disulfide	5.0	Not Detected	16	Not Detected
3-Chloropropene	20	Not Detected	63	Not Detected
Methylene Chloride	5.0	Not Detected	17	Not Detected
Methyl tert-butyl ether	5.0	Not Detected	18	Not Detected
trans-1,2-Dichloroethene	5.0	Not Detected	20	Not Detected
Hexane	5.0	Not Detected	18	Not Detected
1,1-Dichloroethane	5.0	Not Detected	20	Not Detected
2-Butanone (Methyl Ethyl Ketone)	5.0	5.7	15	17
cis-1,2-Dichloroethene	5.0	8.5	20	34
Tetrahydrofuran	5.0	22	15	64
Chloroform	5.0	Not Detected	24	Not Detected
1,1,1-Trichloroethane	5.0	Not Detected	27	Not Detected
Cyclohexane	5.0	Not Detected	17	Not Detected
Carbon Tetrachloride	5.0	Not Detected	31	Not Detected
2,2,4-Trimethylpentane	5.0	Not Detected	23	Not Detected
Benzene	5.0	Not Detected	16	Not Detected
1,2-Dichloroethane	5.0	Not Detected	20	Not Detected
Heptane	5.0	Not Detected	20	Not Detected
Trichloroethene	5.0	1600	27	8900
1,2-Dichloropropane	5.0	Not Detected	23	Not Detected
1,4-Dioxane	20	Not Detected	72	Not Detected
Bromodichloromethane	5.0	Not Detected	34	Not Detected
cis-1,3-Dichloropropene	5.0	Not Detected	23	Not Detected
4-Methyl-2-pentanone	5.0	Not Detected	20	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
trans-1,3-Dichloropropene	5.0	Not Detected	23	Not Detected
1,1,2-Trichloroethane	5.0	Not Detected	27	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: SVE T1

Lab ID#: 0604225R1-01A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041407	Date of Collection:	4/11/06
Dil. Factor:	10.0	Date of Analysis:	4/14/06 02:46 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	5.0	7.1	34	48
2-Hexanone	20	Not Detected	82	Not Detected
Dibromochloromethane	5.0	Not Detected	42	Not Detected
1,2-Dibromoethane (EDB)	5.0	Not Detected	38	Not Detected
Chlorobenzene	5.0	Not Detected	23	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected
Styrene	5.0	Not Detected	21	Not Detected
Bromoform	5.0	Not Detected	52	Not Detected
Cumene	5.0	Not Detected	24	Not Detected
1,1,2,2-Tetrachloroethane	5.0	Not Detected	34	Not Detected
Propylbenzene	5.0	Not Detected	24	Not Detected
4-Ethyltoluene	5.0	Not Detected	24	Not Detected
1,3,5-Trimethylbenzene	5.0	Not Detected	24	Not Detected
1,2,4-Trimethylbenzene	5.0	Not Detected	24	Not Detected
1,3-Dichlorobenzene	5.0	Not Detected	30	Not Detected
1,4-Dichlorobenzene	5.0	6.4	30	39
alpha-Chlorotoluene	5.0	Not Detected	26	Not Detected
1,2-Dichlorobenzene	5.0	Not Detected	30	Not Detected
1,2,4-Trichlorobenzene	20	Not Detected	150	Not Detected
Hexachlorobutadiene	20	Not Detected	210	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130
1,2-Dichloroethane-d4	96	70-130
4-Bromofluorobenzene	94	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: SVE T2

Lab ID#: 0604225R1-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name: 1041318 Date of Collection: 4/11/06
Dil. Factor: 40.0 Date of Analysis: 4/14/06 09:56 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	20	Not Detected	99	Not Detected
Freon 114	20	Not Detected	140	Not Detected
Chloromethane	80	Not Detected	160	Not Detected
Vinyl Chloride	20	Not Detected	51	Not Detected
1,3-Butadiene	20	Not Detected	44	Not Detected
Bromomethane	20	Not Detected	78	Not Detected
Chloroethane	20	Not Detected	53	Not Detected
Freon 11	20	Not Detected	110	Not Detected
Ethanol	80	Not Detected	150	Not Detected
Freon 113	20	Not Detected	150	Not Detected
1,1-Dichloroethene	20	140	79	540
Acetone	80	Not Detected	190	Not Detected
2-Propanol	80	Not Detected	200	Not Detected
Carbon Disulfide	20	Not Detected	62	Not Detected
3-Chloropropene	80	Not Detected	250	Not Detected
Methylene Chloride	20	Not Detected	69	Not Detected
Methyl tert-butyl ether	20	Not Detected	72	Not Detected
trans-1,2-Dichloroethene	20	Not Detected	79	Not Detected
Hexane	20	Not Detected	70	Not Detected
1,1-Dichloroethane	20	Not Detected	81	Not Detected
2-Butanone (Methyl Ethyl Ketone)	20	Not Detected	59	Not Detected
cis-1,2-Dichloroethene	20	39	79	150
Tetrahydrofuran	20	56	59	160
Chloroform	20	Not Detected	98	Not Detected
1,1,1-Trichloroethane	20	Not Detected	110	Not Detected
Cyclohexane	20	Not Detected	69	Not Detected
Carbon Tetrachloride	20	Not Detected	120	Not Detected
2,2,4-Trimethylpentane	20	Not Detected	93	Not Detected
Benzene	20	Not Detected	64	Not Detected
1,2-Dichloroethane	20	Not Detected	81	Not Detected
Heptane	20	Not Detected	82	Not Detected
Trichloroethene	20	7300	110	39000
1,2-Dichloropropane	20	Not Detected	92	Not Detected
1,4-Dioxane	80	Not Detected	290	Not Detected
Bromodichloromethane	20	Not Detected	130	Not Detected
cis-1,3-Dichloropropene	20	Not Detected	91	Not Detected
4-Methyl-2-pentanone	20	Not Detected	82	Not Detected
Toluene	20	Not Detected	75	Not Detected
trans-1,3-Dichloropropene	20	Not Detected	91	Not Detected
1,1,2-Trichloroethane	20	Not Detected	110	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: SVE T2

Lab ID#: 0604225R1-02A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041318	Date of Collection:	4/11/06
Dil. Factor:	40.0	Date of Analysis:	4/14/06 09:56 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	20	26	140	180
2-Hexanone	80	Not Detected	330	Not Detected
Dibromochloromethane	20	Not Detected	170	Not Detected
1,2-Dibromoethane (EDB)	20	Not Detected	150	Not Detected
Chlorobenzene	20	Not Detected	92	Not Detected
Ethyl Benzene	20	Not Detected	87	Not Detected
m,p-Xylene	20	Not Detected	87	Not Detected
o-Xylene	20	Not Detected	87	Not Detected
Styrene	20	Not Detected	85	Not Detected
Bromoform	20	Not Detected	210	Not Detected
Cumene	20	Not Detected	98	Not Detected
1,1,2,2-Tetrachloroethane	20	Not Detected	140	Not Detected
Propylbenzene	20	Not Detected	98	Not Detected
4-Ethyltoluene	20	Not Detected	98	Not Detected
1,3,5-Trimethylbenzene	20	Not Detected	98	Not Detected
1,2,4-Trimethylbenzene	20	Not Detected	98	Not Detected
1,3-Dichlorobenzene	20	Not Detected	120	Not Detected
1,4-Dichlorobenzene	20	Not Detected	120	Not Detected
alpha-Chlorotoluene	20	Not Detected	100	Not Detected
1,2-Dichlorobenzene	20	Not Detected	120	Not Detected
1,2,4-Trichlorobenzene	80	Not Detected	590	Not Detected
Hexachlorobutadiene	80	Not Detected	850	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	96	70-130
4-Bromofluorobenzene	91	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: SVE T3

Lab ID#: 0604225R1-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041408	Date of Collection:	4/11/06
Dil. Factor:	100	Date of Analysis:	4/14/06 03:26 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	50	Not Detected	250	Not Detected
Freon 114	50	Not Detected	350	Not Detected
Chloromethane	200	Not Detected	410	Not Detected
Vinyl Chloride	50	Not Detected	130	Not Detected
1,3-Butadiene	50	Not Detected	110	Not Detected
Bromomethane	50	Not Detected	190	Not Detected
Chloroethane	50	Not Detected	130	Not Detected
Freon 11	50	Not Detected	280	Not Detected
Ethanol	200	Not Detected	380	Not Detected
Freon 113	50	Not Detected	380	Not Detected
1,1-Dichloroethene	50	240	200	950
Acetone	200	Not Detected	480	Not Detected
2-Propanol	200	Not Detected	490	Not Detected
Carbon Disulfide	50	Not Detected	160	Not Detected
3-Chloropropene	200	Not Detected	630	Not Detected
Methylene Chloride	50	Not Detected	170	Not Detected
Methyl tert-butyl ether	50	Not Detected	180	Not Detected
trans-1,2-Dichloroethene	50	Not Detected	200	Not Detected
Hexane	50	Not Detected	180	Not Detected
1,1-Dichloroethane	50	Not Detected	200	Not Detected
2-Butanone (Methyl Ethyl Ketone)	50	Not Detected	150	Not Detected
cis-1,2-Dichloroethene	50	81	200	320
Tetrahydrofuran	50	Not Detected	150	Not Detected
Chloroform	50	Not Detected	240	Not Detected
1,1,1-Trichloroethane	50	Not Detected	270	Not Detected
Cyclohexane	50	Not Detected	170	Not Detected
Carbon Tetrachloride	50	Not Detected	310	Not Detected
2,2,4-Trimethylpentane	50	Not Detected	230	Not Detected
Benzene	50	Not Detected	160	Not Detected
1,2-Dichloroethane	50	Not Detected	200	Not Detected
Heptane	50	Not Detected	200	Not Detected
Trichloroethene	50	14000	270	76000
1,2-Dichloropropane	50	Not Detected	230	Not Detected
1,4-Dioxane	200	Not Detected	720	Not Detected
Bromodichloromethane	50	Not Detected	340	Not Detected
cis-1,3-Dichloropropene	50	Not Detected	230	Not Detected
4-Methyl-2-pentanone	50	Not Detected	200	Not Detected
Toluene	50	Not Detected	190	Not Detected
trans-1,3-Dichloropropene	50	Not Detected	230	Not Detected
1,1,2-Trichloroethane	50	Not Detected	270	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: SVE T3

Lab ID#: 0604225R1-03A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041408	Date of Collection:	4/11/06
Dil. Factor:	100	Date of Analysis:	4/14/06 03:26 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	50	54	340	370
2-Hexanone	200	Not Detected	820	Not Detected
Dibromochloromethane	50	Not Detected	420	Not Detected
1,2-Dibromoethane (EDB)	50	Not Detected	380	Not Detected
Chlorobenzene	50	Not Detected	230	Not Detected
Ethyl Benzene	50	Not Detected	220	Not Detected
m,p-Xylene	50	Not Detected	220	Not Detected
o-Xylene	50	Not Detected	220	Not Detected
Styrene	50	Not Detected	210	Not Detected
Bromoform	50	Not Detected	520	Not Detected
Cumene	50	Not Detected	240	Not Detected
1,1,2,2-Tetrachloroethane	50	Not Detected	340	Not Detected
Propylbenzene	50	Not Detected	240	Not Detected
4-Ethyltoluene	50	Not Detected	240	Not Detected
1,3,5-Trimethylbenzene	50	Not Detected	240	Not Detected
1,2,4-Trimethylbenzene	50	Not Detected	240	Not Detected
1,3-Dichlorobenzene	50	Not Detected	300	Not Detected
1,4-Dichlorobenzene	50	Not Detected	300	Not Detected
alpha-Chlorotoluene	50	Not Detected	260	Not Detected
1,2-Dichlorobenzene	50	Not Detected	300	Not Detected
1,2,4-Trichlorobenzene	200	Not Detected	1500	Not Detected
Hexachlorobutadiene	200	Not Detected	2100	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
Toluene-d8	99	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	100	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0604225R1-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041307	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	4/13/06 03:36 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.50	Not Detected	2.5	Not Detected
Freon 114	0.50	Not Detected	3.5	Not Detected
Chloromethane	2.0	Not Detected	4.1	Not Detected
Vinyl Chloride	0.50	Not Detected	1.3	Not Detected
1,3-Butadiene	0.50	Not Detected	1.1	Not Detected
Bromomethane	0.50	Not Detected	1.9	Not Detected
Chloroethane	0.50	Not Detected	1.3	Not Detected
Freon 11	0.50	Not Detected	2.8	Not Detected
Ethanol	2.0	Not Detected	3.8	Not Detected
Freon 113	0.50	Not Detected	3.8	Not Detected
1,1-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Acetone	2.0	Not Detected	4.8	Not Detected
2-Propanol	2.0	Not Detected	4.9	Not Detected
Carbon Disulfide	0.50	Not Detected	1.6	Not Detected
3-Chloropropene	2.0	Not Detected	6.3	Not Detected
Methylene Chloride	0.50	Not Detected	1.7	Not Detected
Methyl tert-butyl ether	0.50	Not Detected	1.8	Not Detected
trans-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Hexane	0.50	Not Detected	1.8	Not Detected
1,1-Dichloroethane	0.50	Not Detected	2.0	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.50	Not Detected	1.5	Not Detected
cis-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Tetrahydrofuran	0.50	Not Detected	1.5	Not Detected
Chloroform	0.50	Not Detected	2.4	Not Detected
1,1,1-Trichloroethane	0.50	Not Detected	2.7	Not Detected
Cyclohexane	0.50	Not Detected	1.7	Not Detected
Carbon Tetrachloride	0.50	Not Detected	3.1	Not Detected
2,2,4-Trimethylpentane	0.50	Not Detected	2.3	Not Detected
Benzene	0.50	Not Detected	1.6	Not Detected
1,2-Dichloroethane	0.50	Not Detected	2.0	Not Detected
Heptane	0.50	Not Detected	2.0	Not Detected
Trichloroethene	0.50	Not Detected	2.7	Not Detected
1,2-Dichloropropane	0.50	Not Detected	2.3	Not Detected
1,4-Dioxane	2.0	Not Detected	7.2	Not Detected
Bromodichloromethane	0.50	Not Detected	3.4	Not Detected
cis-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
4-Methyl-2-pentanone	0.50	Not Detected	2.0	Not Detected
Toluene	0.50	Not Detected	1.9	Not Detected
trans-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
1,1,2-Trichloroethane	0.50	Not Detected	2.7	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0604225R1-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041307	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	4/13/06 03:36 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.50	Not Detected	3.4	Not Detected
2-Hexanone	2.0	Not Detected	8.2	Not Detected
Dibromochloromethane	0.50	Not Detected	4.2	Not Detected
1,2-Dibromoethane (EDB)	0.50	Not Detected	3.8	Not Detected
Chlorobenzene	0.50	Not Detected	2.3	Not Detected
Ethyl Benzene	0.50	Not Detected	2.2	Not Detected
m,p-Xylene	0.50	Not Detected	2.2	Not Detected
o-Xylene	0.50	Not Detected	2.2	Not Detected
Styrene	0.50	Not Detected	2.1	Not Detected
Bromoform	0.50	Not Detected	5.2	Not Detected
Cumene	0.50	Not Detected	2.4	Not Detected
1,1,2,2-Tetrachloroethane	0.50	Not Detected	3.4	Not Detected
Propylbenzene	0.50	Not Detected	2.4	Not Detected
4-Ethyltoluene	0.50	Not Detected	2.4	Not Detected
1,3,5-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,2,4-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,3-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,4-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
alpha-Chlorotoluene	0.50	Not Detected	2.6	Not Detected
1,2-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,2,4-Trichlorobenzene	2.0	Not Detected	15	Not Detected
Hexachlorobutadiene	2.0	Not Detected	21	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	96	70-130
4-Bromofluorobenzene	94	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0604225R1-04B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041406	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	4/14/06 01:57 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.50	Not Detected	2.5	Not Detected
Freon 114	0.50	Not Detected	3.5	Not Detected
Chloromethane	2.0	Not Detected	4.1	Not Detected
Vinyl Chloride	0.50	Not Detected	1.3	Not Detected
1,3-Butadiene	0.50	Not Detected	1.1	Not Detected
Bromomethane	0.50	Not Detected	1.9	Not Detected
Chloroethane	0.50	Not Detected	1.3	Not Detected
Freon 11	0.50	Not Detected	2.8	Not Detected
Ethanol	2.0	Not Detected	3.8	Not Detected
Freon 113	0.50	Not Detected	3.8	Not Detected
1,1-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Acetone	2.0	Not Detected	4.8	Not Detected
2-Propanol	2.0	Not Detected	4.9	Not Detected
Carbon Disulfide	0.50	Not Detected	1.6	Not Detected
3-Chloropropene	2.0	Not Detected	6.3	Not Detected
Methylene Chloride	0.50	Not Detected	1.7	Not Detected
Methyl tert-butyl ether	0.50	Not Detected	1.8	Not Detected
trans-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Hexane	0.50	Not Detected	1.8	Not Detected
1,1-Dichloroethane	0.50	Not Detected	2.0	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.50	Not Detected	1.5	Not Detected
cis-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Tetrahydrofuran	0.50	Not Detected	1.5	Not Detected
Chloroform	0.50	Not Detected	2.4	Not Detected
1,1,1-Trichloroethane	0.50	Not Detected	2.7	Not Detected
Cyclohexane	0.50	Not Detected	1.7	Not Detected
Carbon Tetrachloride	0.50	Not Detected	3.1	Not Detected
2,2,4-Trimethylpentane	0.50	Not Detected	2.3	Not Detected
Benzene	0.50	Not Detected	1.6	Not Detected
1,2-Dichloroethane	0.50	Not Detected	2.0	Not Detected
Heptane	0.50	Not Detected	2.0	Not Detected
Trichloroethene	0.50	Not Detected	2.7	Not Detected
1,2-Dichloropropane	0.50	Not Detected	2.3	Not Detected
1,4-Dioxane	2.0	Not Detected	7.2	Not Detected
Bromodichloromethane	0.50	Not Detected	3.4	Not Detected
cis-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
4-Methyl-2-pentanone	0.50	Not Detected	2.0	Not Detected
Toluene	0.50	Not Detected	1.9	Not Detected
trans-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
1,1,2-Trichloroethane	0.50	Not Detected	2.7	Not Detected



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: Lab Blank

Lab ID#: 0604225R1-04B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041406	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	4/14/06 01:57 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Tetrachloroethene	0.50	Not Detected	3.4	Not Detected
2-Hexanone	2.0	Not Detected	8.2	Not Detected
Dibromochloromethane	0.50	Not Detected	4.2	Not Detected
1,2-Dibromoethane (EDB)	0.50	Not Detected	3.8	Not Detected
Chlorobenzene	0.50	Not Detected	2.3	Not Detected
Ethyl Benzene	0.50	Not Detected	2.2	Not Detected
m,p-Xylene	0.50	Not Detected	2.2	Not Detected
o-Xylene	0.50	Not Detected	2.2	Not Detected
Styrene	0.50	Not Detected	2.1	Not Detected
Bromoform	0.50	Not Detected	5.2	Not Detected
Cumene	0.50	Not Detected	2.4	Not Detected
1,1,2,2-Tetrachloroethane	0.50	Not Detected	3.4	Not Detected
Propylbenzene	0.50	Not Detected	2.4	Not Detected
4-Ethyltoluene	0.50	Not Detected	2.4	Not Detected
1,3,5-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,2,4-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,3-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,4-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
alpha-Chlorotoluene	0.50	Not Detected	2.6	Not Detected
1,2-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,2,4-Trichlorobenzene	2.0	Not Detected	15	Not Detected
Hexachlorobutadiene	2.0	Not Detected	21	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	98	70-130
1,2-Dichloroethane-d4	95	70-130
4-Bromofluorobenzene	102	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0604225R1-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041305	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/13/06 01:12 PM

Compound	%Recovery
Freon 12	90
Freon 114	109
Chloromethane	100
Vinyl Chloride	88
1,3-Butadiene	95
Bromomethane	101
Chloroethane	86
Freon 11	96
Ethanol	96
Freon 113	99
1,1-Dichloroethene	97
Acetone	97
2-Propanol	100
Carbon Disulfide	99
3-Chloropropene	102
Methylene Chloride	108
Methyl tert-butyl ether	99
trans-1,2-Dichloroethene	94
Hexane	100
1,1-Dichloroethane	100
2-Butanone (Methyl Ethyl Ketone)	106
cis-1,2-Dichloroethene	101
Tetrahydrofuran	95
Chloroform	100
1,1,1-Trichloroethane	99
Cyclohexane	101
Carbon Tetrachloride	102
2,2,4-Trimethylpentane	100
Benzene	100
1,2-Dichloroethane	103
Heptane	103
Trichloroethene	103
1,2-Dichloropropane	104
1,4-Dioxane	102
Bromodichloromethane	109
cis-1,3-Dichloropropene	105
4-Methyl-2-pentanone	111
Toluene	102
trans-1,3-Dichloropropene	103
1,1,2-Trichloroethane	100



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0604225R1-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041305	Date of Collection:	NA
Dil. Factor:	1.00	Date of Analysis:	4/13/06 01:12 PM

Compound	%Recovery
Tetrachloroethene	102
2-Hexanone	105
Dibromochloromethane	109
1,2-Dibromoethane (EDB)	104
Chlorobenzene	97
Ethyl Benzene	97
m,p-Xylene	94
o-Xylene	94
Styrene	102
Bromoform	107
Cumene	89
1,1,2,2-Tetrachloroethane	91
Propylbenzene	88
4-Ethyltoluene	87
1,3,5-Trimethylbenzene	82
1,2,4-Trimethylbenzene	81
1,3-Dichlorobenzene	81
1,4-Dichlorobenzene	80
alpha-Chlorotoluene	83
1,2-Dichlorobenzene	78
1,2,4-Trichlorobenzene	85
Hexachlorobutadiene	90

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	98	70-130
1,2-Dichloroethane-d4	95	70-130
4-Bromofluorobenzene	98	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0604225R1-05B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/14/06 11:08 AM

Compound	%Recovery
Freon 12	87
Freon 114	105
Chloromethane	96
Vinyl Chloride	83
1,3-Butadiene	92
Bromomethane	97
Chloroethane	80
Freon 11	99
Ethanol	88
Freon 113	100
1,1-Dichloroethene	97
Acetone	91
2-Propanol	94
Carbon Disulfide	96
3-Chloropropene	100
Methylene Chloride	102
Methyl tert-butyl ether	95
trans-1,2-Dichloroethene	90
Hexane	96
1,1-Dichloroethane	98
2-Butanone (Methyl Ethyl Ketone)	100
cis-1,2-Dichloroethene	99
Tetrahydrofuran	89
Chloroform	100
1,1,1-Trichloroethane	100
Cyclohexane	97
Carbon Tetrachloride	103
2,2,4-Trimethylpentane	98
Benzene	99
1,2-Dichloroethane	103
Heptane	98
Trichloroethene	103
1,2-Dichloropropane	104
1,4-Dioxane	94
Bromodichloromethane	106
cis-1,3-Dichloropropene	106
4-Methyl-2-pentanone	104
Toluene	102
trans-1,3-Dichloropropene	103
1,1,2-Trichloroethane	99



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: CCV

Lab ID#: 0604225R1-05B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/14/06 11:08 AM

Compound	%Recovery
Tetrachloroethene	101
2-Hexanone	96
Dibromochloromethane	105
1,2-Dibromoethane (EDB)	104
Chlorobenzene	96
Ethyl Benzene	95
m,p-Xylene	92
o-Xylene	92
Styrene	101
Bromoform	101
Cumene	87
1,1,2,2-Tetrachloroethane	88
Propylbenzene	86
4-Ethyltoluene	83
1,3,5-Trimethylbenzene	79
1,2,4-Trimethylbenzene	78
1,3-Dichlorobenzene	79
1,4-Dichlorobenzene	78
alpha-Chlorotoluene	79
1,2-Dichlorobenzene	75
1,2,4-Trichlorobenzene	86
Hexachlorobutadiene	89

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	98	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0604225R1-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041304	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/13/06 12:05 PM

Compound	%Recovery
Freon 12	90
Freon 114	112
Chloromethane	99
Vinyl Chloride	89
1,3-Butadiene	109
Bromomethane	106
Chloroethane	90
Freon 11	98
Ethanol	102
Freon 113	101
1,1-Dichloroethene	98
Acetone	104
2-Propanol	102
Carbon Disulfide	112
3-Chloropropene	128
Methylene Chloride	111
Methyl tert-butyl ether	103
trans-1,2-Dichloroethene	101
Hexane	107
1,1-Dichloroethane	101
2-Butanone (Methyl Ethyl Ketone)	114
cis-1,2-Dichloroethene	103
Tetrahydrofuran	97
Chloroform	101
1,1,1-Trichloroethane	102
Cyclohexane	105
Carbon Tetrachloride	104
2,2,4-Trimethylpentane	119
Benzene	102
1,2-Dichloroethane	104
Heptane	103
Trichloroethene	105
1,2-Dichloropropane	106
1,4-Dioxane	97
Bromodichloromethane	106
cis-1,3-Dichloropropene	91
4-Methyl-2-pentanone	110
Toluene	103
trans-1,3-Dichloropropene	102
1,1,2-Trichloroethane	103



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0604225R1-06A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041304	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/13/06 12:05 PM

Compound	%Recovery
Tetrachloroethene	104
2-Hexanone	101
Dibromochloromethane	105
1,2-Dibromoethane (EDB)	107
Chlorobenzene	100
Ethyl Benzene	103
m,p-Xylene	93
o-Xylene	86
Styrene	105
Bromoform	92
Cumene	103
1,1,2,2-Tetrachloroethane	92
Propylbenzene	105
4-Ethyltoluene	99
1,3,5-Trimethylbenzene	75
1,2,4-Trimethylbenzene	58 Q
1,3-Dichlorobenzene	80
1,4-Dichlorobenzene	79
alpha-Chlorotoluene	93
1,2-Dichlorobenzene	75
1,2,4-Trichlorobenzene	73
Hexachlorobutadiene	74

Q = Exceeds Quality Control limits.

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	97	70-130
4-Bromofluorobenzene	99	70-130



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0604225R1-06B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041403	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/14/06 11:46 AM

Compound	%Recovery
Freon 12	87
Freon 114	109
Chloromethane	102
Vinyl Chloride	86
1,3-Butadiene	108
Bromomethane	102
Chloroethane	85
Freon 11	97
Ethanol	99
Freon 113	99
1,1-Dichloroethene	96
Acetone	102
2-Propanol	100
Carbon Disulfide	111
3-Chloropropene	125
Methylene Chloride	108
Methyl tert-butyl ether	102
trans-1,2-Dichloroethene	100
Hexane	105
1,1-Dichloroethane	100
2-Butanone (Methyl Ethyl Ketone)	111
cis-1,2-Dichloroethene	101
Tetrahydrofuran	96
Chloroform	99
1,1,1-Trichloroethane	100
Cyclohexane	103
Carbon Tetrachloride	103
2,2,4-Trimethylpentane	118
Benzene	100
1,2-Dichloroethane	104
Heptane	102
Trichloroethene	103
1,2-Dichloropropane	105
1,4-Dioxane	97
Bromodichloromethane	105
cis-1,3-Dichloropropene	90
4-Methyl-2-pentanone	110
Toluene	102
trans-1,3-Dichloropropene	100
1,1,2-Trichloroethane	100



AN ENVIRONMENTAL ANALYTICAL LABORATORY

Client Sample ID: LCS

Lab ID#: 0604225R1-06B

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	1041403	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 4/14/06 11:46 AM

Compound	%Recovery
Tetrachloroethene	102
2-Hexanone	99
Dibromochloromethane	103
1,2-Dibromoethane (EDB)	103
Chlorobenzene	97
Ethyl Benzene	99
m,p-Xylene	90
o-Xylene	85
Styrene	102
Bromoform	89
Cumene	100
1,1,2,2-Tetrachloroethane	89
Propylbenzene	101
4-Ethyltoluene	95
1,3,5-Trimethylbenzene	72
1,2,4-Trimethylbenzene	56 Q
1,3-Dichlorobenzene	77
1,4-Dichlorobenzene	76
alpha-Chlorotoluene	90
1,2-Dichlorobenzene	72
1,2,4-Trichlorobenzene	71
Hexachlorobutadiene	73

Q = Exceeds Quality Control limits.

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	97	70-130
4-Bromofluorobenzene	97	70-130

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Page 1 of 1

PROJECT #		PROJECT NAME		# OF CONTAINERS		MATRIX		REQUESTED PARAMETERS	
20577.10		Hookston Station		1		WASTES			
SAMPLER (PRINT NAME)		(SIGNATURE)		RECEIVING LABORATORY					
Rob Dyer		<i>Rob Dyer</i>							
Air Toxics									
SAMPLE I.D.	DATE	TIME	PM	GRAB	SAMPLING METHOD	WTS	WTS	SAMPLING VOLUME	
NA SUE T1	4/11-06	12:16	X		Tedlar N	N	N	Tedlar	1
NA SUE T2	4/11-06	12:26	X		Tedlar N	N	N	Tedlar	1
NA SUE T3	4/11-06	17:40	X		Tedlar N	N	N	Tedlar	1
RECEIVED BY: [Signature] DATE: [Date] TIME: [Time]									
RELINQUISHED BY (SIGNATURE)		DATE		TIME		RECEIVED BY		DATE	
<i>[Signature]</i>		4/11-06		11:30		<i>[Signature]</i>		4/12/06	
RELINQUISHED BY (SIGNATURE)		DATE		TIME		RECEIVED BY		DATE	
<i>[Signature]</i>		4/12/06		11:30		<i>[Signature]</i>		4/12/06	
REINQUISHED BY (SIGNATURE)		DATE		TIME		RECEIVED BY		DATE	
REMARKS ON SAMPLE RECEIPT									
<input type="checkbox"/> BOTTLE INTACT <input type="checkbox"/> CUSTODY SEALS <input type="checkbox"/> CHILLED <input type="checkbox"/> PRESERVED <input type="checkbox"/> SEALS INTACT <input type="checkbox"/> SEE REMARKS									
ERIM REMARKS									
SEND REPORT TO: Rob Dyer									

WHITE - LABORATORY COPY

CANARY - FIELD COPY

PINK - DATABASE

GOLD - PROJECT FILE

CUSTODY SEAL INTACT?
Y N NONE TEMP

FIELD REMARKS
 5 day T.A.T.
 Please send E.O.F.
 to rob.dyer@erim.com

TO-15

R.G.D.

R.G.D.

Attachment D
Data Evaluation Computations

Attachment D-1
SVE Pilot Test - Performance Testing System Readings
Hookston Station
Pleasant Hill, California

Baselin Readings				
Location	Time	Depth to Water (ft)	PID Reading	Gage Pressure (in H2O)
TW-1	9:30	14.51	6	0
TW-2	9:30	14.52	6	0
TW-3	9:35	14.58	3	0

System Readings								
Time	Applied Vacuum (in H2O)	Temp (F)	Temp (C)	Velocity (fpm)	Flow (acfm)	Flow (scfm)	Influent PID Reading	Effluent PID Reading
12:07	10	63.1	17.2	545	107	106	6	0
12:10	60	66.1	18.8	615	121	112	3	0
12:13	94	64.7	18.1	890	175	154	6	0
12:16	145	64.3	17.8	920	181	146	10	0
12:20	250	64.5	17.9	880	173	108	20	0
12:26	300	64.2	17.8	950	187	97	33	NM
12:36	340	63.7	17.5	945	186	77	NM	NM

Notes:

NM = Not Measured

Attachment D-2
SVE Pilot Test - Soil Air Permeability Calculations for Transient Conditions
Hookston Station
Pleasant Hill, California

Under transient conditions, from Johnson et al 1990:

$$P' = \frac{Q\mu}{4\pi bK} \left[-0.5772 - \ln\left(\frac{r^2 E\mu}{4KP_{atm}}\right) + \ln(t) \right]$$

Where:

P' = Gage pressure at a distance r and time t r = radial distance from extraction well
 Q = Volumetric Flow rate E = air filled soil void fraction
 μ = viscosity of air P_{atm} = atmospheric pressure
 b = stratum thickness t = time
 K = soil permeability to air flow

At a given distance r , this equation can be rewritten as:

$$P'(\ln(t)) = A \ln(t) + B$$

Where A is the slope of the plot of P' vs. $\ln(t)$ and is equal to:

$$A = \frac{Q\mu}{4\pi bK}$$

From the plot of observed change in pressure with respect to time we get the following slopes:

TW-2	0.5372 in H ₂ O	or	89.93 lbm/ft·s ²
TW-3	1.889 in H ₂ O	or	316.22 lbm/ft·s ²
TW-4	0.3557 in H ₂ O	or	59.54 lbm/ft·s ²

note: $1 \text{ in H}_2\text{O} = 0.036 \frac{\text{lb}_f}{\text{in}^2} \left(\frac{144 \text{ in}^2}{\text{ft}^2} \right) \left(\frac{32.2 \text{ lbm} \cdot \text{ft}}{\text{s}^2 \cdot \text{lb}_f} \right) = 167.4 \frac{\text{lbm}}{\text{ft} \cdot \text{s}^2}$

Knowing that:

$$A = \frac{Q\mu}{4\pi bK}$$

The permeability can be calculated by rearranging the equation and solving for K :

$$K = \frac{Q\mu}{4\pi bA}$$

Attachment D-2
SVE Pilot Test - Soil Air Permeability Calculations for Transient Conditions
Hookston Station
Pleasant Hill, California

Given the calculated slopes and the following field data:

Q =	145 scfm	or	2.42 scfs
b =	12 ft		
μ =	1.20E-05		lbm/ft·s
A _{TW-2} =	89.93		lbm/ft·s ²
A _{TW-3} =	316.22		lbm/ft·s ²
A _{TW-4} =	59.54		lbm/ft·s ²

$$K_{TW-2} = \frac{2.42 \left(\frac{ft^3}{s} \right) \cdot 1.2 \times 10^{-5} \left(\frac{lbm}{ft \cdot s} \right)}{4 \cdot \pi \cdot 12(ft) \cdot 89.9 \left(\frac{lbm}{ft \cdot s^2} \right)} = 2.14 \times 10^{-9} ft^2$$

K _{TW-2} =	2.13853E-09 ft ²	=	201 darcy
K _{TW-3} =	6.08161E-10 ft ²	=	57 darcy
K _{TW-4} =	3.22973E-09 ft ²	=	304 darcy

note:

$$9.41 \times 10^{10} \left(\frac{darcy}{ft^2} \right)$$

*Attachment D-3
SVE Pilot Test - Soil Air Permeability Calculations for Steady-State Conditions
Hookston Station
Pleasant Hill, California*

Under steady-state conditions from the USACE Manual:

$$K = \left(\frac{Q\mu P_w}{\pi b} \right) \frac{\ln(R_2 / R_1)}{P_2^2 - P_1^2}$$

Where:

K = soil permeability to air flow

Q = Volumetric Flow rate

μ = viscosity of air

b = stratum thickness

P_w = absolute pressure at extraction well

$R_{1,2}$ = radial distance from extraction well to observation points

$P_{1,2}$ = absolute pressure at monitoring points

Given the following field data:

b =	12	ft
μ =	1.20E-05	lbm/ft*s
R _w =	0.167	ft
R _{TW-3} =	5	ft
R _{TW-4} =	10	ft
R _{TW-2} =	20	ft

Given the following steady state conditions:

Q =	145	scfm	or	2.42	scfs
P_w =	319.2	in H ₂ O	or	5.33E+04	lbm/ft*s ²
P_{TW-3} =	404.5	in H ₂ O	or	6.76E+04	lbm/ft*s ²
P_{TW-4} =	408.8	in H ₂ O	or	6.83E+04	lbm/ft*s ²
P_{TW-2} =	408.3	in H ₂ O	or	6.82E+04	lbm/ft*s ²

The following soil permeabilities are calculated:

$K_{TW-2,3}$ =	6.60E-10	ft ²	(9.4135 E10 darcy/ft ²)	=	62	darcy
$K_{TW-4,3}$ =	2.92E-10	ft ²	(9.4135 E10 darcy/ft ²)	=	27	darcy

*Attachment D-4
SVE Pilot Test - Radius of Influence Calculations
Hookston Station
Pleasant Hill, California*

Using the steady-state equation:

$$K = \left(\frac{Q\mu P_w}{\pi b} \right) \frac{\ln(R_2 / R_1)}{P_2^2 - P_1^2}$$

In order to determine the radial distance that we would find a given pressure the equation is rearranged.

Solving for R₂:

$$R_2 = e^{\left(\frac{\pi b K (P_2^2 - P_1^2)}{Q \mu P_w} \right)} R_1$$

Where:

K = soil permeability to air flow

μ = viscosity of air

Q = Volumetric Flow rate

b = stratum thickness

P_w = absolute pressure at extraction well

P_{1,2} = absolute pressure at monitoring points

R_{1,2} = radial distance from extraction well to observation points

Given the following field data:

Q =	2.42	scfs		
b =	12	ft		
K =	60	darcy	(9.41 E10 darcy/ft ²) =	6.38E-10 ft ²
μ =	1.20E-05	lbm/ft*s		
R _{TW-3} =	5	ft		
P _w =	319.2	in H ₂ O	or	5.33E+04 lbm/ft*s ²
P _{TW-3} =	404.5	in H ₂ O	or	6.76E+04 lbm/ft*s ²

Assuming:

P ₂ =	409.19	in H ₂ O	or	6.83E+04 lbm/ft*s ²
------------------	--------	---------------------	----	--------------------------------

Then

R ₂ =	26.14	ft
------------------	-------	----

It is currently recommended that a minimum pore gas velocity of 3 to 30 ft/day be used for the design criteria for determining the radius of influence.

Attachment D-4
SVE Pilot Test - Radius of Influence Calculations
Hookston Station
Pleasant Hill, California

Using Darcy's Law:

$$q_s = \frac{K}{\mu\eta_a} \left(\frac{dP}{dS} \right)$$

Where:

q_s = flow velocity

K = soil permeability to air flow

μ = viscosity of air

η_a = air filled porosity

dP/dS = pressure gradient

Given the following field data:

$$\begin{aligned} K &= 60 \text{ darcy} \quad (9.41 \text{ E}10 \text{ darcy/ft}^2) = 6.38\text{E-}10 \text{ ft}^2 \\ \mu &= 1.20\text{E-}05 \text{ lbm/ft*s} \\ \eta_a &= 30 \% \end{aligned}$$

Where:

$$\frac{dP}{dS} = \frac{(\text{Applied Extraction Vacuum* vent efficiency}) - \text{vacuum at monitoring point}}{\text{distance from extraction well to monitoring point}}$$

Given that:

Applied Extraction Vacuum = 90 in H₂O

Calculated vacuum = 0.01 in H₂O

Assuming:

vent efficiency = 10 %

$$\frac{dP}{dS} = 0.34 \frac{\text{inH}_2\text{O}}{\text{ft}} \left(\frac{\text{lbf/in}^2}{27.7 \text{ inH}_2\text{O}} \right) \left(\frac{144 \text{ in}^2}{\text{ft}^2} \right) \left(\frac{32.2 \text{ lbm*ft/s}^2}{1 \text{ lbf}} \right)$$

$$\frac{dP}{dS} = 57.57 \frac{\text{lbm}}{\text{ft}^2*\text{s}^2}$$

$$q_s = \frac{K}{\mu\eta_a} \left(\frac{dP}{dS} \right) = \left(\frac{6.38\text{E-}10 \text{ ft}^2}{1.20\text{E-}05 \text{ lbm/ft*s} \cdot 0.3} \right) \left(57.57 \frac{\text{lbm}}{\text{ft}^2*\text{s}^2} \right)$$

$$q_s = 0.010196 \text{ ft/s} = 15 \text{ ft/day}$$

*Attachment D-5
SVE Pilot Test - Mass Removal Calculations
Hookston Station
Pleasant Hill, California*

SVE T₁ VOC Concentrations:			
1,1 DCE conc. ¹	=	100	ug/m ³
cis 1,2 DCE conc. ¹	=	34	ug/m ³
TCE conc. ¹	=	8,900	ug/m ³
PCE conc. ¹	=	48	ug/m ³
Total VOC conc.	=	9,082	ug/m ³

SVE T₂ VOC Concentrations:			
1,1 DCE conc. ¹	=	540	ug/m ³
cis 1,2 DCE conc. ¹	=	150	ug/m ³
TCE conc. ¹	=	39,000	ug/m ³
PCE conc. ¹	=	180	ug/m ³
Total VOC conc.	=	39,870	ug/m ³

SVE T₃ VOC Concentrations:			
1,1 DCE conc. ¹	=	950	ug/m ³
cis 1,2 DCE conc. ¹	=	320	ug/m ³
TCE conc. ¹	=	76,000	ug/m ³
PCE conc. ¹	=	370	ug/m ³
Total VOC conc.	=	77,640	ug/m ³

Average VOC Concentrations:			
Avg. 1,1 DCE conc. ¹	=	530	ug/m ³
Avg. cis 1,2 DCE conc. ¹	=	168	ug/m ³
Avg. TCE conc. ¹	=	41,300	ug/m ³
Avg. PCE conc. ¹	=	199	ug/m ³
Avg. Total VOC conc.	=	42,197	ug/m ³

1,1 DCE

Max. Daily Extraction Rate	=	6 g/day	or	0.01 lbs/day
Avg. Daily Extraction Rate	=	3 g/day	or	0.01 lbs/day
Estimated Mass Extracted	=	0.77 g	or	0.00 lbs

cis 1,2 DCE

Max. Daily Extraction	=	2 g/day	or	0.00 lbs/day
Avg. Daily Extraction	=	1 g/day	or	0.00 lbs/day
Estimated Mass Extracted	=	0.24 g	or	0.00 lbs

TCE

Max. Daily Extraction	=	449 g/day	or	0.99 lbs/day
Avg. Daily Extraction	=	244 g/day	or	0.54 lbs/day
Estimated Mass Extracted	=	60 g	or	0.13 lbs

PCE

Max. Daily Extraction Rate	=	2 g/day	or	0.00 lbs/day
Avg. Daily Extraction Rate	=	1 g/day	or	0.00 lbs/day
Estimated Mass Extracted	=	0.29 g	or	0.00 lbs

Total VOCs

Max. Daily Extraction	=	459 g/day	or	1.01 lbs/day
Avg. Daily Extraction	=	249 g/day	or	0.55 lbs/day
Estimated Mass Extracted	=	61 g	or	0.13 lbs

Notes:

¹Based on an average of the three vapor samples collected

Daily Extraction Rate = ([Conc] ug/m³) * (.001 m³/L) * ([flow rate] ft³/min) * (28.317 L/ft³)*(1440 min/day)

Average Flow Rate = 145 scfm

VOC = volatile organic compounds

DCE = dichloroethene

TCE = trichloroethene

PCE = tetrachloroethene

scfm=standard cubic foot per minute

Appendix F
Geotechnical Laboratory Report

Table F-1
Soil Geotechnical Results
Hookston Station
Pleasant Hill, California

Sample Location	Sample Depth (feet)	Visual Description	Aquifer Zone	Grain Size Distribution				Organic Content (%)	Specific Gravity	Dry Bulk Density (g/cm ³)	Total Porosity (%)	Effective Porosity (%)	Air-filled Porosity (%)	Water-filled Porosity (%)	Moisture (%)	Percent Saturation (%)	Hydraulic Conductivity (cm/sec)
				% gravel	% sand	%silt	% clay										
				ASTM D422				Walkley-Black	ASTM D 854m		API RP40 and ASTM D2325m				ASTM D 5084		
October 2003																	
B-73	7.5-9	na	Vadose	0.0	11.2	41.3	47.5	4.6*	2.60	1.51†	41.9†	na	na	na	na	na	na
B-88	9.5	na	Vadose	0.0	4.2	39.8	56.0	4.7*	2.60	1.66†	36.2†	na	na	na	na	na	na
MW-13A	7	na	Vadose	0.0	19.2	38.9	41.9	3.7*	2.62	1.23†	53.1†	na	na	na	na	na	na
February 2004																	
MW-15A	15.5	na	A-Zone	15.6	60.2	14.9	9.3	1.1*	na	na	na	na	na	na	na	na	na
MW-15B	50	na	B-Zone	0.7	25.5	46.9	26.9	1.7*	na	na	na	na	na	na	na	na	na
MW-16A	16.5	na	A-Zone	0.0	38.1	43.1	18.8	1.5*	na	na	na	na	na	na	na	na	na
April 2006																	
TW-1	6.5	Dark Brown CLAY w/ sand	Vadose	0.0	22.7	47.4	29.9	0.2	2.72	1.62	40.4	2.1	4.0	36.4	22.4	90	na
TW-1	10	Mottled Light Brown Sandy CLAY	Vadose	0.0	34.7	44.2	21.1	<0.1	2.71	1.61	40.5	5.1	4.3	36.2	22.4	89.5	na
TW-1	30	Mottled greenish gray CLAY w/ sand	A-Zone	0.0	29.1	45.4	25.5	<0.1	2.71	1.49	45	1.7	0.7	44.2	29.6	98.4	4.0x10 ⁻⁸
TW-1	39.5	Mottled dark gray CLAY	A-Zone	0.0	5.9	34.1	60	0.3	2.72	1.4	48.6	0.1	1.0	47.6	34	97.9	1.0x10 ⁻⁸
TW-1	46.5	Greenish gray silty SAND w/ gravel	B-Zone	19.3	64.7	10.5	5.5	<0.1	2.71	1.69	37.5	21.1	2.8	34.7	20.5	88.2	5.0x10 ⁻⁷
TW-1	75	Greenish Gray CLAY w/ sand	B-Zone	1.2	27.8	40.5	30.5	<0.1	2.72	1.62	40.2	1.5	2.2	38.0	23.3	94.5	2.0x10 ⁻⁸
TW-2	12	Mottled brown CLAY w/ sand	Vadose	1.0	21.2	46.2	31.6	<0.1	2.7	1.5	44.4	1.2	2.8	41.6	27.7	93.7	na
TW-2	19	Mottled grayish brown CLAY	A-Zone	0.0	11	57.3	31.7	<0.1	2.71	1.51	44.3	2.7	0.7	43.6	28.9	98.5	na
TW-3	7.5	Brown CLAY	Vadose	0.0	12.9	54.6	32.5	0.3	2.72	1.55	42.8	5.4	8.8	34.0	21.9	79.4	na
TW-3	14.5	Brown SILT	A-Zone	0.0	3.2	56.6	40.2	0.7	2.74	1.49	45.6	3.8	2.8	42.8	28.7	93.9	na
TW-3	21.5	Brown sandy-CLAY	A-Zone	0.0	40.7	34.9	24.4	<0.1	2.71	1.68	37.9	1	7.9	30.0	17.9	79.2	na
TW-4	7.5	Brown CLAY	Vadose	0.0	7	54.4	38.6	0.4	2.75	1.59	41.9	2.5	4.4	37.5	23.5	89.5	na
TW-4	17	Brown CLAY	A-Zone	0.0	5.5	49.6	44.9	0.6	2.72	1.45	46.7	3.4	3.0	43.7	30.1	93.6	na
SVE-1	11.5	Brown CLAY	Vadose	0.0	8.3	49.3	42.4	0.1	2.76	1.51	45.2	3.3	4.2	41.0	27.1	90.7	na

Notes:

ASTM = American Society for Testing and Materials

cm/sec = Centimeters per second

g/cm³ = Gallons per cubic centimeter

* = Samples collected in 2003 and 2004 were analyzed for organic content using ASTM D 2974-00 Method C - 440 degrees Celsius

† = Samples collected in 2003 were analyzed for bulk density using method D2937 and porosity using D2937 and D854.

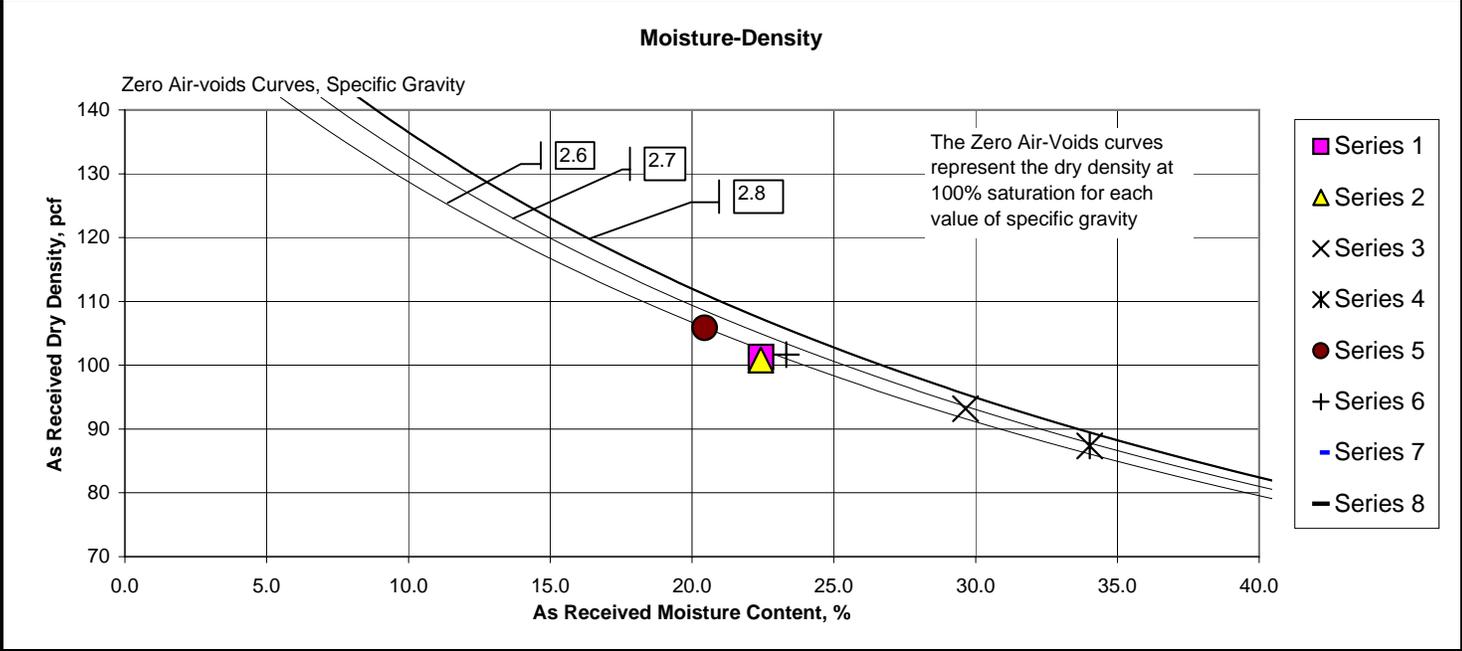


Total and Effective Porosity Report (API RP40 and ASTM D2325m)

Job No: 586-004 Project No.: 0020557.10
 Client: Environmental Resources Mgmt Date: 5/15/06
 Project Name: Hookston By: PJ

Boring:	TW-1	TW-1	TW-1	TW-1	TW-1	TW-1		
Sample:								
Depth, ft:	6.5	10	30	39.5	46.5	75		
Visual Description:	Dark Brown CLAY w/ Sand	Mottled Light Brown Sandy CLAY	Mottled Greenish Gray CLAY w/ Sand	Mottled Dark Gray CLAY	Greenish Gray Silty SAND w/ Gravel	Greenish Gray CLAY w/ Sand		
Total Porosity, %	40.4	40.5	45.0	48.6	37.5	40.2		
Effective Porosity, %	2.1	5.1	1.7	0.1	6.7	1.5		
Air-filled Porosity, %	4.0	4.3	0.7	1.0	2.8	2.2		
Water-filled Porosity, %	36.4	36.2	44.2	47.6	34.7	38.0		
Saturation, %	94.7	87.5	96.2	99.8	82.0	92.1		
Moisture, %	22.4	22.4	29.6	34.0	20.5	23.3		
Wet Unit wt, pcf	124.0	123.4	120.8	117.1	127.5	125.4		
Dry Unit wt, pcf	101.3	100.8	93.2	87.4	105.9	101.7		
Series	1	2	3	4	5	6	7	8

Note: All reported values above are for the "as received" condition except for the effective porosity which is measured at a tension of 1/3 Bar.





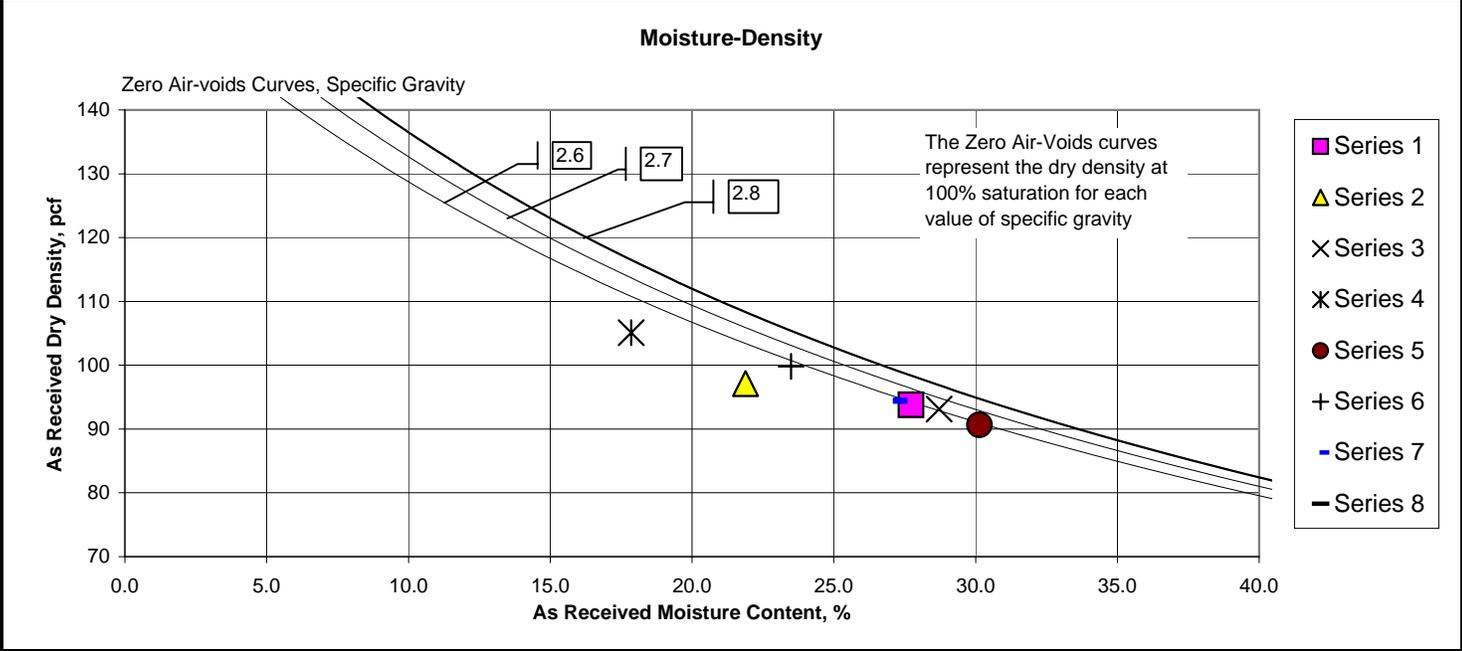
Total and Effective Porosity Report

(API RP40 and ASTM D2325m)

Job No: 586-005 Project No.: 0020557.10
 Client: Environmental Resources Mgmt Date: 5/15/06
 Project Name: Hookston By: PJ

Boring:	TW-2	TW-3	TW-3	TW-3	TW-4	TW-4	SVE-1	
Sample:								
Depth, ft:	12	7.5	14.5	21.5	17	7.5	11.5	
Visual Description:	Mottled Brown CLAY w/ Sand	Brown CLAY	Brown SILT	Brown Sandy CLAY	Brown CLAY	Brown CLAY	Brown CLAY	
Total Porosity, %	44.4	42.8	45.6	37.9	46.7	41.9	45.2	
Effective Porosity, %	1.2	5.4	3.8	1.0	3.4	2.5	3.3	
Air-filled Porosity, %	2.8	8.8	2.8	7.9	3.0	4.4	4.2	
Water-filled Porosity, %	41.6	34.0	42.8	30.0	43.7	37.5	41.0	
Saturation, %	97.2	87.5	91.6	97.4	92.8	93.9	93.9	
Moisture, %	27.7	21.9	28.7	17.9	30.1	23.5	27.1	
Wet Unit wt, pcf	119.8	118.4	119.9	123.8	117.9	123.2	120.1	
Dry Unit wt, pcf	93.8	97.1	93.1	105.1	90.6	99.8	94.4	
Series	1	2	3	4	5	6	7	8

Note: All reported values above are for the "as received" condition except for the effective porosity which is measured at a tension of 1/3 Bar.





