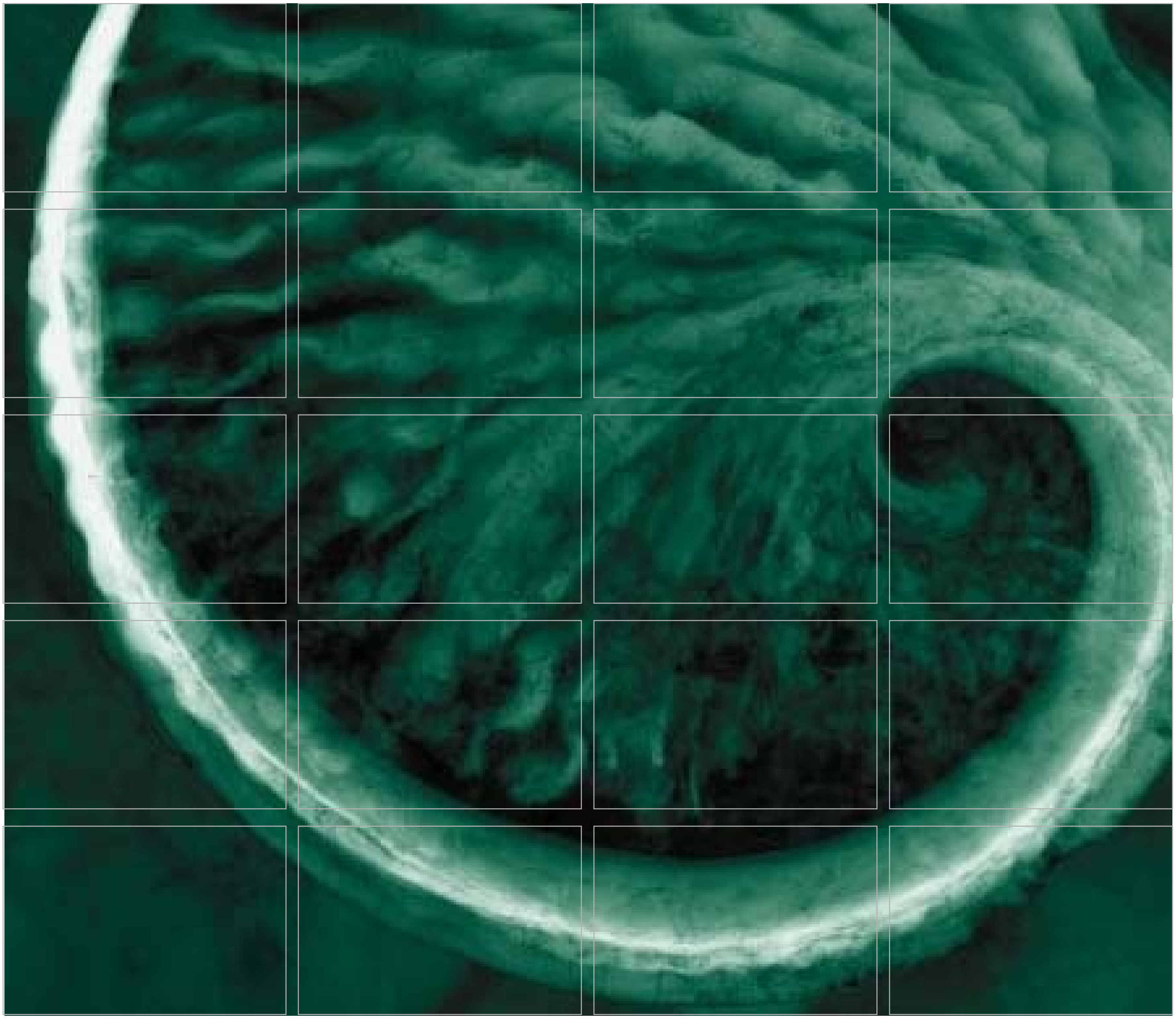


Remedial Design and Implementation Plan for A-Zone Permeable Reactive Barrier

Hookston Station Site
Pleasant Hill, California

Prepared for:
Hookston Station
Responsible Parties

29 June 2007

www.erm.com

ERM

Delivering sustainable solutions in a more competitive world

Hookston Station Responsible Parties

Remedial Design and Implementation Plan for A-Zone Permeable Reactive Barrier

Hookston Station Site
Pleasant Hill, California

29 June 2007

Project No. 20557

Jim Warner, P.G.
Principal-in-Charge

Brian Bjorklund, P.G., CHG
Project Manager

Arun Chemburkar, P.E.
Project Engineer

REGISTERED PROFESSIONAL ENGINEER
ARUN S. CHEMBURKAR
No. CH004926
Exp 6/2008
CHEMICAL
STATE OF CALIFORNIA

Environmental Resources Management
1777 Botelho Drive, Suite 260
Walnut Creek, California 94596
T: 925-946-0455
F: 925-946-9968

TABLE OF CONTENTS

LIST OF FIGURES

(Figures immediately follow the text)

LIST OF TABLES

(Tables immediately follow the figures)

LIST OF ACRONYMS

bgs	Below ground surface
BP	Biopolymer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chemical of concern
CPT	Cone penetrometer testing
CTEH	Center for Toxicology and Environmental Health
DCE	Dichloroethene
Eh	Oxidation reduction potential
ERM	ERM-West, Inc.
ESL	Environmental Screening Level
FS	Feasibility Study
MCL	Maximum Contaminant Level
MIP	Membrane interface probe
MSL	Mean sea level
MTBE	Methyl-tert-butyl ether
PCE	Tetrachloroethene
pH	Acidity/alkalinity
PRB	Permeable reactive barrier
RDIP	Remedial Design and Implementation Plan
RI	Remedial Investigation
RPs	Responsible Parties
RWQCB	San Francisco Bay Regional Water Quality Control Board
TCE	Trichloroethene

USEPA	United States Environmental Protection Agency
VHF	Vertical hydraulic fracturing
VOC	Volatile organic compound
µg/L	Microgram per liter
$\mu g/m^3$	Microgram per cubic meter

EXECUTIVE SUMMARY

This *Remedial Design and Implementation Plan for A-Zone Permeable Reactive Barrier* (RDIP) 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 (Hookston RPs) for the Hookston Station Parcel in Pleasant Hill, California. The Hookston 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 RDIP has been prepared to comply with the requirements of RWQCB Order Number R2-2007-0009.

Volatile organic compounds (VOCs) have impacted the Hookston Station Parcel and the downgradient area. The Hookston Station RPs has 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 Investigation Report* (ERM 2004), the *Baseline Risk Assessment* (CTEH 2006), and the *Feasibility Study* (ERM 2006a) have been approved by the RWQCB. These documents provide the basis for the remedial action objectives, cleanup goals, impacted areas/volume of media, and the remediation methods presented in this RDIP.

This RDIP specifically addresses the installation of a zero-valent iron permeable reactive barrier (PRB) in the A-Zone to clean up ground water. The FS determined that this remedial alternative best meets the risk management goals for the impacted area. A separate RDIP will be presented for the B-Zone chemical oxidation remediation program, following a brief pilot study that is currently underway at the Hookston Station Parcel.

1.0 INTRODUCTION

On behalf of the Hookston Station Responsible Parties (Hookston RPs), ERM-West, Inc. (ERM) has prepared and submitted this *Remedial Design and Implementation Plan for A-Zone Permeable Reactive Barrier* (RDIP) to the Regional Water Quality Control Board San Francisco Bay Region (RWQCB) for the construction of a zero-valent iron permeable reactive barrier for the Hookston Station site in Pleasant Hill, California. The Hookston RPs includes 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. The Hookston Station Parcel is located at the intersection of Hookston and Bancroft Roads in Pleasant Hill, California (Figure 1-1). Features of the Hookston Station Parcel and surrounding area are shown on Figure 1-2.

The chemicals of concern (COCs) that originate from the Hookston Station Parcel include TCE and its associated degradation compounds. This document details the A-Zone ground water remediation plan to protect human health and the environment in accordance with Regional Water Quality Control Board (RWQCB) Order No. R2-2007-0009, dated 23 January 2007.