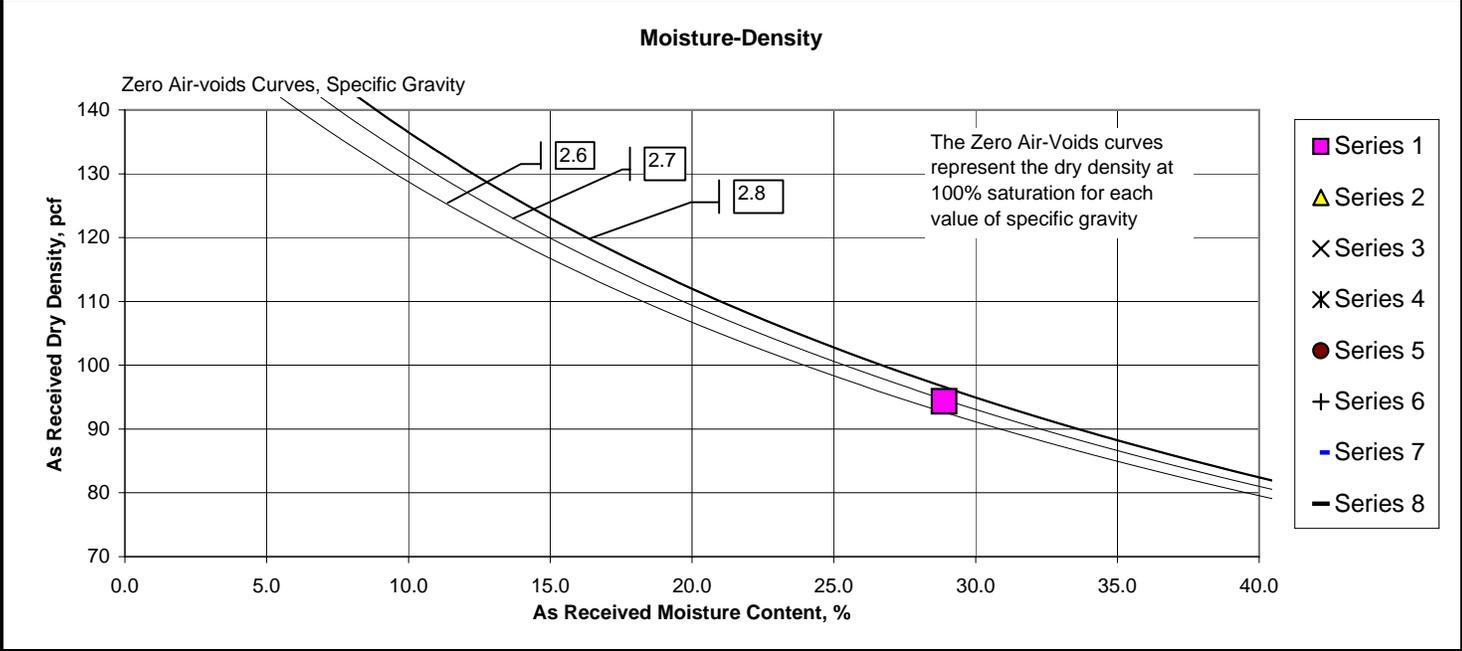
Total and Effective Porosity Report

(API RP40 and ASTM D2325m)

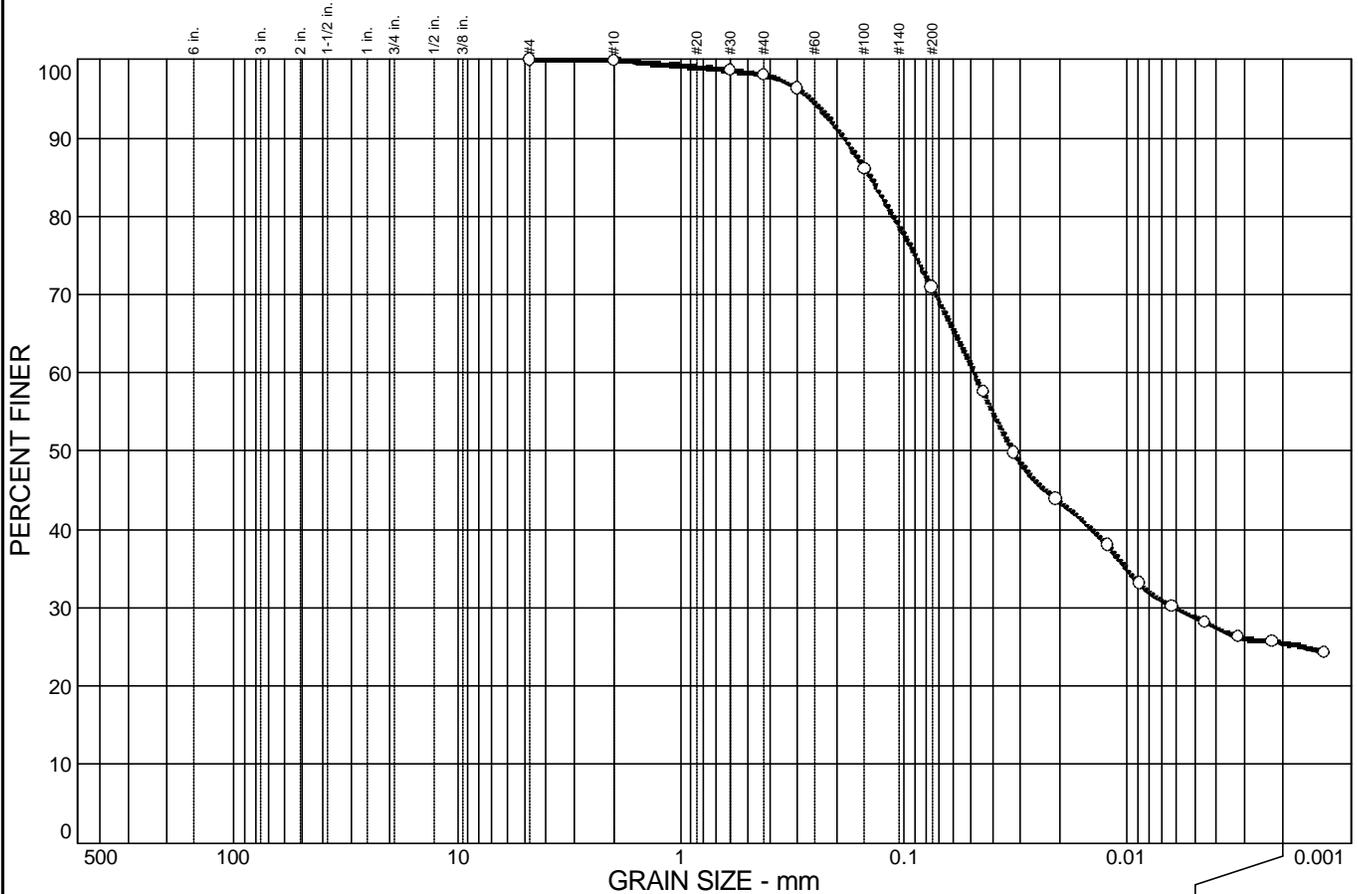
Job No: 586-006 Project No.: 0020557.10
 Client: Environmental Resources Mgmt Date: 5/15/06
 Project Name: Hookston By: PJ

Boring:	TW-2								
Sample:									
Depth, ft:	19								
Visual Description:	Mottled Grayish Brown CLAY								
Total Porosity, %	44.3								
Effective Porosity, %	2.7								
Air-filled Porosity, %	0.7								
Water-filled Porosity, %	43.6								
Saturation, %	94.1								
Moisture, %	28.9								
Wet Unit wt, pcf	121.6								
Dry Unit wt, pcf	94.3								
Series	1	2	3	4	5	6	7	8	

Note: All reported values above are for the "as received" condition except for the effective porosity which is measured at a tension of 1/3 Bar.



PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.1	1.9	27.1	45.4	25.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#30	98.6		
#40	98.0		
#50	96.3		
#100	86.0		
#200	70.9		
0.0443 mm.	57.6		
0.0323 mm.	49.8		
0.0208 mm.	43.9		
0.0123 mm.	38.0		
0.0088 mm.	33.1		
0.0063 mm.	30.2		
0.0045 mm.	28.2		
0.0032 mm.	26.3		
0.0022 mm.	25.7		
0.0013 mm.	24.3		

Soil Description

Greenish Gray CLAY w/ Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D₈₅= 0.143 D₆₀= 0.0485 D₅₀= 0.0326

D₃₀= 0.0061 D₁₅= D₁₀=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-1

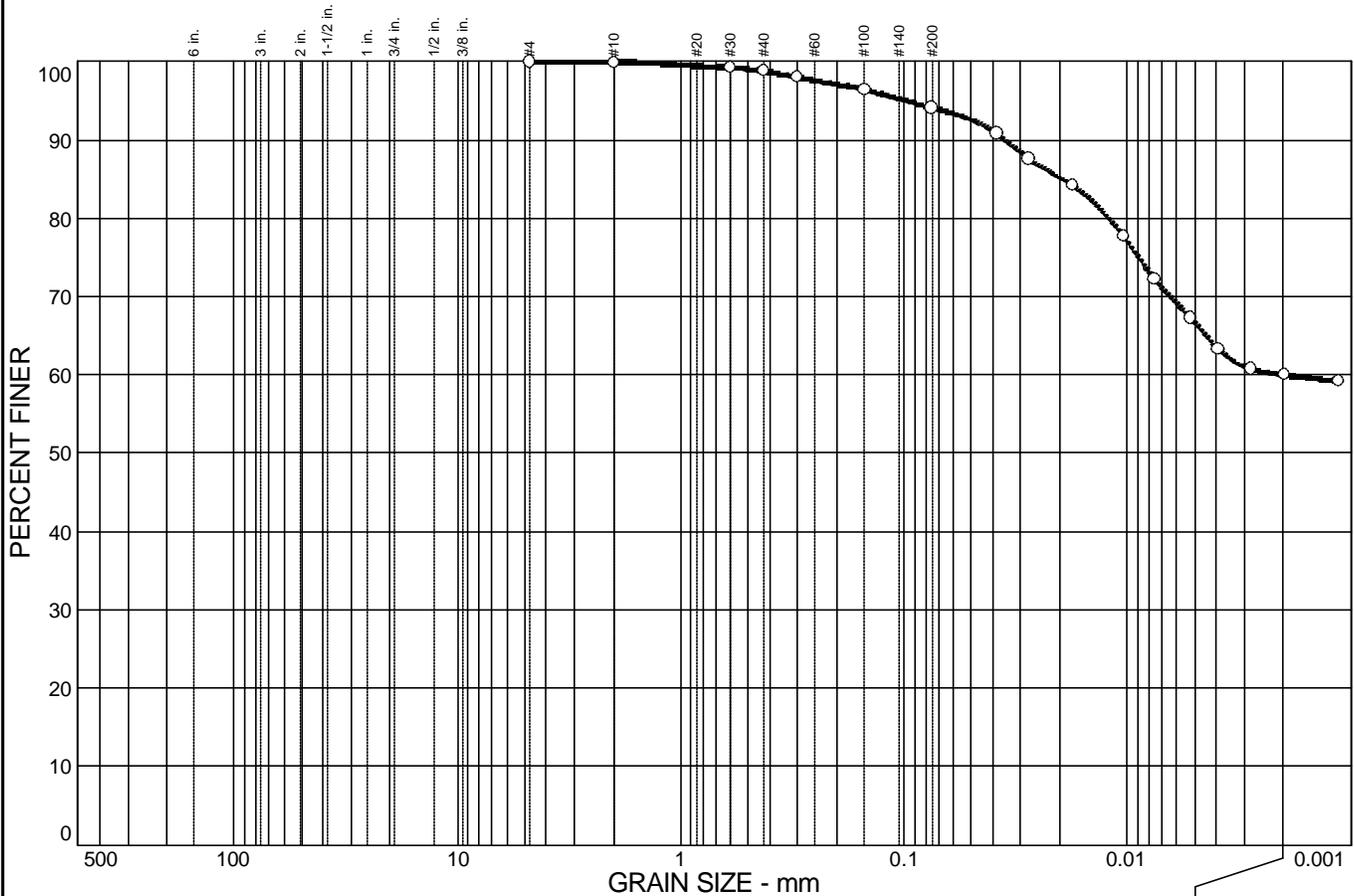
Date: 4/20/06
Elev./Depth: 30'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-004

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.1	1.1	4.7	34.1	60.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.9		
#30	99.2		
#40	98.8		
#50	98.0		
#100	96.4		
#200	94.1		
0.0383 mm.	90.8		
0.0275 mm.	87.6		
0.0175 mm.	84.2		
0.0104 mm.	77.7		
0.0075 mm.	72.2		
0.0052 mm.	67.3		
0.0039 mm.	63.3		
0.0028 mm.	60.8		
0.0020 mm.	60.0		
0.0011 mm.	59.2		

Soil Description

Dark Gray CLAY

Atterberg Limits

PL= LL= PI=

Coefficients

D₈₅= 0.0194 D₆₀= 0.0020 D₅₀=

D₃₀= D₁₅= D₁₀=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-1

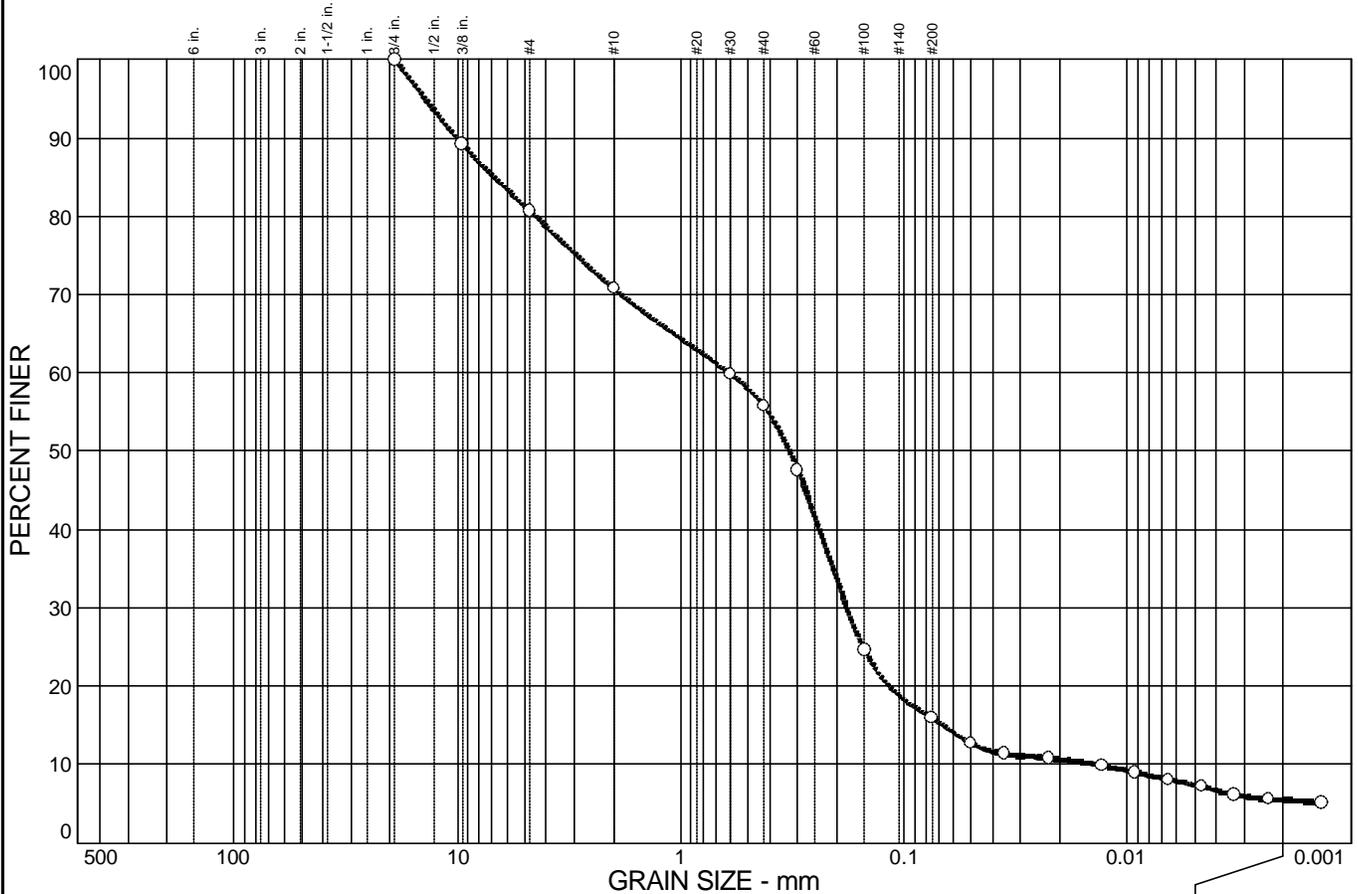
Date: 4/20/06
Elev./Depth: 39.5'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-004

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	19.3	9.9	15.0	39.8	10.5	5.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	89.2		
#4	80.7		
#10	70.8		
#30	59.9		
#40	55.8		
#50	47.6		
#100	24.6		
#200	16.0		
0.0502 mm.	12.7		
0.0358 mm.	11.4		
0.0224 mm.	10.8		
0.0130 mm.	9.9		
0.0092 mm.	9.0		
0.0066 mm.	8.1		
0.0047 mm.	7.2		
0.0033 mm.	6.1		
0.0023 mm.	5.6		
0.0013 mm.	5.1		

Soil Description

Greenish Gray Silty SAND w/ Gravel (cemented)

Atterberg Limits

PL= LL= PI=

Coefficients

D₈₅= 6.86 D₆₀= 0.607 D₅₀= 0.326
D₃₀= 0.181 D₁₅= 0.0667 D₁₀= 0.0136
C_u= 44.62 C_c= 3.96

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-1

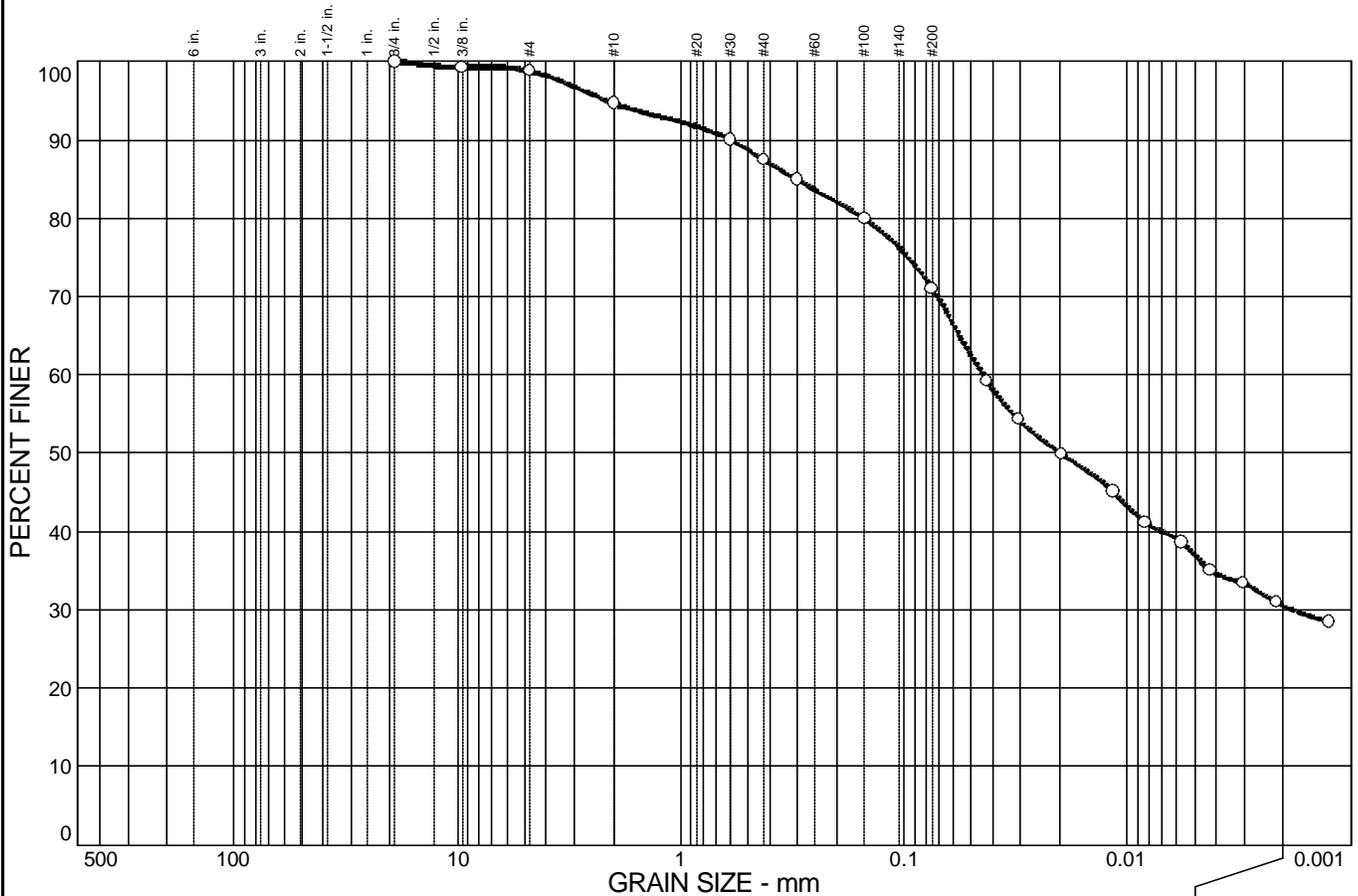
Date: 4/20/06
Elev./Depth: 46.5'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-004

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	1.2	4.1	7.2	16.5	40.5	30.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4 in.	100.0		
3/8 in.	99.3		
#4	98.8		
#10	94.7		
#30	90.0		
#40	87.5		
#50	84.9		
#100	79.9		
#200	71.0		
0.0426 mm.	59.2		
0.0308 mm.	54.4		
0.0196 mm.	49.9		
0.0116 mm.	45.1		
0.0083 mm.	41.2		
0.0057 mm.	38.6		
0.0043 mm.	35.1		
0.0030 mm.	33.4		
0.0022 mm.	31.0		
0.0012 mm.	28.5		

Soil Description

Greenish Gray CLAY w/ Sand

PL= **Atterberg Limits** PI=

Coefficients

D₈₅= 0.304 D₆₀= 0.0444 D₅₀= 0.0199

D₃₀= 0.0018 D₁₅= D₁₀=

C_u= C_c=

USCS= **Classification** AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-1

Date: 4/20/06
Elev./Depth: 75'

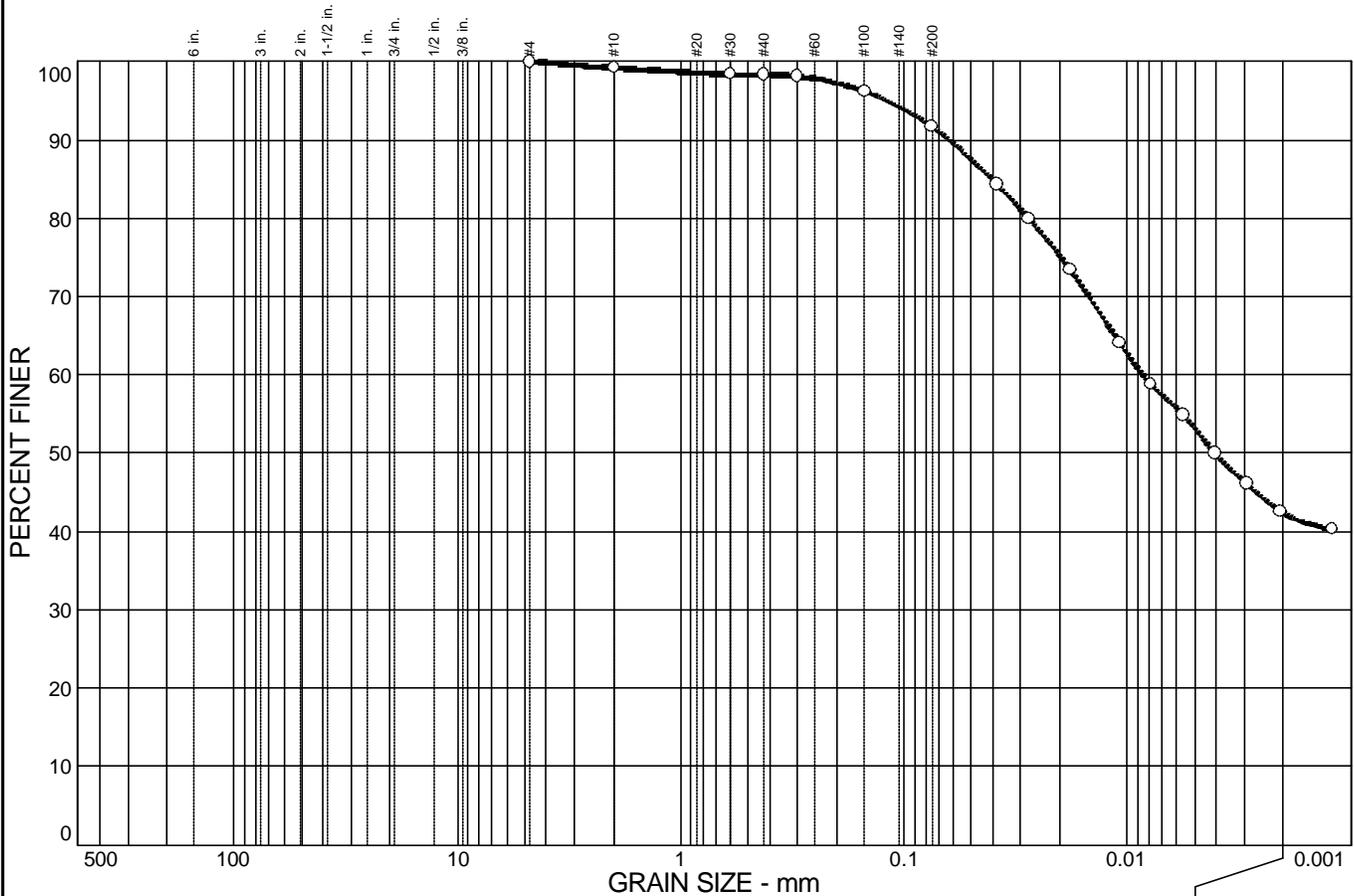
COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10

Project No: 586-004

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.8	0.9	6.6	49.3	42.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.2		
#30	98.4		
#40	98.3		
#50	98.1		
#100	96.2		
#200	91.7		
0.0383 mm.	84.3		
0.0277 mm.	80.0		
0.0180 mm.	73.4		
0.0108 mm.	64.1		
0.0078 mm.	58.8		
0.0056 mm.	54.9		
0.0041 mm.	50.0		
0.0029 mm.	46.1		
0.0021 mm.	42.6		
0.0012 mm.	40.3		

Soil Description
Brown CLAY

Atterberg Limits
 PL= LL= PI=

Coefficients
 D₈₅= 0.0405 D₆₀= 0.0085 D₅₀= 0.0041
 D₃₀= D₁₅= D₁₀=
 C_u= C_c=

Classification
 USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: SVE-1

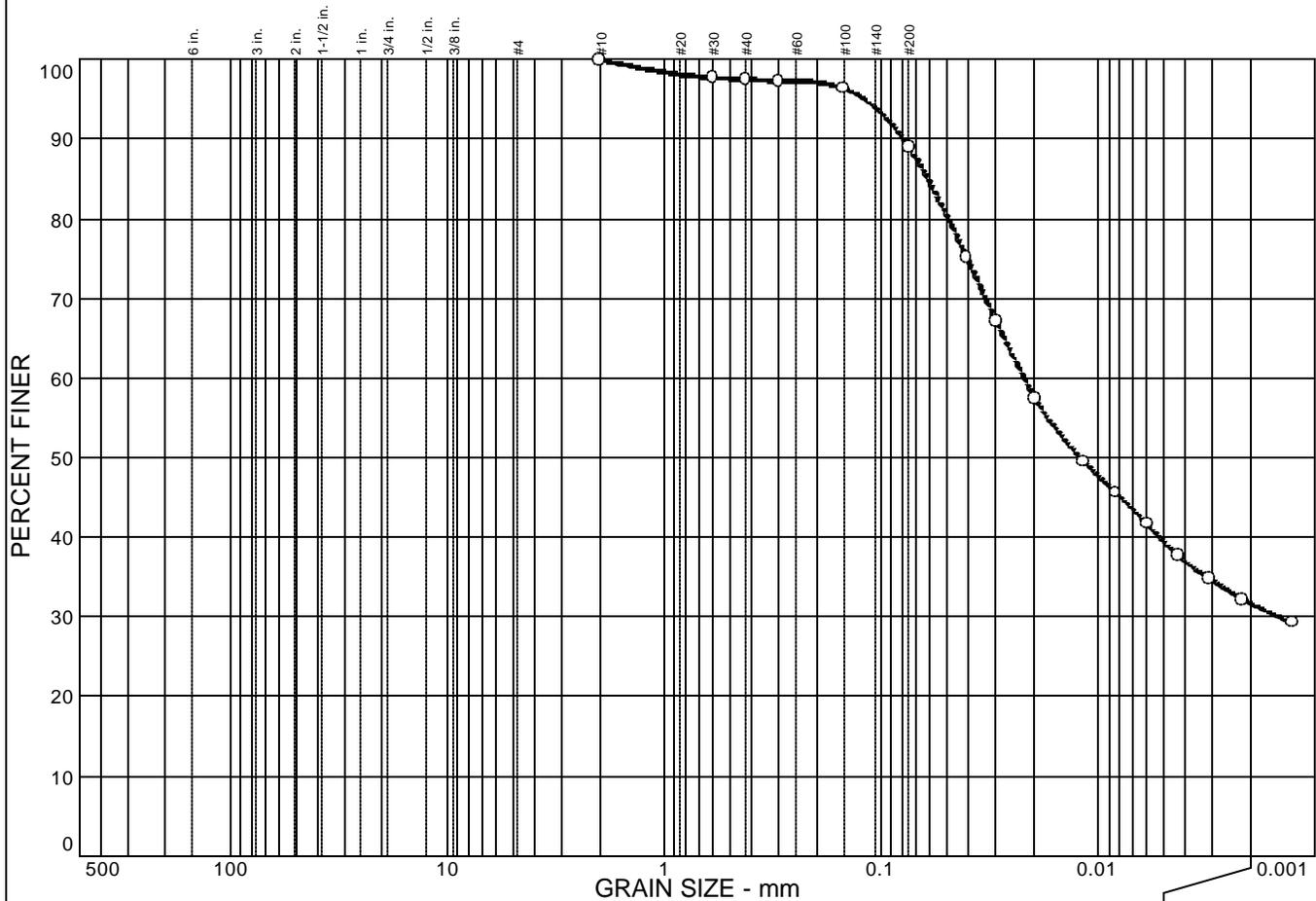
Date: 4/26/06
Elev./Depth: 11.5'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-005

Figure

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	11.0	57.3	31.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#30	97.7		
#40	97.5		
#50	97.3		
#100	96.4		
#200	89.0		
0.0408 mm.	75.1		
0.0298 mm.	67.2		
0.0196 mm.	57.4		
0.0117 mm.	49.5		
0.0084 mm.	45.6		
0.0060 mm.	41.7		
0.0043 mm.	37.7		
0.0031 mm.	34.8		
0.0022 mm.	32.2		
0.0013 mm.	29.3		

Soil Description

Mottled Grayish Brown CLAY

Atterberg Limits

PL= LL= PI=

Coefficients

D₈₅= 0.0614 D₆₀= 0.0222 D₅₀= 0.0122

D₃₀= 0.0015 D₁₅= D₁₀=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-2-19

Date: 4/26/06
Elev./Depth:

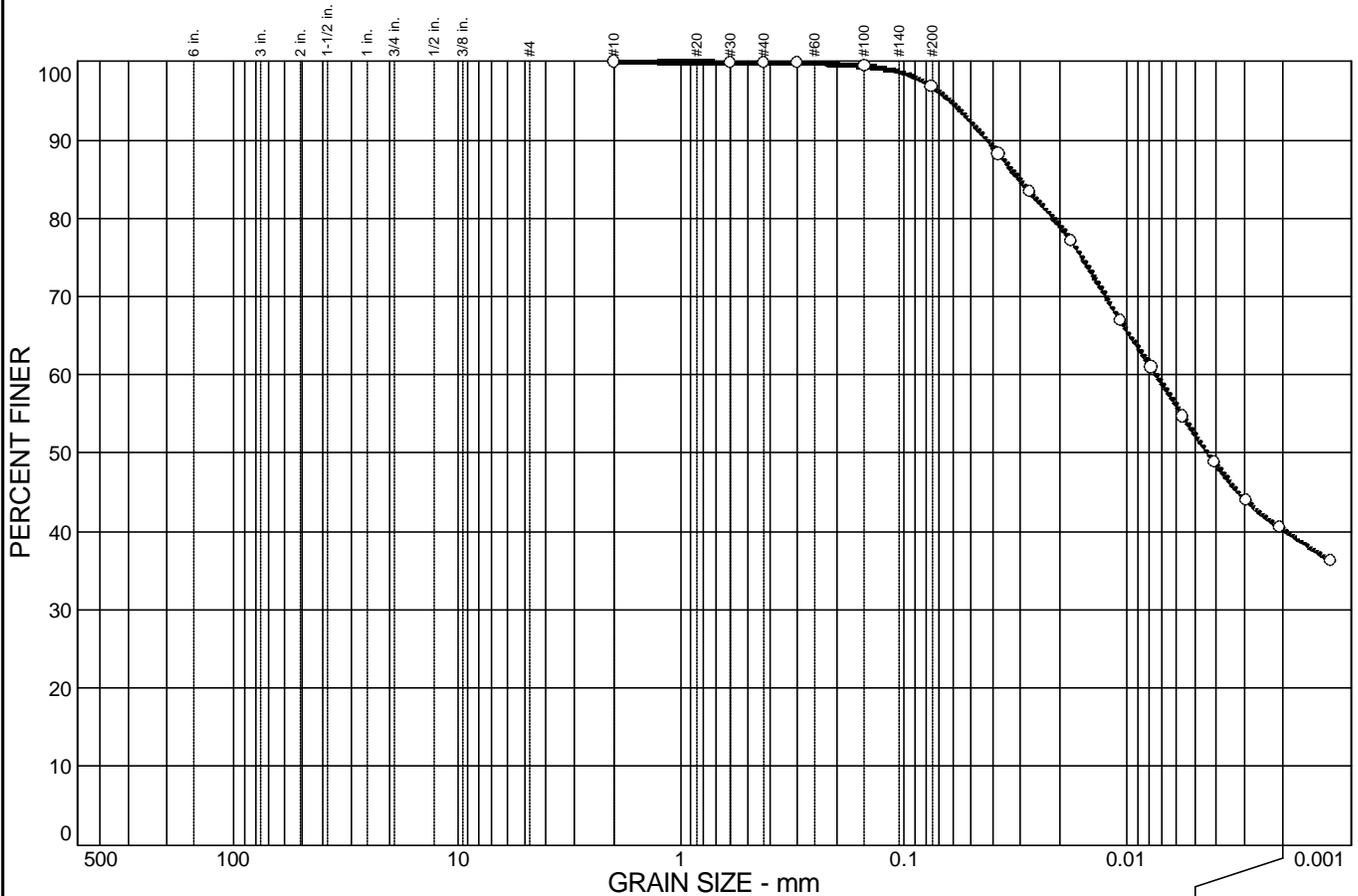
COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10

Project No: 586-006

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	3.0	56.6	40.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#30	99.8		
#40	99.8		
#50	99.8		
#100	99.4		
#200	96.8		
0.0377 mm.	88.2		
0.0273 mm.	83.4		
0.0178 mm.	77.1		
0.0108 mm.	66.9		
0.0078 mm.	61.0		
0.0057 mm.	54.7		
0.0041 mm.	48.9		
0.0029 mm.	44.0		
0.0021 mm.	40.6		
0.0012 mm.	36.3		

Soil Description
Brown SILT

Atterberg Limits
 PL= LL= PI=

Coefficients
 D₈₅= 0.0305 D₆₀= 0.0074 D₅₀= 0.0044
 D₃₀= D₁₅= D₁₀=
 C_u= C_c=

Classification
 USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-3

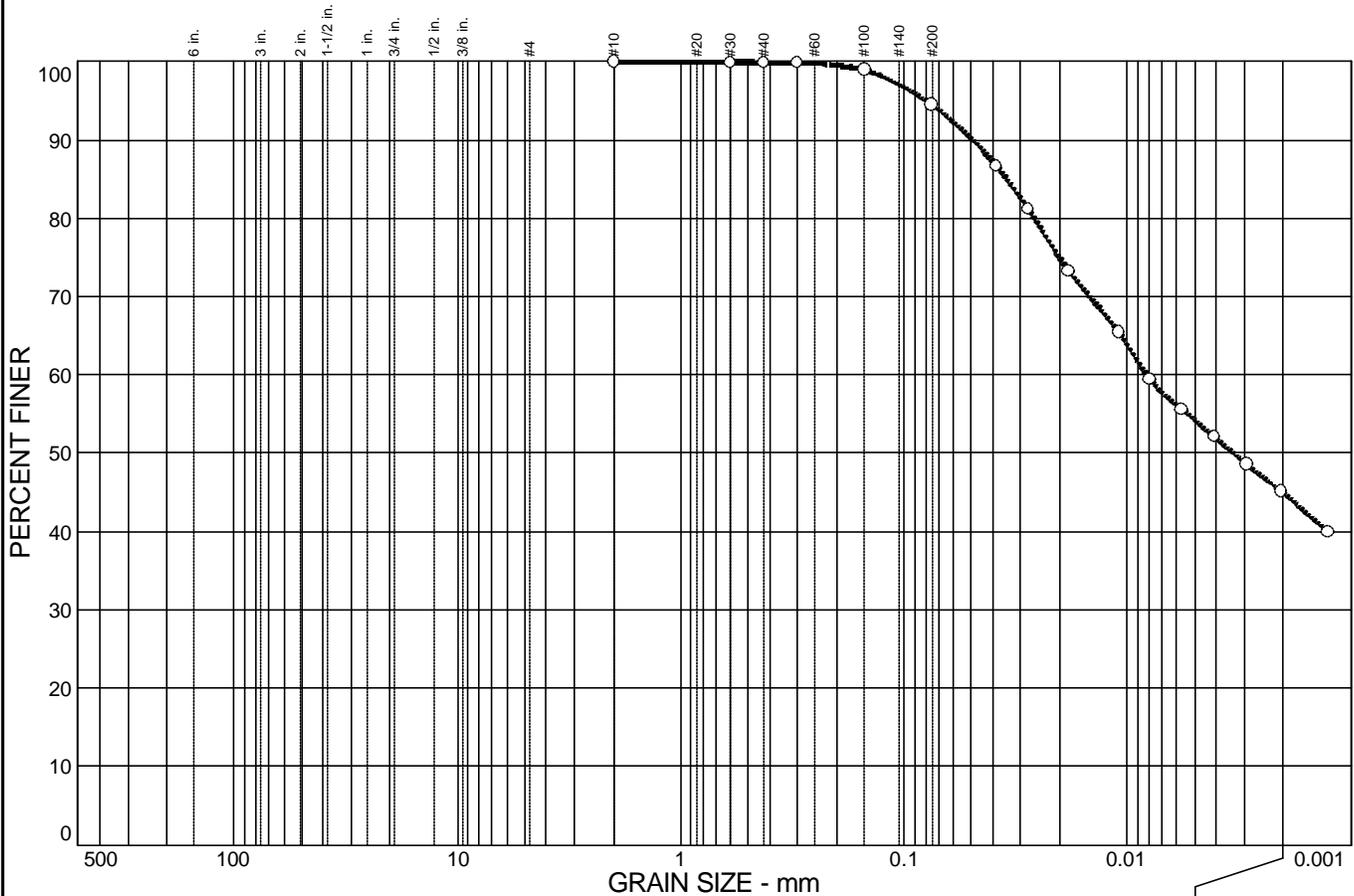
Date: 4/26/06
Elev./Depth: 14.5'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-005

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	5.3	49.6	44.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#30	99.9		
#40	99.8		
#50	99.8		
#100	98.9		
#200	94.5		
0.0385 mm.	86.6		
0.0280 mm.	81.2		
0.0183 mm.	73.3		
0.0109 mm.	65.4		
0.0079 mm.	59.5		
0.0057 mm.	55.6		
0.0041 mm.	52.1		
0.0029 mm.	48.6		
0.0020 mm.	45.1		
0.0013 mm.	39.9		

Soil Description

Brown CLAY

Atterberg Limits

PL= LL= PI=

Coefficients

D₈₅= 0.0348 D₆₀= 0.0082 D₅₀= 0.0033

D₃₀= D₁₅= D₁₀=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-4

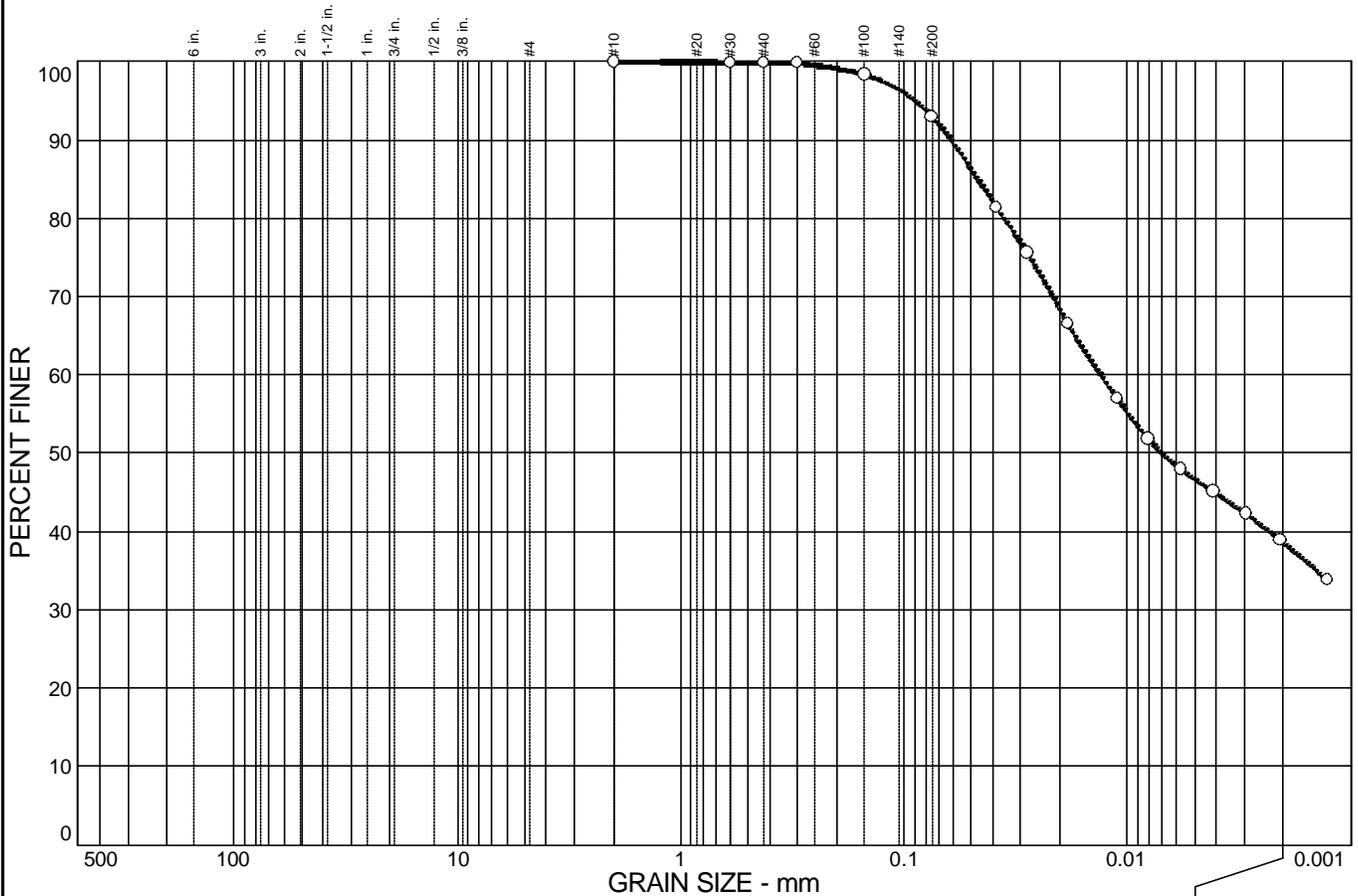
Date: 4/26/06
Elev./Depth: 17'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-005

Figure

PARTICLE SIZE DISTRIBUTION TEST REPORT



% + 3"	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	6.8	54.4	38.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#30	99.8		
#40	99.8		
#50	99.8		
#100	98.3		
#200	93.0		
0.0386 mm.	81.4		
0.0281 mm.	75.6		
0.0185 mm.	66.6		
0.0111 mm.	57.0		
0.0080 mm.	51.8		
0.0058 mm.	48.0		
0.0041 mm.	45.1		
0.0029 mm.	42.3		
0.0021 mm.	38.9		
0.0013 mm.	33.8		

Soil Description
Brown CLAY

Atterberg Limits
 PL= LL= PI=

Coefficients
 D₈₅= 0.0469 D₆₀= 0.0132 D₅₀= 0.0070
 D₃₀= D₁₅= D₁₀=
 C_u= C_c=

Classification
 USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.:
Location:

Source of Sample: TW-4

Date: 4/26/06
Elev./Depth: 7.5'

COOPER TESTING LABORATORY

Client: Environmental Resources Management
Project: Hookston - 0020557.10
Project No: 586-005

Figure



Specific Gravity by Pycnometer
ASTM D 854m

CTL Job#:	586-004	Project Name:	Hookston	Date:	04/18/06
Client:	Environmental Resources Management	Project No.:	20557.1	Run By:	MD
				Checked	DC

Boring:	TW-1	TW-1	TW-1	TW-1	TW-1	TW-1		
Sample:								
Depth, ft.:	6.5	10	30	39.5	46.5	75		
Pan No.:								
Soil Description (visual)	Dark Brown CLAY w/ Sand	Mottled Light Brown Sandy CLAY	Greenish Gray CLAY w/ Sand	Dark Gray CLAY	Greenish Gray Silty SAND w/ Gravel (cemented)	Greenish Gray CLAY w/ Sand		
Dish No.								
Air-Dry Weight, gm	30.16	36.08	31.06	22.35	30.32	37.59		
Oven-Dry Weight., gm	29.57	35.58	30.75	22.05	30.10	37.30		
Dish Weight, gm	11.43	11.36	11.43	11.36	11.73	11.72		
Hydroscopic MC, %	3.3	2.1	1.6	2.8	1.2	1.1		
Pycnometer No.:								
Wt Pycn., Soil & H2O (Wb), g	716.7	723.0	711.1	707.6	725.3	723.8		
Test Temp. (T), °C	20.4	20.4	21.0	21.0	21.0	21.6		
Wt Pycn. & H2O @ T (Wa), g	662.8	671.5	662.8	671.5	680.9	671.4		
Wt of Air-Dried Soil (Wm), g	88.02	83.4	77.86	58.74	71.2	83.83		
Wt of Oven-Dried Soil (Wo), g	85.25	81.71	76.63	57.14	70.36	82.89		
Temp. Corr. Factor (K)	1.0006	1.0006	0.9998	0.9998	0.9998	0.9998		
Specific Gravity (20°C) $G_s = \frac{K W_o}{W_o + W_a - W_b}$	2.72	2.71	2.71	2.72	2.71	2.72		



Specific Gravity by Pycnometer
ASTM D 854m

CTL Job#:	586-005	Project Name:	Hookston	Date:	04/26/06
Client:	Environmental Resources Management	Project No.:	20557.1	Run By:	MD
				Checked	DC

Boring:	TW-2	TW-3	TW-3	TW-3	TW-4	TW-4	SVE-1	
Sample:								
Depth, ft.:	12	7.5	14.5	21.5	17	7.5	11.5	
Pan No.:								
Soil Description (visual)	Mottled Brown CLAY w/ Sand	Brown CLAY	Brown SILT	Brown Sandy CLAY	Brown CLAY	Brown CLAY	Brown CLAY	
Dish No.								
Air-Dry Weight, gm	36.60	30.16	30.53	31.26	33.62	34.08	33.32	
Oven-Dry Weight., gm	36.40	30.04	30.14	30.96	33.29	33.74	32.73	
Dish Weight, gm	11.72	11.72	11.72	11.72	11.72	11.78	11.78	
Hydroscopic MC, %	0.8	0.7	2.1	1.6	1.5	1.5	2.8	
Pycnometer No.:								
Wt Pycn., Soil & H2O (Wb), g	714.6	721.9	715.1	713.0	720.8	731.3	728.0	
Test Temp. (T), °C	21.4	21.4	21.6	21.6	21.6	21.6	21.6	
Wt Pycn. & H2O @ T (Wa), g	662.7	671.4	662.7	662.7	671.4	680.8	680.8	
Wt of Air-Dried Soil (Wm), g	83.09	80.29	84.17	81	79.24	80.56	76.04	
Wt of Oven-Dried Soil (Wo), g	82.42	79.77	82.42	79.76	78.05	79.33	73.96	
Temp. Corr. Factor (K)	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	
Specific Gravity (20°C) $G_s = \frac{K W_o}{W_o + W_a - W_b}$	2.70	2.72	2.74	2.71	2.72	2.75	2.76	



Specific Gravity by Pycnometer
ASTM D 854m

CTL Job#:	586-006	Project Name:	Hookston	Date:	04/24/06
Client:	Environmental Resources Management	Project No.:	20557.1	Run By:	MD
				Checked	DC

Boring:	TW-2-19						
Sample:							
Depth, ft.:							
Pan No.:							

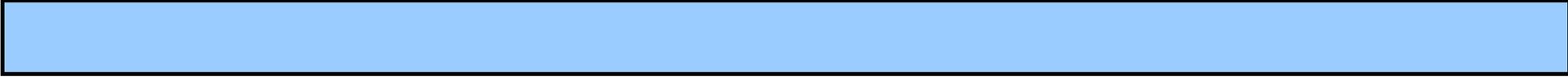
Soil Description (visual)	Mottled Grayish Brown CLAY						
----------------------------------	----------------------------	--	--	--	--	--	--

Dish No.							
Air-Dry Weight, gm	31.16						
Oven-Dry Weight., gm	30.78						
Dish Weight, gm	11.44						

Hydroscopic MC, %	2.0						
--------------------------	-----	--	--	--	--	--	--

Pycnometer No.:							
Wt Pycn., Soil & H2O (Wb), g	720.6						
Test Temp. (T), °C	21.1						
Wt Pycn. & H2O @ T (Wa), g	662.8						
Wt of Air-Dried Soil (Wm), g	93.37						
Wt of Oven-Dried Soil (Wo), g	91.58						
Temp. Corr. Factor (K)	0.9998						

Specific Gravity (20°C)							
Gs = $\frac{K W_o}{W_o+W_a-W_b}$	2.71						





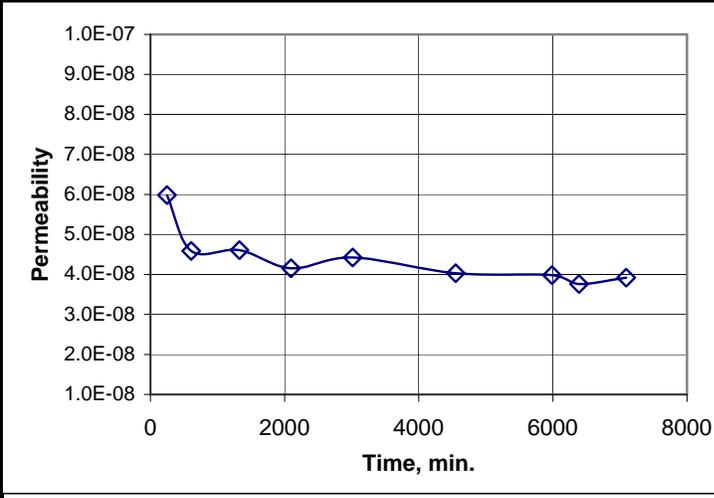
Hydraulic Conductivity ASTM D 5084

Method C: Falling Head Rising Tailwater

Job No: 586-004 **Boring:** TW-1 **Date:** 04/26/06
Client: Environmental Resources Management **Sample:** **By:** MD/PJ
Project: Hookston - 0020557.10 **Depth, ft.:** 30 **Remolded:** **Visual Classification:** Greenish Gray CLAY w/ sand

Max Sample Pressures, psi:				B: = >0.95 ("B" is an indication of saturation)
Cell:	Bottom	Top	Avg. Sigma 3	Max Hydraulic Gradient: = 27
43.5	39.5	37.5	5	

Date	Minutes	Head, (in)	K, cm/sec
4/13/2006	0.00	79.38	Start of Test
4/13/2006	247.00	78.88	6.0E-08
4/13/2006	607.00	78.38	4.6E-08
4/14/2006	1328.00	77.28	4.6E-08
4/14/2006	2096.00	76.48	4.2E-08
4/15/2006	3014.00	75.18	4.4E-08
4/16/2006	4550.00	73.53	4.0E-08
4/17/2006	5987.00	72.03	4.0E-08
4/17/2006	6390.00	71.63	3.8E-08
4/18/2006	7092.00	70.88	3.9E-08



Average Permeability: 4.E-08 cm/sec

Sample Data:	Initial	Final
Height, in	2.98	2.98
Diameter, in	1.94	1.94
Area, in ²	2.94	2.94
Volume in ³	8.77	8.77
Total Volume, cc	143.7	143.7
Volume Solids, cc	82.3	82.3
Volume Voids, cc	61.4	61.4
Void Ratio	0.7	0.7
Porosity, %	42.7	42.7
Saturation, %	99.0	99.3
Specific Gravity	2.71	2.71
Wet Weight, gm	283.8	284.0
Dry Weight, gm	223.0	223.0
Tare, gm	0.00	0.00
Moisture, %	27.3	27.4
Dry Density, pcf	96.8	96.8

Remarks: _____



Hydraulic Conductivity

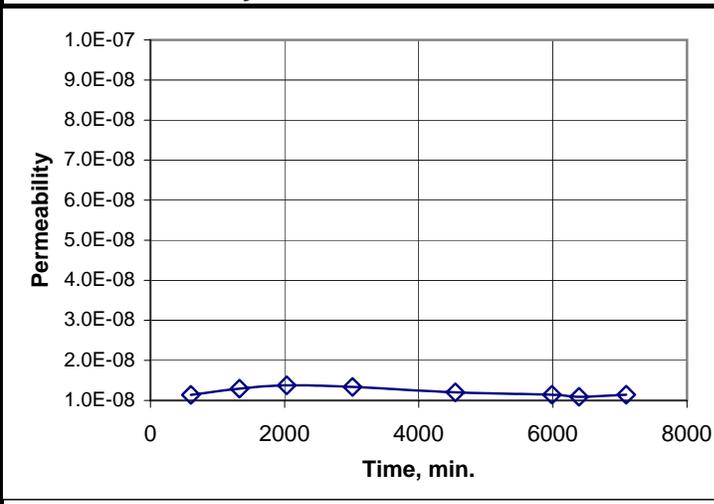
ASTM D 5084

Method C: Falling Head Rising Tailwater

Job No: 586-004 **Boring:** TW-1 **Date:** 04/26/06
Client: Environmental Resources Management **Sample:** **By:** MD/PJ
Project: Hookston - 0020557.10 **Depth, ft.:** 39.5 **Remolded:**
Visual Classification: Dark Gray CLAY

Max Sample Pressures, psi:				B: = >0.95 ("B" is an indication of saturation)
Cell:	Bottom	Top	Avg. Sigma 3	Max Hydraulic Gradient: = 27
53.5	49.5	47.5	5	

Date	Minutes	Head, (in)	K,cm/sec
4/13/2006	0.00	79.38	Start of Test
4/13/2006	604.00	79.13	1.1E-08
4/14/2006	1328.00	78.78	1.3E-08
4/14/2006	2033.00	78.43	1.4E-08
4/15/2006	3013.00	78.08	1.3E-08
4/16/2006	4546.00	77.58	1.2E-08
4/17/2006	5987.00	77.18	1.1E-08
4/17/2006	6390.00	77.03	1.1E-08
4/18/2006	7092.00	76.78	1.1E-08



Average Permeability: 1.E-08 cm/sec

Sample Data:	Initial	Final
Height, in	2.99	3.04
Diameter, in	1.94	1.96
Area, in ²	2.94	3.02
Volume in ³	8.78	9.17
Total Volume, cc	143.8	150.3
Volume Solids, cc	75.1	75.1
Volume Voids, cc	68.8	75.2
Void Ratio	0.9	1.0
Porosity, %	47.8	50.1
Saturation, %	98.6	99.3
Specific Gravity	2.72	2.72
Wet Weight, gm	272.0	278.9
Dry Weight, gm	204.2	204.2
Tare, gm	0.00	0.00
Moisture, %	33.2	36.6
Dry Density, pcf	88.6	84.8

Remarks: _____



Hydraulic Conductivity

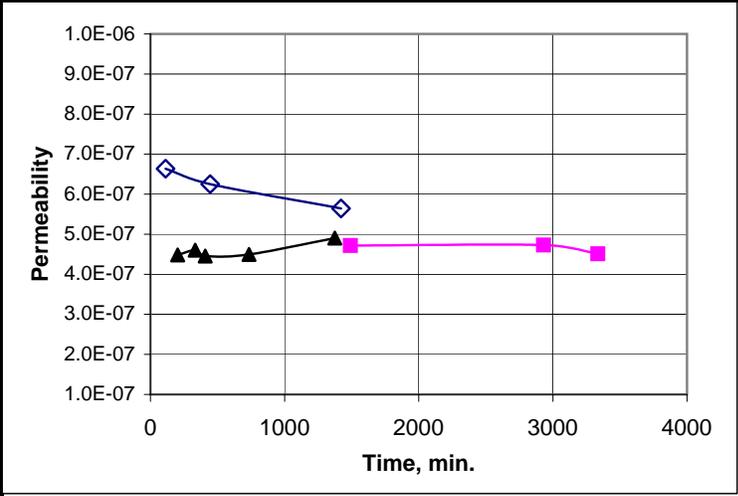
ASTM D 5084

Method C: Falling Head Rising Tailwater

Job No: 586-004 **Boring:** TW-1 **Date:** 04/26/06
Client: Environmental Resources Management **Sample:** **By:** MD/PJ
Project: Hookston - 0020557.10 **Depth, ft.:** 46.5 **Remolded:**
Visual Classification: Greenish Gray Silty SAND w/ Gravel (cemented)

Max Sample Pressures, psi:				B: = >0.95 ("B" is an indication of saturation)
Cell:	Bottom	Top	Avg. Sigma 3	Max Hydraulic Gradient: = 13
63.5	59	58	5	

Date	Minutes	Head, (in)	K, cm/sec
4/14/2006	0.00	94.63	Start of Test
4/14/2006	113.00	92.23	6.6E-07
4/14/2006	445.00	86.03	6.3E-07
4/15/2006	1421.00	72.83	5.6E-07
4/16/2006	1491.00	77.73	4.7E-07
4/17/2006	2931.00	62.53	4.7E-07
4/17/2006	3335.00	58.73	4.5E-07
4/18/2006	203.00	94.73	4.5E-07
4/18/2006	333.00	92.73	4.6E-07
4/18/2006	408.00	91.83	4.5E-07
4/18/2006	735.00	87.03	4.5E-07
4/19/2006	1374.00	78.43	4.9E-07



Average Permeability: 5.E-07 cm/sec

Sample Data:	Initial	Final
Height, in	2.99	2.89
Diameter, in	1.94	1.94
Area, in ²	2.94	2.96
Volume in ³	8.79	8.54
Total Volume, cc	144.1	140.0
Volume Solids, cc	96.3	96.3
Volume Voids, cc	47.7	43.6
Void Ratio	0.5	0.5
Porosity, %	33.1	31.2
Saturation, %	98.9	99.4
Specific Gravity	2.71	2.71
Wet Weight, gm	308.3	304.5
Dry Weight, gm	261.1	261.1
Tare, gm	0.00	0.00
Moisture, %	18.1	16.6
Dry Density, pcf	113.1	116.4

Remarks: This sample contained a 2" diameter rock. This probably had a significant impact on the measured permeability.