1.1 DOCUMENT 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 the Remedial Action Objectives, cleanup goals, and the location and extent of areas of treatment for the Hookston Station Parcel and the downgradient area;
- Section 3.0 presents a description of PRB technologies and examples of PRB usage at similar sites;
- Section 4.0 includes the remedial design details, including pre-design investigation data, the screening and selection of construction methods, and construction parameters;
- Section 5.0 provides an implementation plan, which includes pre-construction activities, construction management, an effectiveness monitoring program, data evaluation and reporting, and an implementation schedule;

- Section 6.0 describes closure and post-closure activities;
- Section 7.0 introduces the site-specific *Health and Safety Plan* that will apply during RDIP field activities; and
- Section 8.0 provides references used in preparing this RDIP.

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

- Appendix A – Bench Scale Treatability Study Results
- Appendix B – Pre-Design CPT/MIP Boring Logs
- Appendix C – Pre-Design Analytical Data

1.2 PURPOSE OF THIS RDIP

The purpose of this RDIP is to present the design details and work activities necessary to implement the remedial strategy that was approved in the *Feasibility Study* (ERM 2006a). As described in RWQCB Order No. R2-2007-0009, this document represents a 90% design plan. Final (100%) design plans will be submitted after final contract negotiations with the installation subcontractor have been completed.

Volatile organic compounds (VOCs) have impacted the Hookston Station Parcel and the downgradient area. This RDIP describes the remediation program proposed for A-Zone ground water that is protective of human health and the environment. This RDIP has been developed in compliance with the remedial design/remedial action requirements described in *National Oil and Hazardous Substance Pollution Contingency Plan* (Code of Federal Regulations 40, Part 435). The following were also used as guidance documents in preparation of this RDIP:

- *Guidance for Scoping the Remedial Design* (USEPA 1995a); and
- *Remedial Design/Remedial Action Handbook* (USEPA 1995b).

1.3 PROJECT BACKGROUND

This section provides a brief summary of the Hookston Station site characterization that pertains to the design of the PRB (geology, hydrogeology, and chemical occurrence in ground water and indoor air), and the overall remediation strategy for the Hookston Station Parcel and downgradient area. A more detailed description of the project background is provided in *Remedial Investigation Report* (ERM 2004) and *Feasibility Study* (ERM 2006a).

1.3.1 Geology and Hydrogeology

The Hookston Station Parcel and surrounding area is underlain by unconsolidated deposits that extend to at least 100 feet below ground surface (bgs), as shown on Figure 1-3 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 50 feet bgs. ERM has defined this zone as the "A-Zone," which 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 thick.
- Directly beneath the A-Zone, a relatively continuous sand unit that is interbedded with silt and clay lenses is present between the approximate depths of 50 and 70 feet bgs (although in some areas it can be as shallow as 30 feet bgs). ERM has defined this zone as the "B-Zone." The sands of the B-Zone are generally 5 to 10 feet thick and include sands, clayey sands, and 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 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 a continuous sand unit that is interbedded with silt and clay lenses. The C-Zone extends to at least 100 feet bgs; the deposits deeper than 100 feet bgs have not been characterized.

Ground water in the A-, B-, and C-Zones flows to the north-northeast. Ground water potentiometric surface maps for each water-bearing zone (based on the First Quarter 2007 monitoring event) are provided as Figures 1-4 through 1-6. 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 across the entire monitored area. Based on ground water level measurements and stratigraphy, the three water-bearing zones are confined to semi-confined. Based on aquifer tests conducted at the site, hydraulic conductivities calculated for the A-Zone and B-Zone ranged from 2 to 40 and 4 to 153 feet per day, respectively. The ground water seepage velocities estimated for the A-Zone and B-Zone were approximately 40 and 300 feet per year, respectively (ERM 2006a).

1.3.2 Chemical Occurrence in Soil

Soil samples were collected at the Hookston Station Parcel for laboratory analysis of volatile organic compounds (VOCs), TPH, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals. The VOC, TPH, SVOC, and PCB concentrations in soil throughout the Hookston Station Parcel are generally low or non-detect, with only a few sample concentrations exceeding the ESLs. Subsurface soil samples collected in one small on-site area contain soil arsenic concentrations above background levels for soils in the San Francisco Bay Area. The results of the *Baseline Risk Assessment* (CTEH 2006) indicate that risks to human health associated with exposure to soils at the Hookston Station parcel are limited to construction workers that may be exposed to arsenic in soil during invasive activities in a very small portion of the Hookston Station Parcel.

1.3.3 Chemical Occurrence in Ground Water

TCE and its degradation products cis-1,2-dichloroethene (DCE) and 1,1-DCE are the most widespread compounds in A- and B-Zone ground water and are the primary COCs for the Hookston Station Parcel. The distributions of tetrachloroethene (PCE), TCE, cis-1,2-DCE, 1,1-DCE, and vinyl chloride in A- and B-Zone ground water (based on First Quarter 2007 data) are illustrated on Figures 1-7 through 1-16. The PCE and associated breakdown products observed in the northwestern corner of the Hookston Station Parcel (e.g., at MW-01, MW-04, MW-07, and MW-22A/B) originate from a separate source upgradient of the Hookston Station Parcel, as described further below.

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

It is important to note that the ground water quality of the area that encompasses the Hookston Station Parcel has been impacted by multiple sources of COCs, as follows:

- Hookston Station Parcel – TCE source area;

- Pitcock Petroleum – Petroleum hydrocarbon source area, including total petroleum hydrocarbons, benzene, and methyl tert-butyl ether (MTBE); and
- Vincent Road Area – PCE/TCE source area.

Figure 1-17 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 to the northeast. The Vincent Road Area PCE/TCE plume originates west of Vincent Road and flows to the northeast 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 VOCs detected in monitoring wells MW-1, MW-4, MW-7, and MW-22A/B, which are in the northwestern portion of the Hookston Station Parcel (Figures 1-4 and 1-5), are not associated with the Hookston Station Parcel TCE plume. These VOC 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 offsite. 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 to the northeast across the northern portion of the Hookston Station Parcel. Based on the ground water chemistry and flow data collected by the Hookston RPs, petroleum hydrocarbons 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 ground water plume that flows to the northeast beyond the Hookston Station Parcel comprises the downgradient study area.

1.3.4 *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. The results of these sampling events were included in the *Remedial Investigation Report* (ERM 2004), *Indoor Air Sampling Report* (ERM 2006b), and *2006 Annual Indoor Air Monitoring*

Report (ERM 2006c). The indoor air sampling locations, summary data tables, and laboratory analytical results were provided in those documents.

The indoor air sampling events were conducted in 2004, Summer 2005-Winter 2006, and Summer 2006. Indoor air samples were collected from 60 homes during one or more of the events. Results of the residential indoor air sampling events were compared to the residential indoor air Environmental Screening Levels (ESLs) (RWQCB 2005). Noteworthy results from the indoor air sampling events, listed in order of frequency of detection, are as follows:

- **Benzene:** Indoor air samples collected from all residences during 2005 and 2006 contained concentrations of benzene that exceed the ESL of 0.085 microgram per cubic meter ($\mu g/m^3$). All crawl space and ambient air samples collected during these events also reported benzene concentrations above 0.085 $\mu g/m^3$. Benzene is not a COC associated with the Hookston Station Parcel.
- **PCE:** Indoor air samples from 57 private residences were analyzed for PCE. Indoor air at 26 of these homes contained concentrations of PCE exceeding the ESL of 0.41 $\mu g/m^3$. These residences are located throughout the downgradient study area. PCE is not a COC that originates from the Hookston Station Parcel. The residential indoor air PCE results are summarized on Figure 1-18.
- **TCE:** Indoor air samples for TCE analyses were collected from 60 private residences during the 2004, Summer 2005-Winter 2006, and Summer 2006 events. Indoor air at nine of the private residences contained concentrations of TCE in indoor air that exceeded the ESL (1.2 $\mu g/m^3$ TCE). 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 $\mu g/L$. The residential indoor air TCE results are summarized on Figure 1-19.
- **Vinyl chloride:** Indoor air samples collected from 42 homes during 2005 and 2006 were analyzed for vinyl chloride. Two homes (1002 Hampton Drive and 1023 Stimel Drive) contained concentrations of vinyl chloride in indoor air exceeding the ESL of 0.032 $\mu g/m^3$. Vinyl chloride was not detected in any other homes.
- **Additional VOCs:** Sixteen indoor air samples collected from 56 homes reported concentrations of 1,2-dichloroethane that exceeded the ESL of 0.12 $\mu g/m^3$. 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 ESLs. None of these VOCs (except 1,1-DCE) are chemicals associated with the Hookston Station Parcel.