Hydraulic Conductivity

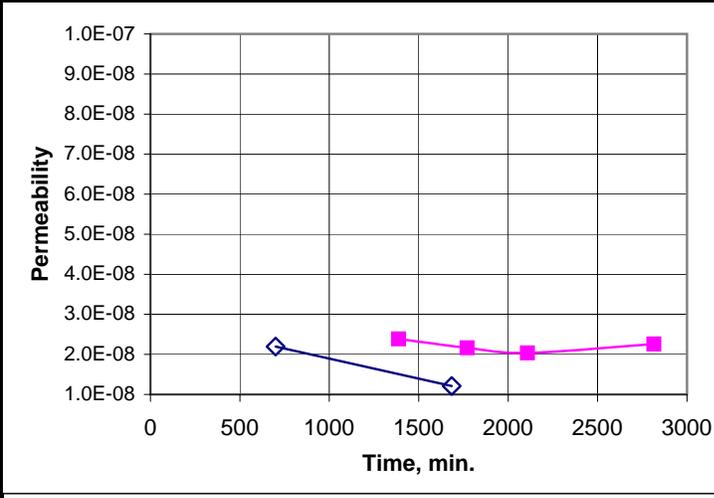
ASTM D 5084

Method C: Falling Head Rising Tailwater

Job No: 586-004 **Boring:** TW-1 **Date:** 04/26/06
Client: Environmental Resources Management **Sample:** **By:** MD/PJ
Project: Hookston - 0020557.10 **Depth, ft.:** 75 **Remolded:** **Visual Classification:** Greenish Gray CLAY w/ Sand

Max Sample Pressures, psi:				B: = >0.95 ("B" is an indication of saturation)
Cell:	Bottom	Top	Avg. Sigma 3	Max Hydraulic Gradient: = 22
53.5	49.5	47.5	5	

Date	Minutes	Head, (in)	K, cm/sec
4/14/2006	0.00	168.67	Start of Test
4/14/2006	700.00	166.76	2.2E-08
4/15/2006	1684.00	166.26	1.2E-08
4/20/2006	1388.00	164.86	2.4E-08
4/20/2006	1771.00	164.06	2.2E-08
4/20/2006	2108.00	163.26	2.0E-08
4/21/2006	2815.00	161.26	2.3E-08



Average Permeability: 2.E-08 cm/sec

Sample Data:	Initial	Final
Height, in	2.96	2.99
Diameter, in	2.88	2.90
Area, in ²	6.51	6.61
Volume in ³	19.28	19.72
Total Volume, cc	316.0	323.2
Volume Solids, cc	191.1	191.1
Volume Voids, cc	124.9	132.1
Void Ratio	0.7	0.7
Porosity, %	39.5	40.9
Saturation, %	95.9	97.9
Specific Gravity	2.72	2.72
Wet Weight, gm	639.6	649.1
Dry Weight, gm	519.8	519.8
Tare, gm	0.00	0.00
Moisture, %	23.0	24.9
Dry Density, pcf	102.6	100.4

Remarks: _____



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408-727-5125 fax

COOPER TESTING LABS
937 Commercial St
Palo Alto, CA 94303

Santa Clara Office
Lab No. 70265
ERM
586-004

Samples Rec'd: 4/17/06

Sam ple #	Analysis Requested	Quantity	Units	Sample Description & Log Number	
11	Chemical Organic	0.2	% dry wt	TW-1-6.5	06-A6842 20
12	Chemical Organic	< 0.1	% dry wt	TW-1-10	06-A6843 20
13	Chemical Organic	< 0.1	% dry wt	TW-1-30	06-A6844 20
14	Chemical Organic	0.3	% dry wt	TW-1-39.5	06-A6845 20
15	Chemical Organic	< 0.1	% dry wt	TW-1-46.5	06-A6846 20
16	Chemical Organic	< 0.1	% dry wt	TW-1-75	06-A6847 20



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COOPER TESTING LABS INC
937 Commercial Street
Palo Alto, CA 94303

Santa Clara Office
Lab No. 70313
ENVIRONMENTAL RESOURCES MANAGEMENT
HOOKSTON
Job No. 586-005

Samples Rec'd: 4/20/06

Sam ple #	Analysis Requested	Quantity	Units	Sample Description & Log Number	
1	Chemical Organic	< 0.1	% dry wt	TW-2-12	06-A7088 20
2	Chemical Organic	0.3	% dry wt	TW-3-7.5	06-A7089 20
3	Chemical Organic	0.7	% dry wt	TW-3-14.5	06-A7090 20
4	Chemical Organic	< 0.1	% dry wt	TW-3-21.5	06-A7091 20
5	Chemical Organic	0.6	% dry wt	TW-4-17	06-A7092 20
6	Chemical Organic	0.4	% dry wt	TW-4-7.5	06-A7093 20
7	Chemical Organic	0.1	% dry wt	SVE-1-11.5	06-A7094 20
8	Chemical Organic	< 0.1	% dry wt	TW-2-19	06-A7095 20

4/25/06

Appendix G
Aquifer Testing

APPENDIX G - AQUIFER TESTING

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D AQUIFER TEST ANALYSES

1.0

INTRODUCTION

In situ aquifer tests and constant-rate pumping aquifer tests were conducted at the Hookston Station Parcel and downgradient study area to support remedial alternative evaluations for the Feasibility Study. This appendix describes the field activities conducted, documents the field and analytical methods used, and presents the results of the aquifer tests.

The aquifer testing was performed in order to evaluate the hydraulic responses and properties of the A-Zone and B-Zone aquifers to pumping stresses, including aquifer transmissivity, hydraulic conductivity, and storativity.

2.0 SCOPE OF WORK

In situ aquifer tests and constant-rate pumping tests were conducted at the Hookston Station Parcel and downgradient study area during 4 to 12 April 2006. In situ aquifer tests were performed at 11 monitoring wells (MW-5, -7, -8B, -14A/B, -15A/B, -16A/B, and -17A/B). A constant-rate pump test was conducted in A-Zone well MW-5, and a constant-rate pump test was conducted in a new B-Zone well, TW-1. Well locations are included on Figure G-1.

The following sections describe the field activities and methods that were completed for these tasks.

2.1 PRE-AQUIFER TEST ACTIVITIES

Activities completed prior to the completion of the aquifer tests included the installation and development of a B-Zone pumping well, TW-1. Prior to installing the well, the following activities were completed:

- A well installation permit was obtained from the Contra Costa County Environmental Health Department;
- Underground Service Alert was notified at least 48 hours prior to the commencement of drilling activities; and
- ForeSite Engineering Services, a private utility locating service, was retained to clear the drilling location.

Gregg Drilling and Testing, Inc., a drilling subcontractor from Martinez, California, was retained to perform the well installation. A hollow-stem auger drill rig was used to conduct the drilling, sampling, and well installation activities on 5 to 6 April 2006. The drilling location was hand-cleared to 5 feet below ground surface (bgs) to minimize the potential for encountering underground utilities during drilling activities. The boring was then advanced to 75 feet bgs with 6-inch diameter hollow stem augers. Soil samples were collected continuously using 18- and 24-inch California-modified split spoon samplers. Boring logs were prepared in the field by an ERM-West, Inc., geologist using the Unified Soil Classification System to describe soils. The geologist recorded vertical changes in soil lithology, color, moisture content, grain size, and texture, as well as any observations of staining or odors.

Soil samples were collected for geotechnical analysis from the unsaturated zone, the A-Zone aquifer, the B-Zone aquifer, and the clay units between the A-, B-, and C-Zones (6.5, 10, 30, 39.5, 46.5, and 75 feet bgs). The samples were collected in shelby tubes or brass liners that were driven with split spoon samplers. Samples were labeled and sent under proper chain-of-custody procedure to Cooper Testing Labs in Palo Alto, California, for the following analysis:

- Grain size distribution (American Society for Testing and Materials [ASTM] D422);
- Dry bulk density, total porosity, effective porosity, air-filled porosity, water-filled porosity, and moisture content (API RP40 and ASTM D2325m);
- Specific gravity (ASTM D854m);
- Percent saturation and hydraulic conductivity (ASTM D5084); and
- Total organic content (Walkley-Black).

The results of the geotechnical testing are provided in Appendix F of the Feasibility Study/Remedial Action Plan.

Once the total depth of the boring was reached and samples were collected, the boring was then over-drilled with 10-inch diameter hollow stem augers in order to accommodate the installation of the well materials. TW-1 was then constructed with 4-inch diameter polyvinyl chloride screen (0.020-inch machine-slotted) from 45 to 75 feet bgs and blank riser pipe to the ground surface. A filter pack of #3 sand was emplaced within the annular space to approximately 3 feet above the top of the screen interval. The transition seal consisted of 3 feet of bentonite chips hydrated with potable water approximately 30 minutes prior to placement of the cement-bentonite seal. TW-1 was completed at the ground surface with a flush-mounted well vault, watertight expansion cap, and secured with a lock.

TW-1 was developed on 8 April 2006 using air-lift techniques. Approximately 600 gallons (roughly 15 well volumes) were removed from the well. The well was also surged during development to remove any sediment that may have entered during installation. Stabilization parameters (pH, specific conductance, turbidity, and temperature) were monitored and recorded during development.

Copies of the well logs are provided as Attachment A.

2.2 *AQUIFER TESTING*

Activities conducted during the aquifer tests are summarized in the following sub-sections.

2.2.1 *Background Monitoring*

Well hydraulics equations used in aquifer test analyses assume static, steady-state initial conditions, wherein water levels are constant in time and space prior to pumping. Before aquifer test data can be analyzed, they must be adjusted for any significant, extraneous water-level fluctuations. Therefore, water level data were collected prior to conducting aquifer tests.

Pre-aquifer test water level data were collected from each of the wells that were utilized during the constant-rate pumping tests (observation wells and pumping wells). Background water level data were also collected from two additional wells (MW-23A/B) prior to and during the pump tests. In addition, a barometric pressure transducer was programmed to take readings of barometric pressure every 10 minutes throughout completion of the aquifer testing.

The water levels were monitored continuously with dataloggers and pressure transducers for a minimum of 2 days prior to the constant-rate pumping tests. These data were evaluated for possible use in correcting the aquifer test data for changes in atmospheric pressure or local uncontrolled aquifer stresses.

2.2.2 *In Situ Aquifer Testing*

In situ aquifer (slug) tests were performed on 4 and 5 April 2006 in six A-Zone wells (MW-5, -7, -14A, -15A, -16A, and -17A) and five B-Zone wells (MW-8B, -14B, -15B, -16B and -17B). The slug tests were conducted in accordance with the standard operating procedure (SOP) for In Situ Aquifer Tests (Attachment B).

The following procedures were followed for the set-up and completion of each slug test.

Prior to conducting the slug test, the depth to water was measured with an electronic sounder and recorded in the field notebook. A pressure transducer was then installed in the well. The transducer was installed at such a depth that the addition and removal of the slug would not interfere with the transducer and that the water level would not fall below the

transducer. The transducer was then secured at the top of the well using a stainless steel hanger. The transducer was then programmed such that the reference value was equal to zero and that readings would be collected every second during the slug test.

A rising-head slug test was performed at each well. Following installation of the pressure transducer and initiation of readings, the slug was gently lowered into the well below static water level. The water level was then monitored until it recovered to static conditions. Following confirmation that the slug was completely submerged within the water column and static water levels were restored, the slug was instantaneously removed from the well. One bailer (1.6-inch diameter by 3 feet) was used in the A-Zone slug tests and two bailers (each 1.6-inch diameter by 3 feet) were used in the B-Zone slug tests. After the slug was removed, the pressure transducer recorded data until the water level stabilized. A laptop computer was used to determine when stabilization had been achieved. In addition, manual water level measurements were recorded during the test. Once the water level had stabilized, the pressure transducer was stopped and a final manual water level measurement was collected and recorded in the field notebook.

2.2.3 *Step-Drawdown Tests*

A step-drawdown test is a single-well test in which the well is pumped at a constant rate until drawdown in the well has stabilized. The pumping rate is then increased to another constant rate until the drawdown has stabilized again. Step-drawdown tests usually consist of at least three different, constant-rate discharge steps. Data collected from these tests may be used to determine the sustainable yield of a well.

Prior to the constant-rate pump tests, a step-drawdown test was performed in each of the wells that were to be used as the “pumping” well for each test (MW-5 and TW-1). These step-drawdown tests were performed to determine the optimal flow rate for each of the constant-rate pumping test. A pressure transducer was installed in the pumping well prior to the start of the step-drawdown test. Water levels were also measured manually with an electric sounder to verify depths measured using the transducer.

During the A-Zone step-drawdown test, MW-5 was pumped at four different rates. The discharge rates used were 1, 3, 4, and 5 gallons per minute (gpm). During the B-Zone step-drawdown test, TW-1 was pumped at four different rates. The discharge rates used were 5, 10, 15, and 18 gpm. Each pumping rate was maintained until drawdown

approximately stabilized. During the test, a plot of drawdown versus elapsed time was created to determine the duration of each pumping rate and estimate the rate increase for the next step.

Discharge rates were measured using an in-line flowmeter to monitor the flow rate and total gallons pumped. The flowmeter was checked periodically by measuring the time it took to fill a 5-gallon bucket. Groundwater extracted during the step-drawdown tests was stored at the Hookston Station Parcel in Baker Tanks pending waste characterization and proper disposal.

2.2.4 *A-Zone Constant-Rate Pump Test*

The A-Zone constant-rate pump test was performed on 10 April 2006. Monitoring well MW-5 was utilized as the pumping well and MW-8A, -11A, -13A, -15A, and -20A were utilized as observation wells. In addition, water levels were monitored in B-Zone observation wells MW-8B, -11B, -13B, -15B, and -20B to record possible influence to the B-Zone as a result of A-Zone pumping. All pump test procedures were completed in accordance with the SOP for Aquifer Pump Tests, included as Attachment C.

The constant-rate pumping rate was determined based on the step-drawdown test data, and a target pumping rate of 4 gpm was chosen. Prior to starting the pumping test, a round of manual water levels was collected from the observation wells and transducers were programmed to begin collecting data on a log scale.

Pumping began at 8:30 a.m. on 10 April 2006. Water levels were measured at logarithmic time intervals in the pumping well and observation wells with dataloggers and pressure transducers at least as frequently as follows:

Elapsed Time (Minutes)	Frequency of Measurement
0 - 10	1 second
10 - 30	1 minute
30 - 60	2 minutes
> 60	5 minutes

Each of the transducers was vented to the atmosphere to minimize interference from barometric pressure changes. Manual water levels were also measured periodically during the tests.

A constant yield of approximately 4 gpm was maintained throughout the test; if the rate deviated by more than 5 percent, the discharge valve was adjusted. The test duration was determined based on the drawdown observed over time in the pumping well and observation wells. Due to the drawdown observed in MW-5 and the surrounding observation wells, the test was stopped at 6:30 p.m. on 10 April 2006. Therefore, the A-Zone constant-rate pumping test was run for a total of 10 hours.

Recovery of water levels in MW-5 and the observation wells was monitored immediately upon cessation of pumping. Measurement frequency was similar to that of the measurements taken during the pumping portion of the test, as described above. The duration of the recovery test was approximately 20 hours.

2.2.5 B-Zone Constant-Rate Pumping Test

The B-Zone constant-rate pump test was performed on 12 April 2006. Test well TW-1 was utilized as the pumping well while MW-8B, -11B, -13B, -15B, and -20B were utilized as observation wells. In addition, water levels were monitored in A-Zone observation wells MW-8A, -11A, -13A, -15A, and -20A to record possible influence to the A-Zone as a result of B-Zone pumping. All pump test procedures were completed in accordance with the SOP for Aquifer Pump Tests, included as Attachment C.

A target pumping rate of 25 gpm was chosen, based upon the results of the step-drawdown test and the storage capacity for discharge water. Prior to starting the pumping test, a round of manual water levels was collected from the pumping well and observation wells and transducers were programmed to begin collecting data on a log scale.

Pumping began at 8:30 a.m. on 12 April 2006. Water levels were measured at a logarithmic time interval in the pumping well and observation wells with dataloggers and pressure transducers at the same scale discussed above for the A-Zone test (Section 2.2.4). Each of the transducers was vented to the atmosphere to minimize interference from barometric pressure changes. Manual water levels were also measured periodically.

A constant yield of approximately 25 gpm was maintained throughout the test; if the rate deviated by more than 5 percent, the discharge valve was adjusted. The test duration was determined based on the drawdown observed over time in the pumping well and observation wells. Due to the drawdown seen in TW-1 and the surrounding observation wells, the test was shut down at 4:30 p.m. on 12 April 2006. The B-Zone constant-rate pumping test was run for a total duration of 8 hours.

Recovery of water levels in TW-1 and the observation wells was monitored immediately upon cessation of pumping. Measurement frequency was similar to that of the measurements taken during the pumping portion of the test, as described above. The duration of the recovery test was approximately 16 hours.

3.0 *RESULTS*

The results of the aquifer test analyses are described in this section. The analytical methods and assumptions used for the analyses are also documented below.

3.1 *AQUIFER TEST ANALYTICAL METHODS AND ASSUMPTIONS*

The data set collected during the aquifer tests includes manual and datalogger data from 21 wells, representing both the A-Zone and B-Zone aquifers. This includes data collected during background, slug tests, step-drawdown tests, constant-rate pumping tests, and recovery tests. The aquifer test data were analyzed with the assistance of aquifer testing analysis software (Waterloo Hydrogeologic, Inc., 2002, and HydroSOLVE, Inc., 2002) to facilitate consistent analysis. Aquifer test time-drawdown and distance-drawdown analyses are provided in Attachment D.

The following analytical methods were used to analyze the aquifer test data:

- Bouwer-Rice Slug Test Method, 1976;
- Cooper-Jacob Time Drawdown Method, 1946 (confined);
- Cooper-Jacob Distance-Drawdown Method, 1946 (confined);
- Papadopulos-Cooper Single Well Method, 1967;
- Theis Method, 1935 (confined); and
- Theis Recovery Method, 1935.

Some notable assumptions include the following:

- The selected analytical methods reflect confined conditions, consistent with the geologic model and data for the Hookston Station Parcel;
- A 16-foot saturated thickness was applied to the A-Zone constant-rate pumping test analysis (based on the sand aquifer thickness at MW-5). This saturated thickness was also applied to the analyses of the A-Zone observation wells for consistency; and
- A 30-foot saturated thickness was applied to the B-Zone constant-rate pumping test analysis (based on the sand aquifer thickness at TW-1).

A 30-foot saturated thickness was also applied to the analyses of the B-Zone observation wells in order to maintain consistency.

3.2 *A-ZONE AQUIFER TEST RESULTS*

The results of the A-Zone aquifer test analyses are summarized below and on Table G-1.

The following A-Zone aquifer characteristics were calculated from the A-Zone slug test data:

- Average transmissivity (T) = 3.1 centimeters squared per second (cm^2/s), or 284 feet squared per day (ft^2/day).
- Average hydraulic conductivity (K) = 6.54×10^{-3} centimeters per second (cm/s), 19 feet per day (ft/day).

During the A-Zone constant-rate pump test, no drawdown was measured in the observation wells; therefore, the data obtained from the pumping well was analyzed using a single well test solution (Papadopulos-Cooper, 1967). For the A-Zone aquifer, the following aquifer characteristics were calculated from the MW-5 constant-rate pumping test:

- $T = 0.59 \text{ cm}^2/\text{s}$ (56 ft^2/day).
- $K = 1.21 \times 10^{-3} \text{ cm}/\text{s}$ (3.4 ft/day).

These results are consistent with published values of K for silty sands and fine sands (Fetter, 1994). Water levels collected in A-Zone observation wells during the B-Zone pump test were analyzed to determine what, if any, connection exists between the two aquifers. Analysis of the water levels collected in B-Zone observation wells during the A-Zone pump test indicates that there was no influence observed in the B-Zone aquifer that is attributable to the A-Zone pumping.

3.4 *B-ZONE AQUIFER TEST RESULTS*

The results of the B-Zone aquifer tests are summarized below and on Table G-2.

The following transmissivity and hydraulic conductivity values were calculated from the results of the B-Zone slug tests:

- Average T value of $1.4 \text{ cm}^2/\text{day}$ (132 ft^2/day).

- Average K value of 5.23×10^{-3} cm/s (15 ft/day).

The following transmissivity and hydraulic conductivity values were calculated from the results of the B-Zone constant-rate test:

- Average T value of $14 \text{ cm}^2/\text{s}$ ($1.32 \times 10^3 \text{ ft}^2/\text{day}$).
- Average K value of 1.89×10^{-2} cm/s (54 ft/day).

These results are consistent with published values of K for a well-sorted sand (Fetter, 1994). Water levels collected in A-Zone observation wells during the B-Zone pump test were analyzed to determine what, if any, connection exists between the two aquifers. Approximately 3 feet of drawdown was observed in MW-13A, located within 10 feet of TW-1. None of the other A-Zone observation wells showed measurable influence as a result of B-Zone pumping. These results suggest that the A-Zone and B-Zone aquifers are to some extent connected, however localized in nature.

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Figures

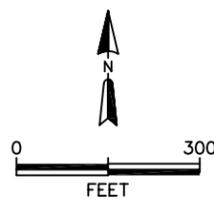
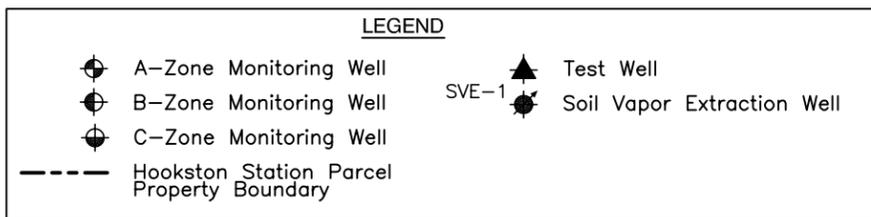
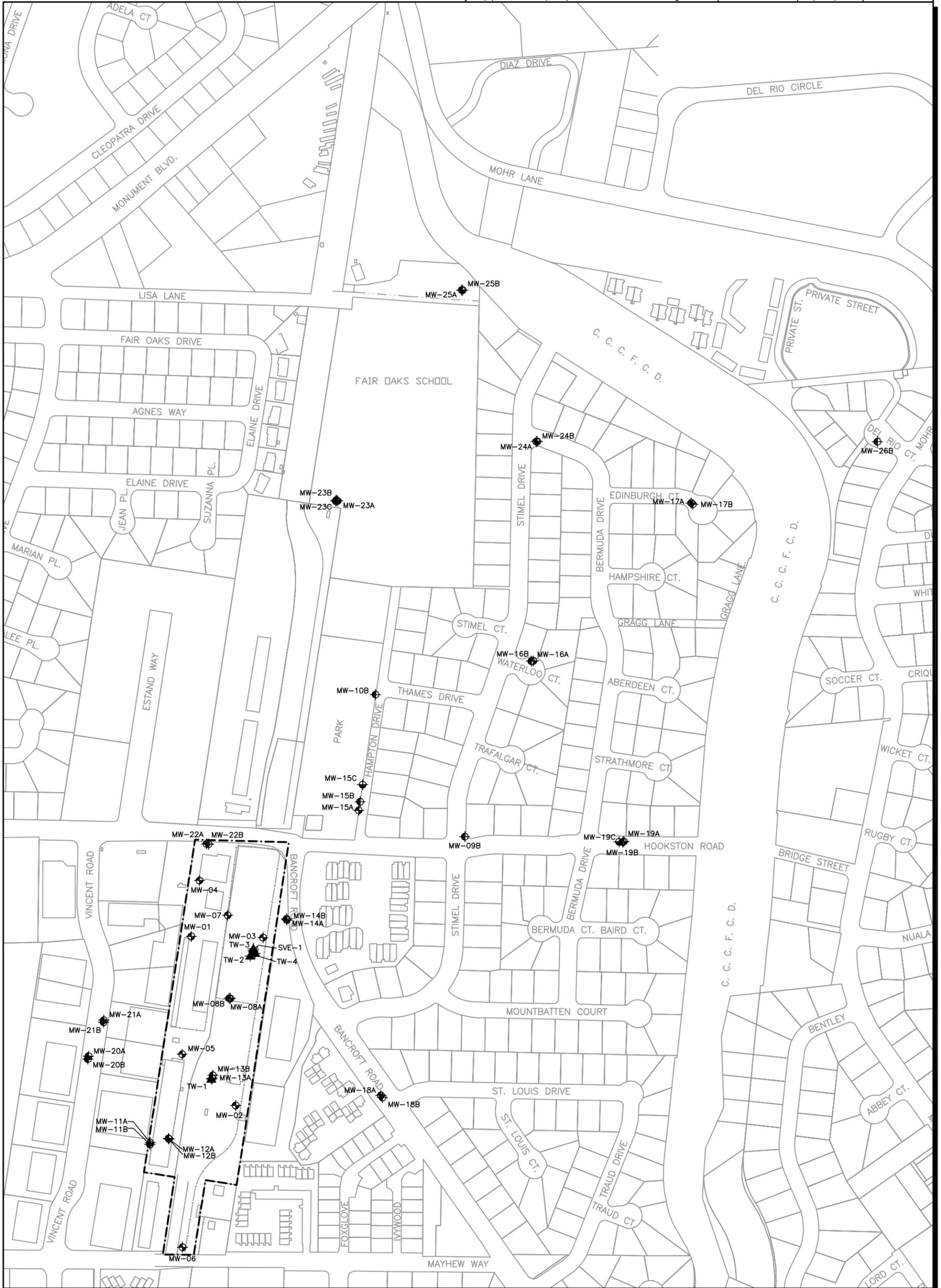


Figure G-1
Well Location Map
Hookston Station
Pleasant Hill, California

Tables

Table G-1
Summary of A-Zone Aquifer Test Results
Hookston Station
Pleasant Hill, California

Well ID	Groundwater Zone	Pumping Well Discharge, gpm	Screen Interval, ft bgs	Distance from Pumping Well, ft	Saturated Thickness, ft	Transmissivity		Hydraulic Conductivity		Storativity
						T, cm ² /s	T, ft ² /day	K, cm/s	K, ft/day	S [unitless]
ERM Constant Rate Pump Test - MW-5 (Screened 10 to 30 feet bgs)										
<i>Single Well Analysis (Papadopulos-Cooper)</i>										
MW-5	A-Zone	4	10-30	0	16	0.59	56	1.21E-03	3.4	n/a
ERM Slug Tests (Bouwer-Rice)										
MW-5	A-Zone	--	10-30	--	16	7.61	7.1E+02	1.56E-02	44	n/a
MW-7	A-Zone	--	15-35	--	20	1.30	1.2E+02	2.13E-03	6	n/a
MW-14A	A-Zone	--	29-34	--	21	1.46	1.4E+02	2.28E-03	6	n/a
MW-15A	A-Zone	--	15-25	--	12	*	*	*	*	*
MW-16A	A-Zone	--	15-25	--	15	1.30	1.2E+02	2.84E-03	8	n/a
MW-17A	A-Zone	--	20.7-30.7	--	12	3.60	3.3E+02	9.84E-03	28	n/a
Average Bouwer-Rice Results						3.1	2.84E+02	6.54E-03	19	n/a

Notes:

bgs = Below ground surface

cm/s = Centimeters per second

cm²/s = Square centimeters per second

ft = Feet

ft/day = Feet per day

ft²/day = Square feet per day

gpm = Gallons per minute

n/a = Not applicable

* Slug tests were performed at MW-15A. The test results were inconclusive and therefore are not presented above.

Table G-2
Summary of B-Zone Aquifer Test Results
Hookston Station
Pleasant Hill, California

Well ID	Ground Water Zone	Pumping Well Discharge, gpm	Screen Interval, ft bgs	Distance from Pumping Well, ft	Saturated Thickness, ft	Transmissivity		Hydraulic Conductivity		Storativity		
						T [cm ² /s]	T [ft ² /day]	K [cm/s]	K [ft/day]	S [unitless]		
ERM Constant Rate Pump Test - TW-1 (Screened 45 to 75 feet bgs)												
<i>Theis Time-Drawdown Analysis (Confined)</i>												
MW-13B	B-Zone	25	45-55	12	30	8	7.46E+02	8.59E-03	24	1.34E-03		
MW-8B	B-Zone	25	45-60	300	30	10	9.39E+02	1.08E-02	31	2.55E-04		
MW-15B	B-Zone	25	49-59	990	30	15	1.39E+03	1.60E-02	45	2.22E-04		
<i>Cooper-Jacob Time-Drawdown Analysis (Confined)</i>												
MW-13B	B-Zone	25	45-55	12	30	8	7.71E+02	8.88E-03	25	6.05E-04		
MW-8B	B-Zone	25	45-60	300	30	11	1.03E+03	1.18E-02	33	2.25E-04		
MW-15B	B-Zone	25	49-59	990	30	20	1.86E+03	2.15E-02	61	2.75E-03		
<i>Cooper-Jacob Distance-Drawdown Analysis (Confined)</i>												
1,000 seconds (MW-13B, MW-8B, MW-15B)	B-Zone	25	Various	15, 300 and 990	30	25	2.38E+03	2.75E-02	78	9.44E-05		
10,000 seconds (MW-13B, MW-8B, MW-15B)	B-Zone	25	Various	15, 300 and 990	30	18	1.74E+03	2.00E-02	57	1.22E-04		
20,000 seconds (MW-13B, MW-8B, MW-15B)	B-Zone	25	Various	15, 300 and 990	30	11	1.04E+03	1.20E-02	34	1.70E-04		
<i>Recovery Analyses (Theis, Confined)</i>												
MW-13B	B-Zone	25	45-55	12	30	7	6.77E+02	1.56E-02	44	n/a		
MW-8B	B-Zone	25	45-60	300	30	9	8.84E+02	2.04E-02	58	n/a		
MW-15B	B-Zone	25	49-59	990	30	25	2.35E+03	5.41E-02	153	n/a		
Average Theis Time-Drawdown Results						11	1.02E+03	1.18E-02	33	6.06E-04		
Average Cooper-Jacob Time-Drawdown Result						13	1.22E+03	1.41E-02	40	1.19E-03		
Average Cooper-Jacob, Distance-Drawdown Results						18	1.72E+03	1.98E-02	56	1.29E-04		
Average Recovery Analysis (Theis, Confined) Results						14	1.30E+03	3.00E-02	85	n/a		
Overall Average Results						14	1.32E+03	1.89E-02	54	6.43E-04		
ERM Slug Tests (Bouwer-Rice)												
MW-8B	B-Zone	--	45-60	--	9	2.6	2.4E+02	9.55E-03	27	n/a		
MW-14B	B-Zone	--	40-50	--	8	1.4	1.3E+02	5.87E-03	17	n/a		
MW-15B	B-Zone	--	49-59	--	10	0.5	4.5E+01	1.59E-03	5	n/a		
MW-16B	B-Zone	--	35-45	--	9	2.1	2.0E+02	7.83E-03	22	n/a		
MW-17B	B-Zone	--	44-54	--	10	0.4	3.8E+01	1.33E-03	4	n/a		
						<i>Average Bouwer-Rice Results</i>		1.4	1.32E+02	5.23E-03	15	n/a

Key:

ft = Feet

bgs = Below ground surface

ft/day = Feet per day

ft²/day = Square feet per day

cm/s = Centimeters per second

cm²/s = Square centimeters per second

gpm = Gallons per minute

Attachment A
Well Construction Logs



ERM
1777 Botelho Drive
Suite 260
Walnut Creek, California 94596
(925) 946-0455

BOREHOLE LOG

Site Id: TW-1

Page 1 of 2

Project Number: 0020557.10
Project Name: UP Hookston Station
Location: Pleasant Hill
Contractor: Gregg
Drilling Method: Hollow Stem Auger
Logged By: A. Cole
Date(s): 04/05/06
Initial Water Level: 26.50'
X-Coordinate: NA
Y-Coordinate: NA

Total Depth: 77.00'
Completed Depth: 75.00'
Borehole Dia.: 10.00in

Blank Casing: type: Sch 40 PVC	dia: 2.00in	fm: 0.50'	to: 45.00'
Screens: type: Slotted	size: 0.020in	dia: 2.00in	fm: 45.00' to: 75.00'
Annular Fill: type: Grout		fm: 0.75'	to: 39.00'
type: Bentonite		fm: 39.00'	to: 42.00'
type: #2/12 Sand Filter		fm: 42.00'	to: 77.00'

Depth (ft)	Graphic Log	USCS Code	Well Construction	Sample Recovery	Blow Count	PID (ppm)	Soil Description and Observations
0.0							Base rock, gravelly sand, 0.5-2.0" subangular gravel.
0.0		CL					CLAY (CL): black, trace silt, low plasticity, soft, wet.
5.0		CL		106 12	0.0		CLAY (CL): olive brown, some silt, trace fine grained sand, medium plasticity, slightly moist.
10.0		SM		85 8	0.0		SILTY SAND (SM): light brown, very fine grained sand, some clay, soft, slightly moist.
15.0		CL		108 12	0.0		CLAY (CL): olive brown, some fine grained sand, stiff, low plasticity, dry.
20.0		CL		112 20	0.0		CLAY (CL): dark brown, trace fine grained sand, stiff, medium plasticity, dry.
25.0		CL		88 14	0.0		CLAY (CL): as above, increased moisture.
30.0		SM		117 21	0.0		SILTY SAND (SM): olive brown, fine to medium grained sand, trace organics (roots), dense, wet.
30.0		ML		108 46	0.0		SILT (ML): olive, some fine grained sand, trace organics (roots), stiff, wet.
35.0		CL		110 14	0.0		CLAY (CL): black, trace fine grained sand, very stiff, low plasticity, dry.
35.0		SM		220 27	0.0		SILTY SAND (SM): gray brown, fine grained sand, dense, wet.
35.0		SM		119 08	0.0		SILTY SAND (SM): as above.
35.0		CL		119 37	0.0		CLAY (CL): black/gray, trace fine grained sand, white organic fibers, very stiff, low plasticity, dry.

Attachment B
Standard Operation Procedure –
In Situ Aquifer Tests

UPRR Hookston Station

Standard Operating Procedure
In Situ Aquifer Tests
Pleasant Hill, California

April 2006

0020557.10

Environmental Resources Management
1777 Botelho Drive, Suite 260
Walnut Creek, California 94596

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3.0	PROCEDURES FOR SLUG TESTS	4
3.1	EQUIPMENT LIST	4
3.2	TEST SET-UP	4
3.3	FALLING-HEAD TEST PROCEDURES	5
3.4	RISING-HEAD TEST PROCEDURES	5
4.0	DECONTAMINATION	7
5.0	DOCUMENTATION	8

The purpose of this document is to define the standard operating procedure (SOP) for performing in situ aquifer tests (slug tests) at the UPRR Hookston Station site in Pleasant Hill, California.

This SOP documents the procedures to be followed for conducting slug tests at the site. Any deviation from this procedure should be thoroughly documented and evaluated prior to proceeding, to ensure that the data quality objectives are met.

This SOP serves as a reference to the project Workplan and applies to all slug test activities conducted by ERM personnel or their subcontractors. This Workplan is to be strictly followed, and any modifications to this SOP shall be approved by the Project Manager (PM) in advance.

The PM is responsible for assigning project staff to complete the slug test activities at the site and to assure that this and any other appropriate procedures are followed by all project personnel.

The project staff assigned to the slug test is responsible for completing all tasks according to this and other appropriate procedures and must report any deviations from the procedure or nonconformance to the PM or Project Quality Assurance/ Quality Control (QA/QC) Officer.

Only qualified personnel shall be allowed to perform this procedure or supervise subcontractors hired to perform this procedure. At a minimum, ERM employees qualified to perform slug tests will be required to:

- Read this SOP;
- Indicate to the PM that they understand all procedures contained in this SOP;
- Have completed the OSHA 40-hour training course and/or 8-hour refresher course, as appropriate; and
- Have slug test experience generally consistent with the procedures described in this SOP.

3.0 *PROCEDURES FOR SLUG TESTS*

3.1 *EQUIPMENT LIST*

The following list of equipment and supplies are required to perform slug tests.

- _____ Pressure transducer and data logger
- _____ Electronic water level probe
- _____ A solid slug (such as PVC pipe filled with sand) of known volume for falling-head slug tests
- _____ A solid or hollow slug (such as a bailer) of known volume for rising-head slug tests
- _____ Rope
- _____ Well construction logs
- _____ 5-gallon bucket
- _____ Decontamination materials
- _____ Field book
- _____ Duct tape

3.2 *TEST SET-UP*

The following procedures will be followed for setting up slug tests.

- 1) Measure the depth to water and record the level in the field notebook.
- 2) Lower the transducer into the well. The transducer should be placed so that slug addition or removal does not interfere with the transducer and that the water level does not fall below the transducer. Be sure the psi setting on the transducer is greater than the water column and estimated increase in water column from the slug (1 psi equals 2.31 feet of water).
- 3) Secure the transducer by taping or tying the cable to the well or other fixed object.
- 4) Prepare the transducer by specifying:

- Reference value equal to zero; and
- Readings collected on logarithmic scale (time interval between readings should be at least one reading per second for the first 10 minutes and lengthen over time).

5) Check the level on the transducer and record in the field book.

3.3 *FALLING-HEAD TEST PROCEDURES*

If falling-head slug tests are to be performed, the following steps should be followed after all the Test Set-Up procedures (Steps 1 through 5) have been completed.

- 6) Lower the slug inside the well to a level above the water table. Start the pressure transducer, wait for five seconds, and then instantaneously lower the slug into the water column. Be careful not to produce a “splash” when lowering the slug and make sure the entire slug volume is entered into the water column.
- 7) Allow the pressure transducer to record data until the water level stabilizes. Use a laptop computer to determine when stabilization has been achieved. Occasionally manually measure the water level with a water-level indicator and record the exact time during the test to calibrate the transducer data.
- 8) Stop the pressure transducer when the water level has stabilized.
- 9) Measure depth to water and record in the field notebook.

3.4 *RISING-HEAD TEST PROCEDURES*

The following steps should be followed after all the Test Set-Up procedures (Steps 1 through 5) and Falling-Head Test Procedures (Steps 6 through 9, if Falling-Head slug tests are performed) have been completed.

- 10) Gently lower a slug into the well below the static water level. Allow the water level to recover to static conditions. Confirm that the slug is completely submerged within the water column. If a falling-head test was previously completed, a rising-head test can be initiated once the water levels have recovered to static conditions following the rising-head test.

- 11) Prepare the transducer by specifying:
 - Reference value equal to zero; and
 - Readings collected on logarithmic scale.
- 12) Start the pressure transducer, wait for five seconds, and then instantaneously remove the slug from the well. Be careful not to produce a “wave” when removing the slug and make sure the slug is completely removed from the well.
- 13) Allow the pressure transducer to record data until the water level stabilizes. Use a laptop computer to determine when stabilization has been achieved, occasionally manually measure the water level with a water-level indicator and record the exact time during the test to calibrate the transducer data.
- 14) Stop the pressure transducer when the water level has stabilized.
- 15) Measure depth to water and record in the field notebook.

All non-disposable equipment will be properly decontaminated prior to beginning the slug tests and between use at each well. Nitrile gloves will be worn whenever handling the equipment. The decontamination procedure is as follows:

- Wash equipment in an Alconox (or equivalent) and water solution using a brush or clean cloth to ensure removal of all contaminants.
- Rinse equipment in fresh tap water.
- Rinse equipment with a deionized water rinse.
- Dry equipment with a paper towel and place in clean plastic, if appropriate.

Decontamination activities will be noted for every sample location in the field note book.

For each slug test, all the pertinent data will be recorded in the field notebook and/or data collection forms. This information should include the following for each slug test:

- Personnel's name;
- Slug test location;
- Description of slug, including volume and materials;
- Static ground water level;
- Date and time of data logger installation;
- Date and time of slug installation and/or removal;
- Manual water level measurements, including date and time;
- Date and time of conclusion of slug test; and
- Weather conditions.

Attachment C
Standard Operation Procedure –
Aquifer Pump Tests

UPRR Hookston Station

Standard Operating Procedure
Aquifer Pump Tests
Pleasant Hill, California

April 2006

0020557.10

Environmental Resources Management
1777 Botelho Drive, Suite 260
Walnut Creek, California 94596

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1.0

PURPOSE AND SCOPE

The purpose of this document is to define the standard operating procedure (SOP) for performing aquifer pump tests at the UPRR Hookston Station site in Pleasant Hill, California.

This SOP documents the procedures to be followed for conducting pump tests at the site. Any deviation from this procedure should be thoroughly documented and evaluated prior to proceeding, to ensure that the data quality objectives are met.

This SOP serves as a reference to the project Workplan and applies to all pump test activities conducted by ERM personnel or their subcontractors. This Workplan is to be strictly followed, and any modifications to this SOP shall be approved by the Project Manager (PM) in advance.

2.0

RESPONSIBILITIES AND QUALIFICATIONS

The PM is responsible for assigning project staff to complete the pump test activities at the site and to assure that this and any other appropriate procedures are followed by all project personnel.

The project staff assigned to the pump test is responsible for completing all tasks according to this and other appropriate procedures and must report any deviations from the procedure or nonconformance to the PM or Project Quality Assurance/ Quality Control (QA/QC) Officer.

Only qualified personnel shall be allowed to perform this procedure or supervise subcontractors hired to perform this procedure. At a minimum, ERM employees qualified to perform pump tests will be required to:

- Read this SOP;
- Indicate to the PM that they understand all procedures contained in this SOP;
- Have completed the OSHA 40-hour training course and/or 8-hour refresher course, as appropriate; and
- Have pump test experience generally consistent with the procedures described in this SOP.

3.0 PUMP TEST PROCEDURES

Aquifer tests will consist of four distinct monitoring phases. Background water levels must first be monitored to identify any extraneous stresses that may impact the test data. A step-drawdown test is then performed to identify the ideal pumping rate for the tested well. The constant-rate test is subsequently performed to monitor the effects of pumping and to calculate hydraulic properties of the aquifer. Finally, aquifer recovery is monitored to confirm the results of the constant-rate pumping test.

The scope of work for each phase of the aquifer test is described below, as well as equipment to be utilized.

3.1 PUMP TEST EQUIPMENT

Typical equipment for pump testing includes the following items:

- Submersible pump;
- Water flow measuring device(s);
- Water level measuring device;
- Pressure transducers;
- Watch or stop watch;
- Data recording forms and data logger;
- Discharge water treatment system/transfer lines;
- Barometer or access to barometric pressure data; and
- Decontamination equipment.

3.2 PRE-PUMPING (BACKGROUND) MONITORING

For each pump test, water levels will be monitored in specified wells for approximately 1 day prior to the start of each test. Pre-pumping water levels will be collected every 10 minutes using electronic transducers. These data will be used to correct the aquifer test data from changes in atmospheric pressure or local uncontrolled aquifer stresses, such as pumping from nearby water supply wells if present. If pumping from

nearby water supply wells appears to affect water levels within the monitoring area, the pumping schedules for relevant wells during the subsequent pumping and recovery tests will be documented.

3.3 *STEP-DRAWDOWN PUMPING TEST/FLOWMETER TESTING*

A step-drawdown test may be performed at each extraction well prior to initiating the constant-rate pumping test to determine the optimal flow rate for the well. A combined transducer/ data logger will be installed in the extraction well prior to the start of the step-drawdown test. Water levels will also be measured manually with an electric sounder to calibrate depths measured using the pressure transducer.

During the step-drawdown test, the well will be pumped at varying rates. The duration of each rate will be determined at the time of the test, but typically each rate is maintained until drawdown approximately stabilizes. During the test, a plot of drawdown versus elapsed time will be created to determine the duration of each pumping rate and to estimate the rate increase for the next step.

3.4 *CONSTANT-RATE PUMPING TEST*

After water levels have recovered from the step-drawdown test to their pre-test static levels, the constant-rate pumping test will be initiated. Each pump test will utilize one extraction (pumping) well and several observation wells.

Water levels will be measured at logarithmic time intervals in the pumped well and surrounding observation wells. Water levels will be measured in the pumping and observation wells with electronic transducers and data loggers at least as frequently as follows:

Elapsed Time (minutes)	Frequency of Measurement
0 - 10	10 seconds
10 - 30	1 minute
30 - 120	10 minutes
120 - end of test	30 minutes

Electronically measured water levels will be checked periodically with manual measurements. Additional wells in the vicinity of the pumping

well may also be manually monitored using an electronic water level meter.

The pumping rate will be determined based on the step-drawdown test data. The pump rate will be monitored with a flow meter.

The duration of each test will be based on the time anticipated to influence the designated observation wells, with allowance for delayed drainage. The actual duration of a test will be determined in the field based on the drawdown observed over time.

3.5 *POST-PUMPING (RECOVERY) MONITORING*

Upon completion of the constant rate pump test, recovery of water levels in the extraction and observation wells will be monitored. Measurement frequency will be similar to that of the measurements taken during the pumping portion of the test, as described above. Recovering water levels will be plotted in the field and used to determine the duration of the monitoring time interval. Approximately 90 percent of drawdown will be deemed a sufficient degree of recovery to terminate the test.

3.6 *INVESTIGATIVE DERIVED WASTES*

Investigative derived wastes (IDW) will include pumping water and decontamination water. All IDW will be containerized on-site in 55-gallon drums or other appropriate storage vessels until waste characterization is complete and off-site disposal can be arranged.

4.0

DECONTAMINATION

All non-disposable equipment will be properly decontaminated prior to beginning any tasks associated with the pump tests (including background measurements) and between use at each well. Nitrile gloves will be worn whenever handling the equipment. The decontamination procedure is as follows:

- Wash equipment in an Alconox (or equivalent) and water solution using a brush or clean cloth to ensure removal of all contaminants.
- Rinse equipment in fresh tap water.
- Rinse equipment with a deionized water rinse.
- Dry equipment with a paper towel and place in clean plastic, if appropriate.

Decontamination activities will be noted for every sample location in the field note book.