1.3.5 Hookston Station Remediation Strategy

The FS provided a detailed comparative analysis to provide a basis for determining which remedial alternative is most appropriate for protecting human health and the environment and managing long-term health risks. Remedial Alternative 4 was selected and was ultimately approved as the preferred remedial alternative. Alternative 4 consists of the following components:

- Zero-valent iron PRB for A-Zone ground water;
- Chemical oxidation for B-Zone ground water;
- Institutional controls for arsenic-impacted on-site subsurface soil in the form of a Soil Management Plan;
- Vapor intrusion prevention components for residences in the downgradient study area in which TCE is present in indoor air at concentrations that exceed the indoor air ESL;
- 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; and
- Institutional controls for new well installation within the impacted area until ground water cleanup goals are achieved.

This remedial alternative was selected because it ranked higher, or as high, as the other alternatives evaluated in the FS for every evaluation criterion, it satisfied the threshold criteria of protectiveness and compliance with applicable or relevant and appropriate requirements, and is expected to be effective at satisfying all balancing and modifying criteria (long-term effectiveness and permanence, reduction of toxicity, mass, and volume through treatment, short-term effectiveness, implementability, and State and community acceptance).

This RDIP has been prepared to support the first component of this overall remedial strategy, the A-Zone PRB. The remedial design and implementation plan for the B-Zone chemical oxidation program will be submitted to the RWQCB on 31 August 2007 and a workplan for implementing the four remaining components listed above was submitted to the RWQCB on 30 March 2007, as required by RWQCB Order No R2-2007-0009. The implementation of those four components is underway.

2.0 REMEDIATION OBJECTIVES

The following sections present the A-Zone ground water cleanup goals and describe the location and extent of the treatment area.

2.1 CLEANUP GOALS

Within Order No. R2-2007-0009, the RWQCB adopted the following cleanup goals to be protective of human health and the environment.

Ground Water Cleanup Standards (and their basis):

- TCE = 5 micrograms per liter (µg/L) (California Maximum Contaminant Level [MCL])
- cis-1,2-DCE = 6 µg/L (MCL)
- trans-1,2-DCE = 10 µg/L (MCL)
- 1,1-DCE = 6 µg/L (MCL)
- Vinyl chloride = 0.5 µg/L (MCL)

It should be noted that the above cleanup standards apply to all wells within the Hookston Station monitoring network, unless demonstrated ambient levels are higher.

In addition to these general ground water cleanup goals, the RWQCB adopted the following "indoor air vapor intrusion cleanup standards," which are A-Zone ground water concentrations that must be achieved prior to removal of the residential vapor intrusion prevention systems. These standards are:

A-Zone Ground Water Cleanup Standards for Indoor Air Vapor Intrusion (and their basis):

- TCE = 530 µg/L (ESL for Vapor Intrusion)
- cis-1,2-DCE = 6,200 µg/L (ESL for Vapor Intrusion)
- trans-1,2-DCE = 6,700 µg/L (ESL for Vapor Intrusion)
- 1,1-DCE = 6,300 µg/L (ESL for Vapor Intrusion)
- Vinyl chloride = 3.8 µg/L (ESL for Vapor Intrusion)

There are currently no exceedances of these ground water cleanup goals (for protection of vapor intrusion concerns) for cis-1,2-DCE, trans-1,2-DCE, or 1,1-DCE.

2.2 LOCATION AND EXTENT OF AREAS OF TREATMENT

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

2.2.1 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. The current extent of the A-Zone and B-Zone ground water impacts, based on First Quarter 2007 monitoring data, for COCs originating in whole or in part from the Hookston Station Parcel are shown on Figures 1-8 to 1-11 and 1-13 to 1-16. 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 A-Zone ground water will be in areas where indoor air TCE impacts have been observed at concentrations above the residential indoor air ESL (1.2 $\mu g/m^3$ TCE). 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, which was ultimately adopted as a cleanup standard for the downgradient portion of the mixed plume. The success of reducing breathable indoor air concentrations for the Hookston Station Parcel COCs will be based on a measurement at the exposure area (i.e., inside the residences).

The area within the A-Zone 500 µg/L TCE contour interval (based on First Quarter 2007 data) in the downgradient study area, which is generally where indoor air impacts above the residential indoor air ESL (1.2 $\mu g/m^3$ TCE) have been observed, is approximately 1 acre (Figure 1-8). The area of ground water impacts above the MCLs is larger, extending from the Hookston Station Parcel to the Walnut Creek channel. The proposed PRB will transect the A-Zone plume and use natural ground water flow so that this large impacted area may be treated with a relatively small remediation footprint.

2.2.2 *Indoor Air*

Based on current data, nine homes have (at some point in the past) contained TCE concentrations in indoor air above the residential indoor air ESL (1.2 µg/m^3). These are also generally located over the core of the mixed plume in the downgradient study area where TCE ground water concentrations are 500 µg/L or greater. The nine homes with indoor air concentrations exceeding the ESL in indoor air are within, or immediately adjacent to, the first block of residential homes located between Hookston Road, Hampton Drive, Thames Drive, and Stimel Drive (Figure 1-19). Vapor intrusion systems were offered to all nine homes and were subsequently installed in seven of those homes, and in all seven homes TCE concentrations are now below the ESL.

3.0 PERMEABLE REACTIVE BARRIER TECHNOLOGY

The following section describes PRB technology and identifies nearby sites that also utilize PRBs to remediate ground water. Sources for additional information about PRB technology are also presented.

3.1 TECHNOLOGY DESCRIPTION

PRBs are used to treat dissolved chemicals in ground water. The PRB is installed across the water-bearing zone to be treated, so that the impacted ground water will flow through the PRB. PRBs have applicability for many chemicals, including chlorinated ethenes such as TCE.

The PRB is developed by placing a zone of reactive material in the path of ground water flow. Figure 3-1 presents a conceptual view of the treatment of ground water using a PRB. The zone of reactivity must be designed using parameters such as chemical concentrations, ground water flow velocity, and other hydrogeological parameters. The reactive medium used for PRBs treating chlorinated ethenes 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, which ultimately degrade to carbon dioxide, water, and chloride ions.

There are several methods used to construct PRBs. A screening of construction alternatives is described in Section 4.2.

3.2 EXAMPLES OF PRBS AT SIMILAR SITES

Numerous sites with similar characteristics to those at Hookston Station have been treated using PRBs. Locally, full-scale PRBs have been constructed at the following locations:

- **DuPont Facility, Oakley, CA.** The PRB was constructed using hydraulic fracturing (trenchless) technologies by GeoSierra, Inc. Ground water at the chemical facility was impacted with elevated levels of carbon tetrachloride, Freon 113®, Freon 11®, and 1,2-dichloroethane. The first phase of the PRB was completed in 2001 and subsequent sampling of the downgradient monitoring wells verified that contaminant concentrations had decreased by 90%. The second phase of the PRB was completed in 2005 and included: (1) the extension of the PRB to its full-scale length of 485 feet, extending from 60 to 115 feet bgs, and (2) the installation of an upgradient, shallow PRB that is 485 feet long and constructed from 25 to 50 feet bgs. This site is regulated by the Department of Toxic Substances Control. Details on this construction effort may be found at:

  - http://www.dupontoakley.com/
  - http://www.geosierra.com/

- **General Electric (former Intersil site), Sunnyvale, CA.** This PRB was installed using a shallow funnel and gate (trenched) construction method. Initial concentrations of contaminants were 50 to 200 µg/L TCE; 450 to 1,000 µg/L cis-1,2-DCE; 100 to 500 µg/L vinyl chloride; and 20 to 60 µg/L Freon 113®. Beginning in 1987, a pump-and-treat system was used to remediate ground water. The system required significant costs to maintain and was subsequently replaced with an in-situ PRB. The pump-and-treat system was removed and the property has been restored to full economic use. The cleanup goal established for the site is to reduce contaminant concentrations to levels below State of California MCLs and Primary Drinking Water Standards: 5 µg/L TCE; 6 µg/L cis-1,2-DCE; 0.5 µg/L vinyl chloride; and 1,200 µg/L Freon 113®. Since the PRB was installed, VOC concentrations have been reported below cleanup goals from monitoring wells located within the iron wall of the PRB.

Resources with other PRB remediation examples are available on the internet at the following websites:

http://www.rtdf.org/public/permbarr/prbsumms

http://www.clu-in.org/download/rtdf/prb/reactbar.pdf

http://clu-in.org/download/rtdf/fieldapp_prb.pdf

http://www.geosierra.com

http://www.eti.ca

http://www.permeablereactivebarrier.com

4.0 REMEDIAL DESIGN

This section presents the results of a pre-design investigation, screens applicable construction methods for a zero-valent iron PRB, and describes the design parameters for the PRB.