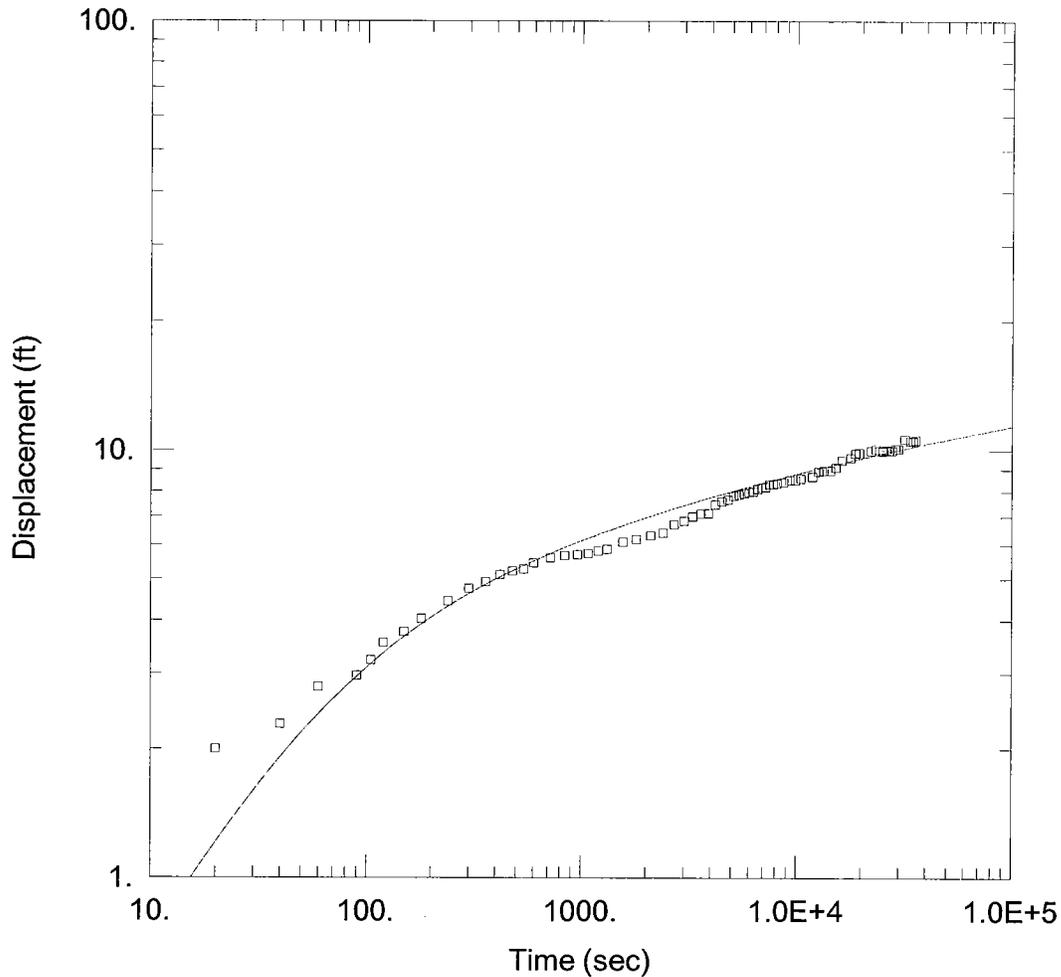
5.0

DOCUMENTATION

For phase of the pump test, all pertinent data will be recorded in the field notebook and/or data collection forms. This information should include the following for each pump test:

- Personnel's name;
- Well location;
- Static ground water level;
- Date and time of data logger installation;
- Date and time data logger is turned on;
- Date and time pumping is initiated;
- Pumping rate;
- Manual water level measurements, including date and time;
- Date and time pumping is stopped;
- Date and time data loggers are turned off; and
- Weather conditions.

Attachment D
Aquifer Test Analyses



A-ZONE PUMP TEST

Data Set: C:\Program Files\HydroSOLVE\AQTESOLV for Windows Demo 3.5\Hookston MW-5.aqt
 Date: 06/23/06 Time: 11:25:04

PROJECT INFORMATION

Company: ERM-West, Inc.
 Client: Hookston Station
 Project: 0020557.10
 Location: Pleasant Hill, CA
 Test Well: MW-5
 Test Date: 4/10/06

AQUIFER DATA

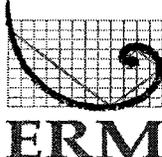
Saturated Thickness: 16. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells			Observation Wells		
Well Name	X (ft)	Y (ft)	Well Name	X (ft)	Y (ft)
MW-5	0	0	□ MW-5	0	0

SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper
 $T = 0.5914 \text{ cm}^2/\text{sec}$ $S = 0.01192$
 $r(w) = 0.666 \text{ ft}$ $r(c) = 0.1666 \text{ ft}$



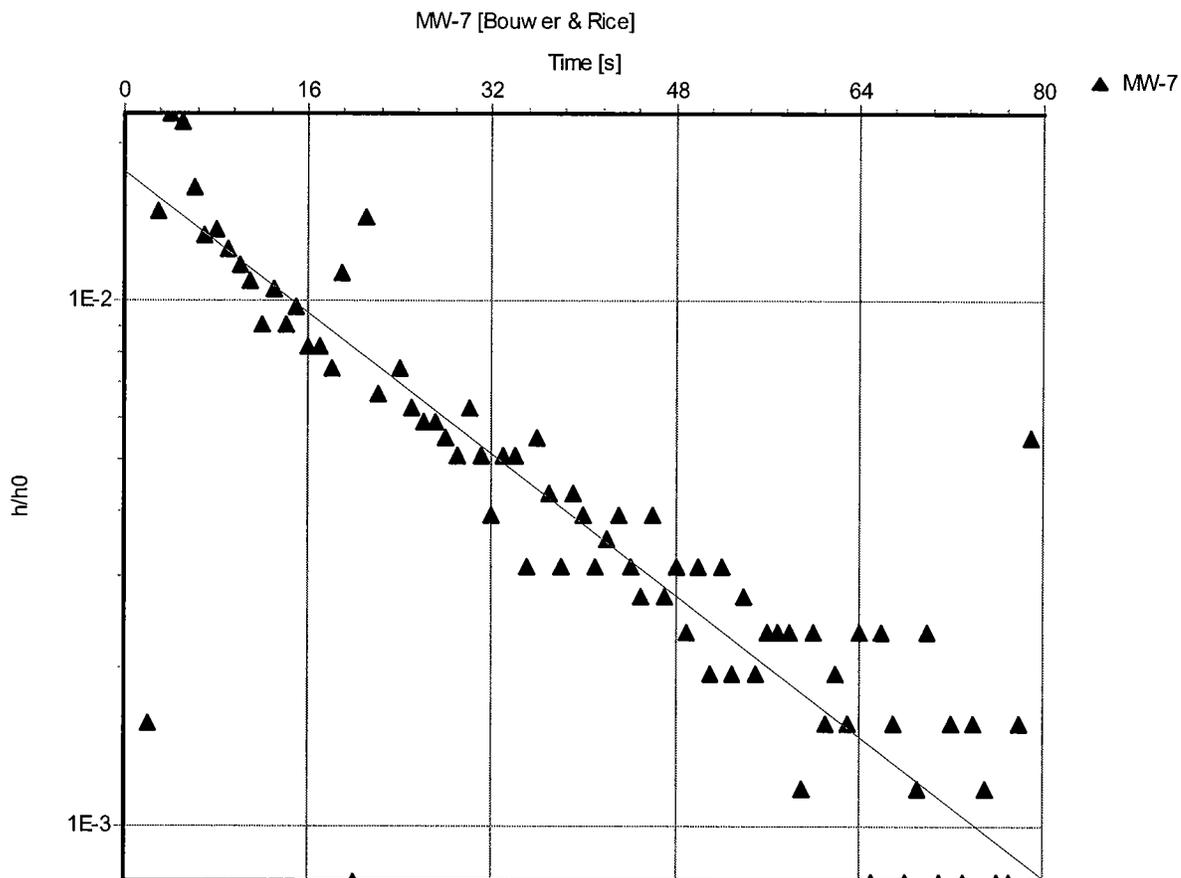
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 1777 Botelho Drive, Suite 260
 Walnut Creek, CA 94596
 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: MW-7
Analysis Method: Bouwer & Rice

Analysis Results: Conductivity: 2.13E-3 [cm/s]

<u>Test parameters:</u>	Test Well:	MW-7	Aquifer Thickness:	20 [ft]
	Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
	Screen length:	20 [ft]		
	Boring radius:	0.666 [ft]		
	r(eff):	0.363 [ft]		

Comments:

Evaluated by:
 Evaluation Date: 5/1/2006



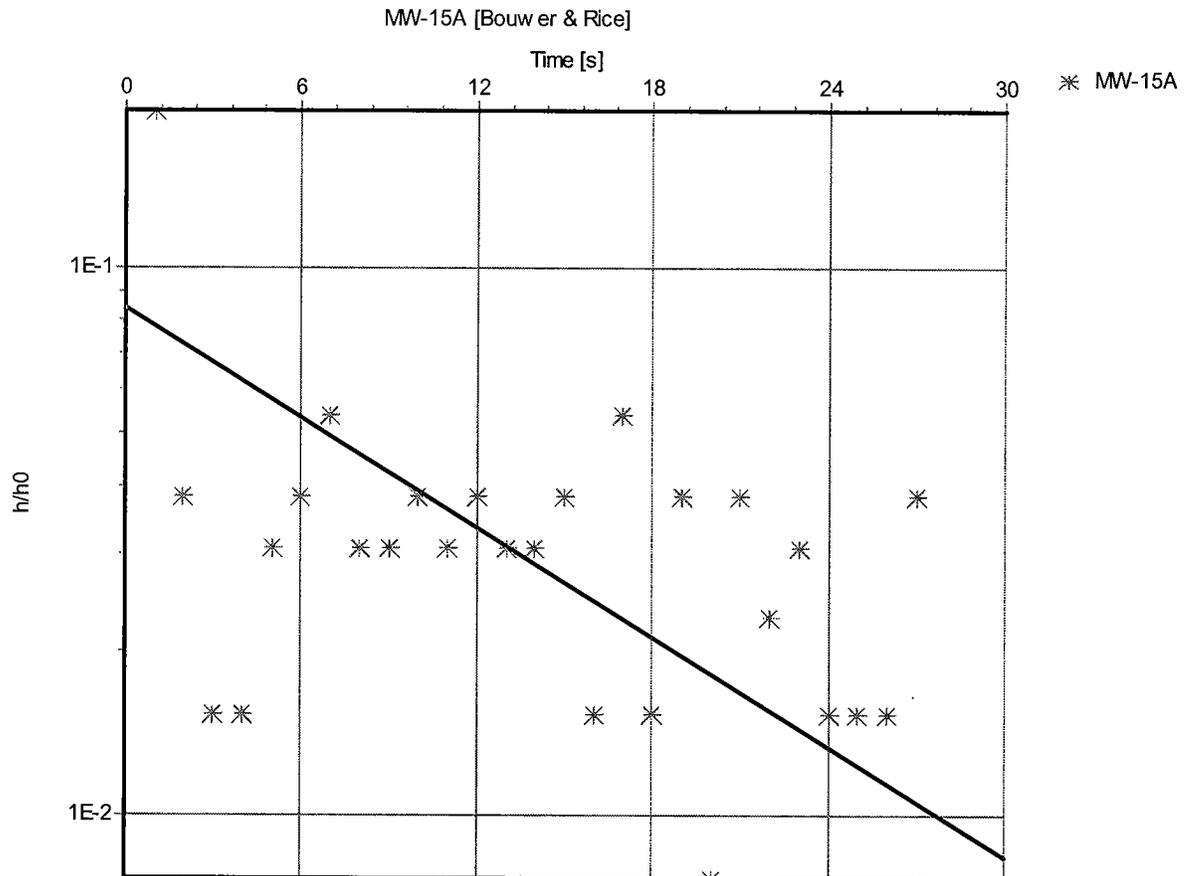
ERM-West, Inc.
 1777 Botelho Drive, Suite 260
 Walnut Creek, CA 94596
 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: **MW-15A**
Analysis Method: **Bouwer & Rice**

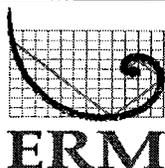
Analysis Results: Conductivity: 6.94E-3 [cm/s]

Test parameters:

Test Well:	MW-15A	Aquifer Thickness:	12 [ft]
Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
Screen length:	10 [ft]		
Boring radius:	0.666 [ft]		
r(eff):	0.363 [ft]		

Comments:

Evaluated by:
 Evaluation Date: 5/1/2006



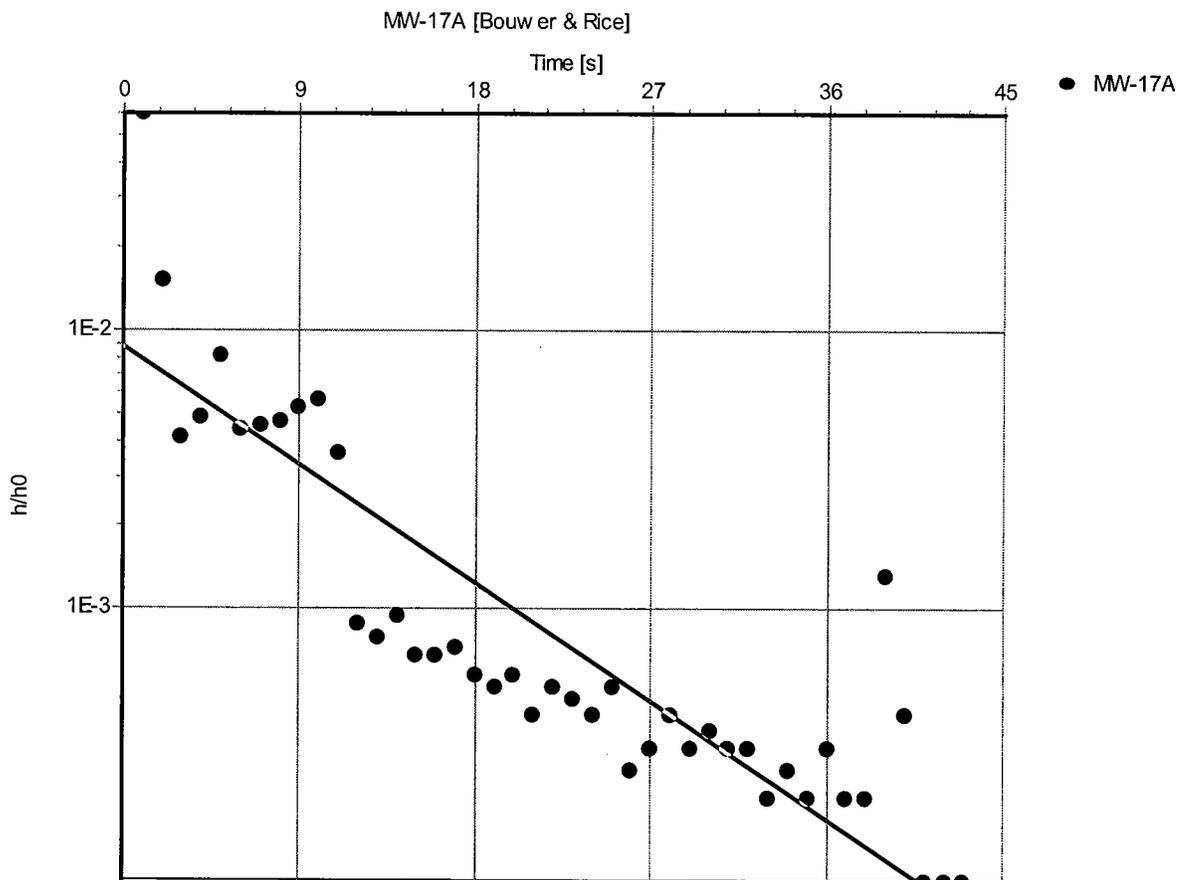
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Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



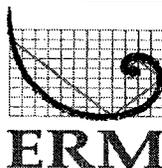
Slug Test: MW-17A
Analysis Method: Bouwer & Rice

Analysis Results: Conductivity: 9.84E-3 [cm/s]

<u>Test parameters:</u>	Test Well:	MW-17A	Aquifer Thickness:	12 [ft]
	Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
	Screen length:	10 [ft]		
	Boring radius:	0.666 [ft]		
	r(eff):	0.363 [ft]		

Comments:

Evaluated by:
 Evaluation Date: 5/1/2006



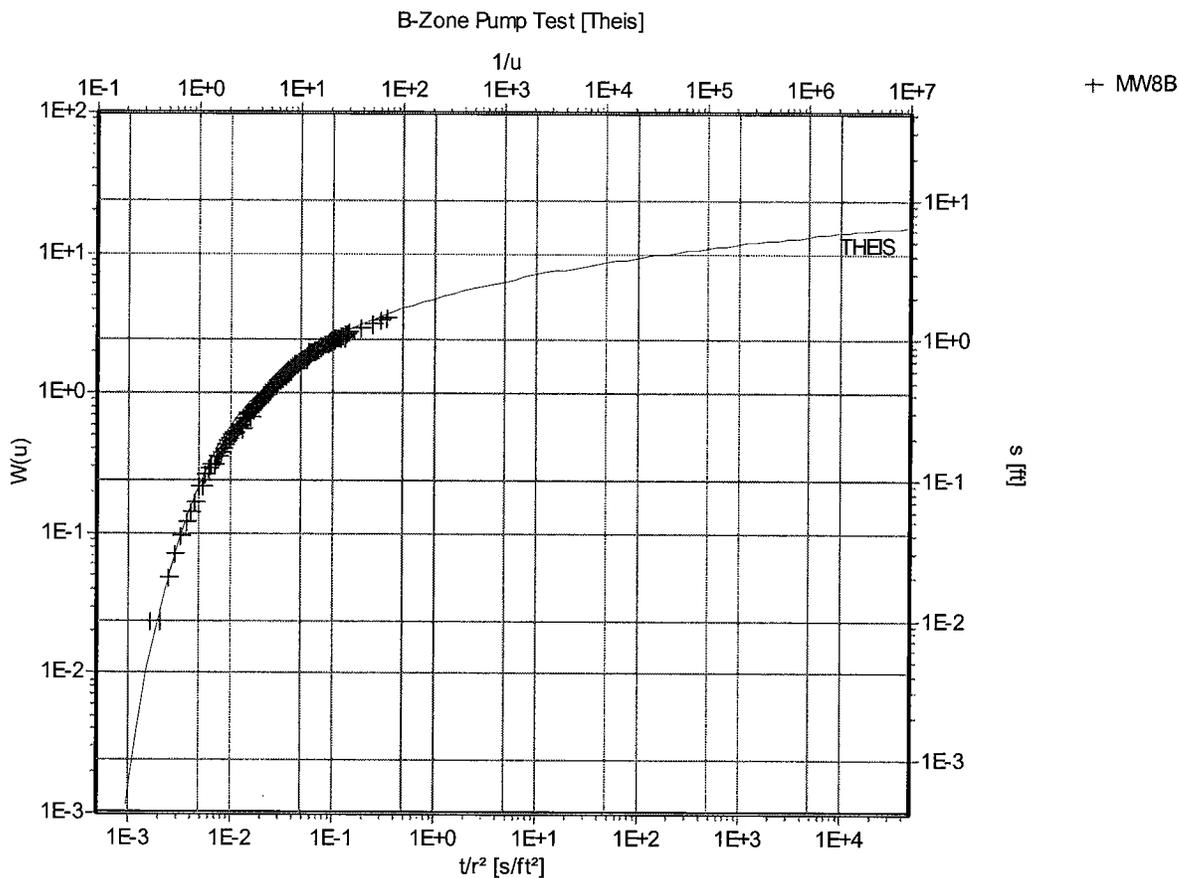
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 925-946-0455

Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Pumping Test: **B-Zone Pump Test**

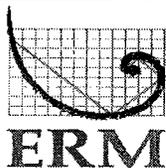
Analysis Method: **Theis**

<u>Analysis Results:</u>	Transmissivity:	9.88E+0 [cm ² /s]	Conductivity:	1.08E-2 [cm/s]
	Storativity:	2.07E-4		

<u>Test parameters:</u>	Pumping Well:	TW-1	Aquifer Thickness:	30 [ft]
	Casing radius:	0.333 [ft]	Confined Aquifer	
	Screen length:	30 [ft]		
	Boring radius:	0.8333 [ft]		
	Discharge Rate:	25 [U.S. gal/min]		

Comments:

Evaluated by: RLS
 Evaluation Date: 4/26/2006



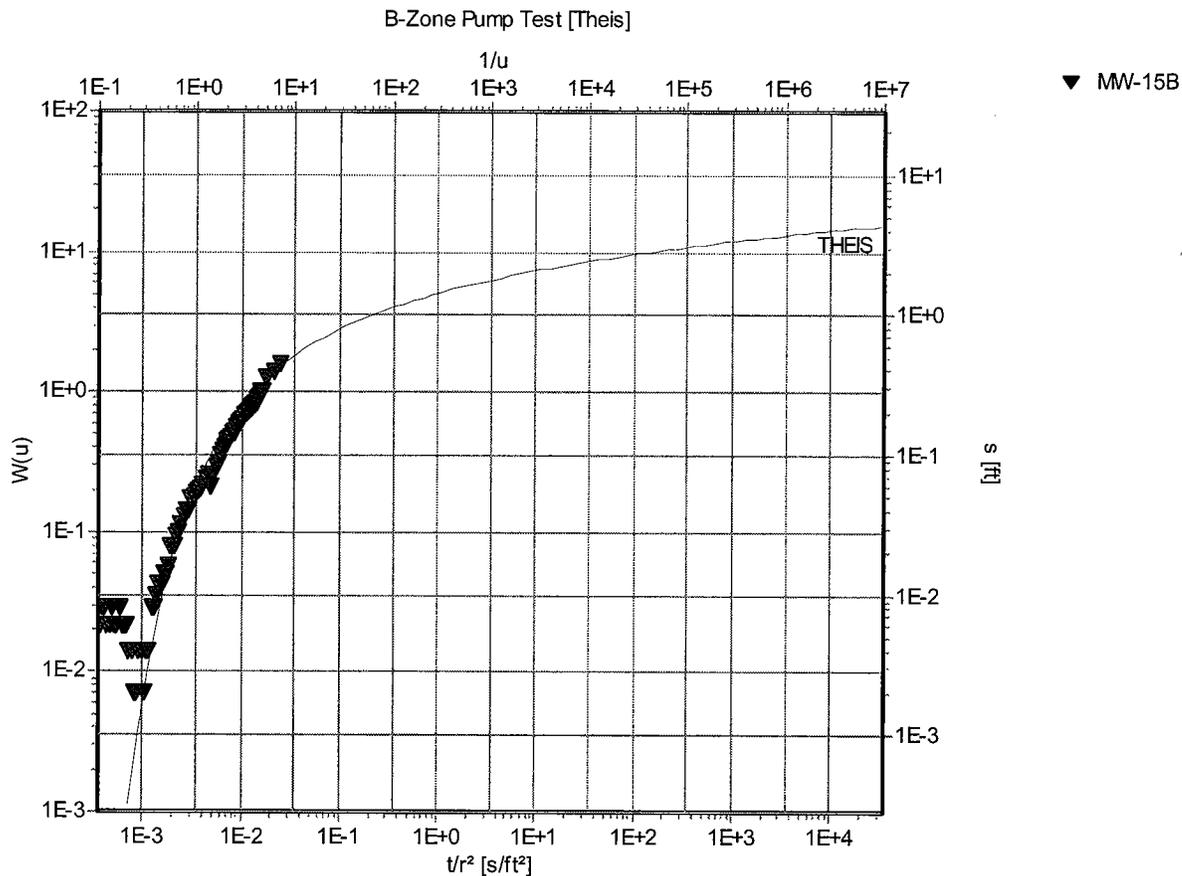
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Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Pumping Test: **B-Zone Pump Test**

Analysis Method: **Theis**

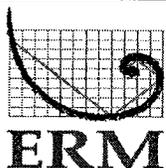
<u>Analysis Results:</u>	Transmissivity:	1.46E+1 [cm ² /s]	Conductivity:	1.60E-2 [cm/s]
	Storativity:	2.22E-4		

<u>Test parameters:</u>	Pumping Well:	TW-1	Aquifer Thickness:	30 [ft]
	Casing radius:	0.333 [ft]	Confined Aquifer	
	Screen length:	30 [ft]		
	Boring radius:	0.8333 [ft]		
	Discharge Rate:	25 [U.S. gal/min]		

Comments:

Evaluated by: RLS

Evaluation Date: 4/26/2006



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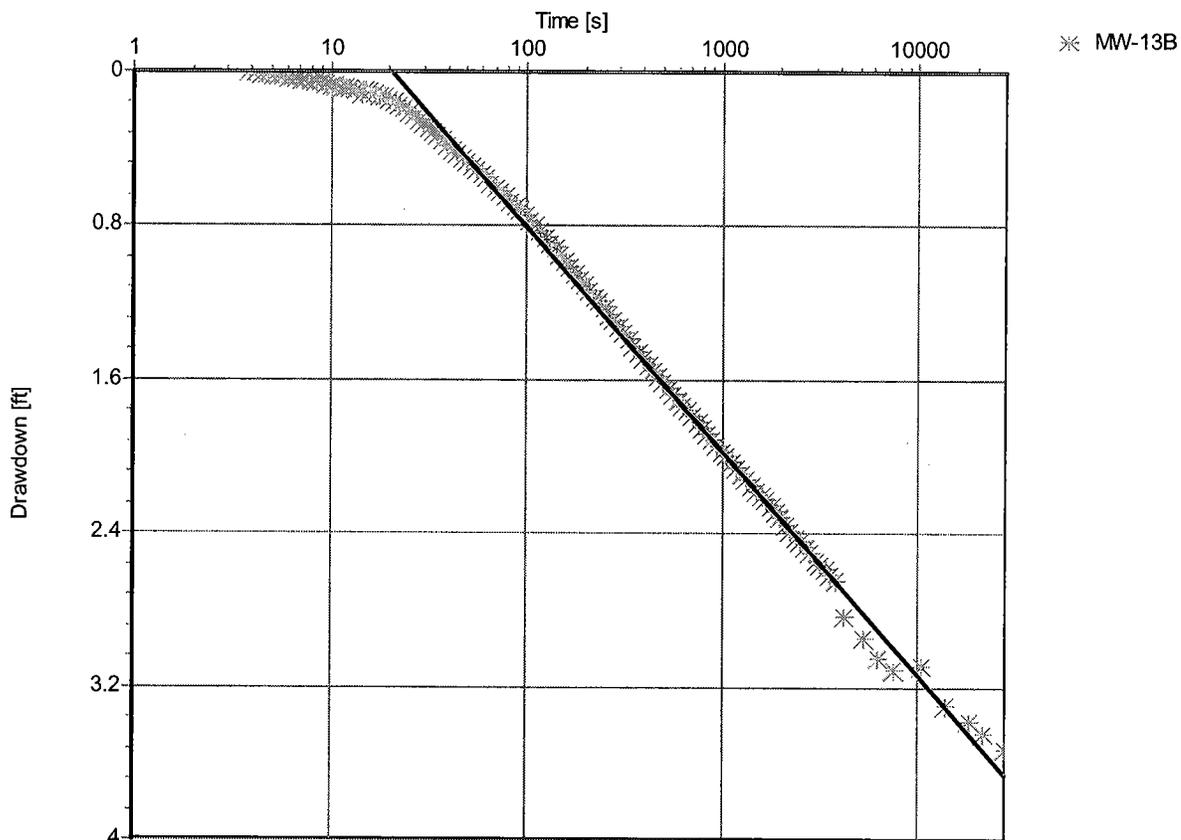
Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:

B-Zone Pump Test [Cooper-Jacob Time-Draw down]



Pumping Test: **B-Zone Pump Test**

Analysis Method: **Cooper-Jacob Time-Drawdown**

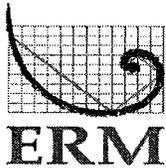
Analysis Results: Transmissivity: 8.12E+0 [cm²/s] Conductivity: 8.88E-3 [cm/s]

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 30 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]

Comments:

Evaluated by: RLS

Evaluation Date: 4/26/2006



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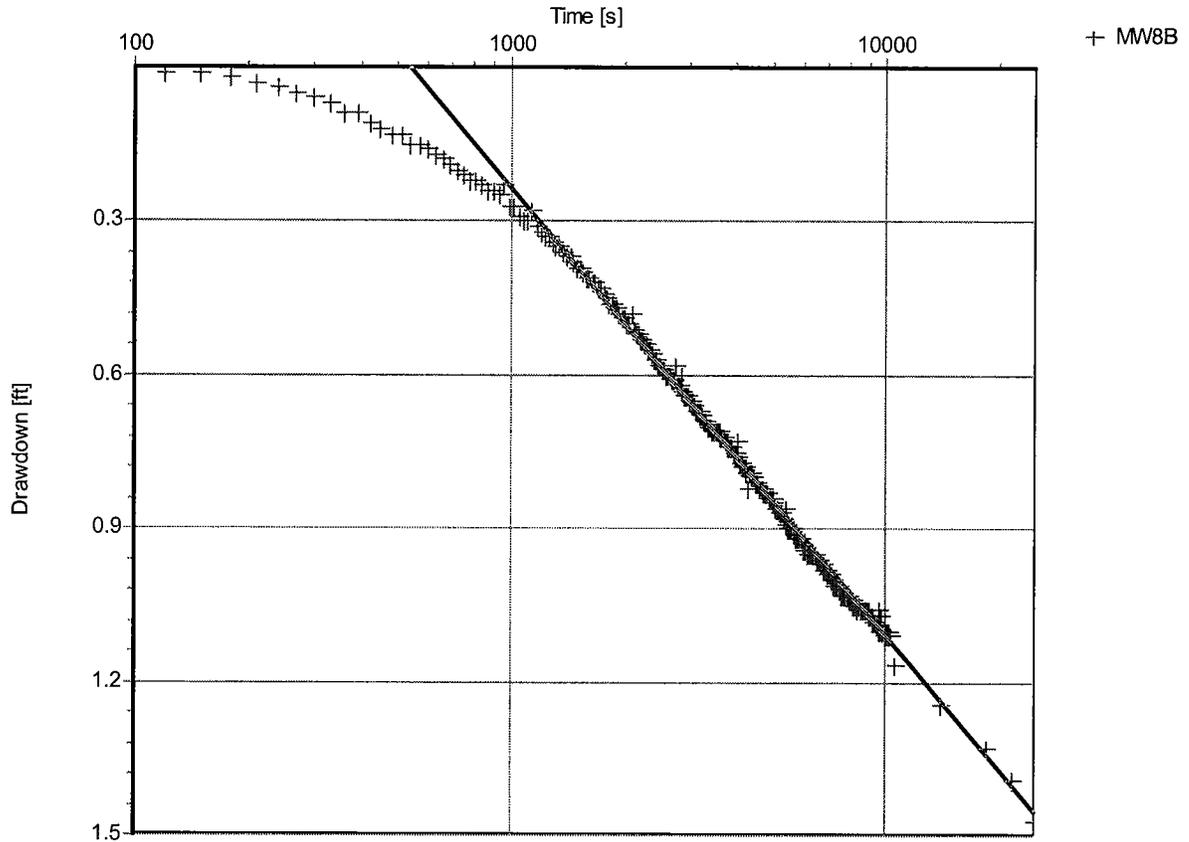
Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:

B-Zone Pump Test [Cooper-Jacob Time-Draw down]



Pumping Test: **B-Zone Pump Test**

Analysis Method: **Cooper-Jacob Time-Drawdown**

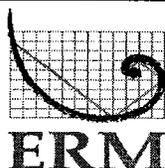
<u>Analysis Results:</u>	Transmissivity:	1.08E+1 [cm ² /s]	Conductivity:	1.18E-2 [cm/s]
	Storativity:	1.92E-4		

<u>Test parameters:</u>	Pumping Well:	TW-1	Aquifer Thickness:	30 [ft]
	Casing radius:	0.333 [ft]	Confined Aquifer	
	Screen length:	30 [ft]		
	Boring radius:	0.8333 [ft]		
	Discharge Rate:	25 [U.S. gal/min]		

Comments:

Evaluated by: RLS

Evaluation Date: 4/26/2006



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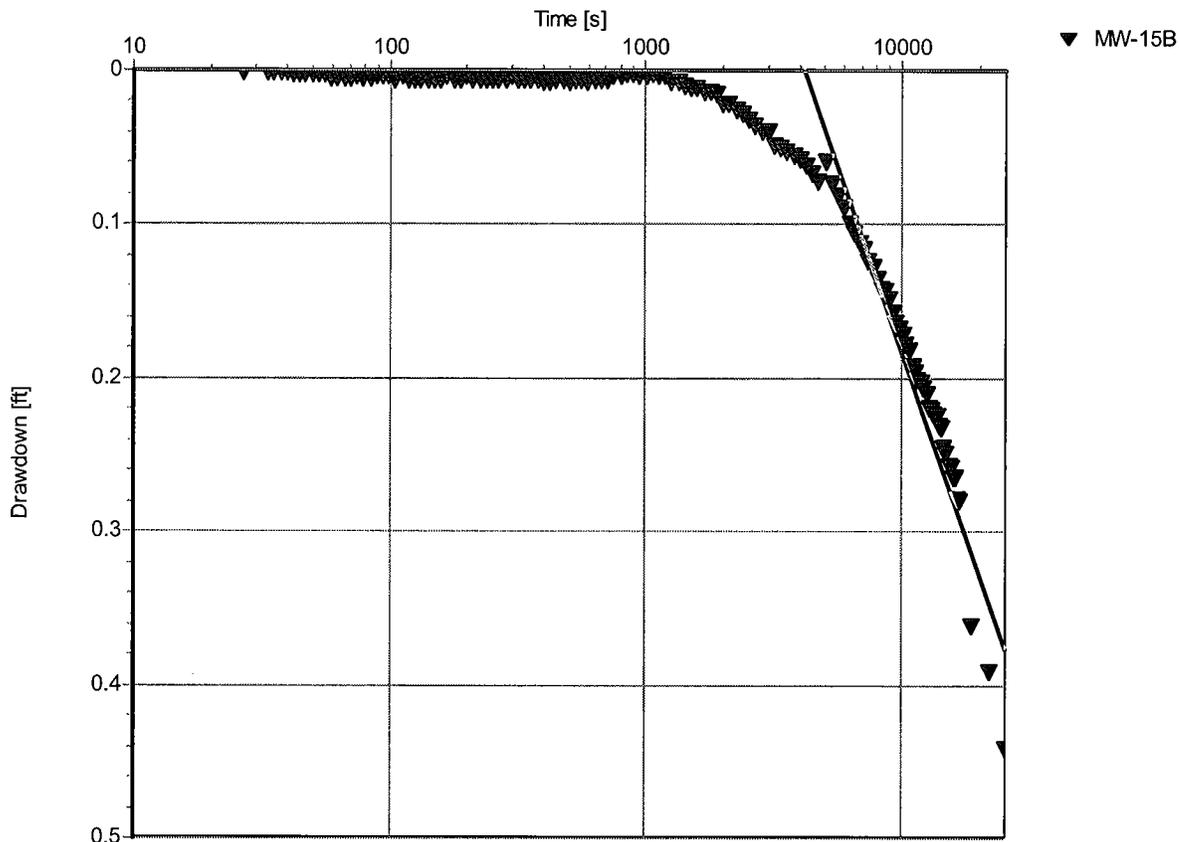
Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:

B-Zone Pump Test [Cooper-Jacob Time-Draw down]



Pumping Test: **B-Zone Pump Test**

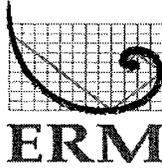
Analysis Method: **Cooper-Jacob Time-Drawdown**

Analysis Results: Transmissivity: 1.96E+1 [cm²/s] Conductivity: 2.15E-2 [cm/s]

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 30 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]

Comments:

Evaluated by: RLS
 Evaluation Date: 4/26/2006



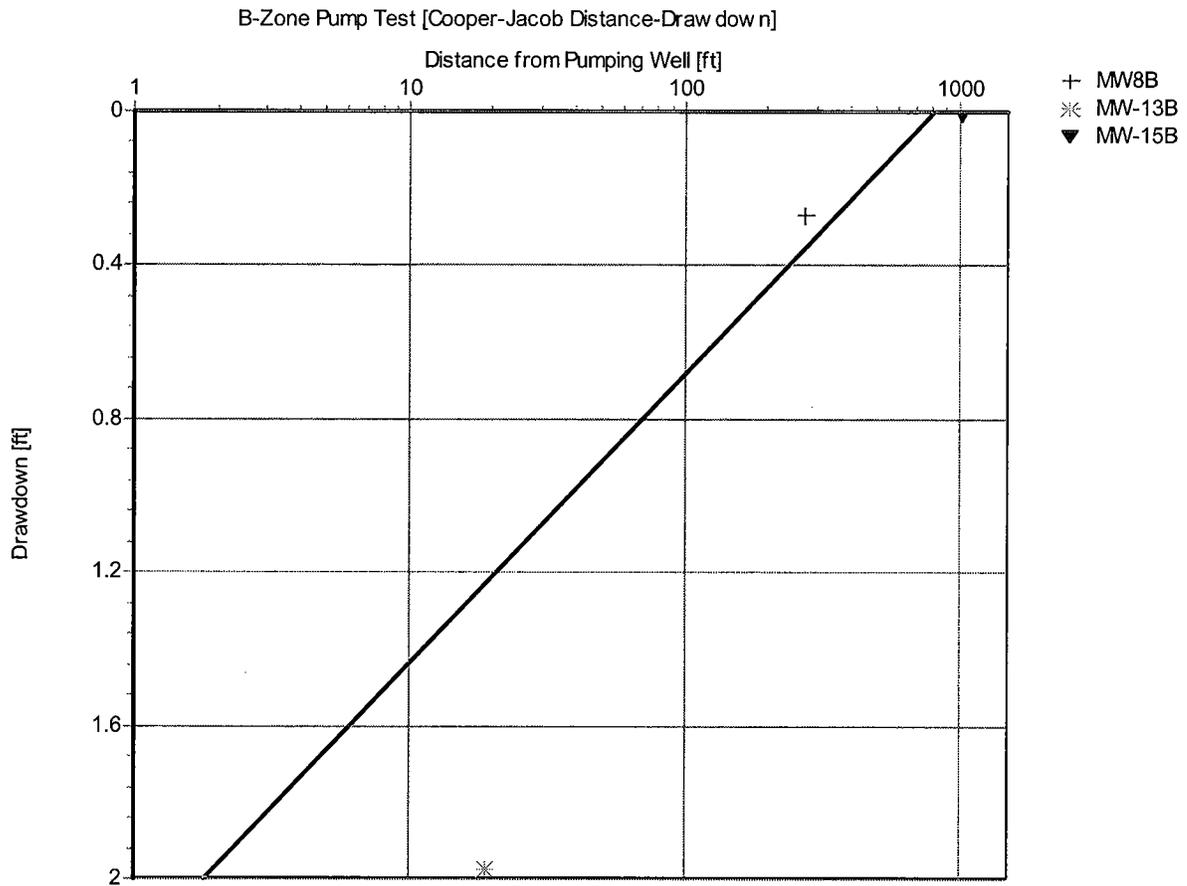
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 Walnut Creek, CA 94596
 925-946-0455

Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



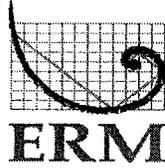
Pumping Test: B-Zone Pump Test
Analysis Method: Cooper-Jacob Distance-Drawdown

Analysis Results: Transmissivity: 2.51E+1 [cm²/s] Conductivity: 2.75E-2 [cm/s]
 Storativity: 9.44E-5

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 30 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]
 Calculation Time: 1000 [s]

Comments:

Evaluated by: RLS
 Evaluation Date: 4/26/2006



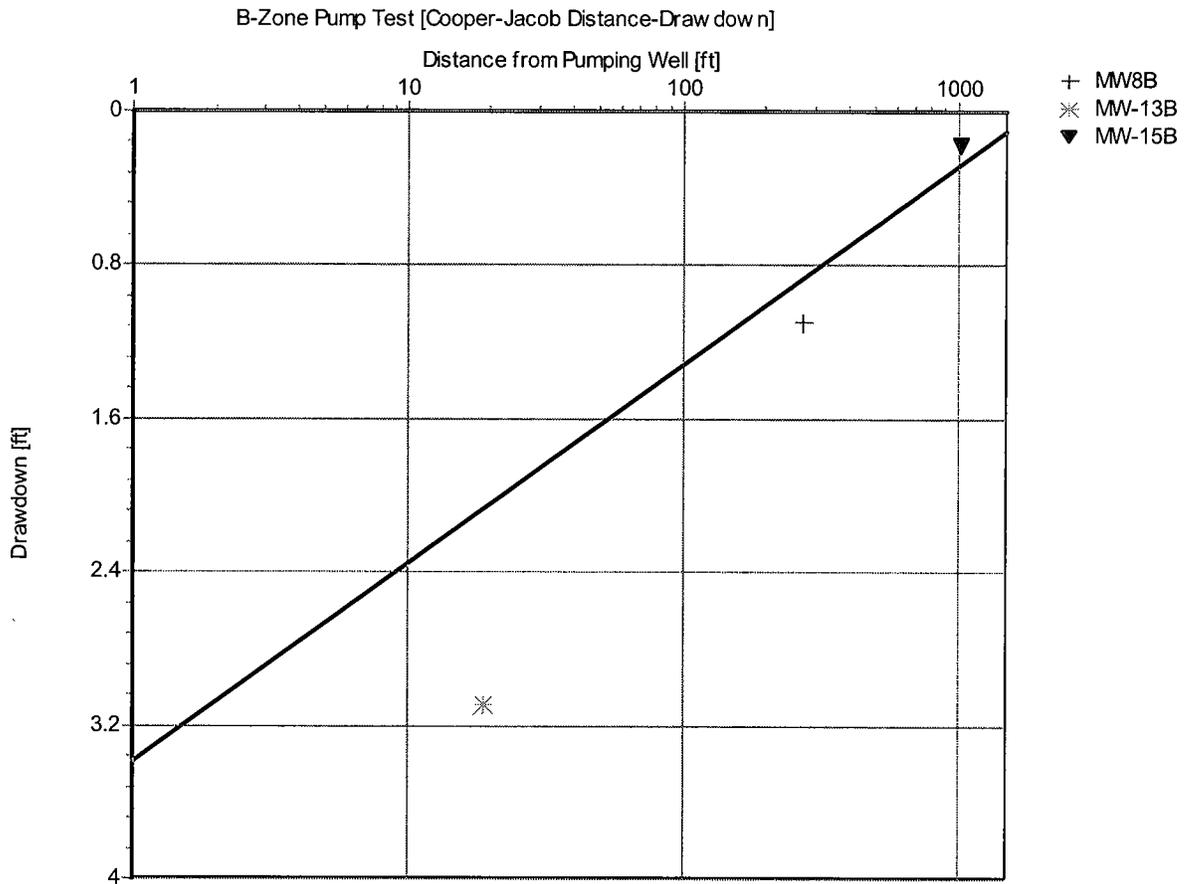
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Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Pumping Test: B-Zone Pump Test

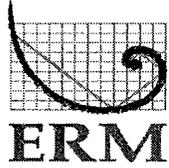
Analysis Method: Cooper-Jacob Distance-Drawdown

Analysis Results: Transmissivity: 1.83E+1 [cm²/s] Conductivity: 2.00E-2 [cm/s]
 Storativity: 1.22E-4

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 30 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]
 Calculation Time: 10000 [s]

Comments:

Evaluated by: RLS
 Evaluation Date: 4/26/2006



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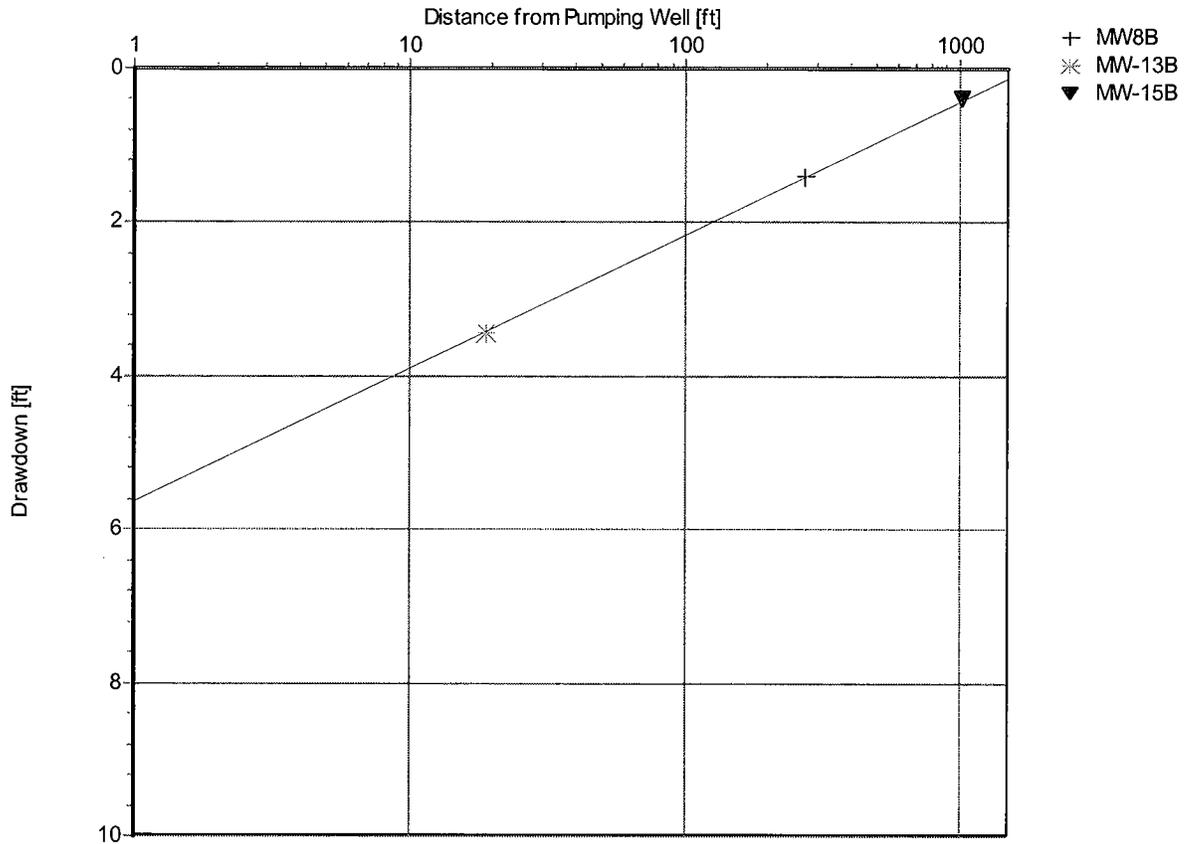
Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:

B-Zone Pump Test [Cooper-Jacob Distance-Draw down]



Pumping Test: **B-Zone Pump Test**

Analysis Method: **Cooper-Jacob Distance-Drawdown**

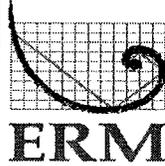
Analysis Results: Transmissivity: 1.09E+1 [cm²/s] Conductivity: 1.20E-2 [cm/s]
 Storativity: 1.70E-4

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 30 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]
 Calculation Time: 20000 [s]

Comments:

Evaluated by:

Evaluation Date: 4/26/2006



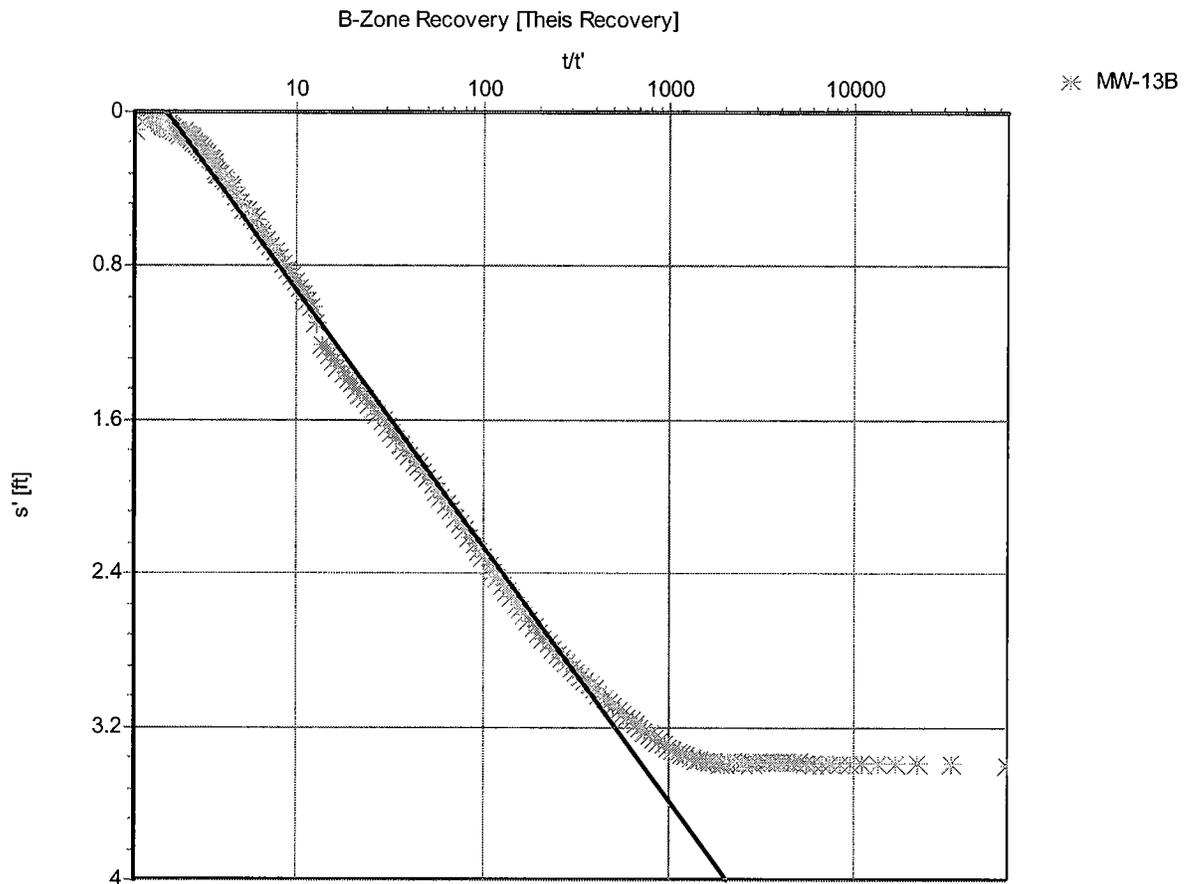
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 925-946-0455

Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Pumping Test: **B-Zone Recovery**

Analysis Method: **Theis Recovery**

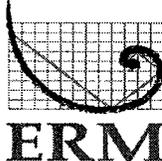
Analysis Results: Transmissivity: 7.13E+0 [cm²/s] Conductivity: 1.56E-2 [cm/s]

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 15 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]
 Pumping Time 20000 [s]

Comments:

Evaluated by:

Evaluation Date: 4/26/2006



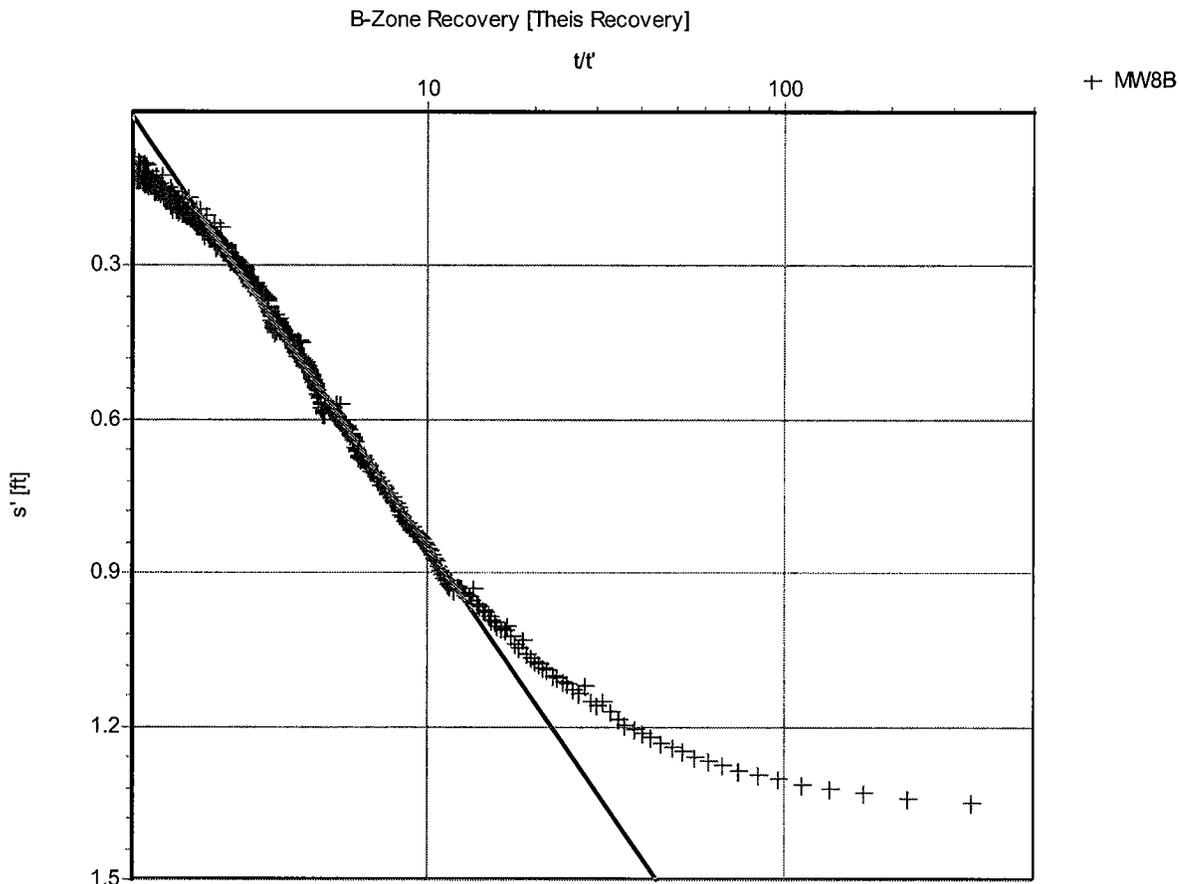
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 Walnut Creek, CA 94596
 925-946-0455

Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Pumping Test: **B-Zone Recovery**

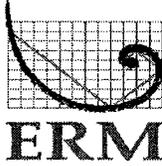
Analysis Method: **Theis Recovery**

Analysis Results: Transmissivity: 9.31E+0 [cm²/s] Conductivity: 2.04E-2 [cm/s]

Test parameters: Pumping Well: TW-1 Aquifer Thickness: 15 [ft]
 Casing radius: 0.333 [ft] Confined Aquifer
 Screen length: 30 [ft]
 Boring radius: 0.8333 [ft]
 Discharge Rate: 25 [U.S. gal/min]
 Pumping Time 20000 [s]

Comments:

Evaluated by: RLS
 Evaluation Date: 4/26/2006



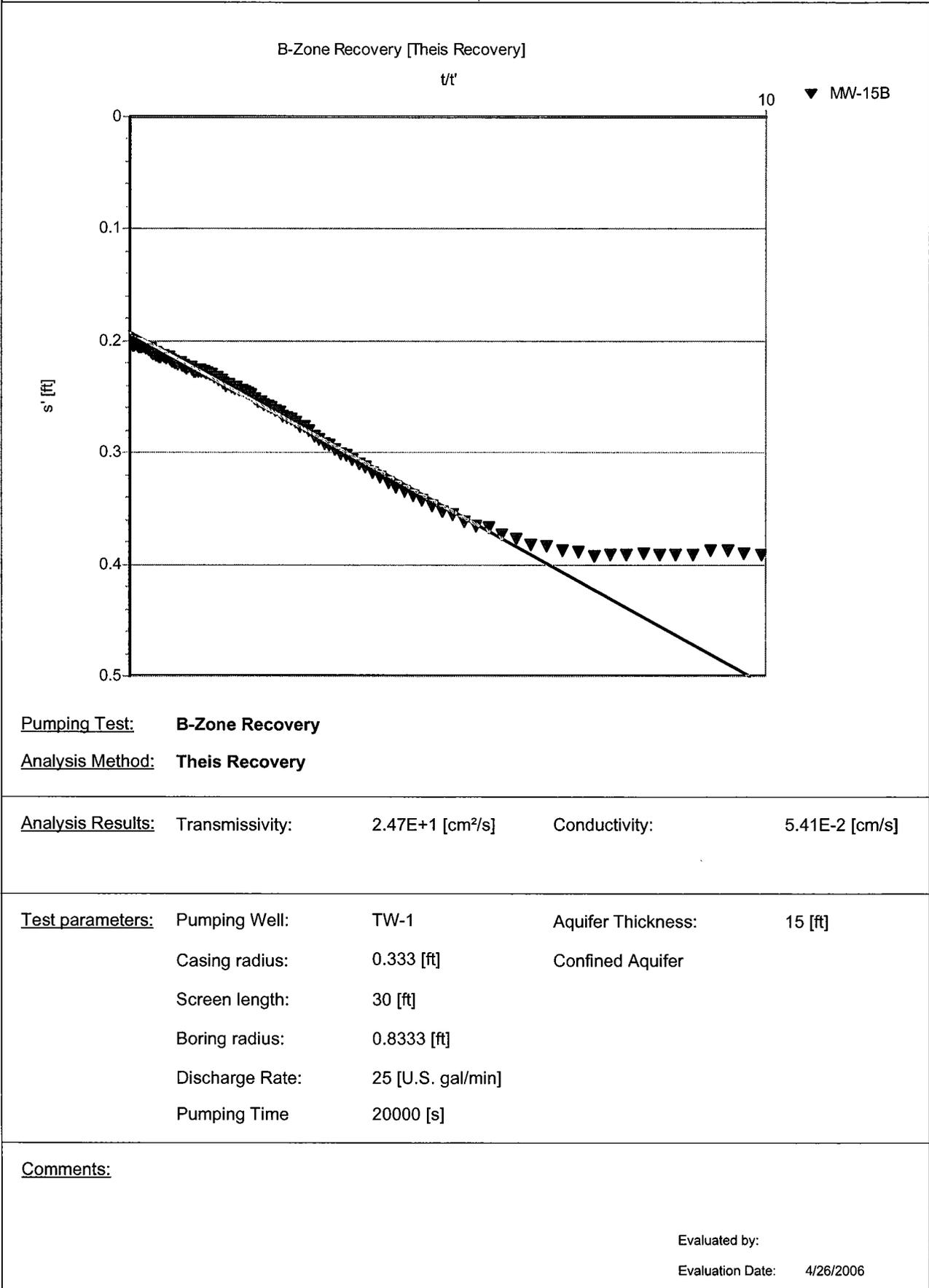
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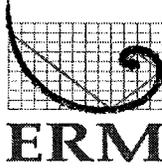
Pumping Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:





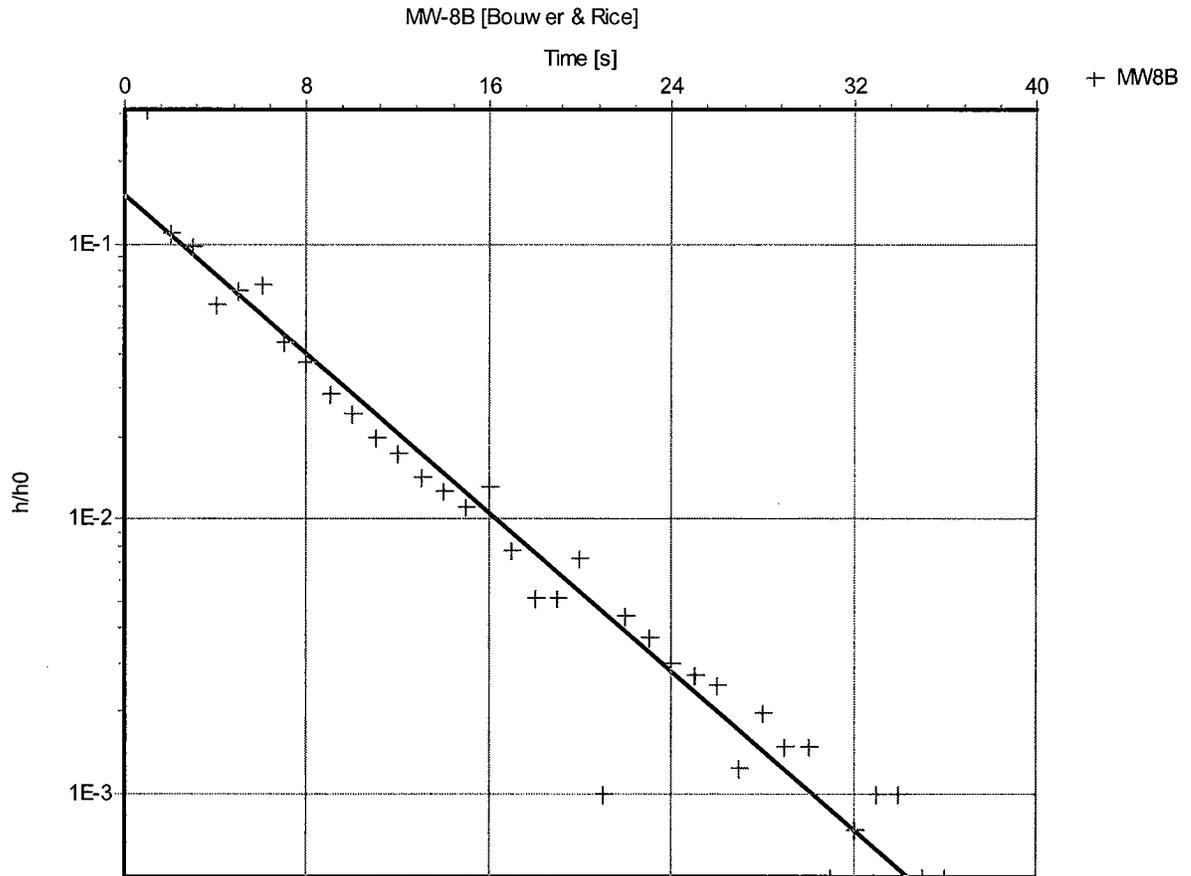
ERM-West, Inc.
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 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: MW-8B

Analysis Method: Bouwer & Rice

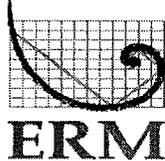
Analysis Results: Conductivity: 9.55E-3 [cm/s]

<u>Test parameters:</u>	Test Well:	MW8B	Aquifer Thickness:	9 [ft]
	Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
	Screen length:	15 [ft]		
	Boring radius:	0.666 [ft]		
	r(eff):	0.363 [ft]		

Comments:

Evaluated by:

Evaluation Date: 5/1/2006



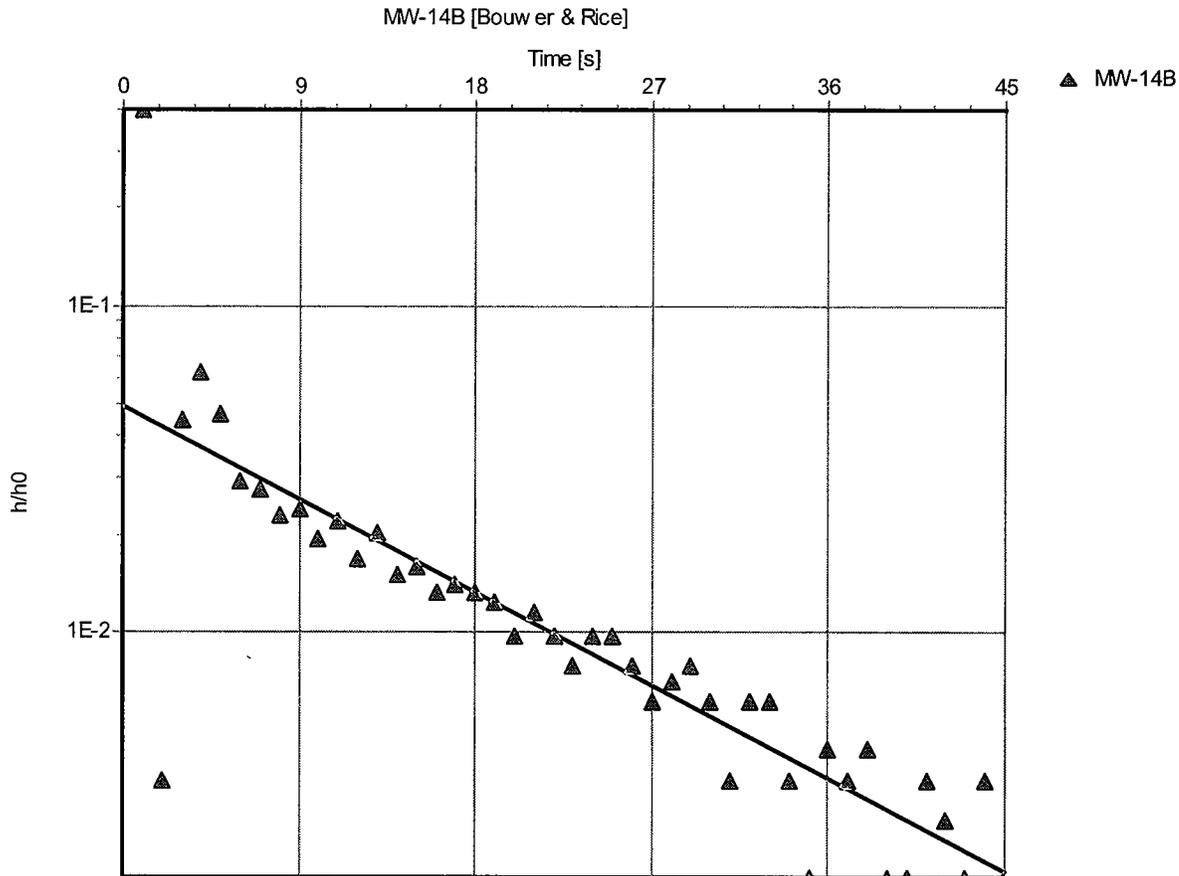
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 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



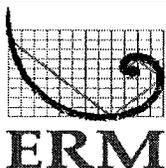
Slug Test: **MW-14B**
Analysis Method: **Bouwer & Rice**

Analysis Results: Conductivity: 5.87E-3 [cm/s]

<u>Test parameters:</u>	Test Well:	MW-14B	Aquifer Thickness:	8 [ft]
	Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
	Screen length:	10 [ft]		
	Boring radius:	0.666 [ft]		
	r(eff):	0.363 [ft]		

Comments:

Evaluated by:
 Evaluation Date: 5/1/2006



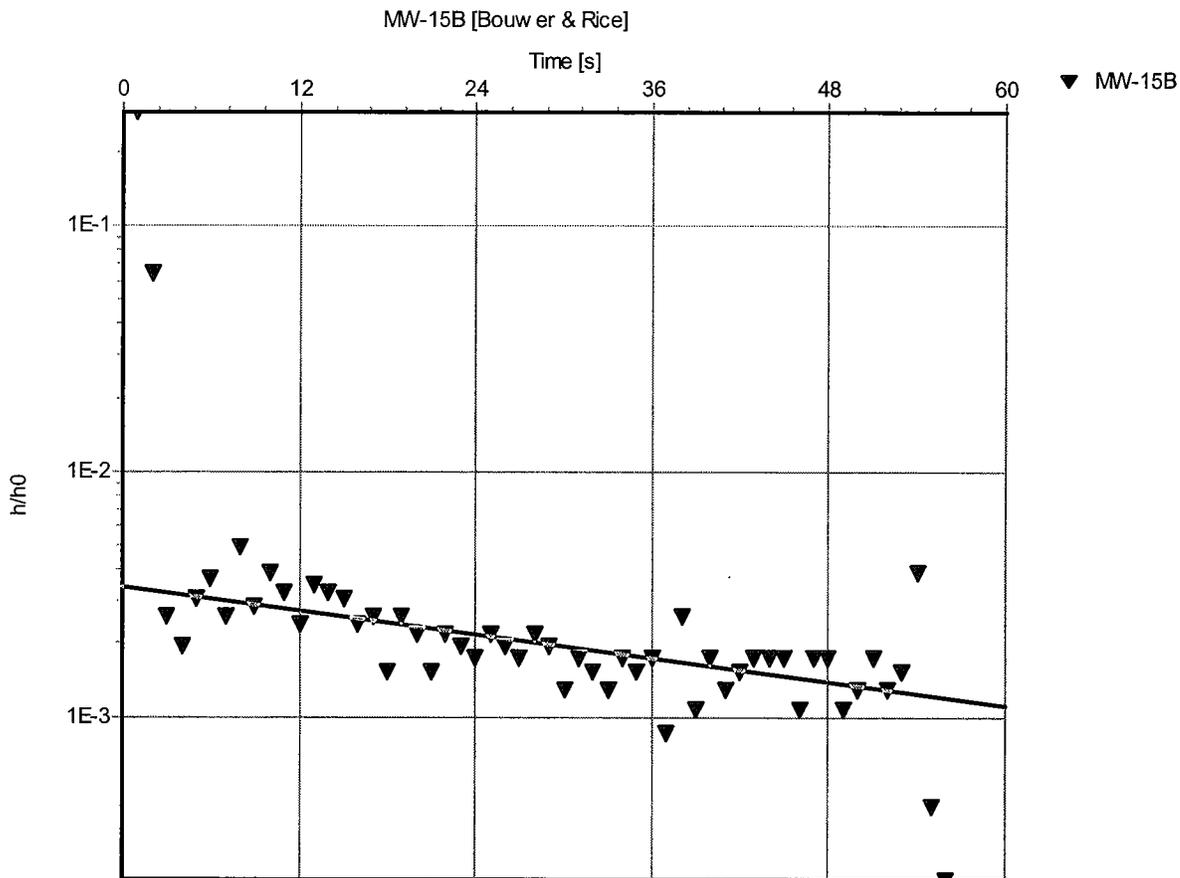
ERM-West, Inc.
 1777 Botelho Drive, Suite 260
 Walnut Creek, CA 94596
 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: MW-15B

Analysis Method: Bouwer & Rice

Analysis Results:

Conductivity: 1.59E-3 [cm/s]

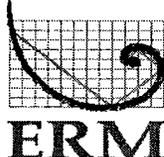
Test parameters:

Test Well:	MW-15B	Aquifer Thickness:	10 [ft]
Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
Screen length:	10 [ft]		
Boring radius:	0.666 [ft]		
r(eff):	0.363 [ft]		

Comments:

Evaluated by:

Evaluation Date: 5/1/2006



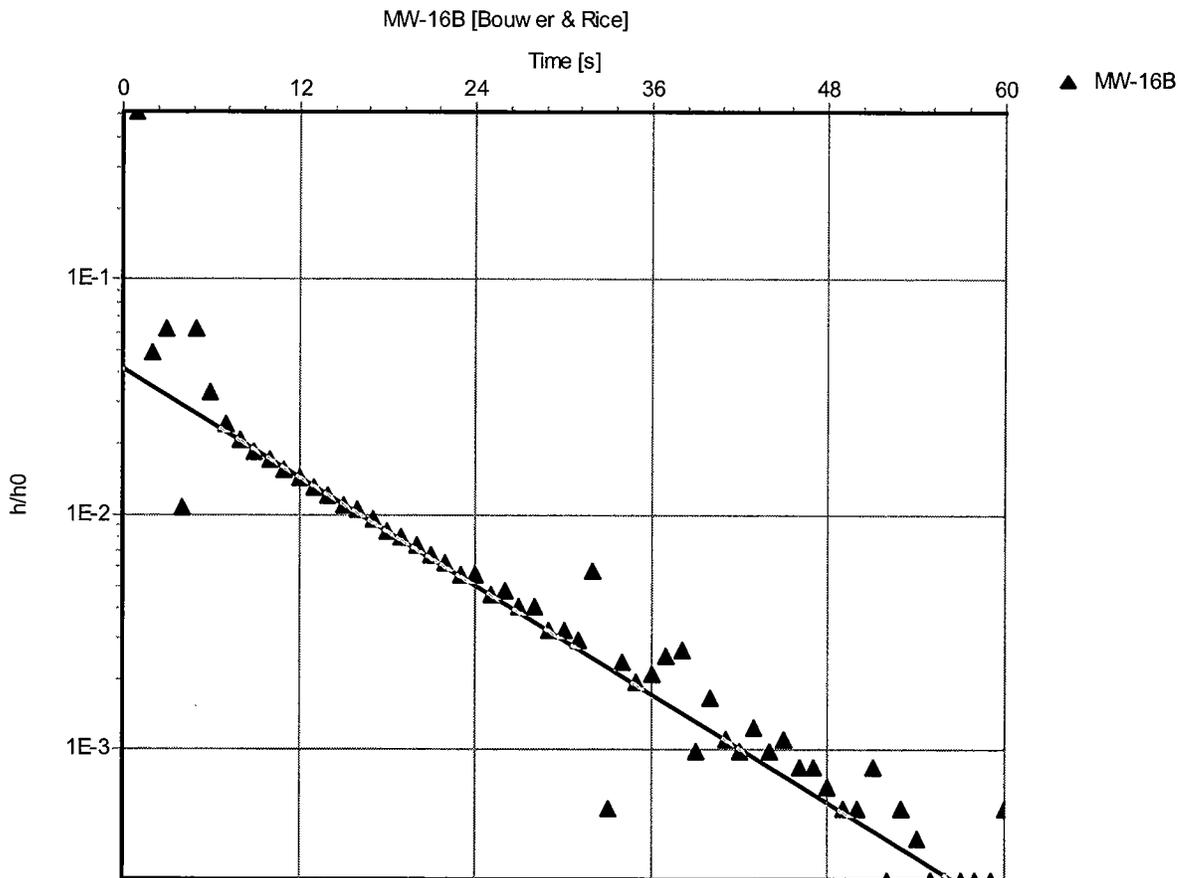
ERM-West, Inc.
 1777 Botelho Drive, Suite 260
 Walnut Creek, CA 94596
 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: **MW-16B**

Analysis Method: **Bouwer & Rice**

Analysis Results:

Conductivity: 7.38E-3 [cm/s]

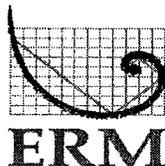
Test parameters:

Test Well:	MW-16B	Aquifer Thickness:	9 [ft]
Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
Screen length:	10 [ft]		
Boring radius:	0.666 [ft]		
$r(\text{eff})$:	0.363 [ft]		

Comments:

Evaluated by:

Evaluation Date: 5/1/2006



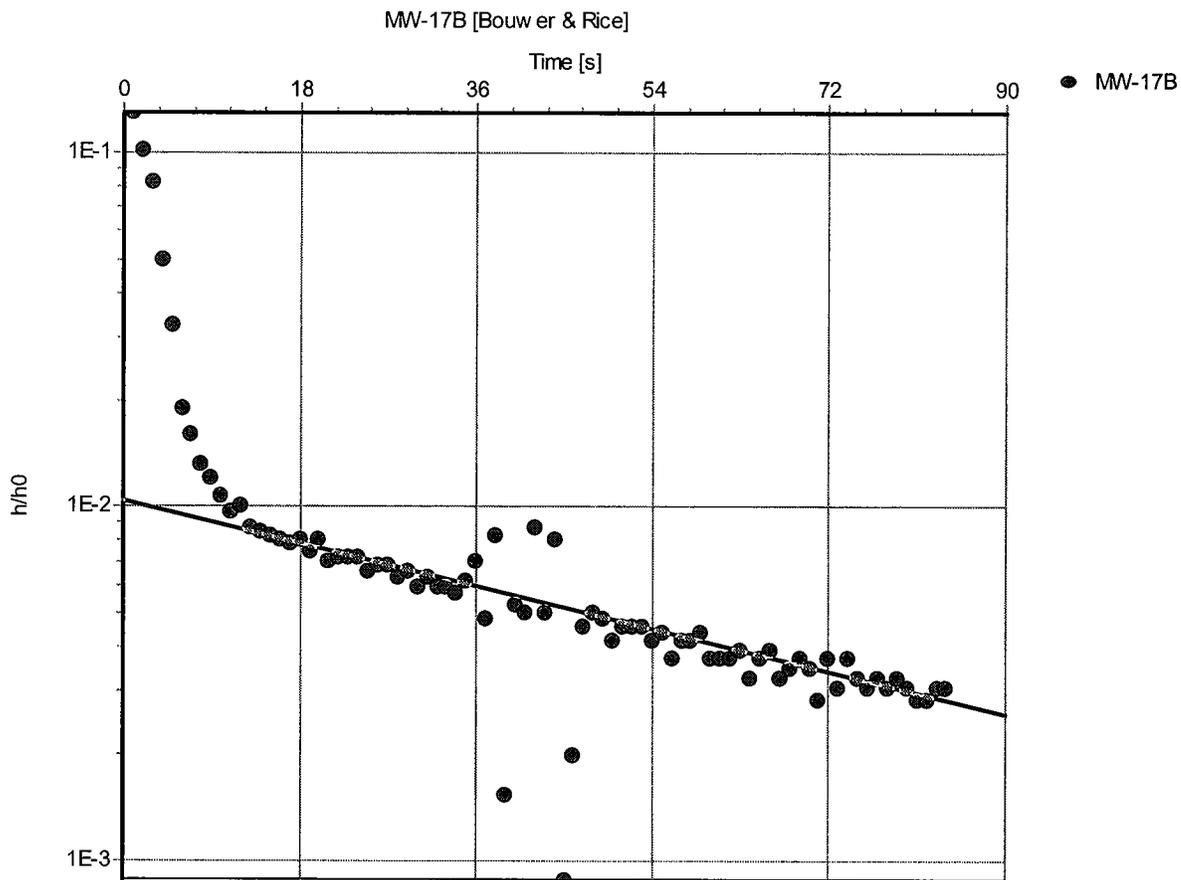
ERM-West, Inc.
 1777 Botelho Drive, Suite 260
 Walnut Creek, CA 94596
 925-946-0455

Slug Test Analysis Report

Project: Hookston Aquifer Testing

Number: 0020557.10

Client:



Slug Test: MW-17B

Analysis Method: Bouwer & Rice

Analysis Results:

Conductivity: 1.33E-3 [cm/s]

Test parameters:

Test Well:	MW-17B	Aquifer Thickness:	10 [ft]
Casing radius:	0.1666 [ft]	Gravel Pack Porosity (%):	25
Screen length:	10 [ft]		
Boring radius:	0.666 [ft]		
r(eff):	0.363 [ft]		

Comments:

Evaluated by:

Evaluation Date: 5/1/2006

Appendix H
Risk-Based Cleanup Concentrations for
Chemicals of Concern

Risk-Based Concentrations for Chemicals of Interest

- (1) Risk-Based Concentrations for Arsenic in On-site Soils**
- (2) Risk-Based Concentrations for Chemicals in Indoor Air**
- (3) Risk-Based Concentrations for Chemicals in Groundwater Used for Irrigation**
- (4) Risk-Based Concentrations for Chemicals in Groundwater Used to Fill Backyard Swimming Pools**

Summary of Risk-Based Concentrations for Soil, Indoor Air, and Groundwater

Medium	Receptor	Exposure Scenario	Chemical of Interest	*Cancer Risk-Based Concentration	**Noncancer Risk-Based Concentration
On-site Soil	Commercial/ Industrial Worker	Direct contact with on-site soil	Arsenic	4.3 mg/kg (target risk = 10 ⁻⁵)	440 mg/kg
	Construction Worker	Direct contact with on-site soil	Arsenic	31.0 mg/kg (target risk = 10 ⁻⁵)	912 mg/kg
Off-site Indoor Air	Residents	Inhalation of indoor air	Trichloroethylene	0.96 ug/m ³	69 ug/m ³
			cis-1,2-Dichloroethylene	NC	63 ug/m ³
			trans-1,2-Dichloroethylene	NC	125 ug/m ³
			1,1-Dichloroethylene	NC	357 ug/m ³
			Vinyl chloride	0.025 ug/m ³	181 ug/m ³
Off-site Groundwater	Residents	Inhalation of chemicals released from groundwater during irrigation	Trichloroethylene	1890 ug/L	33,900 ug/L
			cis-1,2-Dichloroethylene	NC	30,800 ug/L
			trans-1,2-Dichloroethylene	NC	61,700 ug/L
			1,1-Dichloroethylene	NC	176,000 ug/L
		Swimming contact with groundwater used to fill a backyard pool	Trichloroethylene	1105 ug/L	815 ug/L
			cis-1,2-Dichloroethylene	NC	42,700 ug/L
			trans-1,2-Dichloroethylene	NC	85,500 ug/L
			1,1-Dichloroethylene	NC	155,000 ug/L
Vinyl chloride	121 ug/L	19,600 ug/L			

* Target risk = 1 x 10⁻⁶ unless noted

**Total Hazard Quotient = 1

NC – not carcinogenic

(1) Risk-Based Concentrations for Arsenic in On-site Soils

Risk-based concentrations for arsenic in soil were calculated for the on-site commercial/industrial worker (C/I worker) and on-site construction worker. Exposure assumptions, toxicity factors, and equations used to calculate risk-based concentrations for arsenic in soil are presented below.

Soil Exposure Parameters and Toxicity Values

Symbol	Definition (units)	Values	References (refer to USEPA 2004 for full references)
CSF _o	Cancer slope factor oral (mg/kg-d) ⁻¹	--	Arsenic = 9.46
CSF _i	Cancer slope factor inhaled (mg/kg-d) ⁻¹	--	Arsenic = 12.0
RfD _o	Reference dose oral (mg/kg-d)	--	Arsenic = 3E-04
RfD _i	Reference dose inhaled (mg/kg-d)	--	Arsenic = 8.57E-06
TR	Target cancer risk	10 ⁻⁵	Feasibility Study
THQ	Target hazard quotient	1	Feasibility Study
BW _a	Body weight, adult (kg)	70	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002) Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
AT _c	Average time – carcinogens (days)	25,550	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
AT _n	Average time – noncarcinogens (days)	ED*365	USEPA 2004
SA _{aw}	Exposed surface area, C/I worker (cm ² /day)	3,300	Dermal Assessment, USEPA 2004 (EPA/540/R-99/005))
SA _{ac/tw}	Exposed surface area, construction worker (cm ² /day)	5,800	Exposure Factors, USEPA 1997 (EPA/600/P-95/002Fa)
AF _{aw}	Adherence factor, C/I worker (mg/cm ²)	0.20	Dermal Assessment, USEPA 2004 (EPA/540/R-99/005)
AF _{ctw}	Adherence factor, construction worker (mg/cm ²)	0.51	SFRWQCB, 2005
ABS	Skin absorption (unitless)	--	Arsenic = 0.03
IRA _a	Inhalation rate – adult (m ³ /day)	20	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
IRS _o	Soil ingestion – occupational (mg/day)	50	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
*IRS _{ctw}	Soil ingestion – construction/trench worker (mg/day)	330	USEPA 2001
*EF _{ctw}	Exposure frequency – construction/trench worker (d/y)	20	SFRWQCB, 2005
ED _o	Exposure duration – occupational (years)	25	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
*ED _{ctw}	Exposure duration – construction/trench worker (years)	7	SFRWQCB, 2005
PEF _{res/oc}	Particulate emission factor (m ³ /kg) - residential/occupational exposure scenarios	1.32E+09	Soil Screening Guidance (USEPA 1996a)
*PEF _{ctw}	Particulate emission factor (m ³ /kg) - construction/trench worker exposure scenarios	1.44E+06	SFRWQCB, 2005.

Equations Used to Calculate Risk-Based Soil Concentrations for Arsenic

Cancer Risk

$$C(\text{mg/kg}) = \frac{\text{TR} \times \text{BW} \times \text{AT}_c}{\text{EF} \times \text{ED} \left[\left(\frac{\text{IRS} \times \text{CSF}}{10^6 \text{mg/kg}} \right) + \left(\frac{\text{SA} \times \text{AF} \times \text{ABS} \times \text{CSF}_o}{10^6 \text{mg/kg}} \right) + \left(\frac{\text{IRA}_a \times \text{CSF}_i}{\text{PEF}} \right) \right]}$$

Noncancer Risk

$$C(\text{mg/kg}) = \frac{\text{THQ} \times \text{BW}_a \times \text{AT}_n}{\text{EF} \times \text{ED} \left[\left(\frac{1}{\text{RfD}_o} \times \frac{\text{IRS}}{10^6 \text{mg/kg}} \right) + \left(\frac{1}{\text{RfD}_o} \times \frac{\text{SA} \times \text{AF} \times \text{ABS}}{10^6 \text{mg/kg}} \right) + \left(\frac{1}{\text{RfD}_i} \times \frac{\text{IRA}}{\text{PEF}} \right) \right]}$$

(2) Risk-Based Concentrations for Chemicals in Indoor Air

Risk-based concentrations of for chemicals in indoor air were calculated for off-site residents. Exposure assumptions, toxicity factors, and equations are presented below.

Resident Exposure Parameters and Toxicity Values-Indoor Air Exposure

Symbol	Definition (units)	Value	References
CSF _i	Cancer slope factor inhaled (mg/kg-d) ⁻¹	Trichloroethylene – 0.007 cis-1,2-Dichloroethylene – not applicable trans-1,2-Dichloroethylene – not applicable 1,1-Dichloroethylene – not applicable Vinyl chloride – 0.27	CTEH, 2006
RfD _i	Reference dose inhaled (mg/kg-d)	Trichloroethylene – 0.011 cis-1,2-Dichloroethylene – not detected trans-1,2-Dichloroethylene – not detected 1,1-Dichloroethylene – 0.057 Vinyl chloride – 0.029	CTEH, 2006
TR	Target cancer risk	10 ⁻⁶	Feasibility Study
THQ	Target hazard quotient	1	Feasibility Study
BW	Body weight, adult (kg) Body weight, child (kg)	70 15	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002) Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
AT _c	Average time – carcinogens (days)	25,550	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
AT _n	Average time – noncarcinogens (days)	ED*365	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
IRA _a	Inhalation rate – adult (m ³ /day)	20	CTEH, 2006
IRA _c	Inhalation rate – child (m ³ /day)	10	CTEH, 2006
EF	Exposure frequency (days/year)	350	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
ED _a ED _c	Exposure duration – adult (years) Exposure duration – child (years)	24 6	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)

Equations Used to Calculate Risk-Based Indoor Air Concentrations for Residents

Cancer Risk

$$C(\text{ug}/\text{m}^3) = \frac{\text{TR} \times \text{AT}_c \times 1000 \text{ ug}/\text{mg}}{\text{EF} \times \left[\left(\frac{\text{ED}_a \times \text{IRA}_a}{\text{BW}_a} \right) + \left(\frac{\text{ED}_c \times \text{IRA}_c}{\text{BW}_c} \right) \right]} \times \text{CSF}_i$$

Noncancer Risk

$$C(\text{ug}/\text{m}^3) = \frac{\text{THQ} \times \text{BW}_c \times \text{AT}_n \times 1000 \text{ ug}/\text{mg}}{\text{EF} \times \text{ED}_c \times \text{IRA}_c \times \left(\frac{1}{\text{RfD}_i} \right)}$$

(3) Risk-Based Concentrations for Chemicals in Groundwater Used for Irrigation by Residents

Risk-based concentrations for chemicals in groundwater used as irrigation water by off-site residents were calculated using the exposure assumptions, toxicity factors, and equations are presented below.

Exposure Parameters and Toxicity Values- Irrigation Scenario

Symbol	Definition (units)	Value	References
CSF _i	Cancer slope factor inhaled (mg/kg-d) ⁻¹	Trichloroethylene – 0.007 cis-1,2-Dichloroethylene – not applicable trans-1,2-Dichloroethylene – not applicable 1,1-Dichloroethylene – not applicable Vinyl chloride – 0.27	CTEH, 2006
RfD _i	Reference dose inhaled (mg/kg-d)	Trichloroethylene – 0.011 cis-1,2-Dichloroethylene – 0.01 trans-1,2-Dichloroethylene – 0.02 1,1-Dichloroethylene – 0.057 Vinyl chloride – 0.029	CTEH, 2006
TR	Target cancer risk	10 ⁻⁶	Feasibility Study
THQ	Target hazard quotient	1	Feasibility Study
BW _a BW _c	Body weight, adult (kg) Body weight, child (kg)	70 15	RAGS (Part A), USEPA 1989 (EPA/540/1-89/002) Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)
AT _c	Average time – carcinogens (days)	25,550	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
AT _n	Average time – noncarcinogens (days)	ED*365	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
VF _{irr}	Volatilization factor for irrigation scenario (L/m ³)	0.00845	See accompanying text for derivation
IRA _a	Inhalation rate – adult (m ³ /day)	6.7	CTEH, 2006 (8 hours/day x 0.830 m ³ /hour)
IRA _c	Inhalation rate – child (m ³ /day)	3.3	CTEH, 2006 (8 hours/day x 0.415 m ³ /hour)
EF	Exposure frequency (days/year)	63	See text for explanation
ED _a ED _c	Exposure duration – adult (years) Exposure duration – child (years)	24 6	Exposure Factors, USEPA 1991 (OSWER No. 9285.6-03)

Discussion of Assumptions

The volatilization factor (VF_{irr}; L/m³) used to estimate volatile emissions from irrigation water into air was derived based on several assumptions regarding the amount of water used for irrigation. Shallow ground water is assumed to be used to irrigate a yard. In the irrigation scenario, residents are assumed to water a residential lawn during the warmest weeks of the year (18 weeks). Volatile organic compounds are assumed to completely volatilize over an 8 hour period starting with the onset of irrigation. Residents are assumed to be exposed over the entire 8 hour volatilization period by inhaling the volatilizing VOCs. Such a scenario is likely to occur over nighttime hours when residents are at home and evaporation of the irrigation water is efficiently minimized.

The following assumptions were used to estimate VOC emissions from ground water used for irrigation.

Amount of ground water for irrigation

Conservatively, 7.62 cm (3 inches) of water per week are assumed to be needed for lawn irrigation weekly. According to Maddaus and Mayer (“Splash or Sprinkle? Comparing the Water Use of Swimming Pools and Irrigated Landscapes”, undated), annual irrigation water use in arid climates (Boulder, Denver, San Diego, Phoenix, Tempe, Scottsdale, Walnut Valley, Las Virgenes, and Lompoc) ranged from 20.8 to 45.4 inches per year. Given the assumptions below (18 weeks of irrigation at 3 inches per week), annual irrigation with ground water is assumed to be 54 inches per year. This is a reasonably conservative estimate of the amount of ground water used to irrigate lawns in the Hookston Station area.

Number of weeks of lawn irrigation

Lawn irrigation is assumed to occur over 18 weeks (May 15 through September 15).

Number of irrigation events during the irrigation season

Lawns are assumed to be irrigated every other day for 18 weeks for 63 irrigation events per season or 3.5 events per week.

Area irrigated

The USEPA default residential exposure unit of 0.5 acre (20,235,000 cm²) is assumed.

Total amount of water used per irrigation event

= (7.62 cm per week/3.5 irrigation events per week) x 20,235,000 cm² x 0.001 cm³/L = 44,100 L

Rate of volatile emissions from ground water

VOCs are assumed to entirely volatilize within 8 hours.

Emission Calculations

The rate of volatilization of the VOCs from ground water used for irrigation is calculated according to the formula below:

VOC concentration in water (ug/L) x 44,100 L/irrigation event x (irrigation event/28,800 seconds) x (1/20,235,000 cm²) x 0.000001 g/ug = Average rate of VOC flux (g/cm²/sec)

Calculation of Air Concentrations

The residential VOC air concentrations of resulting from emission from using ground water for irrigation were calculated according to the formula:

$$C_{\text{air}} = \frac{\text{Rate of VOC flux} \times 10^4 \text{ cm}^2 / \text{m}^2}{Q / C \times 10^{-9} \text{ kg/ug}}$$

where:

C_{air} = Concentration in air, $\mu\text{g}/\text{m}^3$

Rate of VOC flux = calculated value, $\text{g}/\text{cm}^2/\text{sec}$

If it is assumed that the VOC concentration in ground water is 1 mg/L, the calculated average rate of flux of VOCs during one irrigation event is calculated as

$$1 \text{ mg/L} \times 44,100 \text{ L/event} \times 1 \text{ event/day} \times (1 \text{ day}/28,800 \text{ seconds per 8 hours}) \times (1/20,235,000 \text{ cm}^2) \times 0.001 \text{ g/mg} = 7.57\text{E-}14 \text{ g}/\text{cm}^2/\text{sec}$$

Q/C = inverse concentration factor for air dispersion for a 0.5 acre property in San Francisco ($89.53 \text{ g}/\text{m}^2\text{-s}$ per g/m^3 ; USEPA, 1996)

Using the above equation and the assumptions discussed, the average air concentration after an irrigation event (assumed to be 8 hours) is $0.00845 \text{ mg}/\text{m}^3$. From this information, an irrigation specific volatilization factor can be calculated. This volatilization factor (VF_{irr}) is $0.00845 \text{ mg}/\text{m}^3$ per 1 mg/L or $0.00845 \text{ L}/\text{m}^3$. This value is used in calculating risk-based concentrations for the chemicals of potential concern in ground water used for irrigation.

Equations Used to Calculate Risk-Based Air Concentrations for Chemicals in Irrigation Water

Cancer Risk

$$C(\mu\text{g}/\text{L}) = \frac{\text{TR} \times \text{AT}_c \times 1000 \text{ } \mu\text{g} / \text{mg}}{\text{EF} \times \text{VF}_{irr} \times \left[\left(\frac{\text{IRA}_c \times \text{ED}_c}{\text{BW}_c} \right) + \left(\frac{\text{IRA}_a \times \text{ED}_a}{\text{BW}_a} \right) \right] \times \text{CSF}_i}$$

Noncancer Risk

$$C(\mu\text{g}/\text{L}) = \frac{\text{THQ} \times \text{RfD}_i \times \text{BW}_c \times \text{AT}_n \times 1000 \text{ } \mu\text{g} / \text{mg}}{\text{EF} \times \text{VF}_{irr} \times \text{IRA}_c \times \text{ED}_c}$$

(4) Risk-Based Concentrations for Chemicals in Groundwater Used to Fill Backyard Swimming Pools

Risk-based concentrations for chemicals in groundwater used to fill backyard swimming pools were calculated using the exposure assumptions, toxicity factors, and equations are presented below.

Exposure Parameters and Toxicity Values- Swimming Pool Scenario

Symbol	Description	Value	Reference/ Explanation
CSF _o	Cancer slope factor oral (mg/kg-d) ⁻¹	Trichloroethylene – 0.013 cis-1,2-Dichloroethylene – not applicable trans-1,2-Dichloroethylene – not applicable 1,1-Dichloroethylene – not applicable Vinyl chloride – 0.27	CTEH, 2006
CSF _i	Cancer slope factor inhaled (mg/kg-d) ⁻¹	Trichloroethylene – 0.007 cis-1,2-Dichloroethylene – not applicable trans-1,2-Dichloroethylene – not applicable 1,1-Dichloroethylene – not applicable Vinyl chloride – 0.27	CTEH, 2006
RfD _o	Reference dose oral (mg/kg-d)	Trichloroethylene – 0.0003 cis-1,2-Dichloroethylene – 0.01 trans-1,2-Dichloroethylene – 0.02 1,1-Dichloroethylene – 0.050 Vinyl chloride – 0.003	CTEH, 2006
RfD _i	Reference dose inhaled (mg/kg-d)	Trichloroethylene – 0.011 cis-1,2-Dichloroethylene – 0.01 trans-1,2-Dichloroethylene – 0.02 1,1-Dichloroethylene – 0.057 Vinyl chloride – 0.029	CTEH, 2006
AT _c	Averaging time for exposure; carcinogenic risk (days)	25,550	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
AT _n	Averaging time for exposure; noncarcinogenic risk (days)	4745	See text for explanation (13 years x 365 days per year)
BW	Body weight of child swimmer (kg)	41.5	USEPA 1997. Exposure Factors Handbook. Volume I – General Factors. Office of Health and Environmental Assessment; Average of male and females body weights from 5 through 17 years of age. Table 7-3.
DA _{event-factor}	Dermal uptake factor per swimming exposure (L/mg/cm ²);	chemical-specific	See text for explanation
ED	Exposure duration, child swimmer (years)	13	Assumes swimming age from 5 years through 17 years of age
EF	Exposure frequency (days/yr)	108	See text for explanation
ET	Exposure time (hours)	1	USEPA, 2004

Exposure Parameters and Toxicity Values- Swimming Pool Scenario

Symbol	Description	Value	Reference/ Explanation
IR	Pool water ingestion rate (L/hr)	0.05	RAGS (Page A), USEPA 1989 (EPA/540/1-89/002)
Pool loss factor	Factor used to adjust for loss of COPCs from pool water during season (unitless)	0.12	See text for explanation
SA	Skin surface area exposed during swimming (cm ²)	15,500	USEPA 1997. Exposure Factors Handbook. Volume I – General Factors. Office of Health and Environmental Assessment; Average body surface area of 5 to 18 year old male and female children; Tables 6-6 and 6-7
VF _{pool}	Volatilization factor for swimming pool scenario (L/m ³)	0.000977	See text for explanation
IRA	Inhalation rate for child swimmer (m ³ /hr)	1.9	USEPA 1997. Exposure Factors Handbook. Volume I – General Factors. Office of Health and Environmental Assessment; Inhalation rate for heavy activity; Table 5-23

Cancer Risk

C(ug/L) =

$$C(\text{ug/L}) = \frac{\text{TR} \times \text{BW} \times \text{AT}_c \times 1000 \text{ ug / mg}}{\text{EF} \times \text{ED} \times \left[(\text{CSF}_o \times \text{DA}_{\text{event-factor}} \times \text{SA}) + (\text{CSF}_i \times \text{VF}_{\text{pool}} \times \text{IRA} \times \text{ET}) + (\text{CSF}_o \times \text{IR} \times \text{ET} \times \text{pool loss factor}) \right]}$$

Noncancer Risk

C(ug/L) =

$$C(\text{ug/L}) = \frac{\text{THQ} \times \text{BW} \times \text{AT}_{nc} \times 1000 \text{ ug / mg}}{\text{EF} \times \text{ED} \times \left[\left(\frac{\text{DA}_{\text{event-factor}} \times \text{SA}}{\text{RfD}_o} \right) + \left(\frac{\text{VF}_{\text{pool}} \times \text{IRA} \times \text{ET}}{\text{RfD}_i} \right) + \left(\frac{\text{IR} \times \text{ET} \times \text{pool loss factor}}{\text{RfD}_o} \right) \right]}$$

Discussion of Assumptions

A resident is assumed to fill a backyard pool with ground water containing the chemicals of interest (COIs). Exposure to the COIs in swimming pool water was assumed to occur via skin uptake during swimming, inhalation of volatilizing COIs, and ingestion of pool water.

Pool filling was assumed to occur once per season. Ground water was also assumed to be used to make up for losses resulting from evaporation and splashing.

The swimming season is assumed to last 18 weeks (approximately May 15 through September 15) or 126 days. During this time, a child is assumed to swim 6 days per week for 1 hour per day.

Concentration of the COIs in Swimming Pool Water

Due to their volatile nature, losses of the COIs via volatilization are accounted for by assuming an average rate of volatilization in which 50% of the chemical in the pool water will volatilize with 3.5

days. A typical backyard swimming pool is 30 feet long x 15 feet wide x 5 feet deep and would contain approximately 2250 cubic feet or 64,000 liters of water. Based on estimates for the Sacramento area prepared by the California Spa and Pool Industry Energy, Codes and Legislative Council (SPEC, 2002), a pool this size would require approximately 1000 L per day of water to replenish the pool (from water losses caused by evaporation, splashing, etc.).

Assuming that 1000 L per day of ground water are needed to replenish the pool, what is the seasonal average COI concentration in the over 126 days?

Assume 3.5 day half life (volatilization rate constant of 0.198 days⁻¹)

Assume ground water concentration of COI is 1 mg/L

Assume pool contains 64,000 L of ground water

The first day after filling, the concentration of COI in pool after 24 hours of original filling

$$= 1 \text{ mg/L} \times e^{(-0.198 \times 1)} = 0.82 \text{ mg/L at a volume of } 63,000\text{L}$$

Add to this 1000 L containing 1 mg/L- what is the adjusted COI concentration in pool water?

(Concentration in pool x 63,000 L) + (1 mg/L x 1000 L) divided by 64,000 L

$$= 0.823 \text{ mg/L} \times e^{(-0.198 \times 1)} = 0.675 \text{ mg/L at a volume of } 63,000\text{L}$$

Add to this 1000 L containing 1 mg/L and the adjusted Day 2 COI concentration in pool water is calculated as (0.675 mg/L x 63,000 L) + (1 mg/L x 1000 L) divided by 64,000 L = 0.68 mg/L. This calculation was repeated for 30 days. It was determined that the concentration declines to 0.083 mg/L after about 30 days and remains fairly constant from Day 30 through Day 126. The average COI concentration in water over the 126 day swimming season is 0.12 mg/L. Based on these calculations, a swimming pool loss factor of 0.12 (0.12 mg/L divided by 1 mg/L) was calculated.

Calculation of Skin Uptake of Chemicals in Water

The equation used to calculate the dermally absorbed dose of the chemicals of concern in swimming pool water requires the calculation of a chemical-specific dermally absorbed dose through the skin. This value is called the DA_{event}.

For trichloroethylene (where t_{event} is less than or equal to t*), the DA_{event} is calculated using the following formula:

$$DA_{\text{event}} = 2 \times K_p \times C_{\text{water}} \times \text{swim min igpool loss factor} \times \frac{L}{1000 \text{ cm}^3} \times \sqrt{\frac{6 \times \text{tau} \times t_{\text{event}}}{\text{pi}}}$$

For 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, and vinyl chloride (where t_{event} > t*), DA_{event} is calculated using the formula presented below:

$$DA_{\text{event}} = K_p \times C_{\text{water}} \times \text{swim min igpool loss factor} \times \frac{L}{1000 \text{ cm}^3} \times \left[\frac{t_{\text{event}}}{1 + B} + \left(2\text{tau} \times \frac{1 + 3B + 3B^2}{(1 + B)^2} \right) \right]$$

where:

DA_{event} = dermal dose absorbed through the skin per exposure event (mg/cm²)

K_p = dermal permeability coefficient from Exhibit B-3 of USEPA, 2004 (cm/hr)

C_{water} = concentration in water (mg/L)

tau = Chemical-specific; from Exhibit B-3 of USEPA, 2004 (hours)

t_{event} = hours of exposure to water per event (1 hour)

pi = 3.14

The values of K_p, C_{water}, tau, and the calculated DA_{event} are presented in the table below.

Values of DA_{event} were calculated using spreadsheets developed by the USEPA for use as described in USEPA, 2004 and as available from

<http://www.epa.gov/oswer/riskassessment/ragse/index.htm> (accessed May 11, 2006)

Values for K_p, tau, t*, B, and DA_{event-factor} for the Chemicals of Potential Concern

Chemical	K _p (cm/hr)	tau (hr)	t* (hr)	B	*DA _{event} (mg/cm ²)
Trichloroethylene	0.0120	0.580	1.39	0.051	2.94E-06
cis-1,2-Dichloroethylene	0.0077	0.370	0.89	0.029	1.61E-06
trans-1,2-Dichloroethylene	0.0077	0.370	0.89	0.029	1.61E-06
1,1-Dichloroethylene	0.0120	0.370	0.89	0.044	2.42E-06
Vinyl chloride	0.0056	0.240	0.57	0.017	9.86E-07

*Assumes 1 mg/L as starting concentration for COIs in swimming pool water

A DA_{event} factor for pool water is therefore the VOC-specific DA_{event} (in units of mg/cm²) per 1 mg/L. The chemical-specific or DA_{event} factor is designated as DA_{event-factor} and has the units of L/cm²

Concentration of COIs in Air Above Swimming Pool

The air concentration of COIs above the pool was calculated to evaluate swimmer inhalation of VOCs over the swimming season. Given the assumed half-life of 3.5 days for VOC volatilization from pool water, the average emission rate of VOCs from a swimming pool containing 1 mg/L of VOC is calculated as

$$\frac{1 \text{ mg/L} \times 64,000 \text{ L} \times 0.5}{86,400 \text{ seconds/day} \times 3.5 \text{ days}} = 0.106 \text{ mg/s}$$

To calculate a seasonal average emission rate, the emission rate is multiplied by swimming pool loss factor of 0.12 (calculated above) to give a seasonally adjusted emission rate of 0.0127 mg/s (0.106 mg/s x 0.12).

The box model was used to calculate air concentrations above the swimming pool at receptor height. The seasonally adjusted air concentration is 0.000977 mg/m³ where

Seasonally adjusted emission rate = 0.0127 mg/s

Receptor height above water = 0.5 m

Side of pool perpendicular to the wind = 6.5 m (square root of pool area)

Windspeed = 4 m/s (http://ggweather.com/ca_climate/wind.htm)

$$\frac{0.0127 \text{ mg/s}}{0.5 \text{ m} \times 6.5 \text{ m} \times 4 \text{ m/s}} = 0.000977 \text{ mg/m}^3$$

A seasonally adjusted swimming pool volatilization factor (VF_{pool}) can be calculated as 0.000977 mg/m^3 per 1 mg/L or 0.000977 L/m^3 . This value is used in calculating risk-based concentrations for the chemicals of potential concern in ground water used for swimming pools.

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Appendix I
Ground Water Modeling

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Numerical ground water flow and solute transport models were developed for the Hookston Station to support the evaluation of remedial alternatives for volatile organic compounds (VOCs) in ground water. These models are designed to be representative of the general hydrogeologic conditions in the Hookston Station area. This appendix describes the design of the Hookston Station flow and transport models, the methods that were used to evaluate the remedial alternatives, and presents the results of the model simulations.

It should be noted that these computer models were constructed as a tool to compare the relative effectiveness (e.g., spatial impact and timeframes for VOC concentration reductions) of active remediation systems that are being evaluated within the Feasibility Study (FS). These are not fully calibrated ground water flow and solute transport models, and as such, the results of these modeling efforts should be considered estimates based upon the input parameters and assumptions that are described within this appendix. The modeling results cannot be relied upon for any purpose other than comparing the relative effectiveness of the remedial alternatives.

2.0

MODEL DESIGN

This section describes the principal design elements of the Hookston Station ground water flow and solute transport models. These design elements include the model codes that were selected to develop the models, the major assumptions of the model designs, the model grid and layering, the aquifer and transport properties assigned to the model grid, and the boundary conditions used in the flow and transport models.

The Hookston Station ground water flow and transport models were designed and constructed in accordance with the American Society for Testing and Materials (ASTM) guidelines for ground water modeling (ASTM 1996) and generally accepted industry practice (Anderson and Woessner 1992; Zheng and Bennett 1995). The ASTM guidelines were developed as part of a cooperative agreement between the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), and the United States Navy.

The Hookston Station ground water flow and transport models were constructed with Ground water Vistas™, a computer-aided design program for ground water modeling (Environmental Simulations Inc., 2004). Groundwater Vistas™ fully supports the model codes MODFLOW (McDonald and Harbaugh 1988), PATH3D (Zheng 1989), and MT3DMS (Zheng and Wang 1999), which were used to develop the Hookston Station ground water flow and transport models.

2.1

MODEL CODES

2.1.1

Ground Water Flow

The model code that was used to develop the Hookston Station ground water flow model is MODFLOW (McDonald and Harbaugh 1988), a three-dimensional, finite-difference ground water flow model developed by the USGS. MODFLOW was selected for development of the Hookston Station flow model because it is nonproprietary, well documented, and has been verified for a wide range of field problems (USEPA 1993). Numerous models based on this code have been published in technical journals (Anderson and Woessner 1992).

2.1.2 *Ground Water Flow Paths*

Ground water flow paths were simulated with the model code PATH3D. PATH3D is a three-dimensional, numerical particle tracking code for calculating ground water flow paths and travel times from the head solution output by MODFLOW. This model code was developed at the University of Wisconsin - Madison and the Wisconsin Geological and Natural History Survey (Zheng 1989). PATH3D is well documented and has been verified for a range of field problems.

2.1.3 *Solute Transport*

The Hookston Station solute transport model was developed with MT3DMS. MT3DMS is a three-dimensional, finite-difference solute transport model code developed by Zheng and Wang (1999) with funding from the United States Army Corps of Engineers Waterways Experiment Station. MT3DMS was selected for development of the Hookston Station transport model because it is nonproprietary, well documented, and is designed to be used with MODFLOW. Numerous models based on this and an earlier version of this code, MT3D (Zheng, 1990, 1993), have been published in technical journals (Zheng, and Bennett, 1995).

The MT3DMS transport simulations were solved using a total variation diminishing (TVD) method for solution of the advection term (Zheng and Wang 1999). The TVD method implemented in MT3DMS is a third-order TVD method with a universal flux limiter. This TVD method minimizes numerical dispersion and suppresses spurious oscillations in the model concentration solution while preserving sharp concentration fronts.

2.2 *GROUND WATER FLOW MODEL*

2.2.1 *Assumptions of Model Design*

The following simplifying assumptions were made in the design of the Hookston Station ground water flow model:

- The shallowest ground water flow system (A-Zone) receives no significant recharge by infiltration of precipitation and surface runoff.
- The A-, B-, and C- Zones have a uniform thickness and uniform values of hydraulic conductivity (i.e., values differ from one zone to another, but are uniform throughout a given zone).

- Vertical hydraulic conductivities are equal to one tenth of horizontal hydraulic conductivities.
- Vertical ground water flow between the A- and B-Zones, and the B- and C-Zones, is relatively insignificant.
- Vertical ground water flow between the C-Zone and underlying sediments is relatively insignificant.
- The simulated ground water extraction wells fully screen the aquifers in which they are completed.

2.2.2 *Model Grid*

The model grid constructed for the Hookston Station ground water flow model is a three-layer, 250-row by 200-column, uniformly spaced, finite-difference grid. The model grid is oriented north 55 degrees east, approximately parallel to the direction of ground water flow. The row and column spacing of the model grid is a uniform 25 feet. The overall model area spans 5,000 by 6,250 feet, which is just over 1 square mile (Figure I-1).

2.2.3 *Model Layers*

The ground water flow in the A-, B-, and C-Zones in the Hookston Station area are simulated in the model by three layers.

- Layer 1 represents the A-Zone;
- Layer 2 represents the B-Zone; and
- Layer 3 represents the C-Zone;

The bottom elevation of Layer 1, which represents the base of the A-Zone, is a uniform 40 feet above mean sea level (AMSL), an approximate depth of 30 feet below ground surface (bgs). The top elevation of this layer, which represents the water table, is calculated by MODFLOW during the model simulation period (McDonald and Harbaugh 1988).

The bottom elevation of Layer 2, which represents the base of the B-Zone, is a uniform 0 feet AMSL, an approximate depth of 70 feet bgs. The top elevation of this layer, which represents the base of the A-Zone, is 40 feet AMSL.

The bottom elevation of Layer 3, which represents the base of the C-Zone, is a uniform -30 feet AMSL, an approximate depth of 100 feet bgs. The top elevation of this layer, which represents the base of the B-Zone, is 0 feet AMSL.

The bottom elevations of the model layers are based on geologic logs prepared for soil borings and wells installed at the Hookston Station parcel and nearby areas (ERM 2004) and are typical for this area. Uniform bottom elevations for the three model layers were used as a simplifying assumption in the design of the ground water flow model (Section 2.2.1).

2.2.4 *Flow Conditions*

Flow conditions in Layer 1 (A-Zone) are simulated as unconfined (MODFLOW layer type LAYCON=1) in the Hookston Station ground water flow model. The transmissivity of this layer varies during the model simulation period, and is calculated from the saturated thickness and hydraulic conductivity specified for the layer (McDonald and Harbaugh 1988). Flow conditions in Layer 2 (B-Zone) and Layer 3 (C-Zone) are simulated as unconfined/confined (MODFLOW layer type LAYCON=3). The transmissivities of these model layers vary during the model simulation period, and are calculated from the saturated thickness and hydraulic conductivity specified for the layers (McDonald and Harbaugh 1988). The storage coefficients specified for these model layers may alternate between confined and unconfined values during the model simulation period. This allows the model to realistically simulate the localized dewatering of a confined zone during ground water extraction.

2.2.5 *Flow Boundary Conditions*

The following boundary conditions are used in the Hookston Station ground water flow model:

- The upper boundary of the model grid is a free-surface boundary. The free-surface boundary simulates the water table in the A-Zone. The elevation of this boundary is calculated by MODFLOW during the course of the simulation (McDonald and Harbaugh 1988).
- The lower boundary of the model grid is a no-flow boundary. Downward ground water flow between the C-Zone and the underlying sediments is assumed to be negligible as a simplifying assumption of the model design (Section 2.2.1).

- The southwestern and northeastern margins of the model grid are constant-head boundaries (Figure I-1). These constant-head boundaries simulate the horizontal gradients observed in the ground water flow systems in the Hookston Station area.
- The northwestern and southeastern margins of model grid are no-flow boundaries (Figure I-1). These boundaries of the model grid are approximately parallel to the direction of ground water flow in the A-, B-, and C-Zones.

2.2.6 *Aquifer Flow Properties*

The values of horizontal hydraulic conductivity that are used in the Hookston Station ground water flow model are:

- A-Zone – horizontal conductivity (Kh) 5.0 feet/day, vertical conductivity (Kv) 0.5 feet/day;
- B-Zone – horizontal conductivity (Kh) 50 feet/day, vertical conductivity (Kv) 5 feet/day; and
- C-Zone – horizontal conductivity (Kh) 50 feet/day, vertical conductivity (Kv) 5 feet/day.

The values of horizontal hydraulic conductivity are representative of the A- and B-Zones based on pumping and slug tests (as described in Appendix G of this FS and Treadwell & Rollo 1993) and are within the range of published values for these types of materials (Fetter 1994). Horizontal hydraulic conductivities are assumed to be 10 times vertical conductivities (Kh/Kv=10:1) in the model layers, which are typical conductivity ratios for moderately stratified aquifers with interbedded silts and clays (Freeze and Cherry 1979; Walton 1988).

2.3 *SOLUTE TRANSPORT MODEL*

2.3.1 *Assumptions of Model Design*

The following simplifying assumptions were made in the design of the Hookston Station solute transport model:

- The A-, B-, and C- Zones have uniform values of porosity;

- The A-, B-, and C- Zones have uniform values of longitudinal, transverse, and vertical dispersivity;
- Transverse dispersivities are equal one third of longitudinal dispersivities;
- Vertical dispersivities are equal to one tenth of longitudinal dispersivities;
- The A-, B-, and C-Zones have uniform retardation factors of 1.0 (no sorption by soil matrix); and
- The sources for the VOC plumes in A- and B-Zones are continuous sources with constant concentrations that do not vary over time.

Sorption by the aquifers is not included within the model, as this parameter is largely dependent on the organic content of the aquifer materials. Samples collected from aquifer sands from borings advanced on the Hookston Station parcel (TW-1 through TW-4) contained no detectable amounts of organic carbon (see Table F-1 in Appendix F).

For Alternatives 3 through 6, the solute transport model was run twice. The first run assumed that only the active remedy (e.g., installation of a permeable reactive barrier [PRB]) and dispersion would cause chemical decreases, and that there would be no biodegradation of the plume, which is a conservative modeling assumption. The second run assumes that biodegradation will occur, using a trichloroethylene (TCE) half-life of 19 years for the A-Zone and 4 years for the B-Zone based on bulk attenuation rates calculated from site-specific data (see Appendix D). The one exception to this approach is modeling Alternative 3 (enhanced bioremediation) in the A-Zone, which naturally does assume biodegradation is occurring throughout the plume.

2.3.2

Transport Boundary Conditions and Initial Transport Conditions

Constant-concentration boundaries in Layer 1 (A-Zone) and Layer 2 (B-Zone) were used in the Hookston Station solute transport model to simulate three inferred source areas for the VOC plumes in the A- and B-Zones. These constant-concentration boundaries were located near monitoring wells MW-20A/B, MW-13A/B, MW-14A/B. These source terms were added to the model to simulate the consistently high concentrations of dissolved VOCs in ground water near these locations. The concentration value for the constant boundary in Layer 1 (A-Zone)

near monitoring well MW-20A was set at 500 micrograms per liter ($\mu\text{g}/\text{L}$). The concentration values for the other constant-concentration boundaries in Layer 1 (A-Zone) and Layer 2 (B-Zone) were set at 1,000 $\mu\text{g}/\text{L}$.

The initial concentrations for Layer 1 (A-Zone) and Layer 2 (B-Zone) in the transport simulations of the remedial alternatives were the TCE concentrations in the A- and B-Zones during the first quarter of 2006, as depicted in Figures I-2 and I-3.

2.3.3 *Aquifer Transport Properties*

A uniform porosity of 0.25 and a uniform longitudinal dispersivity of 15.9 feet are used for the A-Zone, and a uniform porosity of 0.20 and a uniform longitudinal dispersivity of 16.5 feet are used for the B-Zone in the Hookston Station solute transport model (Appendix D; Walton 1988; Domenico and Schwartz 1990). Transverse dispersivities were assumed to be one third of the longitudinal dispersivity (ASTM 1995; USEPA 1986) and vertical dispersivities were assumed to be one tenth of longitudinal dispersivity (USEPA 1986).

3.0 *EVALUATION OF REMEDIAL ALTERNATIVES*

The ground water flow and solute transport models developed for the Hookston Station were used to evaluate the relative effectiveness of the following four remedial alternatives presented in the FS:

- Alternative 3 – Bioremediation of the A-Zone and in situ chemical oxidation (ISCO) in the B-Zone;
- Alternative 4 – PRB in the A-Zone and ISCO in the B-Zone;
- Alternative 5 – PRB in the A- and B-Zones; and
- Alternative 6 – Pump-and-treat in the A- and B-Zones.

The ground water flow model was also used to determine the number, location, and flow rates for the withdrawal wells in Alternative 6.

3.1 *ALTERNATIVE 3*

3.1.1 *Simulation of Remedial Systems Operation*

For Alternative 3, bioremediation would be performed in the A-Zone and ISCO would be used for ground water treatment in the B-Zone. Since these treatment systems would not significantly impact long-term natural ground water flow conditions at the Hookston Station parcel and downgradient study area, the steady-state flow solution from the ground water model was used to simulate operation of these remedial systems.

3.1.2 *Reduction in TCE Concentrations by Remedial System*

The reduction in TCE concentrations in the A-Zone by bioremediation and in the B-Zone by ISCO treatment were evaluated with the Hookston Station solute transport model (Section 2.3). For the bioremediation simulation, biodegradation was simulated as irreversible, first-order decay of TCE within the area of Layer 1 (A-Zone) in which injections are proposed (see Figures 6-5 and 6-6 of the FS). Based on the bulk attenuation rates calculated for TCE in Appendix D, a biodegradation rate half-life of 19 years was applied throughout the A-Zone in this simulation. Bioremediation accelerates natural biodegradation rates by 2

to 8 times (Parsons Corporation 2004). Based on these site-specific degradation rates, a biodegradation rate half-life for the area impacted by the treatment (i.e., the areas immediately surrounding the proposed injection areas) was conservatively estimated to be 2 times the average degradation rate half-life for TCE, or 9.5 years. This accelerated biodegradation rate was also applied to the constant-concentration boundaries representing the inferred source areas (not including the Vincent Road tetrachloroethylene (PCE)/TCE source area), as described in Section 2.3.2.

For the B-Zone ISCO simulation, TCE concentrations were assumed to be instantaneously reduced 90 percent by treatment. Therefore, operation of the ISCO system in the B-Zone was simulated by reducing the initial concentrations in Layer 2 (B-Zone) by 90 percent within the area in which ISCO injections are proposed (see Figures 6-5 and 6-8 of the FS). This is a common simplifying assumption used in modeling short-term in situ chemical mass reductions such as those achieved using ISCO.

The transport simulations were performed with the model code MT3DMS using the steady-state flow solution from the ground water model. The transport simulations were run for a total time of 30 years to evaluate the long-term reduction in TCE concentrations by these remedial systems.

The results of the transport simulation of bioremediation in the A-Zone are shown in Figure I-4. This figure shows the steady-state model head solution (ground water elevation contours) and the TCE concentration solution in the A-Zone 30 years after completion of bioremediation treatment. Time-concentration solutions for three monitoring wells (MW-15A, MW-16A, and MW-17A) downgradient of the treatment areas are shown in Figure I-5. Note that under this simulation, bioremediation treatment is not included for the Vincent Road PCE/TCE plume.

The results of the transport simulation of ground water treatment by ISCO in the B-Zone are shown in Figure I-6. This figure shows the steady-state model head solution and the TCE concentration solution in the B-Zone 30 years after completion of treatment by ISCO. Time-concentration solutions for three downgradient monitoring wells (MW-15B, MW-16B, and MW-17B) are shown in Figure I-7. An additional model run that assumed that in addition to the source reduction due to ISCO treatment in the B-Zone, the remainder of the TCE plume would biodegrade, is presented in Figures I-8 and I-9. These figures show a generally smaller ground water plume at the 30-year time step, and overall faster remediation timeframes due the biodegradation.

It should be noted that this simulation does not include ISCO treatment for the B-Zone Vincent Road PCE/TCE plume, nor enhanced bioremediation for the A-Zone Vincent Road PCE/TCE plume. It should also be noted that in this simulation (and others to be discussed below) the configuration of the plume at the 30-year time step might appear slightly different than the shape of the current plume (e.g., the plume axis appears to be slightly more eastern than the current configuration). This is primarily due to one the simplifying assumptions used in these simulations: a uniform ground water flow field that is aligned with the average ground water flow across the study area (as depicted in Figure I-1). In reality, ground water flow is slightly more dynamic and flow paths are not always in a straight line. However, although these simulations may not precisely match the natural system, the alternatives that were evaluated all use the same simplifying assumptions (such as a uniform flow field), thereby allowing a meaningful comparison between technologies.

3.2 *ALTERNATIVE 4*

3.2.1 *Simulation of Remedial Systems Operation*

In Alternative 4, a PRB would be installed in the A-Zone and ISCO would be used for ground water remediation in the B-Zone. Since these treatment systems would not significantly impact long-term natural ground water flow conditions at the parcel and downgradient study area, the steady-state flow solution from the ground water flow model was used to simulate long-term operation of these remedial systems.

3.2.2 *Reduction in TCE Concentrations by Remedial System*

The reduction in TCE concentrations in the A-Zone by long-term operation of the PRB and in the B-Zone by ISCO treatment were evaluated with the Hookston Station solute transport model (Section 2.3). For the PRB simulation, only the A-Zone TCE plume downgradient of the PRB was simulated with the model, since the PRB would treat the upgradient TCE, and the area of interest for the modeling is the downgradient effect of the PRB.

The ISCO treatment in the B-Zone is identical to that described in Alternative 3 (Section 3.1).

The A-Zone transport simulation was performed with the model code MT3DMS using the steady-state flow solution from the ground water model. The transport simulation was run for a total time of 30 years to evaluate the long-term reduction in TCE concentrations by the PRB.

The results of the transport simulation of the long-term operation of the PRB in the A-Zone are shown in Figure I-10. This figure shows the location of the PRB, the steady-state model head solution, and the TCE concentration solution in the A-Zone after 30 years of operation of the remedial system (downgradient of the PRB). Time-concentration solutions for three downgradient monitoring wells (MW-15A, MW-16A, and MW-17A) and a modeled observation well (an imaginary well placed roughly midway between MW-15A and MW-16A (see Figure I-10) are shown in Figure I-11. This simulation assumes no biodegradation of the plume.

Figure I-12 depicts the TCE concentration solution in the A-Zone after 30 years of operation, assuming a TCE half-life of 19 years. Figure I-13 provides time-concentration estimates for the four above-listed monitoring wells, assuming that biodegradation is acting on the remaining plume downgradient of the PRB.

The result of the transport simulation of ground water treatment by ISCO in the B-Zone is described above under Alternative 3 (Figure I-3).

3.3 ALTERNATIVE 5

3.3.1 *Simulation of Remedial System Operation*

In Alternative 5, a PRB would be installed in the A- and B-Zones. Since the PRB would not impact natural ground water flow conditions at the Hookston Station parcel and downgradient study area, the steady-state flow solution from the ground water model was used to simulate long-term operation of this remedial system.

3.3.2 *Reduction in TCE Concentrations by Remedial System*

The reduction in TCE concentrations in the A- and B-Zones by long-term operation of the PRB was evaluated with the Hookston Station solute transport model (Section 2.3). Similar to Alternative 4, for these simulations, only the TCE plume downgradient of the PRB was simulated

with the model, since the PRB would treat upgradient TCE, and the area of interest for the modeling is the downgradient effect of the PRB.

The transport simulations were performed with the model code MT3DMS using the steady-state flow solution from the ground water model. The transport simulations were run for a total time of 30 years to evaluate the reduction in TCE concentrations by long-term operation of this remedial system.

The results of the transport simulation for the A-Zone are discussed above under Alternative 4 (Section 3.2). The results of the transport simulation for the B-Zone PRB are shown in Figure I-14. This figure shows the location of the PRB, the steady-state model head solution, and the TCE concentration solution in the B-Zone after 30 years of operation of the remedial system. Time-concentration solutions for three downgradient monitoring wells (MW-15B, MW-16B, and MW-17B) are shown in Figure I-15. This simulation assumes no biodegradation of the plume.

Figure I-16 depicts the TCE concentration solution in the B-Zone after 30 years of operation, assuming a TCE half life of 4 years. Figure I-17 provides time-concentration estimates for the above-listed monitoring wells, assuming that biodegradation is acting on the remaining plume downgradient of the PRB.

3.4 *ALTERNATIVE 6*

3.4.1 *Simulation of Remedial System Operation*

In Alternative 6, ground water extraction wells would be installed in the A- and B-Zones to capture and treat the VOC plume. Operation of the pump-and-treat system was simulated by adding well nodes (point sinks) to Layer 1 (A-Zone) and Layer 2 (B-Zone) of the ground water flow model to represent the extraction wells. The pumping rate of the well nodes in Layer 1 (A-Zone) was set at 2 gallons per minute and the pumping rate of the wells nodes in Layer 2 (B-Zone) was set at 50 gallons per minutes (Section 2.2.6). The model was then solved for steady-state flow conditions to simulate long-term operation of the pump-and-treat system. The number and location of the well nodes were varied in successive simulations to achieve horizontal and vertical capture of the core of the VOC plume (within the 500 µg/L concentration contour) in the A- and B-Zones.

3.4.2 *Ground Water Capture by Remedial System*

The effectiveness of ground water capture by the extraction wells was evaluated by calculating ground water flow paths to the extraction wells for the head solution from the simulation of treatment system operation (Section 3.4.1) using the particle tracking code PATH3D. Ground water capture by the extraction wells was evaluated by placing particles in Layer 1 (A-Zone) and Layer 2 (B-Zone) along the VOC plume boundaries. For the particle tracking simulations, a uniform effective porosity of 0.25 and retardation factor of 1.0 was used for Layer 1 (A-Zone), and a uniform effective porosity of 0.20 and retardation factory of 1.0 was used for Layer 2 (B-Zone). Path lines were calculated for steady-state flow conditions to fully delineate the ultimate flow paths of the particles within the model grid.

The results of the particle tracking simulations of the withdrawal well systems are shown in Figures I-19 and I-20. These figures show the location of the (hypothetical) extraction wells, the steady-state pumping head solution, and the modeled flow path solution for the withdrawal well systems in the A- and B-Zones. Based on the results of the particle tracking simulation, 15 A-Zone extraction wells to capture the core of the ground water plume (within the 500 µg/L concentration contour). Because of the increased transmissivity of the B-Zone, a fewer number of wells can be used to impart greater hydraulic influence. The model simulations indicate five B-Zone wells could achieve hydraulic capture over a broader area.

3.4.3 *Reduction in TCE Concentrations by Remedial System*

The reduction in TCE concentrations in the A- and B-Zone by long-term operation of the pump-and-treat system was evaluated with the Hookston Station solute transport model (Section 2.3). The transport simulations were performed with the model code MT3DMS using the steady-state ground water flow solution from the simulation of the remedial system operation (Section 3.4.1). The transport simulations were run for a total time of 30 years to evaluate the reduction in TCE concentrations by long-term operation of the remedial system.

The results of the transport simulations of the operation of the pump-and-treat system for the A-Zone are shown in Figure I-20. This figure shows the location of the extraction wells, the steady-state pumping head solution, and the TCE concentration solution in the A-Zone after 30 years of ground water withdrawal. Time-concentration solutions for three

downgradient monitoring wells (MW-15A, MW-16A, and MW-17A) and a modeled observation well (an imaginary well placed roughly midway between MW-15A and MW-16A) are shown in Figure I-21. A modeled TCE concentration map and a time versus concentration graph for the above-listed wells, assuming biodegradation will affect the plume over time, are provided as Figures I-22 and I-23, respectively.

B-Zone simulations of the pump-and-treat alternative are similarly shown in Figures I-24 and I-25 (assuming no biodegradation), and Figures I-26 and I-27 (assuming biodegradation).

Modeling of four of the A-Zone remediation alternatives suggests that the timeframes necessary to achieve reductions in TCE concentration below 530 µg/L (the San Francisco Bay Regional Water Quality Control Board screening level for protection of indoor air vapor intrusion) range from approximately 2 to 5 years. Alternative 3 (in-situ bioremediation) shows concentration decreases to this level in slightly less than 5 years. Alternatives 4 and 5 (PRBs in the A-Zone), estimate a 2 to 3 year timeframe to achieve this level, depending on whether biodegradation of the plume is accounted. Alternative 6 (pump-and-treat) appears to be slightly faster, with 2 to 2.5 year timeframes to reduce concentrations down the axis of the plume to levels below 530 µg/L. Note that the initial TCE concentrations in these downgradient plume axis wells are currently just over 530 µg/L. Based on the assumptions used to create the model, concentration decreases to very low levels (e.g., the Maximum Contaminant Levels) will be achieved over a longer timeframe, which in some portions of the plume may be more than 30 years.

Modeling of the three B-Zone remedial alternatives (ISCO, PRB, and pump-and-treat) suggests that significant reductions will be achieved in the downgradient axis wells within an approximate 2 to 8 year timeframe. The model simulations indicate a potential for short-term increases in the downgradient plume-axis wells, representing high concentrations between MW-14B and MW-15B that pass through the system. Compared with the A-Zone, concentrations generally approach the Maximum Contaminant Levels more quickly in the B-Zone, partly due to the increased ground water flow and (for the modeling runs that assume biodegradation) due to the increased biodegradation rate observed in the B-Zone.

These modeling results have been used in the FS to evaluate the relative effectiveness of the alternatives.

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Figures

Figures



Figure I-1
Model Grid
Hookston Station
Pleasant Hill, California

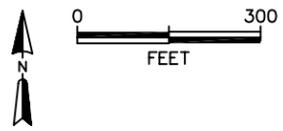
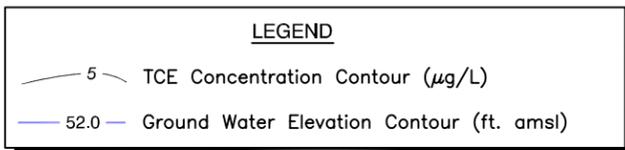
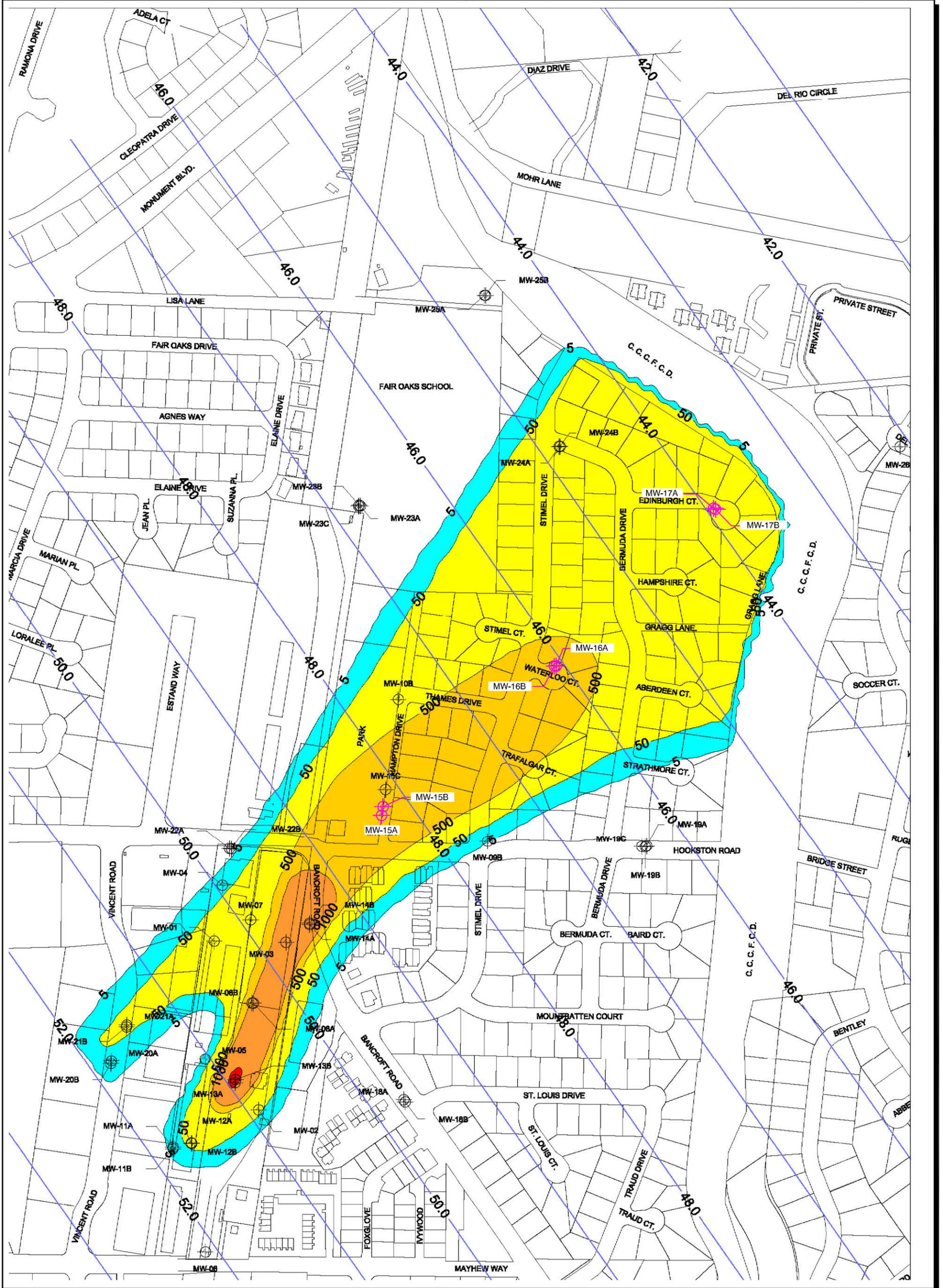


Figure I-2
Initial TCE Concentration in A-Zone
Hookston Station
Pleasant Hill, California

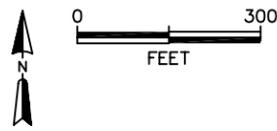
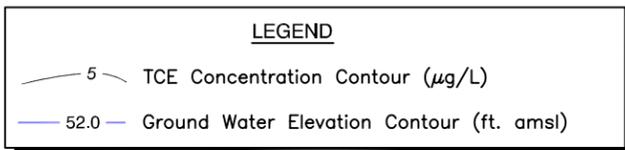
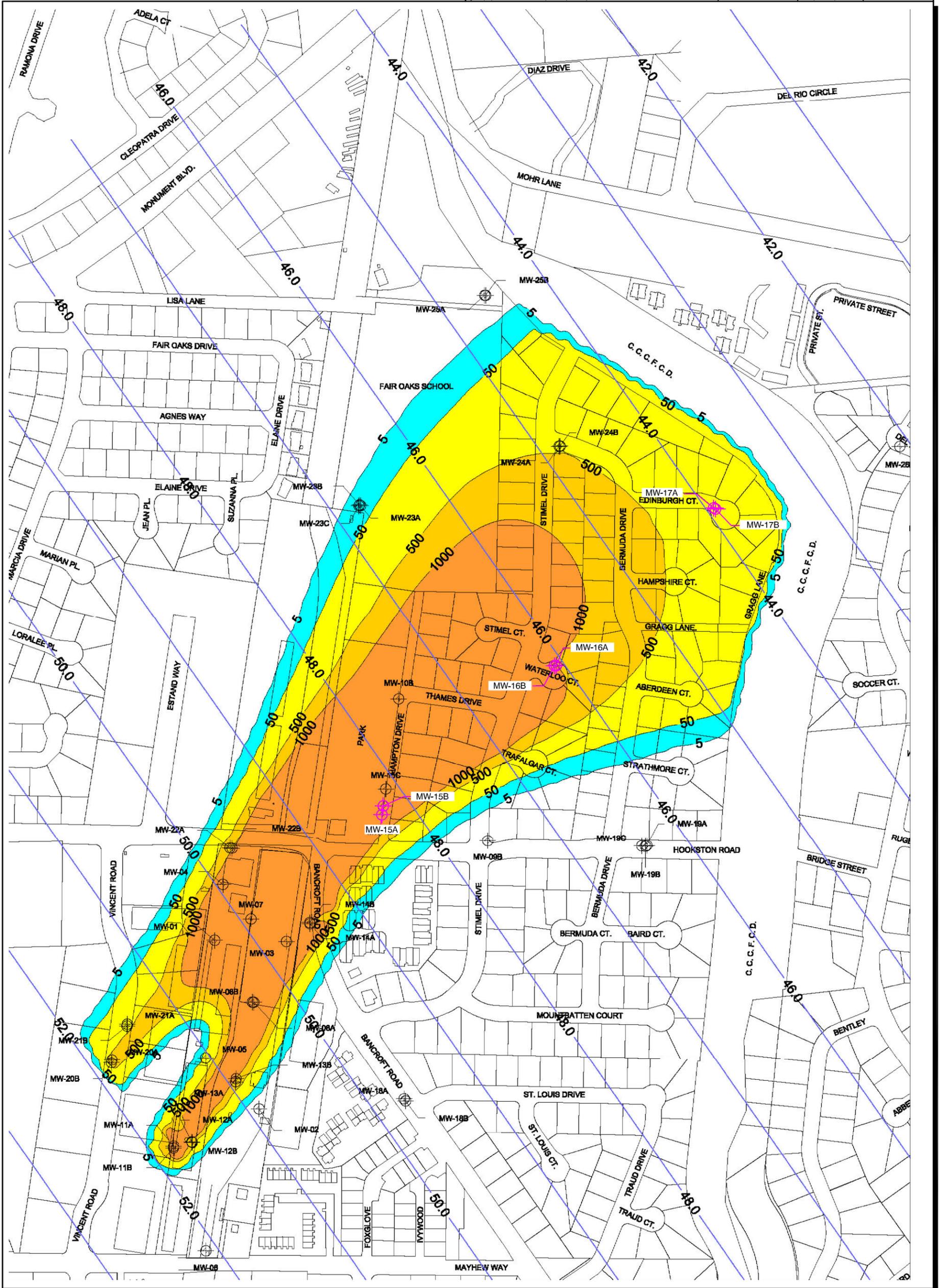


Figure I-3
Initial TCE Concentration in B-Zone
Hookston Station
Pleasant Hill, California

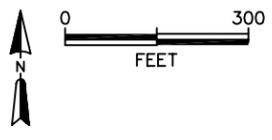
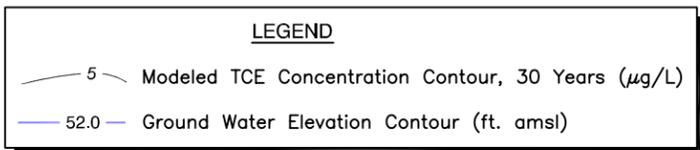
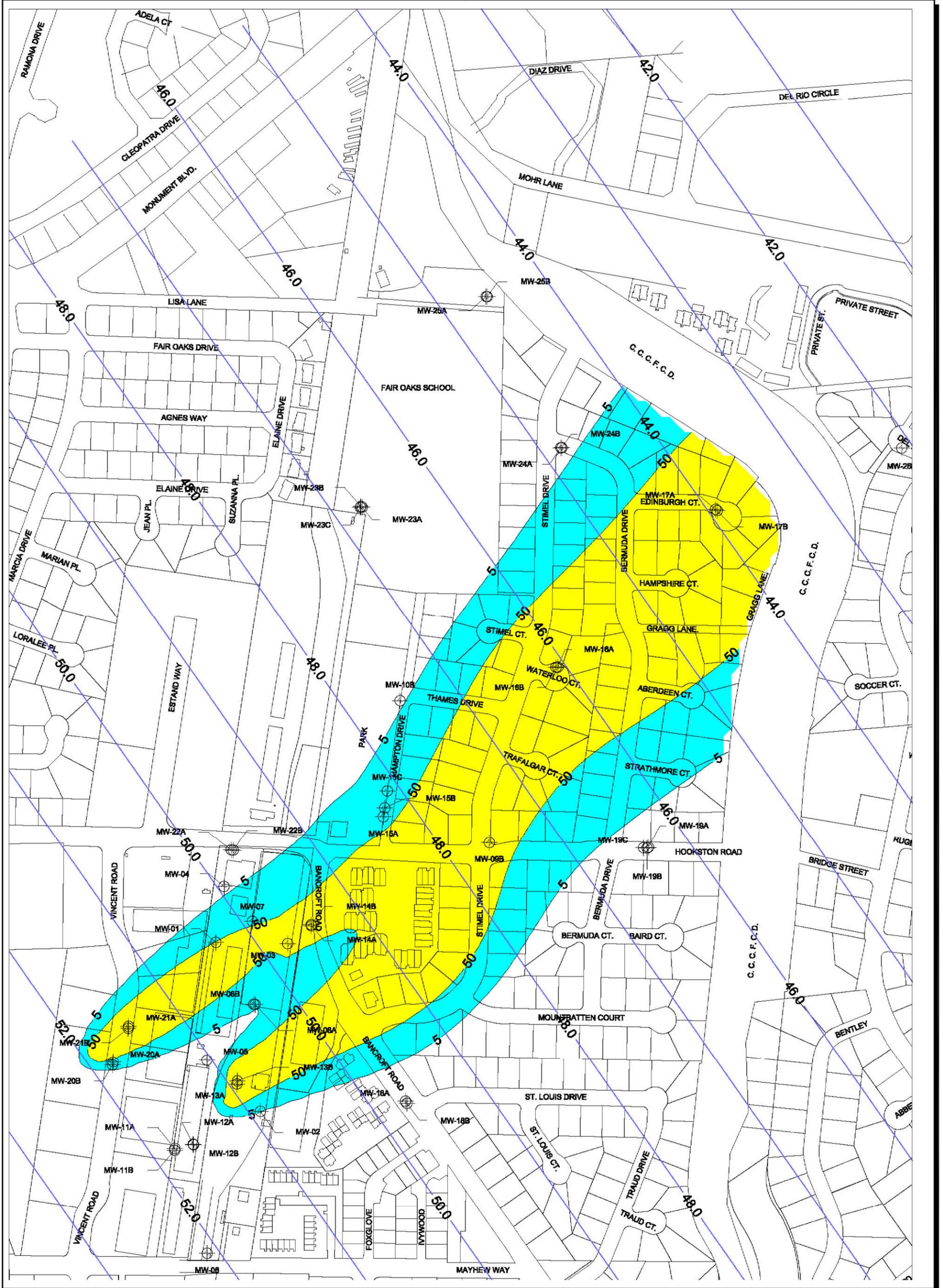


Figure I-4
 Alternative 3
 Bioremediation in A-Zone, TCE Concentration Solution
 Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

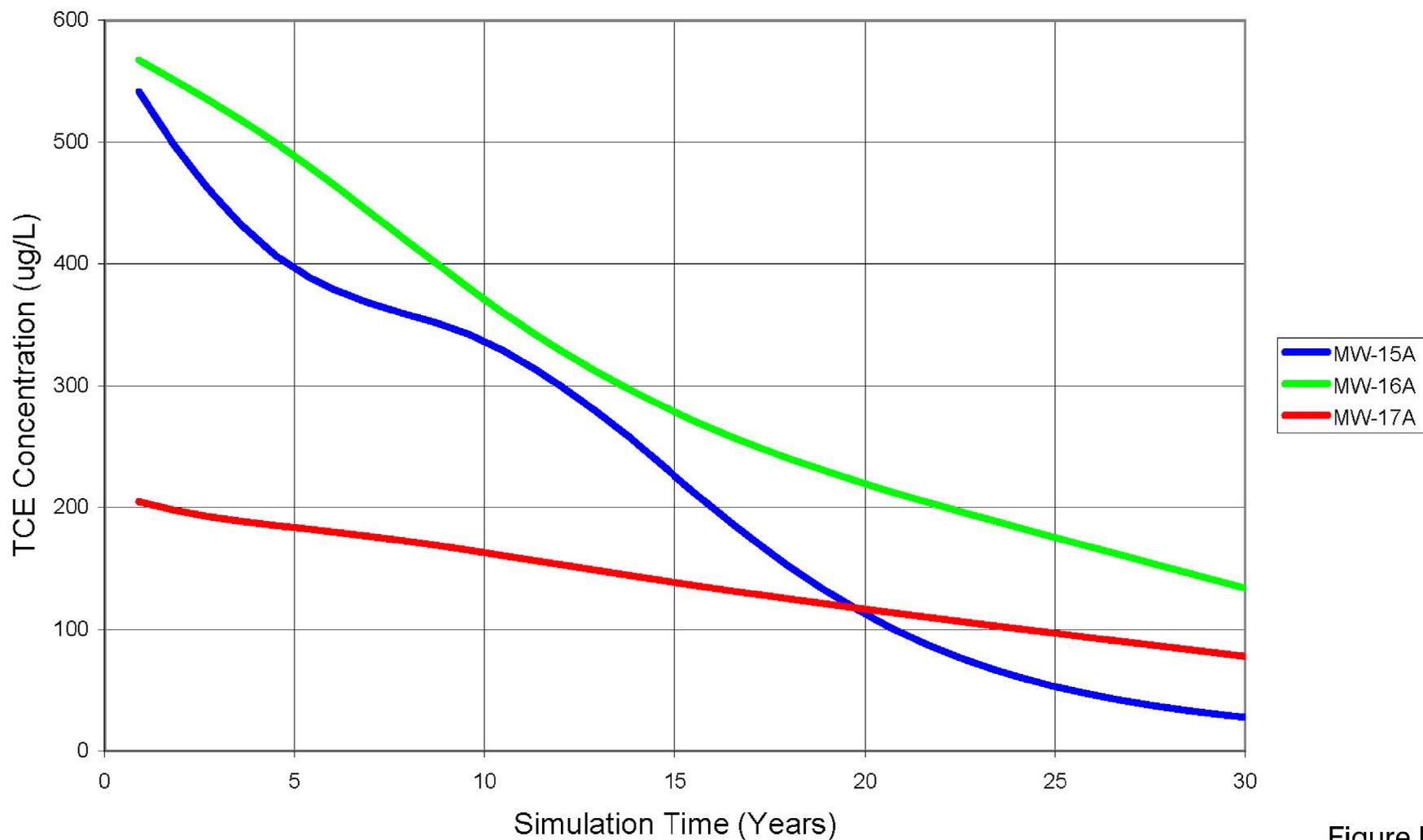


Figure I-5
Alternative 3
Bioremediation in A-Zone
Modeled Concentration vs. Time at Selected A Zone Wells
Hookston Station
Pleasant Hill, California

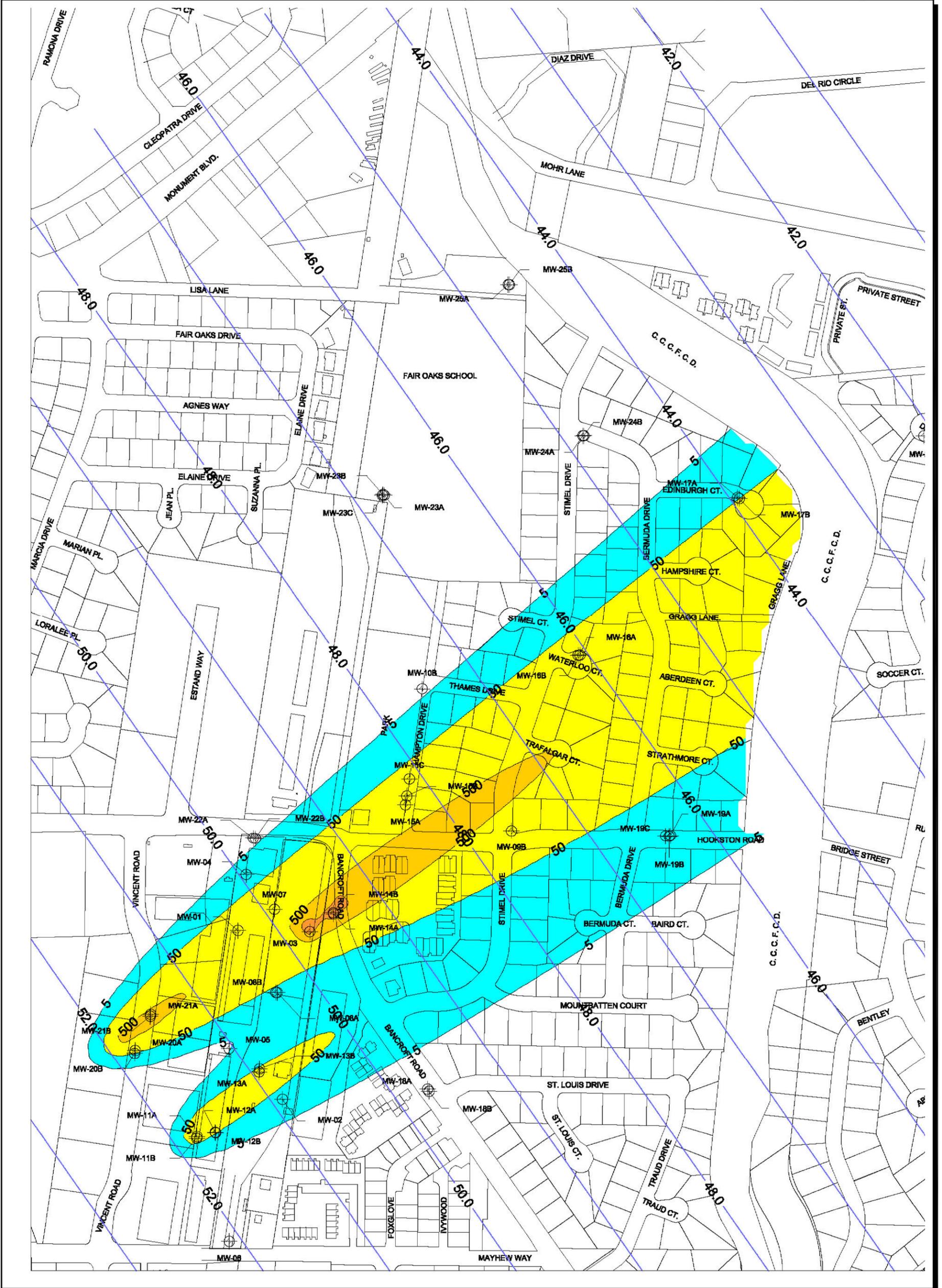


Figure I-6
 Alternative 3
 Chemical Oxidation in B-Zone, No Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

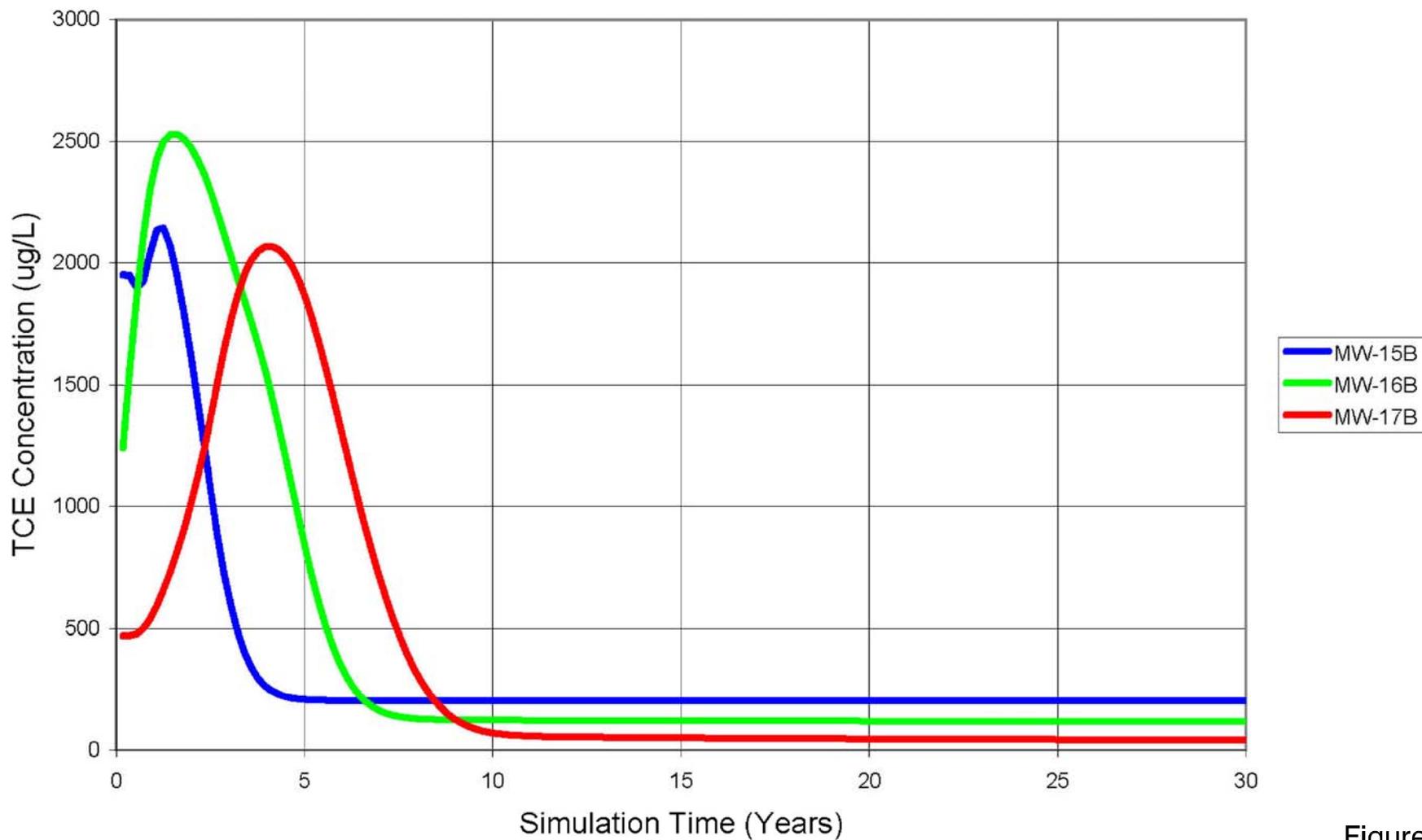


Figure I-7
Alternative 3
Chemical Oxidation in B-Zone, No Degradation
Modeled Concentration vs. Time at Selected B Zone Wells
Hookston Station
Pleasant Hill, California
ERM 07/06

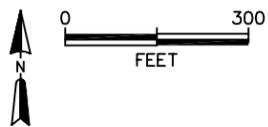
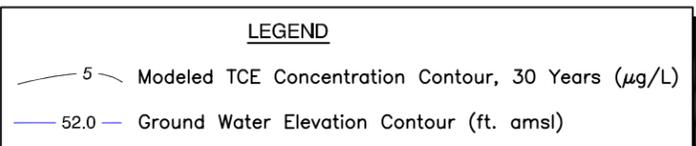
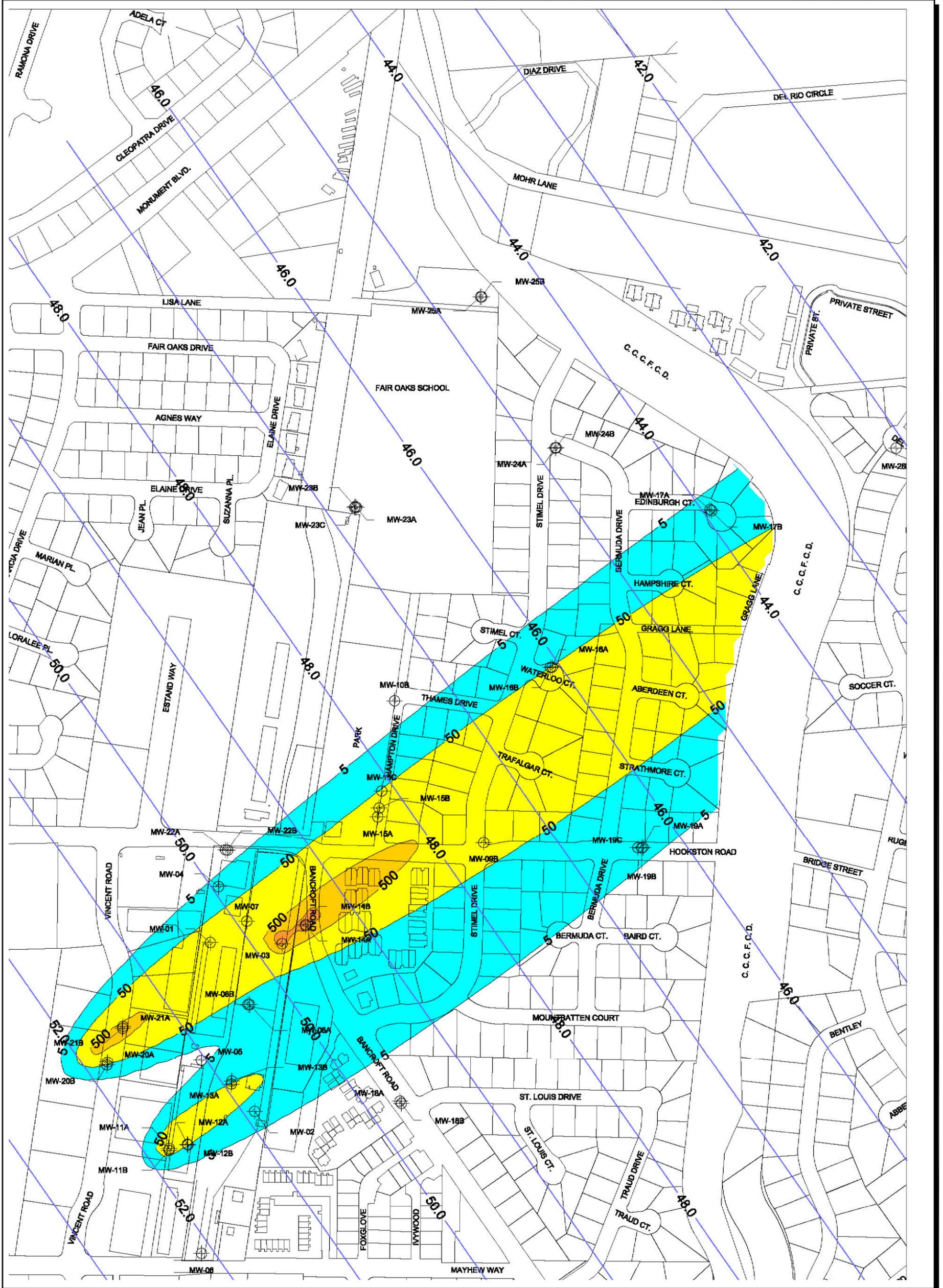


Figure I-8
 Alternative 3
 Chemical Oxidation in B-Zone, With Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

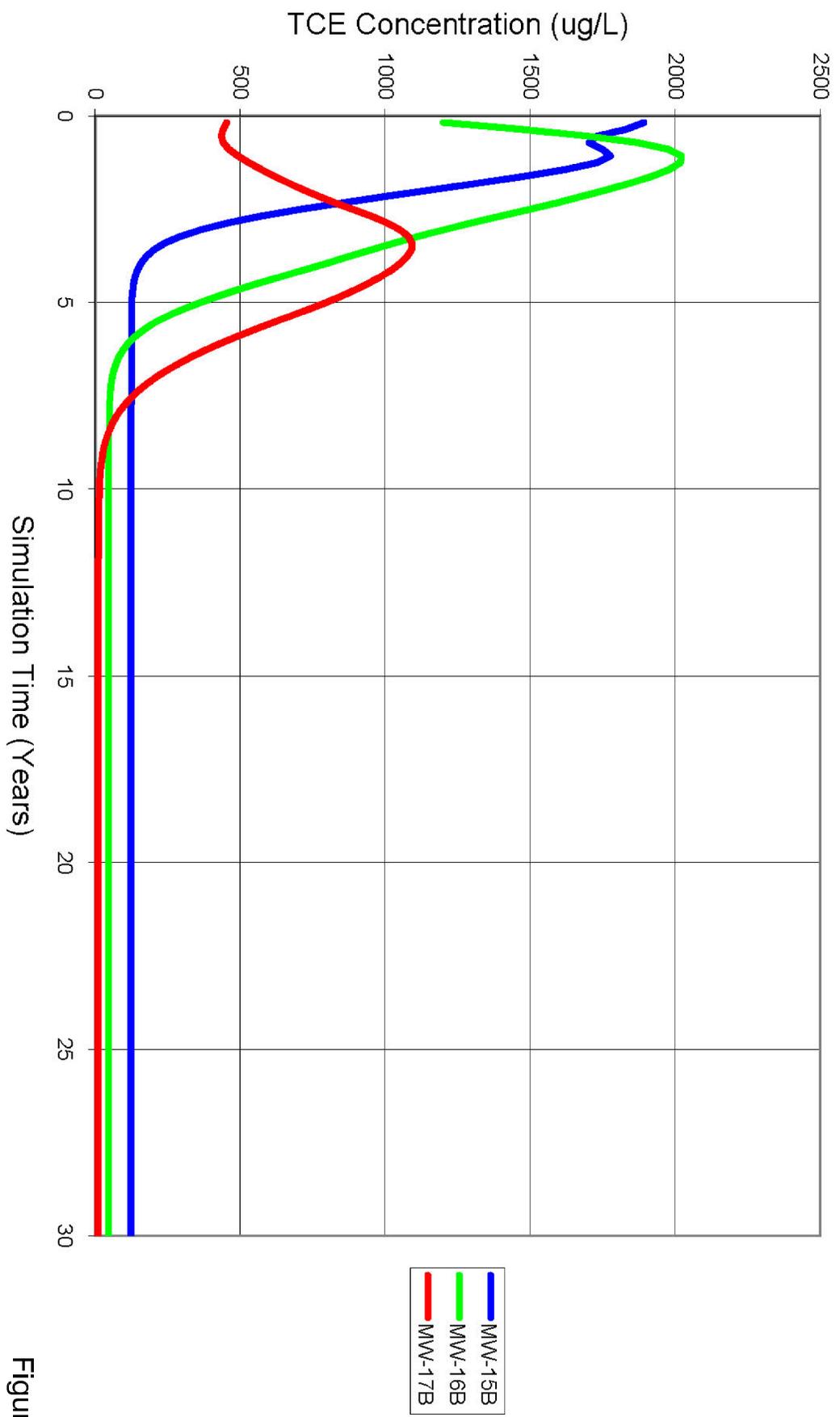
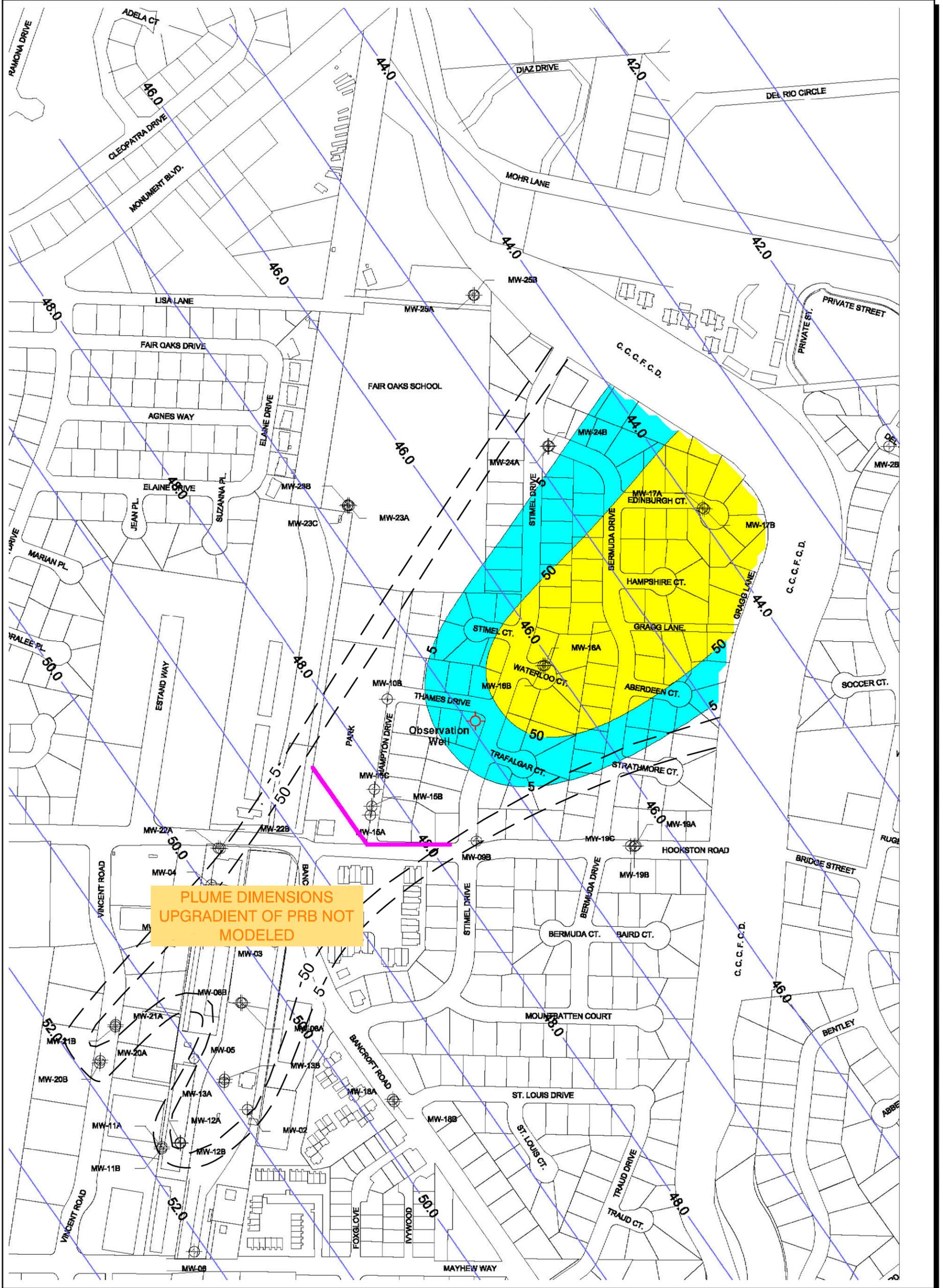


Figure I-9
Alternative 3
Chemical Oxidation in B-Zone, With Degradation
Modeled Concentration vs. Time at Selected A Zone Wells
 Hookston Station
 Pleasant Hill, California



PLUME DIMENSIONS
UPGRADIENT OF PRB NOT
MODELED

LEGEND	
	Modeled TCE Concentration Contour, 30 Years ($\mu\text{g/L}$)
	Current TCE Concentration Contour ($\mu\text{g/L}$)
	Ground Water Elevation Contour (ft. amsl)

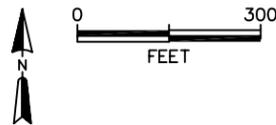


Figure I-10
Alternative 4
PRB in A-Zone, No Degradation
TCE Concentration Solution, Simulation Time 30 Years
Hookston Station
Pleasant Hill, California

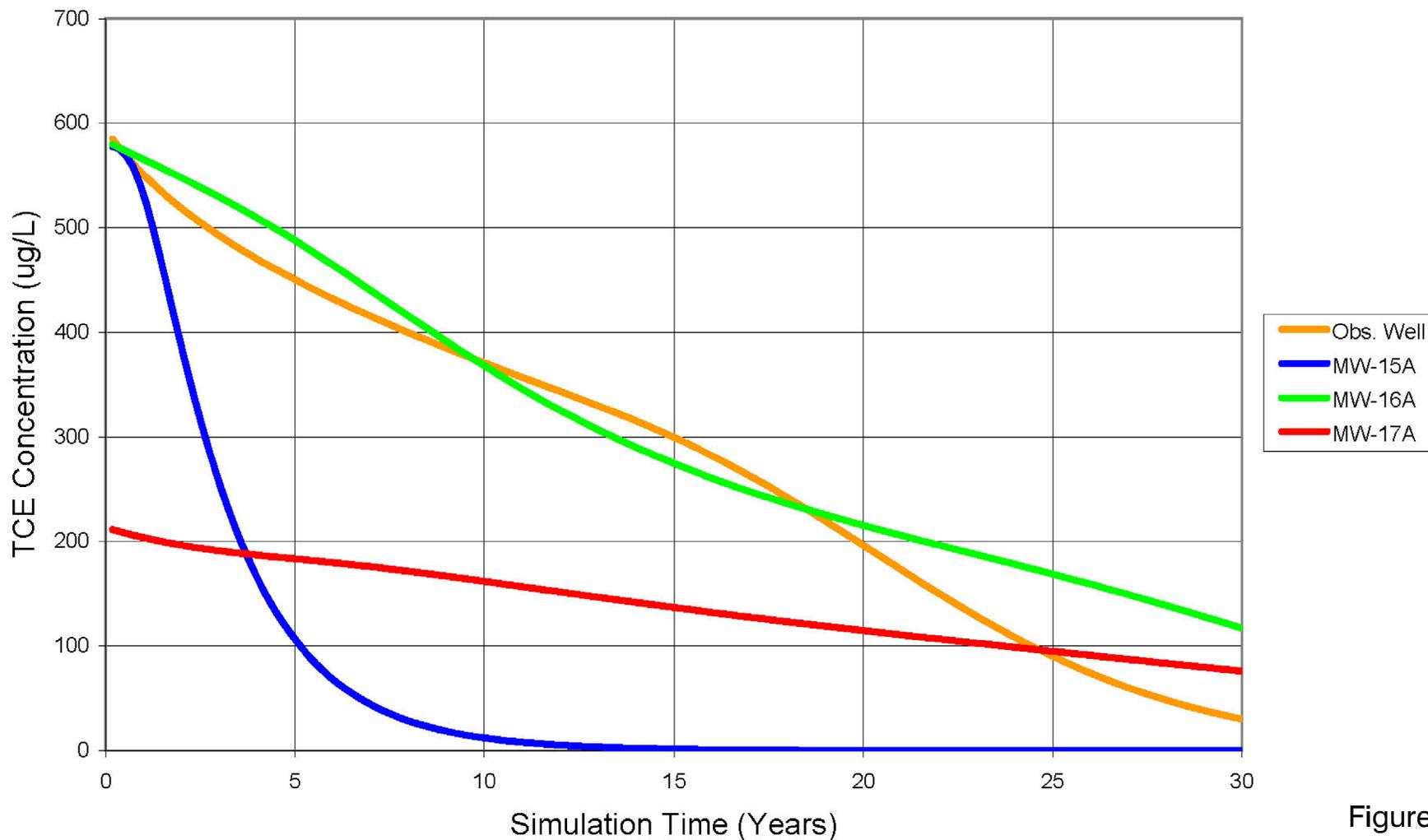
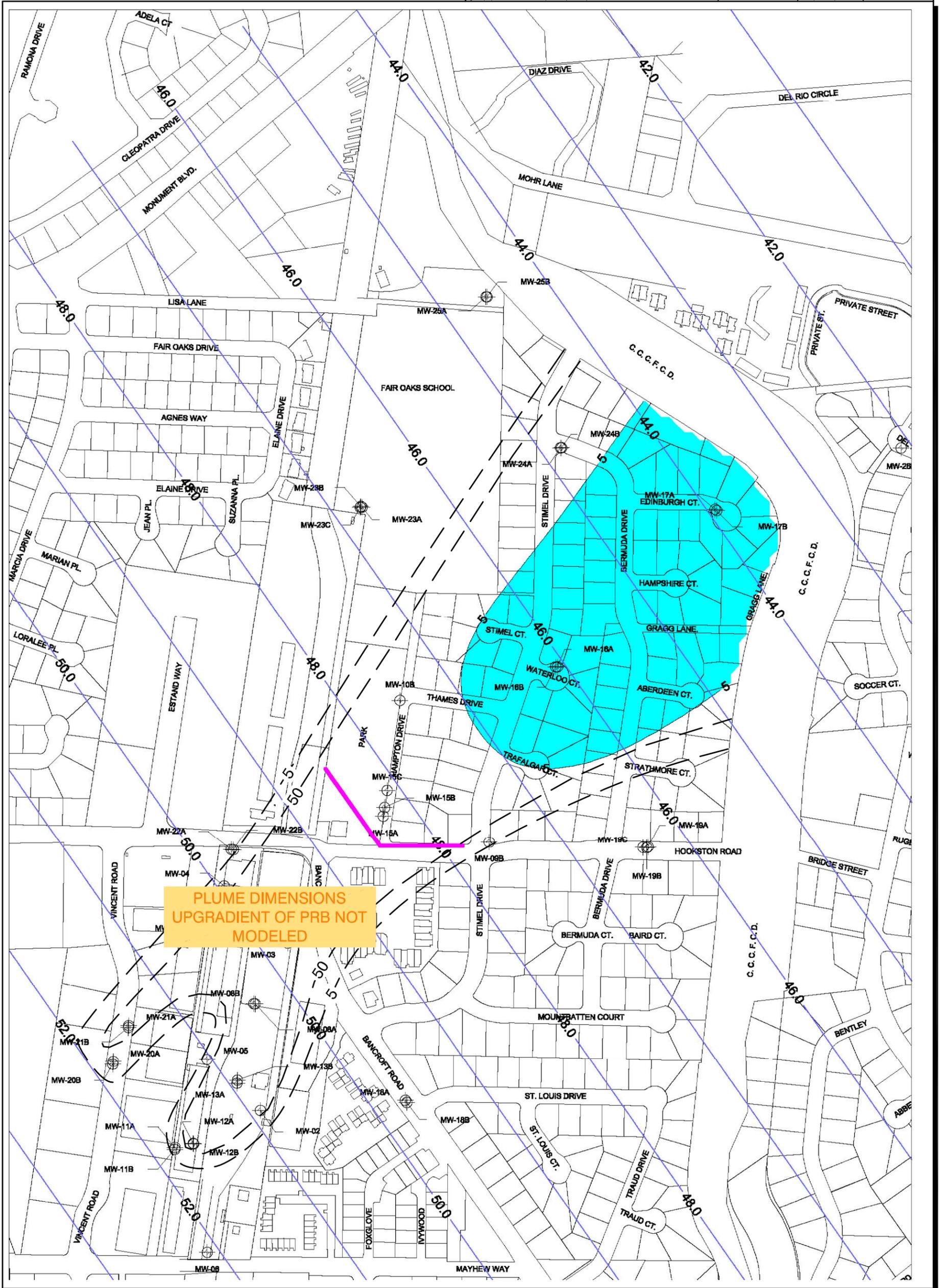


Figure I-11
Alternative 4
PRB in A-Zone, No Degradation
Modeled Concentration vs. Time at Selected A Zone Wells
Hookston Station
Pleasant Hill, California



PLUME DIMENSIONS
UPGRADIENT OF PRB NOT
MODELED

LEGEND	
	Modeled TCE Concentration Contour, 30 Years ($\mu\text{g/L}$)
	Current TCE Concentration Contour ($\mu\text{g/L}$)
	Ground Water Elevation Contour (ft. amsl)

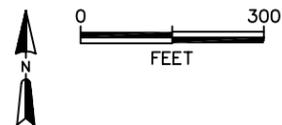


Figure I-12
Alternative 4
PRB in A-Zone, With Degradation
TCE Concentration Solution, Simulation Time 30 Years
Hookston Station
Pleasant Hill, California

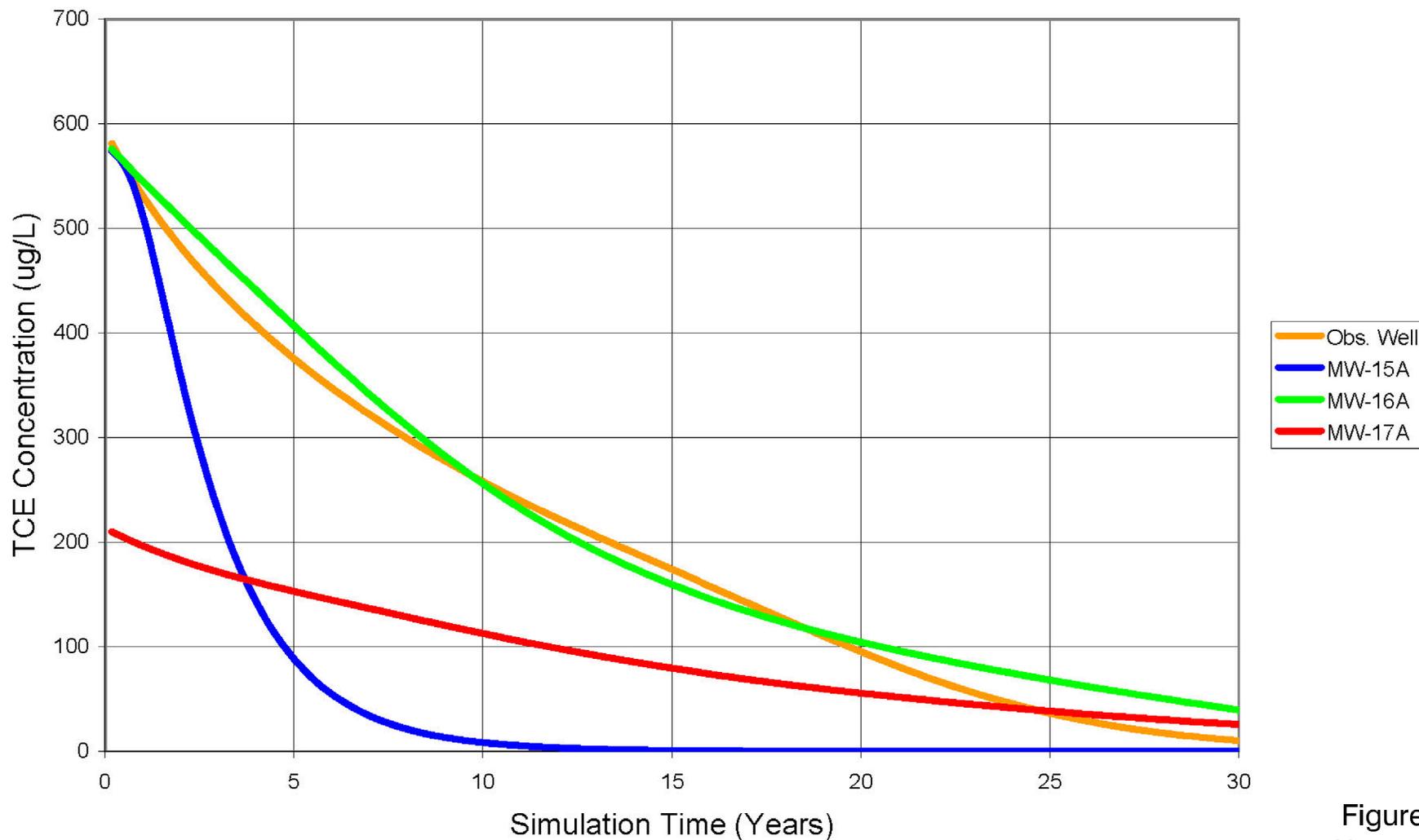
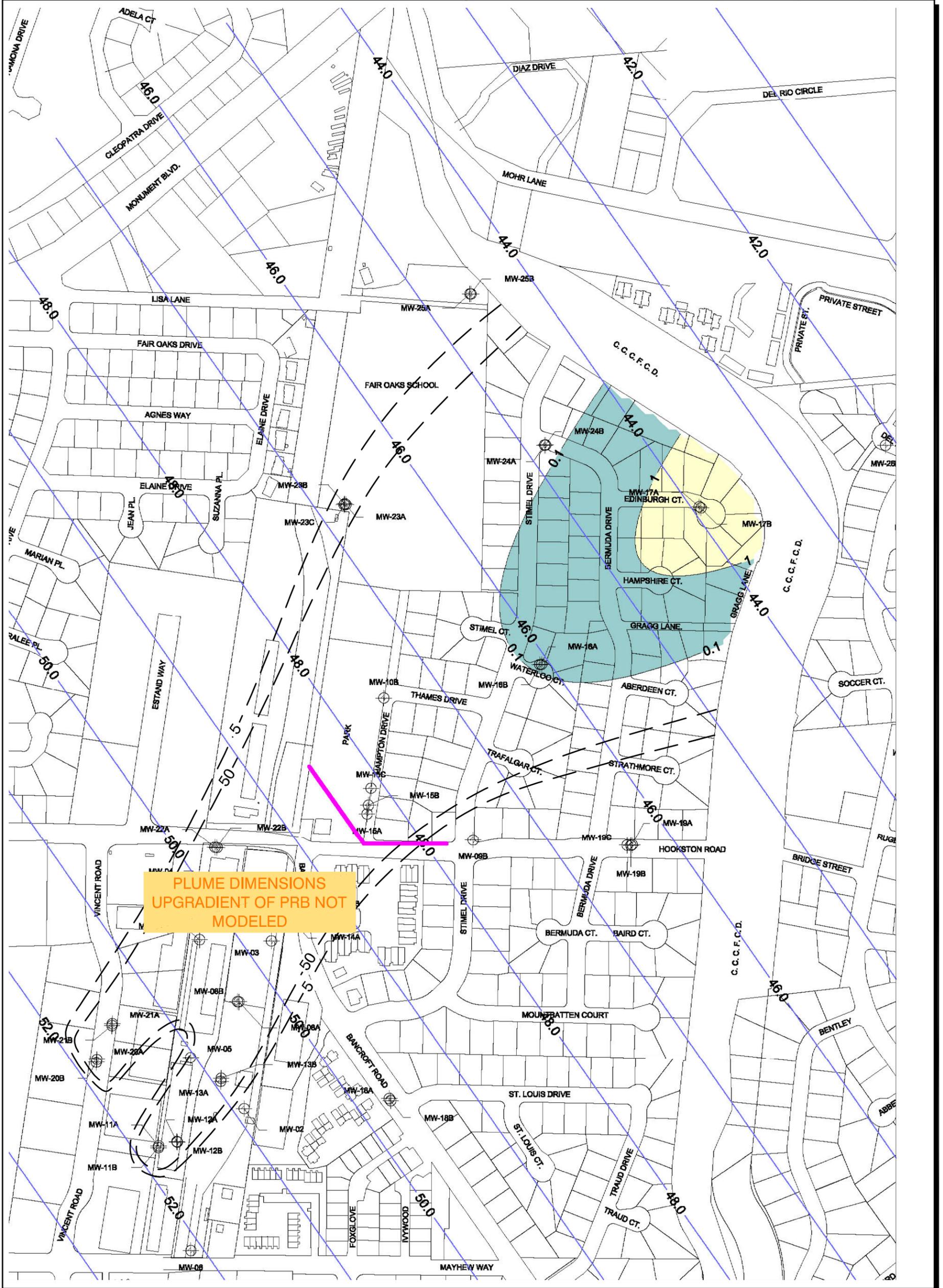


Figure I-13
Alternative 4
PRB in A-Zone, With Degradation
Modeled Concentration vs. Time at Selected A Zone Wells
Hookston Station
Pleasant Hill, California



LEGEND	
	Modeled TCE Concentration Contour, 30 Years (µg/L)
	Current TCE Concentration Contour (µg/L)
	Ground Water Elevation Contour (ft. amsl)

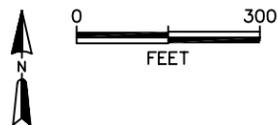


Figure I-14
 Alternative 5
 PRB in B-Zone, No Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

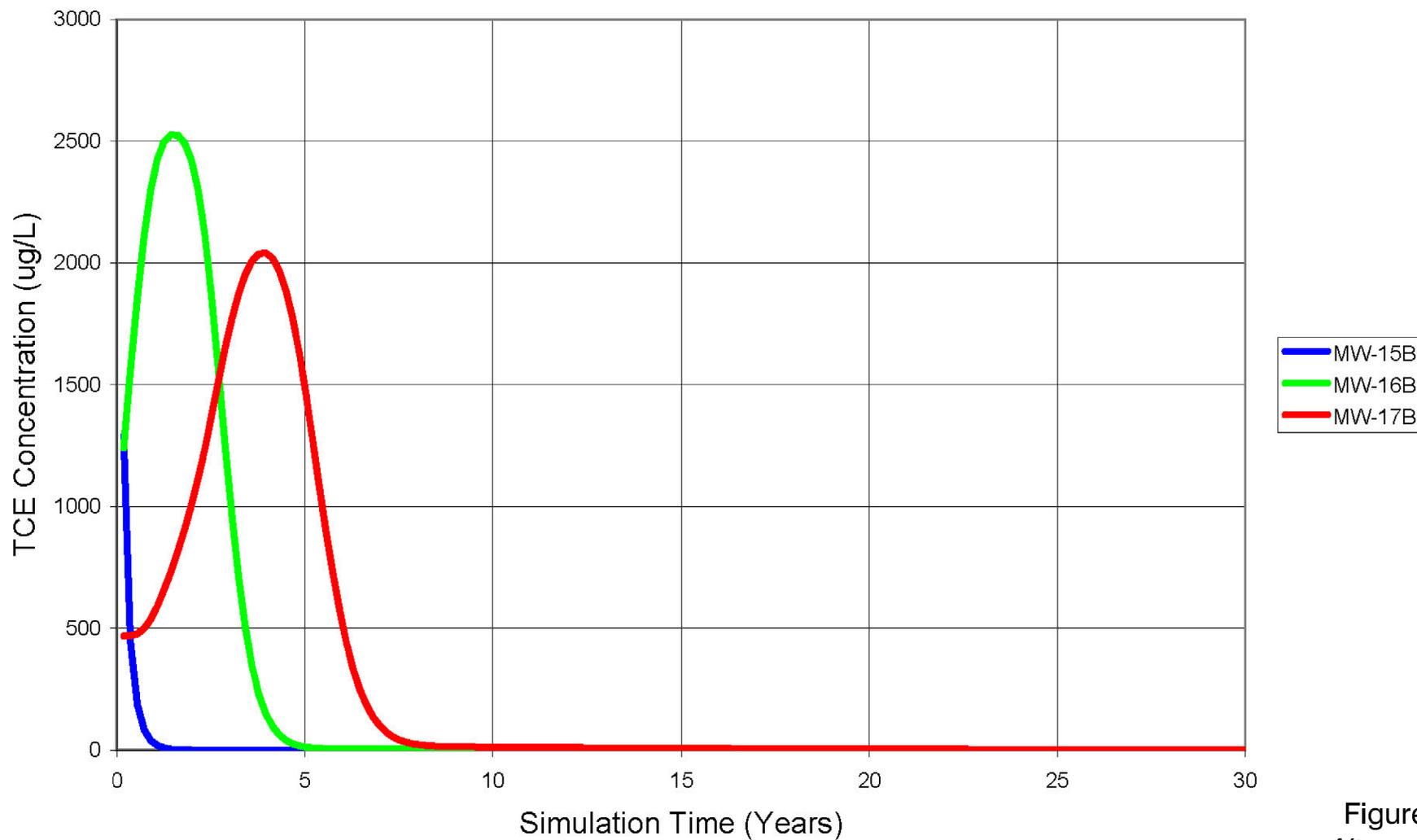
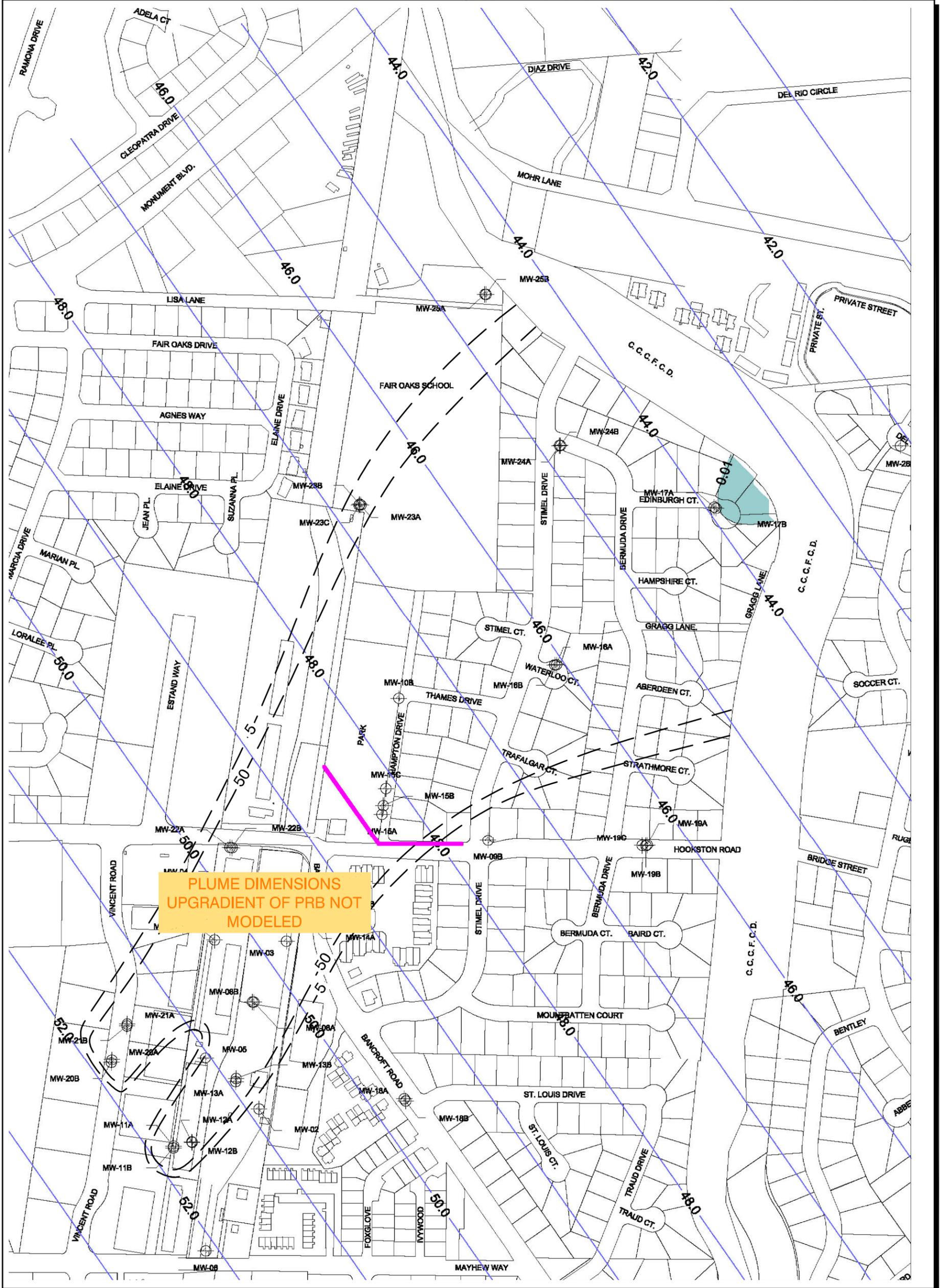


Figure I-15
Alternative 5
PRB in B-Zone, No Degradation
Modeled Concentration vs. Time at Selected B Zone Wells
Hookston Station
Pleasant Hill, California
ERM 07/06



PLUME DIMENSIONS
UPGRADIENT OF PRB NOT
MODELED

LEGEND	
	Modeled TCE Concentration Contour, 30 Years ($\mu\text{g/L}$)
	Current TCE Concentration Contour ($\mu\text{g/L}$)
	Ground Water Elevation Contour (ft. amsl)

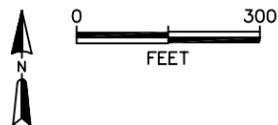


Figure I-16
Alternative 5
PRB in B-Zone, With Degradation
TCE Concentration Solution, Simulation Time 30 Years
Hookston Station
Pleasant Hill, California

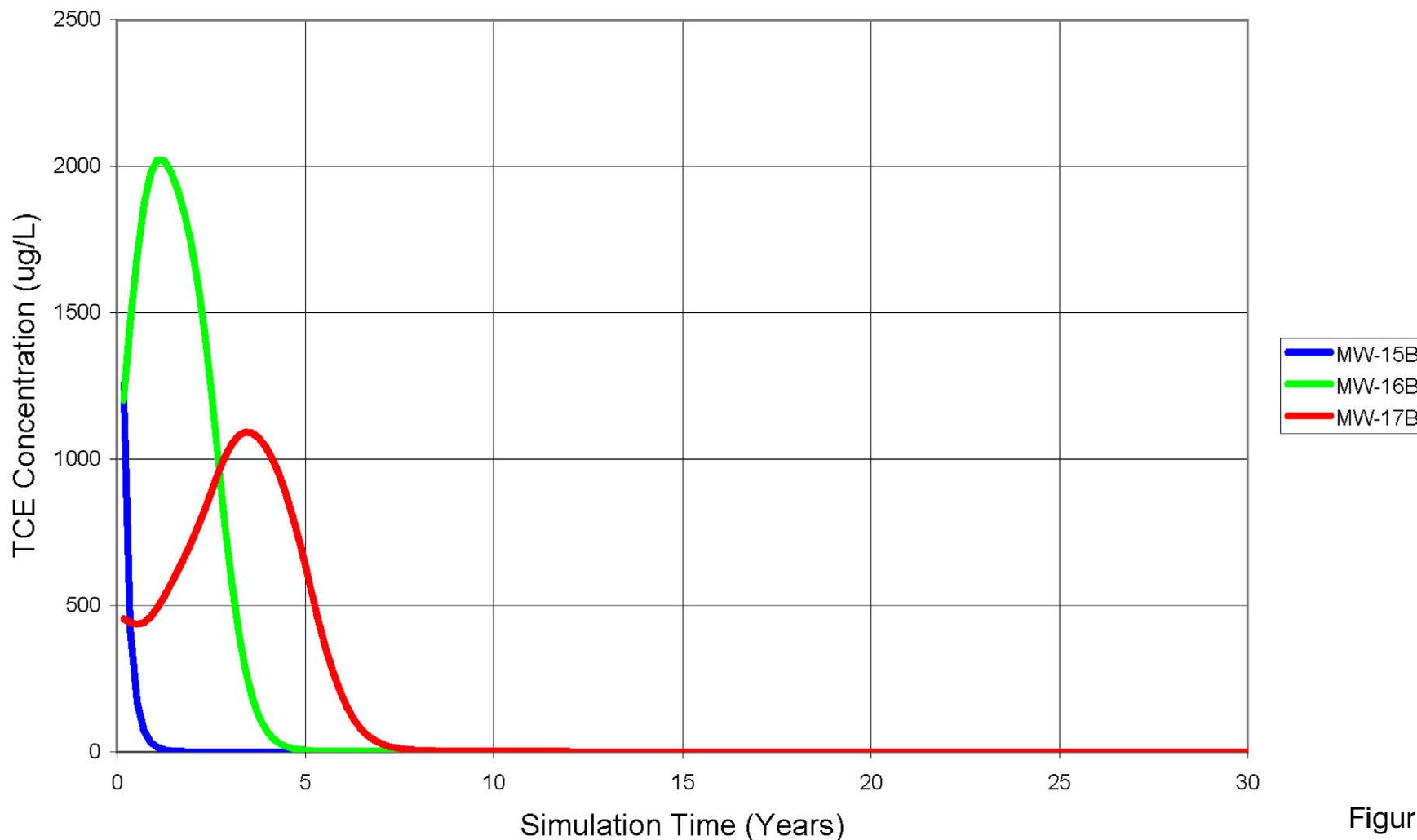
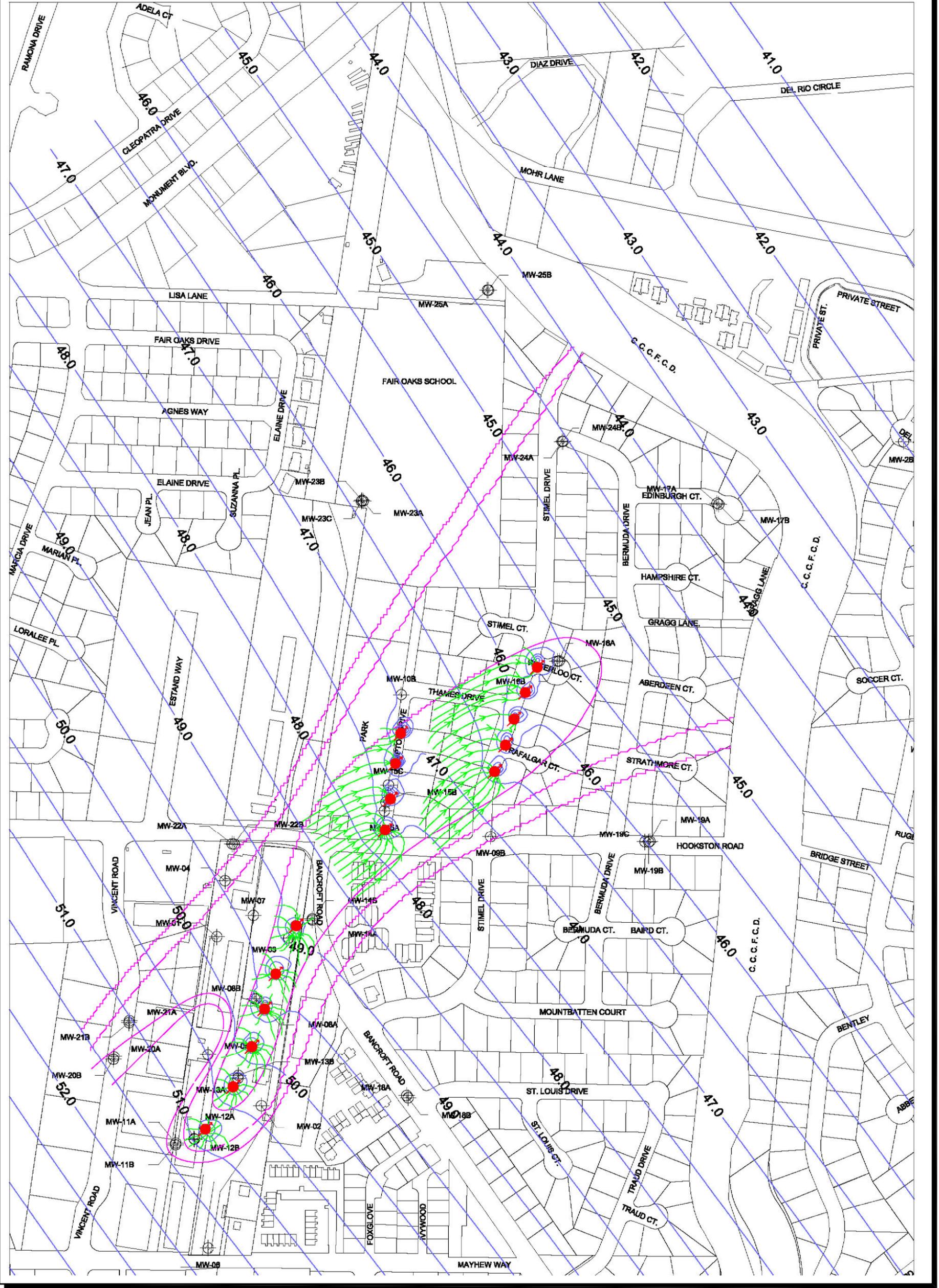


Figure I-17
Alternative 5
PRB in B-Zone, With Degradation
Modeled Concentration vs. Time at Selected B Zone Wells
Hookston Station
Pleasant Hill, California
ERM 07/06



LEGEND

- TCE Plume
- 52.0 Ground Water Elevation Contour (ft. amsl)
- Ground Water Capture Flowline Path (Modeled)
- Ground Water Extraction Well (Hypothetical)

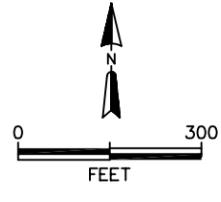
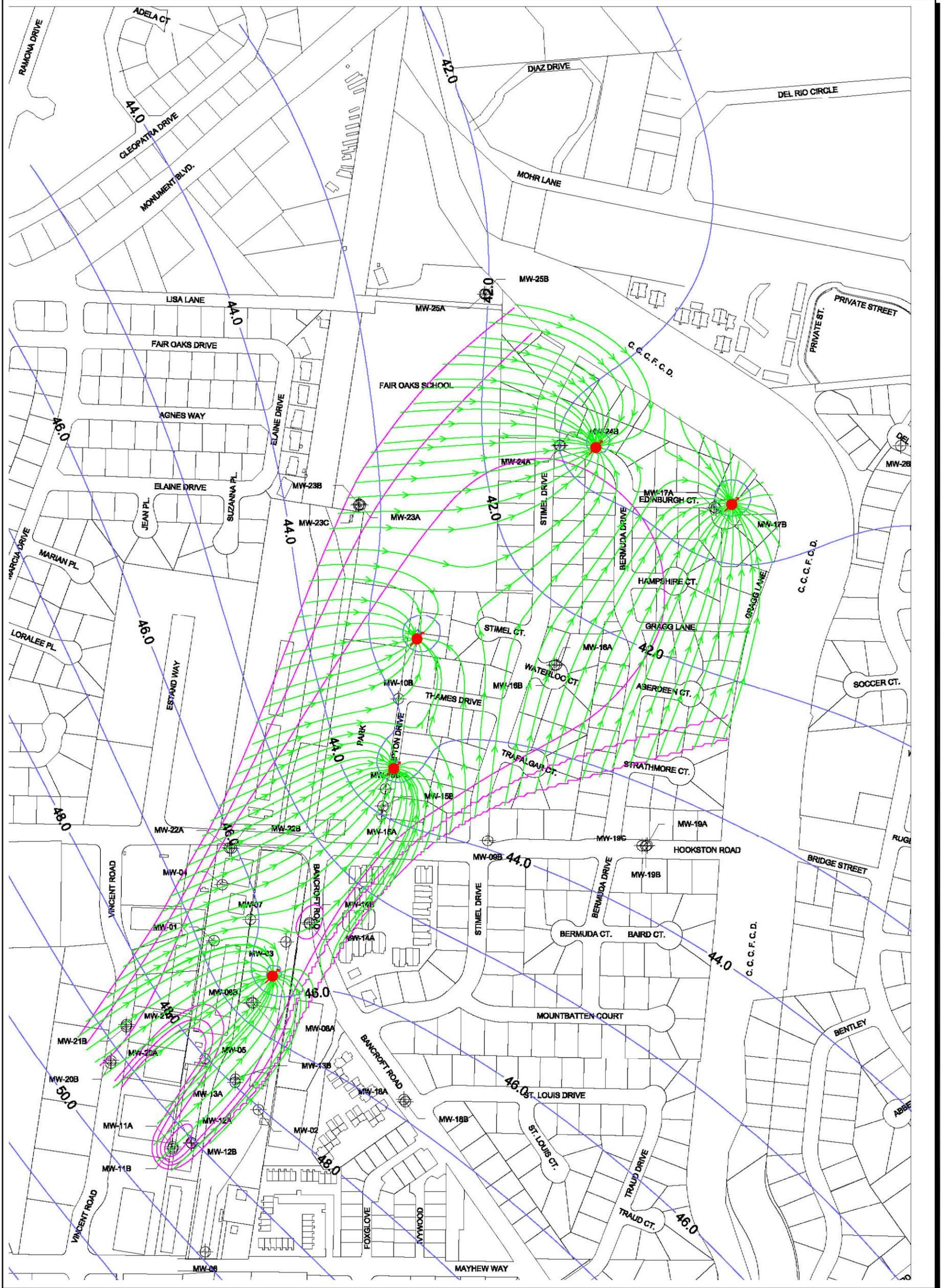


Figure I-18
 Alternative 6
 Pump and Treat
 Ground Water Flow Path Solution, A-Zone
 Hookston Station
 Pleasant Hill, California



LEGEND

- TTCE Plume
- 52.0 Ground Water Elevation Contour (ft. amsl)
- Ground Water Capture Flowline Path (Modeled)
- Ground Water Extraction Well (Hypothetical)

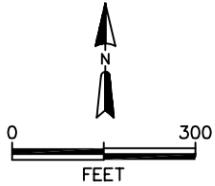
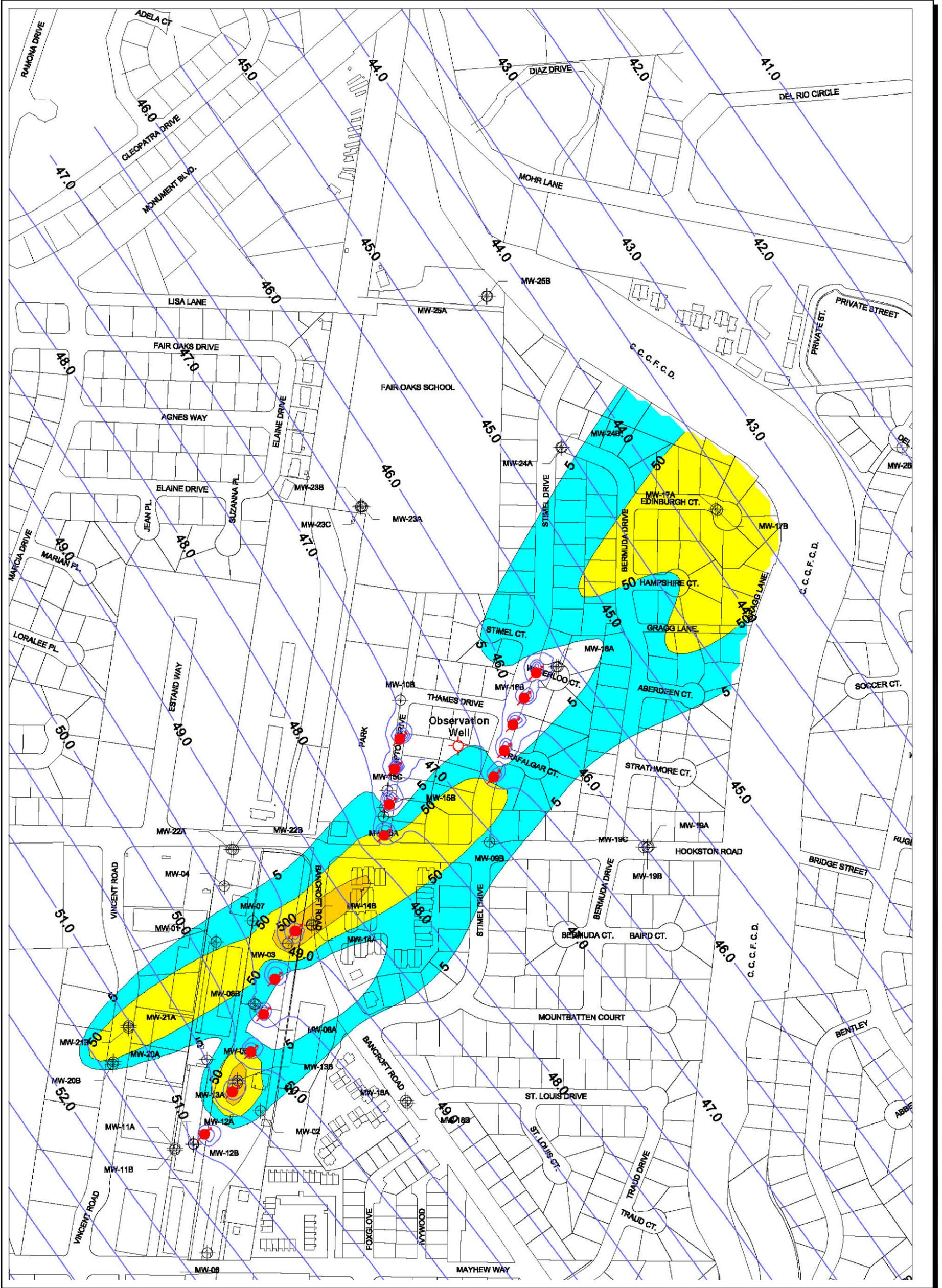


Figure I-19
 Alternative 6
 Pump and Treat
 Ground Water Flow Path Solution, B-Zone
 Hookston Station
 Pleasant Hill, California



LEGEND

- 5 Modeled TCE Concentration Contour, 30 Years ($\mu\text{g}/\text{L}$)
- 52.0 Ground Water Elevation Contour (ft. amsl)
- Ground Water Extraction Well (Hypothetical)

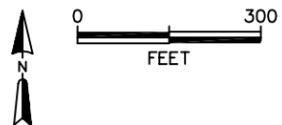


Figure I-20
 Alternative 6
 Pump and Treat in A-Zone, No Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

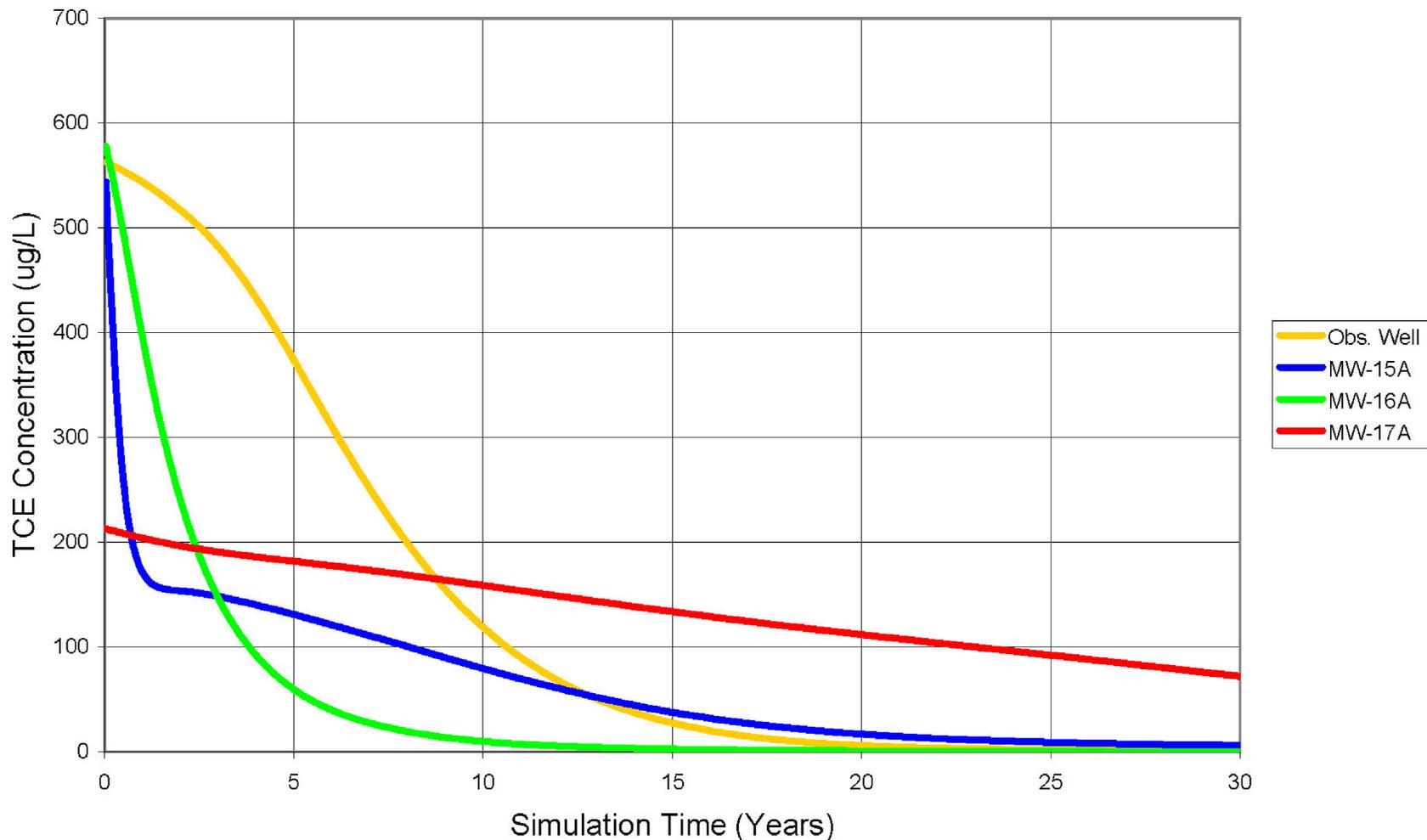
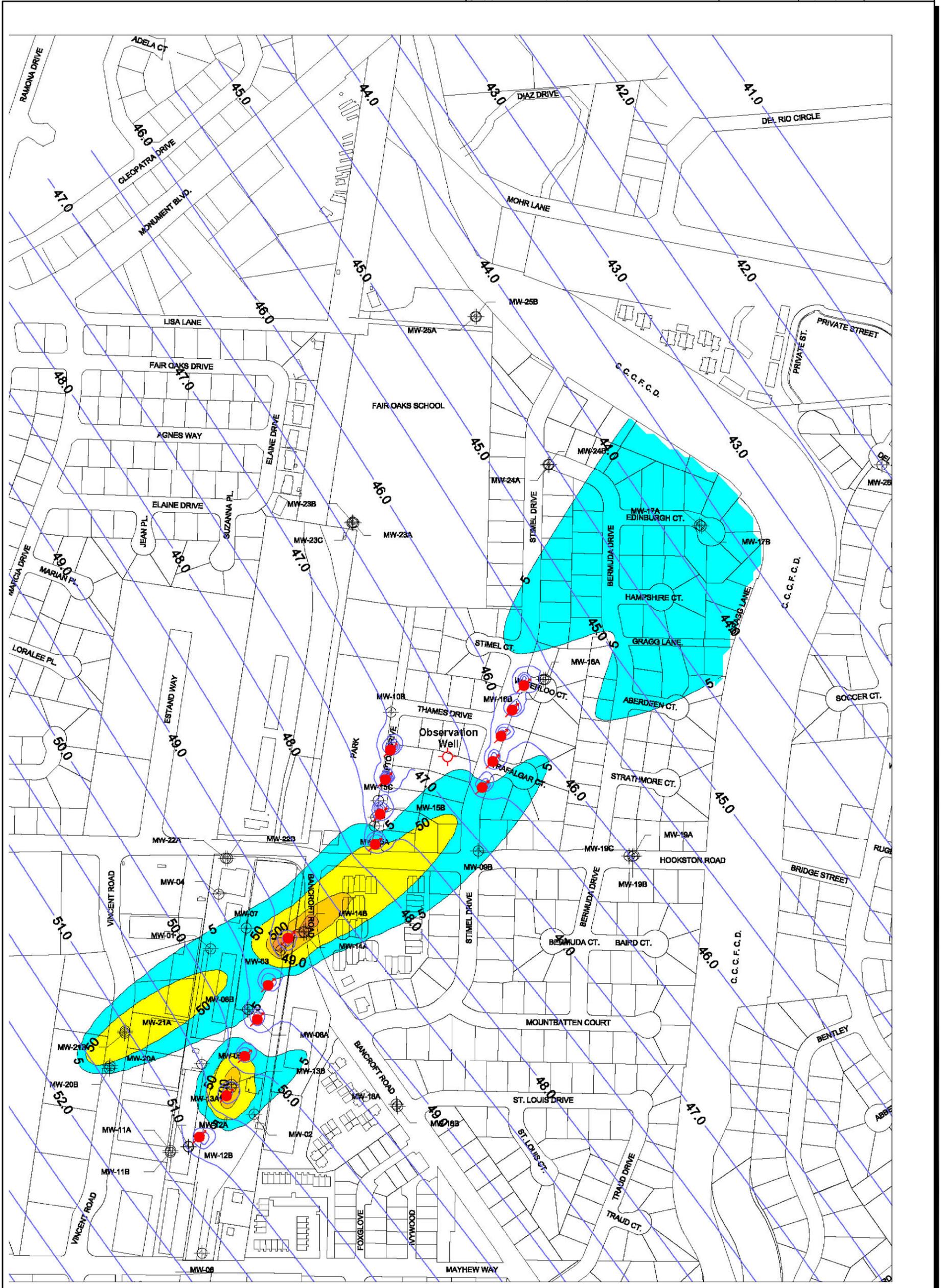


Figure I-21
Alternative 6
Pump and Treat in A-Zone, No Degradation
Modeled Concentration vs. Time at Selected A Zone Wells
Hookston Station
Pleasant Hill, California



LEGEND

- 50 Modeled TCE Concentration Contour, 30 Years (µg/L)
- 52.0 Ground Water Elevation Contour (ft. amsl)
- Ground Water Extraction Well (Hypothetical)

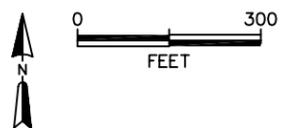


Figure I-22
 Alternative 6
 Pump and Treat in A-Zone, With Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

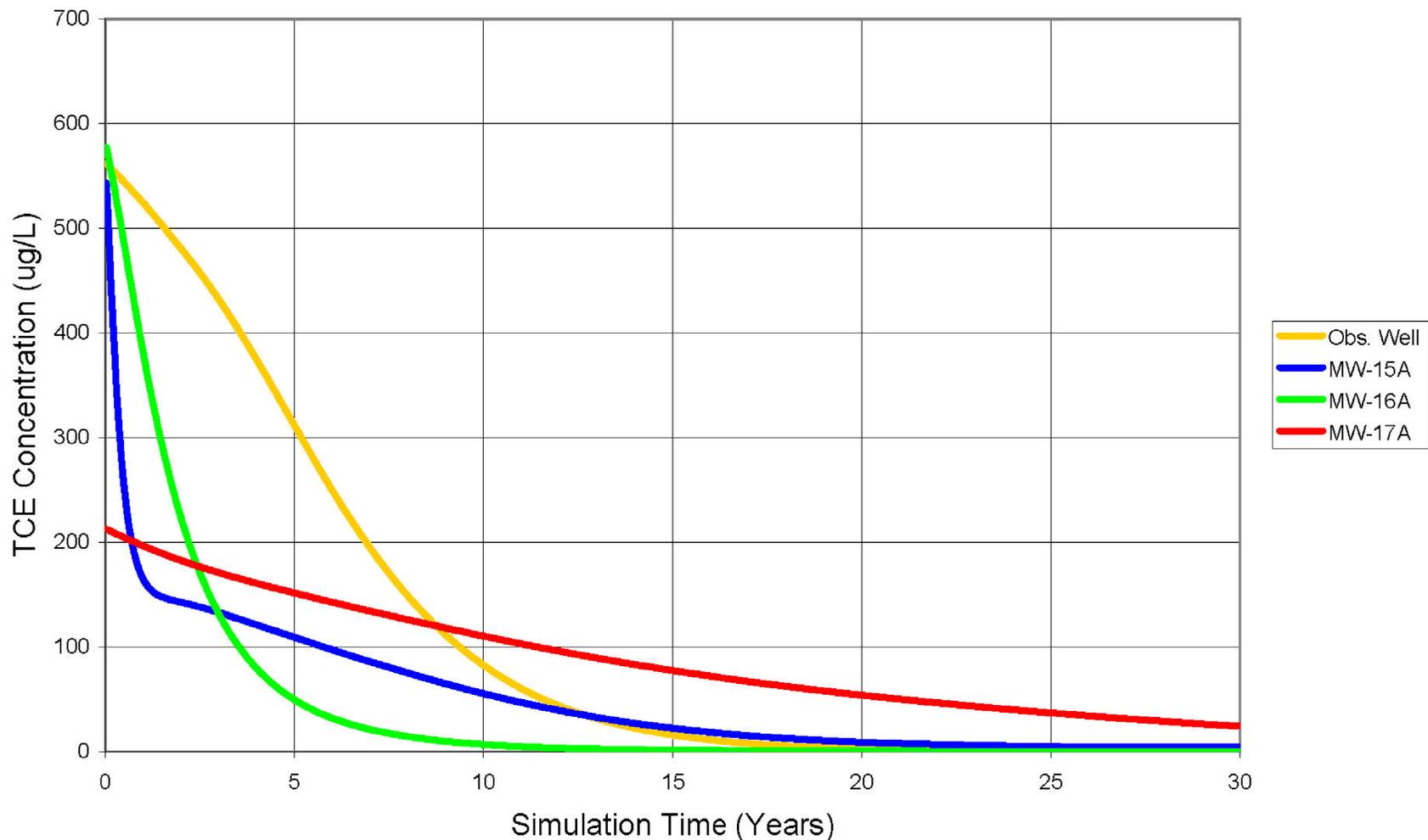


Figure I-23
Alternative 6
Pump and Treat in A-Zone, With Degradation
Modeled Concentration vs. Time at Selected A Zone Wells
Hookston Station
Pleasant Hill, California

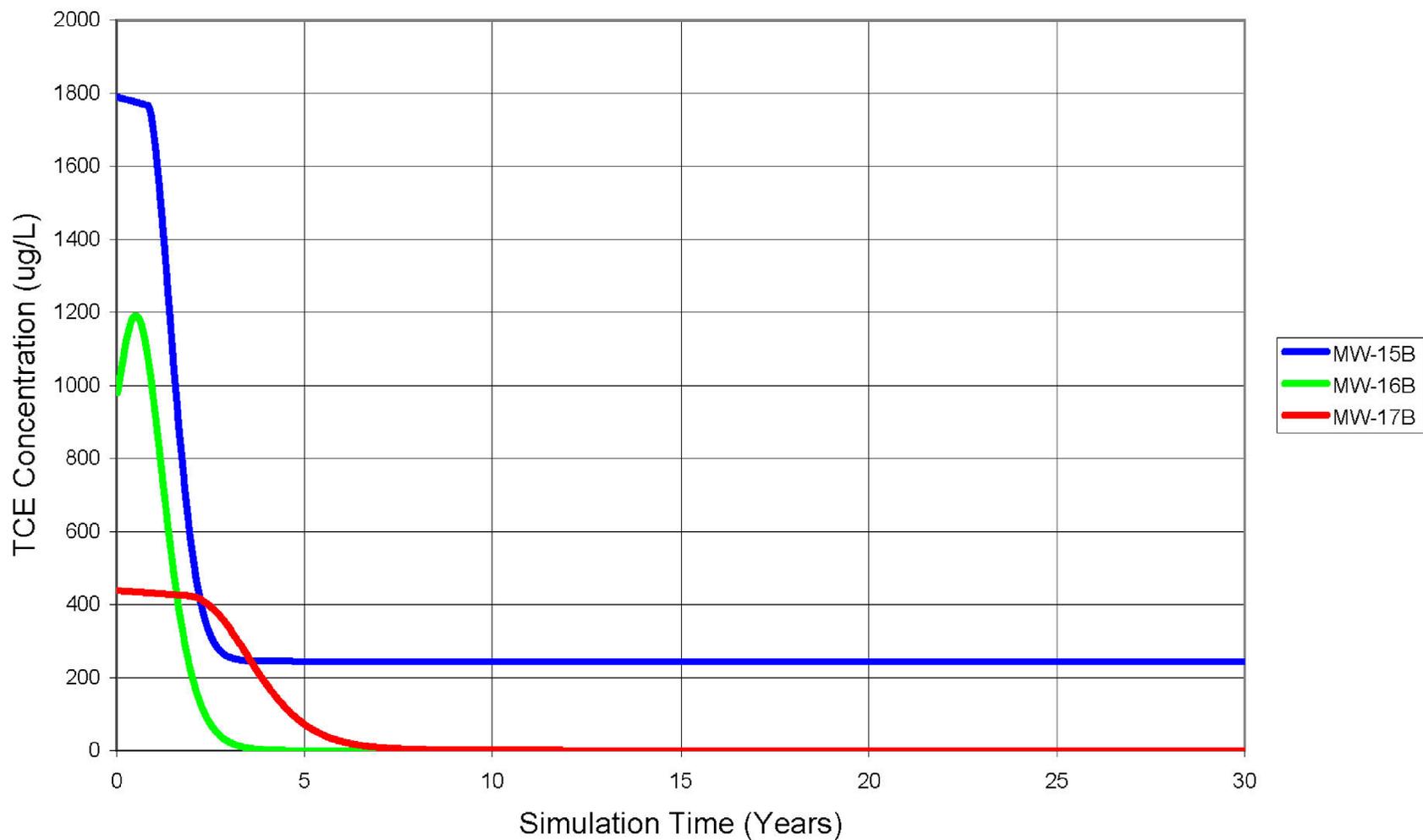
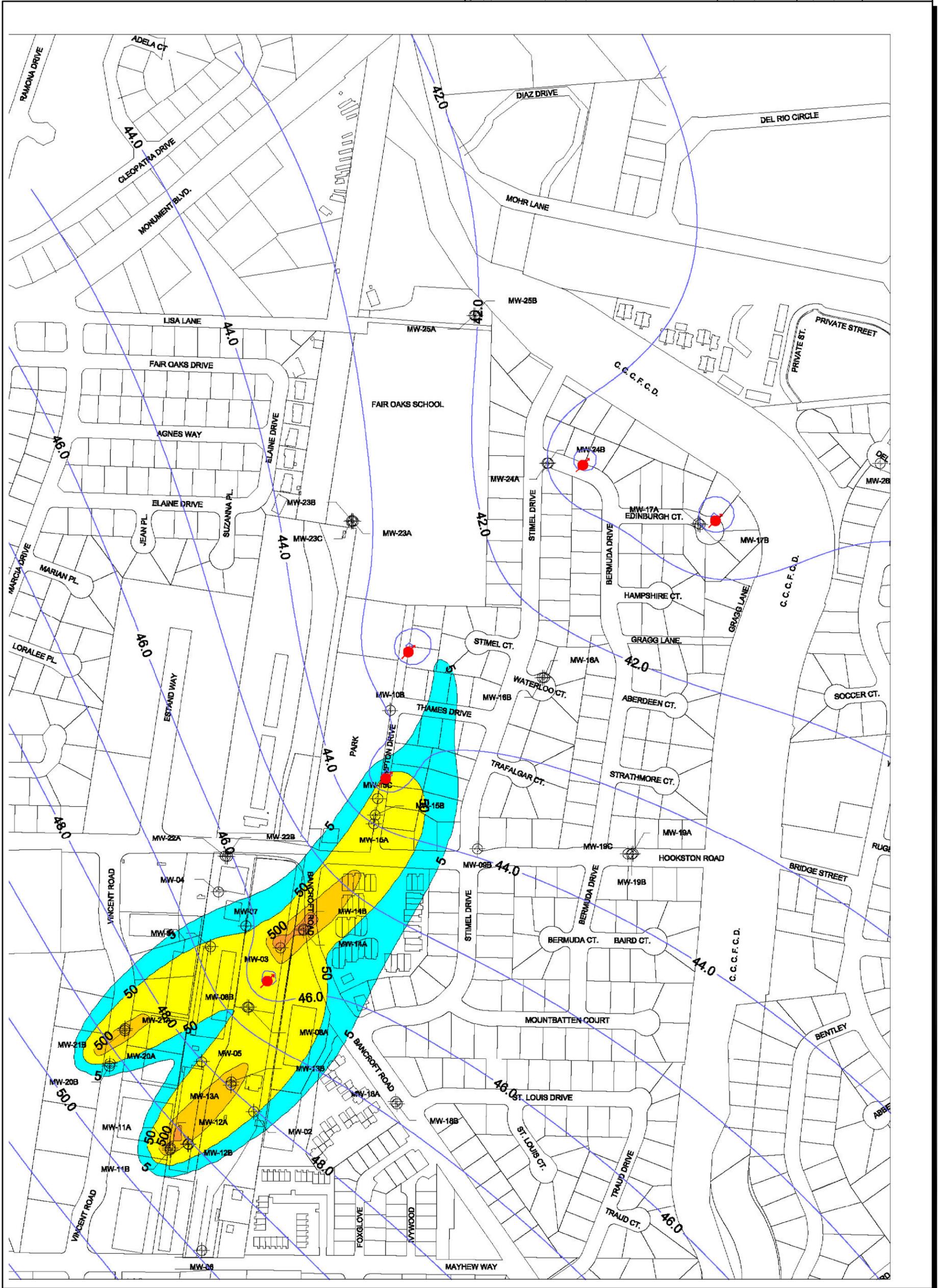


Figure I-25
Alternative 6
Pump and Treat in B-Zone, No Degradation
Modeled Concentration vs. Time at Selected B Zone Wells
Hookston Station
Pleasant Hill, California



LEGEND

- 5 — Modeled TCE Concentration Contour, 30 Years ($\mu\text{g/L}$)
- 52.0 — Ground Water Elevation Contour (ft. amsl)
- Ground Water Extraction Well (Hypothetical)

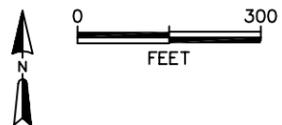


Figure I-26
 Alternative 6
 Pump and Treat in B-Zone, With Degradation
 TCE Concentration Solution, Simulation Time 30 Years
 Hookston Station
 Pleasant Hill, California

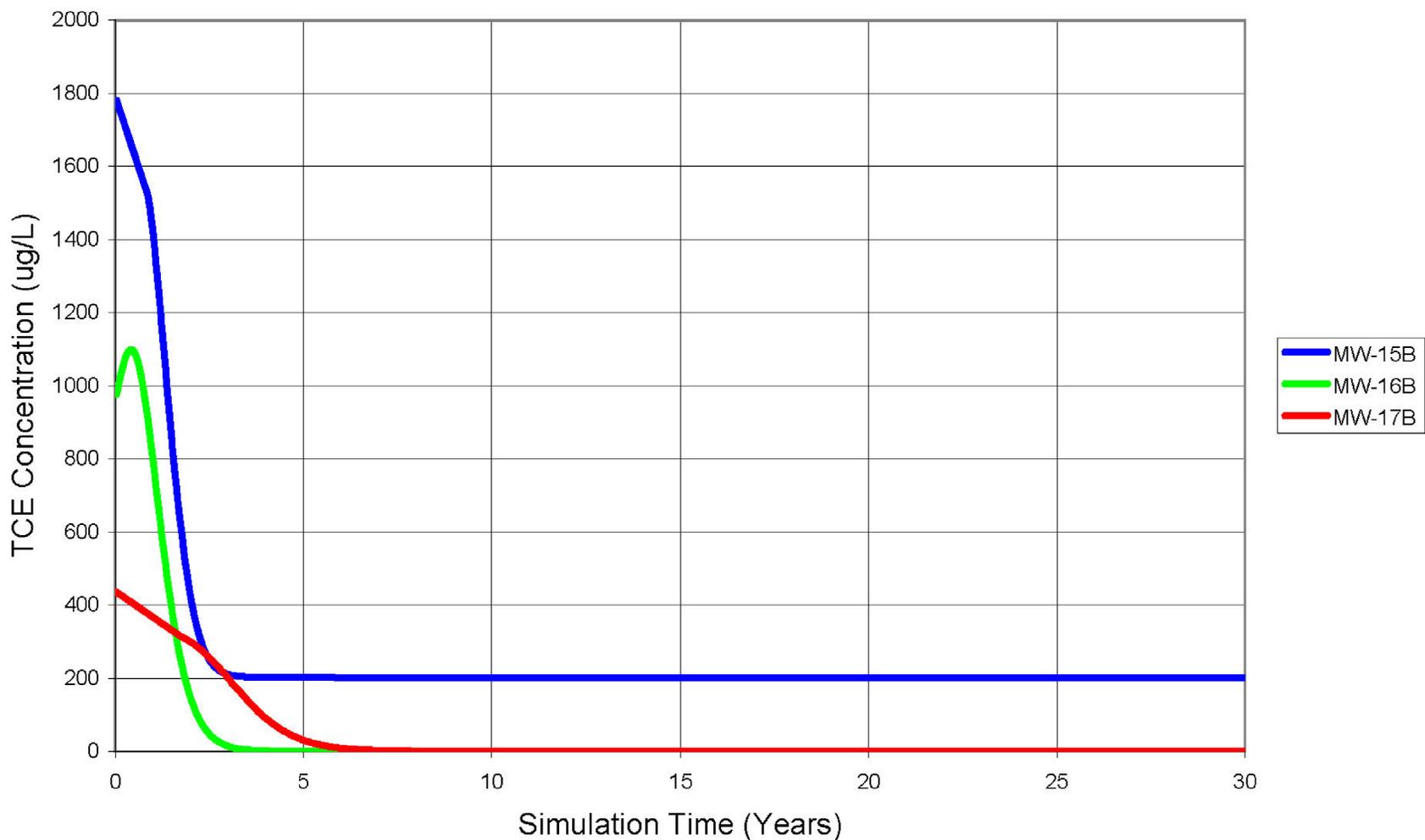


Figure I-27
Alternative 6
Pump and Treat in B Zone, With Degradation
Modeled Concentration vs. Time at Selected B-Zone Wells
Hookston Station
Pleasant Hill, California

Appendix J
Cost Estimates for Remedial
Alternatives

Table J-1
Summary of Costs Associated with Each Alternative
Hookston Station
Pleasant Hill, California

Remedial Alternative	Description	Direct and Indirect Capital Costs	Total O&M Costs (Undiscounted)	NPW of Total O&M Costs	Estimated Total Cost
Alternative 1	No Action	\$0	\$0	\$0	\$0
Alternative 2	Monitored Natural Attenuation - A-Zone and B-Zone Ground Water; Vapor Intrusion Prevention Systems; Private Well Removal.	\$314,010	\$4,584,460	\$2,260,597	\$2,575,000
Alternative 3	Enhanced Anaerobic Bioremediation - A-Zone Ground Water; In Situ Chemical Oxidation - B-Zone Ground Water ; Vapor Intrusion Prevention Systems; Private Well Removal.	\$3,013,987	\$3,000,155	\$1,915,610	\$4,930,000
Alternative 4	Zero-Valent Iron Permeable Reactive Barrier - A-Zone Ground Water; In Situ Chemical Oxidation - B-Zone Ground Water; Vapor Intrusion Prevention Systems; Private Well Removal.	\$3,213,835	\$3,483,641	\$1,979,886	\$5,194,000
Alternative 5	Zero-Valent Iron Permeable Reactive Barrier - A-Zone and B-Zone Ground Water; Vapor Intrusion Prevention Systems; Private Well Removal.	\$7,067,510	\$2,884,073	\$1,670,940	\$8,739,000
Alternative 6	Ground Water Extraction, Treatment, and Disposal - A-Zone and B-Zone Ground Water; Vapor Intrusion Prevention Systems; Private Well Removal	\$1,900,257	\$26,184,172	\$10,905,844	\$12,807,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$

Table J-2
Assumptions and Unit Costs
Hookston Station
Pleasant Hill, California

Item	Value	
Indirect Costs		
Contractor Overhead & Profit	15%	TDC
Engineering and Construction Oversight	15%	TDC
Health and Safety Costs	3%	TDC
Project Management & Administration	10%	TDC
Replacement Costs	7%	TDC
Annual O&M Replacement Costs	7%	TDC
General Contingency	0%	Cap and O&M costs
Net Present Value Discount Rate	7%	
Net Present Value Multipliers for equal payment series	Years	Multiplier
	2	1.81
	3	2.62
	4	3.39
	5	4.10
	6	4.77
	7	5.39
	8	5.97
	9	6.52
	10	7.02
	15	9.11
	20	10.59
	25	11.65
	30	12.41
	35	12.95
	40	13.33
	45	13.61
	50	13.80

Well Installation

<i>Well Installation Costs (incl. labor & expenses)</i>	<i>On Parcel</i>	<i>Off Parcel</i>
A Zone Monitoring Well Detailed Costs		
Mobilization - daily	\$250	\$250
Drilling equipment and labor (\$2,500/day x 1/3 day)	\$833	\$833
Well Materials (\$12/ft x 45 ft)	\$540	\$540
Development equipment and labor (\$1,350/day x 1/4 day)	\$338	\$338
Drums (\$50/ drum x 4)	\$200	\$200
Waste Disposal (\$145/ drum x 4) - nonhazardous	\$580	\$580
ERM Oversight (\$85/hr x 4)	\$340	\$340
Support Vehicle (\$105/day x 1/2)	\$53	\$53
Oversight Equipment and Supplies (\$150/well)	\$150	\$150
Private Utility Locator (\$140/hr x 1/2)	\$70	\$70
Well Permit (\$358 per well)	\$358	\$358
Encroachment Permit	\$0	\$1,000
A Zone Monitoring Well Total Cost	\$3,712	\$4,712

Table J-2
Assumptions and Unit Costs
Hookston Station
Pleasant Hill, California

Item	Value	
B Zone Monitoring Well Detailed Costs		
Mobilization - daily	\$250	\$250
Drilling equipment and labor (\$2,500/day x 1/2 day)	\$1,250	\$1,250
Well Materials (\$12/ft x 70 ft)	\$840	\$840
Development equipment and labor (\$1,350/day x 1/4 day)	\$338	\$338
Drums (\$50/drum x 7)	\$350	\$350
Waste Disposal (\$145/drum x 7) - nonhazardous	\$1,015	\$1,015
ERM Oversight (\$85/hr x 5)	\$425	\$425
Support Vehicle (\$105/day x 1/2)	\$53	\$53
Oversight Equipment and Supplies (\$150/well)	\$150	\$150
Private Utility Locator (\$140/hr x 1/2)	\$70	\$70
Well Permit (\$358 per well)	\$358	\$358
Encroachment Permit	\$0	\$1,000
B Zone Monitoring Well Total Cost	\$5,099	\$6,099
A Zone Extraction Well Detailed Cost		
Mobilization - daily	\$250	\$250
Drilling equipment and labor (\$2,500/day x 1/3 day)	\$833	\$833
Well Materials (\$12/ft x 45 ft)	\$180	\$180
Well vault and well head equipment	\$3,500	\$3,500
Development equipment and labor (\$1,350/day x 1/4 day)	\$338	\$338
Drums (\$50/drum x 4)	\$200	\$200
Waste Disposal (\$145/drum x 4) - nonhazardous	\$580	\$580
ERM Oversight (\$85/hr x 8)	\$680	\$680
Support Vehicle (\$105/day x 1)	\$105	\$105
Oversight Equipment and Supplies (\$150/well)	\$150	\$150
Private Utility Locator (\$140/hr x 1/2)	\$70	\$70
Well Permit (\$358 per well)	\$358	\$358
Encroachment Permit	\$0	\$1,000
A Zone Extraction Well Total Cost	\$7,244	\$8,244
B Zone Extraction Well Detailed Cost		
Mobilization - daily	\$250	\$250
Drilling equipment and labor (\$2,500/day x 1/2 day)	\$1,250	\$1,250
Well Materials (\$19/ft x 70 ft)	\$1,330	\$1,330
Well vault and well head equipment	\$3,500	\$3,500
Development equipment and labor (\$1,350/day x 1/4 day)	\$338	\$338
Drums (\$50/drum x 7)	\$350	\$350
Waste Disposal (\$145/drum x 7) - nonhazardous	\$1,015	\$1,015
ERM Oversight (\$85/hr x 12)	\$1,020	\$1,020
Support Vehicle (\$105/day x 1 1/2)	\$158	\$158
Oversight Equipment and Supplies (\$150/well)	\$150	\$150
Private Utility Locator (\$140/hr x 1/2)	\$70	\$70
Well Permit (\$358 per well)	\$358	\$358
Encroachment Permit	\$0	\$1,000
B Zone Extraction Well Total Cost	\$9,789	\$10,789

Table J-2
Assumptions and Unit Costs
Hookston Station
Pleasant Hill, California

Item	Value	
A Zone Injection Well Cost (Same as extraction well)	\$7,244	\$8,244
B Zone Injection Well Cost (Same as extraction well)	\$9,789	\$10,789
Well Sampling	<u>On Parcel</u>	<u>Off Parcel</u>
Daily Sampling Labor (10 hours 2 technicians @ \$85/hr)	\$1,700	\$1,700
Daily Vehicle Rental	\$105	\$105
Daily Water Quality Meter Rental	\$100	\$100
Daily Water Level Indicator Rental	\$25	\$25
Daily sample pump and equipment rental	\$50	\$50
Supplies (tubing, gloves, etc.) - est. daily	\$150	\$150
Daily Subtotal	\$2,130	\$2,130
Number of wells sampled per day	10	10
Total Well Sampling Costs per well	\$213	\$213
Laboratory Costs		
VOCs - Air (TO-15, including Summa rental)	\$210	
VOCs - GW (8260)	\$75	
MNA Parameters	\$244	
EPA 8000 (Methane, Ethane, Ethene)		\$153.00
EPA 6020 Metals (diss. Fe, Mn)		\$32.00
EPA 300.0 (chloride, sulfate, nitrate)		\$30.00
EPA 9060 (TOC)		\$18.00
EPA 310.1 alkalinity		\$10.80
% of Wells for MNA Samples	50%	
% QA/QC Samples - VOCs	30%	
% QA/QC Samples - MNA Parameters	15%	
Injection Costs		
On Parcel Bioremediation Fluid Direct-Push Injection (A-Zone or B-Zone)		
Daily Direct-Push Drilling Crew	\$2,000	
Daily Injection Equipment Rental	\$500	
Daily Vehicle Rental	\$105	
Daily Oversight Labor (10 hours 2 technicians @ \$85/hr)	\$1,700	
Daily Subtotal	\$4,305	
Number of injection points per day	5	
Total Injection Costs per location	\$861	
Bioremediation Fluid Cost (emulsified soybean oil)	\$1.25	
On Parcel Oxidant Fluid Direct-Push Injection (B-zone)		
Daily Direct-Push Drilling Crew	\$2,000	
Daily Injection Equipment Rental	\$500	
Daily Vehicle Rental	\$105	
Daily Oversight Labor (10 hours 2 technicians @ \$85/hr)	\$1,700	

*Table J-2
Assumptions and Unit Costs
Hookston Station
Pleasant Hill, California*

Item	Value
	Daily Subtotal <u>\$4,305</u>
Number of injection points per day	10
Total Injection Costs per location	<u>\$431</u>
Oxidant Cost (Potassium Permanganate)	<u>\$1.75</u>
 Off Parcel Bioremediation Fluid Injection - Injection Wells	
Daily Direct-Push Drilling Crew	\$2,000
Daily Injection Equipment Rental	\$500
Daily Vehicle Rental	\$105
Daily Oversight Labor (10 hours 2 technicians @ \$85/hr)	\$1,700
	Daily Subtotal <u>\$4,305</u>
Number of injection points per day	5
Total Injection Costs per location	<u>\$861</u>

Table J-3
 Alternative 2- Monitored Natural Attenuation
 Hookston Station
 Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>DIRECT CAPITAL COSTS</u>				
<u>Well Construction</u>				
Work Plan	1	ea.	\$20,000	\$20,000
On Parcel A Zone Monitoring Well	5	ea.	\$3,712	\$18,560
Off Parcel A Zone Monitoring Well	5	ea.	\$4,712	\$23,560
On Parcel B Zone Monitoring Well	5	ea.	\$5,099	\$25,495
Off Parcel B Zone Monitoring Well	5	ea.	\$6,099	\$30,495
Surveying	1	day	\$1,500	\$1,500
	SUBTOTAL			\$119,610
<u>Vapor Intrusion Prevention Systems</u>				
Vapor intrusion prevention system installed in homes within the area of observed indoor air impacts, including barrier with under-barrier vapor extraction and treatment (20 homes)	20	homes	\$5,000.00	\$100,000
	SUBTOTAL			\$100,000
	TOTAL DIRECT CAPITAL COSTS			\$219,610
<u>INDIRECT CAPITAL COSTS</u>				
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$32,942	\$32,942
Engineering and Construction Oversight (15% Total Direct Costs)	1	LS	\$32,942	\$32,942
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$6,588	\$6,588
Project Management & Administration (10% Total Direct Costs)	1	LS	\$21,961	\$21,961
	TOTAL INDIRECT CAPITAL COSTS			\$94,400
	TOTAL CAPITAL COSTS (Direct and Indirect)			\$314,010
<u>O & M COSTS</u>				
<u>Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	60	wells	\$213	\$12,780
Ground Water Analysis - VOCs (60 wells + 30% QA/QC)	78	samples	\$75	\$5,850
Ground Water Analysis - MNA Parameters (30 wells)	30	samples	\$244	\$7,314
Reporting	1	LS	\$15,000	\$15,000
	SUBTOTAL			\$40,944
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$6,142	\$6,142
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,228	\$1,228
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,094	\$4,094
	SUBTOTAL			\$11,464
	Total Costs Per Event			\$52,408
	Annual O&M Cost (Year 1-5, quarterly sampling)			\$209,633
	Annual O&M Cost (Year 6-10, semiannual sampling)			\$104,817
	Annual O&M Cost (Year 11-30, annual sampling)			\$52,408
	SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)			\$2,620,416
	SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)			\$1,448,200
<u>Vapor Intrusion Prevention Systems Maintenance</u>				
Air Monitoring (VOC TO-15 samples)	20	samples	\$210	\$4,200
Electricity (vapor extraction systems, 2 HP fans, Continuous operation)	12	month	\$2,831	\$33,968
Systems Inspection	20	homes	\$350	\$7,000
Systems Maintenance and Repair	1	LS	\$2,500	\$2,500
Reporting	1	LS	\$5,000	\$5,000
	SUBTOTAL			\$48,468

*Table J-3
Alternative 2- Monitored Natural Attenuation
Hookston Station
Pleasant Hill, California*

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
Replacement Costs (7% Total Direct Costs)	1	LS	\$3,393	\$3,393
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$7,270	\$7,270
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,454	\$1,454
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,847	\$4,847
SUBTOTAL				\$17,000
Annual O&M Costs (year 1-30)				\$65,468
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$1,964,044
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$812,397
TOTAL UNDISCOUNTED O&M COSTS				\$4,584,460
TOTAL NET PRESENT WORTH O&M COSTS				\$2,260,597
TOTAL CAPITAL AND O & M COSTS				\$2,574,607
General Contingency (0% of Total Capital and O&M Costs)				\$0
TOTAL COST OF ALTERNATIVE (PRESENT WORTH)				\$2,575,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$

Table J-4
Alternative 3 - A-Zone Enhanced Anaerobic Bioremediation with B-Zone Chemical Oxidation
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>DIRECT CAPITAL COSTS</u>				
<u>Preparation and Well Construction</u>				
Design/Work Plan	1	ea.	\$100,000	\$100,000
On Parcel A Zone Monitoring Well	5	ea.	\$3,712	\$18,560
Off Parcel A Zone Monitoring Well	5	ea.	\$4,712	\$23,560
On Parcel B Zone Monitoring Well	5	ea.	\$5,099	\$25,495
Off Parcel B Zone Monitoring Well	5	ea.	\$6,099	\$30,495
Off-Site A Zone Injection Wells	8	ea.	\$8,244	\$65,952
Surveying	1	day	\$1,500	\$1,500
SUBTOTAL				\$265,562
<u>A-Zone Bioremediation Injection</u>				
On-Site A-Zone Direct-Push Injection of Bioremediation ammendment - 15 to 25 feet bgs (120,000 square feet, 20' on center rows with 60' spacing, 100 locations and 3 applications)	300	Injection	\$861	\$258,300
On-Site A-Zone Ammendment (100 locations, 1780 pounds oil emulsion per location (220 gallons at 8.1 pounds per gallons, 3 applications)	534,000	lbs.	\$1.25	\$667,500
Off-Site A-Zone Injection of Bioremediation ammendment - 15 to 30 feet bgs (8 injection wells and 10 applications)	80	Injection	\$2,000	\$160,000
Off-Site A-Zone Ammendment (8 injection wells, 3500 pounds oil emulsion per well [10 annual applications])	280,000	lbs.	\$1.25	\$350,000
SUBTOTAL				\$1,435,800
<u>B-Zone Oxidant Injection</u>				
B-Zone Direct-Push Injection of Potassium Permanganate - 45 to 60 feet bgs (60,000 square feet, 150 locations and 3 applications)	450	Injection	\$431	\$193,725
Potassium Permanganate (450 Zone B injections with 560 gallons of solution containing 143 lbs per injection)	64,350	lbs.	\$1.75	\$112,600
SUBTOTAL				\$306,325
<u>Vapor Intrusion Prevention Systems</u>				
Vapor intrusion prevention system installed in homes within the area of observed indoor air impacts, including barrier with under-barrier vapor extraction and treatment (20 homes)	20	homes	\$5,000.00	\$100,000
SUBTOTAL				\$100,000
TOTAL DIRECT CAPITAL COSTS				\$2,107,687
<u>INDIRECT CAPITAL COSTS</u>				
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$316,153	\$316,153
Engineering and Construction Oversight (15% Total Direct Costs)	1	LS	\$316,153	\$316,153
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$63,231	\$63,231
Project Management & Administration (10% Total Direct Costs)	1	LS	\$210,769	\$210,769
TOTAL INDIRECT CAPITAL COSTS				\$906,300
TOTAL CAPITAL COSTS (Direct and Indirect)				\$3,013,987
<u>O & M COSTS</u>				
<u>Hookston Station Parcel A-Zone Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	15	wells	\$213	\$3,195
Ground Water Analysis - VOCs (15 wells + 30% QA/QC)	20	samples	\$75	\$1,500
Ground Water Analysis - MNA Parameters (8 wells)	8	samples	\$244	\$1,950
Reporting	1	LS	\$5,000	\$5,000
SUBTOTAL				\$11,645
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$1,747	\$1,747

Table J-4
Alternative 3 - A-Zone Enhanced Anaerobic Bioremediation with B-Zone Chemical Oxidation
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$349	\$349
Project Management & Administration (10% Total Direct Costs)	1	LS	\$1,165	\$1,165
SUBTOTAL				\$3,300
Total Costs Per Event				\$14,945
Annual O&M Cost (Year 1-5, quarterly sampling)				\$59,782
Annual O&M Cost (Year 6-10, semiannual sampling)				\$29,891
SUBTOTAL UNDISCOUNTED O&M COSTS (10 years)				\$448,362
SUBTOTAL NET PRESENT WORTH O&M COSTS (10 years) (1)				\$332,499
<u>Downgradient Study Area A-Zone Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	15	wells	\$213	\$3,195
Ground Water Analysis - VOCs (15 wells + 30% QA/QC)	20	samples	\$75	\$1,500
Ground Water Analysis - MNA Parameters (8 wells)	8	samples	\$244	\$1,950
Reporting	1	LS	\$7,500	\$7,500
SUBTOTAL				\$14,145
Contractor Overhead & Profit (15% Total Direct Costs)				\$2,122
Health and Safety Costs (3% Total Direct Costs)				\$424
Project Management & Administration (10% Total Direct Costs)				\$1,415
SUBTOTAL				\$4,000
Total Costs Per Event				\$18,145
Annual O&M Cost (Year 1-5, quarterly sampling)				\$72,582
Annual O&M Cost (Year 6-10, semiannual sampling)				\$36,291
Annual O&M Cost (Year 11-30, annual sampling)				\$18,145
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$725,816
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$501,412
<u>B-Zone Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	30	wells	\$213	\$6,390
Ground Water Analysis - VOCs (30 wells + 30% QA/QC)	39	samples	\$75	\$2,925
Ground Water Analysis - MNA Parameters (15 wells)	15	samples	\$244	\$3,657
Reporting	1	LS	\$12,500	\$12,500
SUBTOTAL				\$25,472
Contractor Overhead & Profit (15% Total Direct Costs)				\$3,821
Health and Safety Costs (3% Total Direct Costs)				\$764
Project Management & Administration (10% Total Direct Costs)				\$2,547
SUBTOTAL				\$7,100
Total Costs Per Event				\$32,572
Annual O&M Cost (Year 1-3, quarterly sampling)				\$130,288
Annual O&M Cost (Year 4-8, semiannual sampling)				\$65,144
Annual O&M Cost (Year 9-30, annual sampling)				\$32,572
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$1,433,168
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$769,643
<u>Vapor Intrusion Prevention Systems Maintenance</u>				
Air Monitoring (VOC TO-15 samples)	20	samples	\$210	\$4,200
Electricity (vapor extraction systems, 2 HP fans, Continuous operation)	12	month	\$2,831	\$33,968
Systems Inspection	20	homes	\$350	\$7,000
Systems Maintenance and Repair	1	LS	\$2,500	\$2,500
Reporting	1	LS	\$5,000	\$5,000

Table J-4
Alternative 3 - A-Zone Enhanced Anaerobic Bioremediation with B-Zone Chemical Oxidation
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
SUBTOTAL				\$48,468
Replacement Costs (7% Total Direct Costs)	1	LS	\$3,393	\$3,393
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$7,270	\$7,270
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,454	\$1,454
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,847	\$4,847
SUBTOTAL				\$17,000
Annual O&M Costs (year 1-6)				\$65,468
SUBTOTAL UNDISCOUNTED O&M COSTS (6 years)				\$392,809
SUBTOTAL NET PRESENT WORTH O&M COSTS (6 years) (1)				\$312,056
TOTAL UNDISCOUNTED O&M COSTS				\$3,000,155
NET PRESENT WORTH OF TOTAL O&M COSTS				\$1,915,610
TOTAL CAPITAL AND O & M COSTS				\$4,929,597
General Contingency (0% of Total Capital and O&M Costs)				\$0
TOTAL COST OF ALTERNATIVE (PRESENT WORTH)				\$4,930,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$

Table J-5
Alternative 4 - A-Zone PRB with B-Zone Chemical Oxidation
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>DIRECT CAPITAL COSTS</u>				
<u>Preparation and Well Construction</u>				
Design/Work Plan	1	ea.	\$100,000	\$100,000
On Parcel A Zone Monitoring Well	5	ea.	\$3,712	\$18,560
Off Parcel A Zone Monitoring Well	5	ea.	\$4,712	\$23,560
On Parcel B Zone Monitoring Well	5	ea.	\$5,099	\$25,495
Off Parcel B Zone Monitoring Well	5	ea.	\$6,099	\$30,495
Surveying	2	day	\$1,500	\$3,000
SUBTOTAL				\$201,110
<u>A-Zone PRB Construction</u>				
Column reductive dechlorination test	1	ea.	\$25,000	\$25,000
Hydraulic testing	1	ea.	\$30,000.00	\$30,000
Mobilization/Site Prep	1	LS	\$160,000.00	\$160,000
PRB Installation (Trenched and Placed in Zone A from 15'-35' bgs)	10000	SF	\$139.00	\$1,390,000
Site Restoration	1	LS	\$35,000.00	\$35,000
SUBTOTAL				\$1,640,000
<u>B-Zone Oxidant Injection</u>				
Zone B Direct-Push Injection of Potassium Permanganate - 45 to 60 feet bgs (60,000 square feet, 150 locations and 3 applications)	450	Injection	\$431	\$193,725
Potassium Permanganate (450 Zone B injections with 560 gallons of solution containing 143 lbs per injection)	64,350	lbs.	\$1.75	\$112,600
SUBTOTAL				\$306,325
<u>Vapor Intrusion Prevention Systems</u>				
Vapor intrusion prevention system installed in homes within the area of observed indoor air impacts, including barrier with under-barrier vapor extraction and treatment (20 homes)	20	homes	\$5,000.00	\$100,000
SUBTOTAL				\$100,000
TOTAL DIRECT CAPITAL COSTS				\$2,247,435
<u>INDIRECT CAPITAL COSTS</u>				
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$337,115	\$337,115
Engineering and Construction Oversight (15% Total Direct Costs)	1	LS	\$337,115	\$337,115
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$67,423	\$67,423
Project Management & Administration (10% Total Direct Costs)	1	LS	\$224,744	\$224,744
TOTAL INDIRECT CAPITAL COSTS				\$966,400
TOTAL CAPITAL COSTS (Direct and Indirect)				\$3,213,835
<u>O & M COSTS</u>				
<u>A-Zone Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	30	wells	\$213	\$6,390
Ground Water Analysis - VOCs (30 wells + 30% QA/QC)	39	samples	\$75	\$2,925
Ground Water Analysis - MNA Parameters (15 wells)	15	samples	\$244	\$3,657
Reporting	1	LS	\$15,000	\$15,000
SUBTOTAL				\$27,972
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$4,196	\$4,196
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$839	\$839
Project Management & Administration (10% Total Direct Costs)	1	LS	\$2,797	\$2,797
SUBTOTAL				\$7,800

Table J-5
Alternative 4 - A-Zone PRB with B-Zone Chemical Oxidation
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
Total Costs Per Event				\$35,772
Annual O&M Cost (Year 1-5, quarterly sampling)				\$143,088
Annual O&M Cost (Year 6-10, semiannual sampling)				\$71,544
Annual O&M Cost (Year 11-30, annual sampling)				\$35,772
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$1,788,600
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$988,488
Off-Site B-Zone Ground Water Monitoring Cost Per Event				
Well Sampling Labor and Equipment	30	wells	\$213	\$6,390
Ground Water Analysis - VOCs (30 wells + 30% QA/QC)	39	samples	\$75	\$2,925
Ground Water Analysis - MNA Parameters (15 wells)	15	samples	\$244	\$3,657
Reporting	1	LS	\$12,500	\$12,500
SUBTOTAL				\$25,472
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$3,821	\$3,821
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$764	\$764
Project Management & Administration (10% Total Direct Costs)	1	LS	\$2,547	\$2,547
SUBTOTAL				\$7,100
Total Costs Per Event				\$32,572
Annual O&M Cost (Year 1-3, quarterly sampling)				\$130,288
Annual O&M Cost (Year 4-8, semiannual sampling)				\$65,144
Annual O&M Cost (Year 9-30, annual sampling)				\$32,572
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$1,433,168
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$769,643
Vapor Intrusion Prevention Systems Maintenance				
Air Monitoring (VOC TO-15 samples)	20	samples	\$210	\$4,200
Electricity (vapor extraction systems, 2 HP fans, Continuous operation)	12	month	\$2,831	\$33,968
Systems Inspection	20	homes	\$350	\$7,000
Systems Maintenance and Repair	1	LS	\$2,500	\$2,500
Reporting	1	LS	\$5,000	\$5,000
SUBTOTAL				\$48,468
Replacement Costs (7% Total Direct Costs)	1	LS	\$3,393	\$3,393
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$7,270	\$7,270
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,454	\$1,454
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,847	\$4,847
SUBTOTAL				\$17,000
Annual O&M Costs (year 1-4)				\$65,468
SUBTOTAL UNDISCOUNTED O&M COSTS (4 years)				\$261,873
SUBTOTAL NET PRESENT WORTH O&M COSTS (4 years) (1)				\$221,754
TOTAL UNDISCOUNTED O&M COSTS				\$3,483,641
NET PRESENT WORTH OF TOTAL O&M COSTS				\$1,979,886
TOTAL CAPITAL AND O & M COSTS				\$5,193,721
General Contingency (0% of Total Capital and O&M Costs)				\$0
TOTAL COST OF ALTERNATIVE (PRESENT WORTH)				\$5,194,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$

Table J-6
Alternative 5 - A-Zone and B-Zone PRBs
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>DIRECT CAPITAL COSTS</u>				
<u>Preparation and Well Construction</u>				
Design/Work Plan	1	ea.	\$100,000	\$100,000
On Parcel A Zone Monitoring Well	5	ea.	\$3,712	\$18,560
Off Parcel A Zone Monitoring Well	5	ea.	\$4,712	\$23,560
On Parcel B Zone Monitoring Well	5	ea.	\$5,099	\$25,495
Off Parcel B Zone Monitoring Well	5	ea.	\$6,099	\$30,495
Surveying	2	day	\$1,500	\$3,000
	SUBTOTAL			\$201,110
<u>A-Zone PRB Construction</u>				
Column reductive dechlorination test	1	ea.	\$25,000	\$25,000
Hydraulic testing	1	ea.	\$30,000.00	\$30,000
PRB Installation (Injected in Zone A from 15'-35' bgs)	480	ft	\$3,615.00	\$1,735,200
	SUBTOTAL			\$1,790,200
<u>B-Zone PRB Construction</u>				
Column reductive dechlorination test	1	ea.	\$25,000	\$25,000
Hydraulic testing	1	ea.	\$30,000.00	\$30,000
PRB Installation (Injected in Zone B from 40'-70' bgs)	480	ft	\$5,825.00	\$2,796,000
	SUBTOTAL			\$2,851,000
<u>Vapor Intrusion Prevention Systems</u>				
Vapor intrusion prevention system installed in homes within the area of observed indoor air impacts, including barrier with under-barrier vapor extraction and treatment (20 homes)	20	homes	\$5,000.00	\$100,000
	SUBTOTAL			\$100,000
TOTAL DIRECT CAPITAL COSTS				\$4,942,310
<u>INDIRECT CAPITAL COSTS</u>				
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$741,347	\$741,347
Engineering and Construction Oversight (15% Total Direct Costs)	1	LS	\$741,347	\$741,347
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$148,269	\$148,269
Project Management & Administration (10% Total Direct Costs)	1	LS	\$494,231	\$494,231
	TOTAL INDIRECT CAPITAL COSTS			\$2,125,200
TOTAL CAPITAL COSTS (Direct and Indirect)				\$7,067,510
<u>O & M COSTS</u>				
<u>A-Zone and B-Zone Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	60	wells	\$213	\$12,780
Ground Water Analysis - VOCs (60 wells + 30% QA/QC)	78	samples	\$75	\$5,850
Ground Water Analysis - MNA Parameters (30 wells)	30	samples	\$244	\$7,314
Reporting	1	LS	\$15,000	\$15,000
	SUBTOTAL			\$40,944
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$6,142	\$6,142
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,228	\$1,228
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,094	\$4,094
	SUBTOTAL			\$11,500
Total Costs Per Event				\$52,444

Table J-6
Alternative 5 - A-Zone and B-Zone PRBs
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
Annual O&M Cost (Year 1-5, quarterly sampling)				\$209,776
Annual O&M Cost (Year 6-10, semiannual sampling)				\$104,888
Annual O&M Cost (Year 11-30, annual sampling)				\$52,444
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$2,622,200
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$1,449,186
<u>Vapor Intrusion Prevention Systems Maintenance</u>				
Air Monitoring (VOC TO-15 samples)	20	samples	\$210	\$4,200
Electricity (vapor extraction systems, 2 HP fans, Continuous operation)	12	month	\$2,831	\$33,968
Systems Inspection	20	homes	\$350	\$7,000
Systems Maintenance and Repair	1	LS	\$2,500	\$2,500
Reporting	1	LS	\$5,000	\$5,000
SUBTOTAL				\$48,468
Replacement Costs (7% Total Direct Costs)	1	LS	\$3,393	\$3,393
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$7,270	\$7,270
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,454	\$1,454
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,847	\$4,847
SUBTOTAL				\$17,000
Annual O&M Costs (year 1-4)				\$65,468
SUBTOTAL UNDISCOUNTED O&M COSTS (4 years)				\$261,873
SUBTOTAL NET PRESENT WORTH O&M COSTS (4 years) (1)				\$221,754
TOTAL UNDISCOUNTED O&M COSTS				\$2,884,073
NET PRESENT WORTH OF TOTAL O&M COSTS				\$1,670,940
TOTAL CAPITAL AND O & M COSTS				\$8,738,450
General Contingency (0% of Total Capital and O&M Costs)				\$0
TOTAL COST OF ALTERNATIVE (PRESENT WORTH)				\$8,739,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$

Table J-7
Alternative 6 - Ground Water Extraction with Ex-Situ Treatment and Disposal
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>DIRECT CAPITAL COSTS</u>				
<u>Preparation Work/Construction</u>				
Work Plan (Design and Permitting)	1	ea.	\$100,000	\$100,000
AQMD Permitting	1	LS	\$10,000	\$10,000
On Parcel A Zone Monitoring Well	5	ea.	\$3,712	\$18,560
Off Parcel A Zone Monitoring Well	5	ea.	\$4,712	\$23,560
On Parcel B Zone Monitoring Well	5	ea.	\$5,099	\$25,495
Off Parcel B Zone Monitoring Well	5	ea.	\$6,099	\$30,495
On Parcel A Zone Extraction Wells	6	ea.	\$7,244	\$43,464
On Parcel B Zone Extraction Wells	1	ea.	\$9,789	\$9,789
Off Parcel A Zone Extraction Wells	9	ea.	\$8,244	\$74,196
Off Parcel B Zone Extraction Wells	4	ea.	\$10,789	\$43,154
On Parcel Trenching	1000	ft	\$50.00	\$50,000
Off parcel Trenching	3500	ft	\$75.00	\$262,500
A-Zone Piping (2" pv c)	2550	ft	\$3.20	\$8,160
B-Zone Piping (4" pv c)	2800	ft	\$7.38	\$20,664
Conduit	3500	ft	\$11.92	\$41,720
Pad and treatment building	1	ea.	\$50,000.00	\$50,000
Surveying	2	day	\$1,500	\$3,000
				\$814,757
SUBTOTAL				
<u>Equipment</u>				
Tray Air Stripping System	1	ea.	\$97,868	\$97,868
A-Zone Extraction pumps	15	ea.	\$1,828	\$27,420
B-Zone Extraction pumps	5	ea.	\$2,305	\$11,525
Ancillary equipment (PLC, transfer pumps, tanks, etc)	1	LS	\$60,000	\$60,000
System installation	1	LS	\$100,000	\$100,000
Air treatment by Activated Carbon	2	ea.	\$33,644	\$67,288
As-Built Drawings and O&M Manual Preparation	1	LS	\$25,000	\$25,000
System Startup and Optimization	1	LS	\$25,000	\$25,000
				\$414,100
SUBTOTAL				
<u>Vapor Intrusion Prevention Systems</u>				
Vapor intrusion prevention system installed in homes within the area of observed indoor air impacts, including barrier with under-barrier vapor extraction and treatment (20 homes)	20	homes	\$5,000.00	\$100,000
				\$100,000
SUBTOTAL				
TOTAL DIRECT CAPITAL COSTS				\$1,328,857
<u>INDIRECT CAPITAL COSTS</u>				
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$199,328	\$199,328
Engineering and Construction Oversight (15% Total Direct Costs)	1	LS	\$199,328	\$199,328
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$39,866	\$39,866
Project Management & Administration (10% Total Direct Costs)	1	LS	\$132,886	\$132,886
				\$571,400
TOTAL INDIRECT CAPITAL COSTS				
TOTAL CAPITAL COSTS (Direct and Indirect)				\$1,900,257
<u>O & M COSTS</u>				

Table J-7
Alternative 6 - Ground Water Extraction with Ex-Situ Treatment and Disposal
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>Groundwater Treatment System Maintenance (year 1-10)</u>				
System O&M Labor	12	month	\$10,000	\$120,000
System O&M Subs	1	LS	\$30,000	\$30,000
System O&M equipment	12	month	\$2,250	\$27,000
System Sampling and Analysis - VOCs	240	samples	\$75	\$18,000
System Sampling and Analysis - TDS and Metals	2	samples	\$300	\$600
Well redevelopment (1/4 of all extraction wells per year)	5	wells	\$5,000	\$25,000
Supplies	12	month	\$2,000	\$24,000
Monthly Reporting	12	month	\$5,000	\$60,000
Annual Reporting	1	LS	\$15,000	\$15,000
AQMD Reporting (quarterly)	4	qtr	\$1,800	\$7,200
Discharge Reporting (quarterly)	4.0	qtr	\$1,200.00	\$4,800
Activated carbon replacement	6100	lb	\$1.50	\$9,150
Monthly vapor samples	3	samples	\$210.00	\$630
Discharge Permit	1	LS	\$2,415.00	\$2,415
Discharge fee	147.2	mil gal	\$809.05	\$119,066
Electricity	12	month	\$4,097	\$49,165
				\$512,026
SUBTOTAL				
Replacement Costs (7% Total Direct Costs)	1	LS	\$35,842	\$35,842
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$76,804	\$76,804
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$15,361	\$15,361
Project Management & Administration (10% Total Direct Costs)	1	LS	\$51,203	\$51,203
				\$179,209
SUBTOTAL				
Annual System Maintenance Costs (Year 1-10)				\$691,236
<u>Groundwater Treatment System Maintenance (year 11-30)</u>				
System O&M Labor	12	month	\$10,000	\$120,000
System O&M Subs	1	LS	\$30,000	\$30,000
System O&M equipment	12	month	\$2,250	\$27,000
System Sampling and Analysis - VOCs	240	samples	\$75	\$18,000
System Sampling and Analysis - TDS and Metals	2	samples	\$300	\$600
Well redevelopment (1/4 of all extraction wells per year)	5	wells	\$5,000	\$25,000
Supplies	12	month	\$2,000	\$24,000
Monthly Reporting	12	month	\$5,000	\$60,000
Annual Reporting	1	LS	\$15,000	\$15,000
AQMD Reporting (quarterly)	4	qtr	\$1,800	\$7,200
Discharge Reporting (quarterly)	4.0	qtr	\$1,200.00	\$4,800
Activated carbon replacement	6100	lb	\$1.50	\$9,150
Monthly vapor samples	3	samples	\$210.00	\$630
Discharge Permit	1	LS	\$2,415.00	\$2,415
Discharge fee	147.2	mil gal	\$1,471.00	\$216,484
Electricity	12	month	\$4,097	\$49,165
				\$609,444
SUBTOTAL				
Replacement Costs (7% Total Direct Costs)	1	LS	\$42,661	\$42,661
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$91,417	\$91,417
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$18,283	\$18,283
Project Management & Administration (10% Total Direct Costs)	1	LS	\$60,944	\$60,944
				\$213,305
SUBTOTAL				
Annual System Maintenance Costs (Year 10-30)				\$822,750

Table J-7
Alternative 6 - Ground Water Extraction with Ex-Situ Treatment and Disposal
Hookston Station
Pleasant Hill, California

DESCRIPTION	QUANTITY		COST	
	Number	Unit	Unit Cost	Total Cost
<u>Ground Water Monitoring Cost Per Event</u>				
Well Sampling Labor and Equipment	60	wells	\$213	\$12,780
Ground Water Analysis - VOCs (60 wells + 30% QA/QC)	78	samples	\$75	\$5,850
Ground Water Analysis - MNA Parameters (30 wells)	30	samples	\$244	\$7,314
Reporting	1	LS	\$15,000	\$15,000
SUBTOTAL				\$40,944
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$6,142	\$6,142
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,228	\$1,228
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,094	\$4,094
SUBTOTAL				\$11,464
Total Costs Per Event				\$52,408
Annual O&M Cost (Year 1-5, operation and quarterly sampling)				\$900,869
Annual O&M Cost (Year 6-10, operation and semiannual sampling)				\$796,052
Annual O&M Cost (Year 11-30, operation and annual sampling)				\$875,158
SUBTOTAL UNDISCOUNTED O&M COSTS (30 years)				\$25,987,767
SUBTOTAL NET PRESENT WORTH O&M COSTS (30 years) (1)				\$10,734,035
<u>Vapor Intrusion Prevention Systems Maintenance</u>				
Air Monitoring (VOC TO-15 samples)	20	samples	\$210	\$4,200
Electricity (vapor extraction systems, 2 HP fans, Continuous operation)	12	month	\$2,831	\$33,968
Systems Inspection	20	homes	\$350	\$7,000
Systems Maintenance and Repair	1	LS	\$2,500	\$2,500
Reporting	1	LS	\$5,000	\$5,000
SUBTOTAL				\$48,468
Replacement Costs (7% Total Direct Costs)	1	LS	\$3,393	\$3,393
Contractor Overhead & Profit (15% Total Direct Costs)	1	LS	\$7,270	\$7,270
Health and Safety Costs (3% Total Direct Costs)	1	LS	\$1,454	\$1,454
Project Management & Administration (10% Total Direct Costs)	1	LS	\$4,847	\$4,847
SUBTOTAL				\$17,000
Annual O&M Costs (year 1-3)				\$65,468
SUBTOTAL UNDISCOUNTED O&M COSTS (3 years)				\$196,404
SUBTOTAL NET PRESENT WORTH O&M COSTS (3 years) (1)				\$171,809
TOTAL UNDISCOUNTED O&M COSTS				\$26,184,172
NET PRESENT WORTH OF TOTAL O&M COSTS				\$10,905,844
TOTAL CAPITAL AND O & M COSTS				\$12,806,101
General Contingency (0% of Total Capital and O&M Costs)				\$0
TOTAL COST OF ALTERNATIVE (PRESENT WORTH)				\$12,807,000

Notes:

(1) Present worth calculated using equal series present worth analysis where $i = 7\%$