4.1 PRE-DESIGN INVESTIGATION RESULTS

Investigation activities were conducted in January-February 2007 to collect additional data to assist with the design of the PRB. The investigation included a bench-scale treatability study and the collection of ground water samples and geophysical data along the proposed PRB alignment.

4.1.1 Bench-Scale Treatability Study Results

A bench-scale treatability study was performed using site ground water collected from MW-14A. The bench-scale test included a column containing 100% granular iron obtained from Connelly GPM of Chicago, Illinois. A copy of the treatability study is included in Appendix A.

Ground water samples collected during the laboratory column test were used to evaluate the following specific objectives:

- Characterize the chlorinated breakdown products of TCE (i.e., cis-1,2-DCE, 1,1-DCE, and vinyl chloride) in site ground water;
- Determine degradation rates of these compounds in site ground water using a commercial source of granular iron;
- Observe changes in inorganic geochemistry as a result of the pH, oxidation reduction potential (Eh), and alkalinity changes, including possible mineral precipitation.

The treatability study concluded:

- The Connelly granular iron degraded the TCE, cis-1,2-DCE, 1,1-DCE, and vinyl chloride present in site ground water to below the Hookston Station ground water cleanup goals;
- Based on the field-anticipated half-lives and the field ground water temperature, a residence time of 5.4 days resulting in an iron thickness of 0.6 foot would be required for the zero-valent iron PRB at the site;
- Eh and pH trends were consistent with bench-scale tests completed for other sites with similar water quality and types of granular iron; and

- The anticipated low quantity of carbonate mineral precipitates that may be formed in the iron PRB will not significantly affect PRB system performance.

It should be noted that the treatability study completed for the Hookston Station Parcel was performed using a type of iron typically used for open trench or biopolymer slurry trench installations. Following ERM's review of the pre-design data (described below) and further evaluation of construction alternatives (Section 4.2), the Hookston RPs are currently performing a separate treatability study using a finer-grained iron that is used in hydraulic fracture applications. The reaction rates of finer-grained iron are typically much faster than the coarse-grained material, so a separate treatability test is necessary to determine half-lives of contaminants across an injected PRB. The results of this new study will be provided to the RWQCB under separate cover once completed.

4.1.2 *Cone Penetrometer Testing/Membrane Interface Probe Borings*

The Hookston RPs collected additional site characterization data within Len Hester Park and along Hookston Road in February 2007. The purpose of this investigation was to collect geological and chemical distribution data along the proposed PRB alignment for use in designing the A-Zone PRB and the associated performance-monitoring network. All work was completed in accordance with ERM's *Workplan for Pre-Design Soil and Ground Water Investigation*, dated 10 January 2007. These data were used to determine the location, length, and depth of the PRB.

The pre-design investigation consisted of collecting geological and ground water quality data from 11 soil borings along the proposed PRB alignment (Figure 4-1). The borings were advanced with a cone-penetrometer testing (CPT) rig equipped with a membrane interface probe (MIP). CPT drilling techniques allow for the collection of continuous, detailed stratigraphic and hydrogeological data with minimal site disturbance and waste generation. The MIP continuously monitors the presence of total VOCs in the subsurface using a mobile laboratory that is equipped with a photoionization detector, a flame ionization detector, and an electron-capture detector. All drilling activities were conducted in accordance with the *CPT Standard Operating Procedures* documented in the *Phase I Remedial Investigation Sampling and Analysis Plan* (ERM 2000).

Borings ranged in depth from approximately 50 to 80 feet bgs. Geophysical logs from the CPT rig and chemical distribution logs from the MIP rig are provided in Appendix B. Ground water samples were collected using HydroPunch sampling techniques during and immediately after the CPT/MIP borings were completed. The ground water results are summarized on Figures 4-2 and 4-3 and on Table 4-1. Copies of the laboratory reports from this investigation are provided in Appendix C.

A cross-sectional diagram depicting CPT soil behavior type, MIP data (specifically, the electron-capture detector results, which best respond to chlorinated solvents such as TCE), and TCE in ground water is provided as Figure 4-3. The following observations are made using these pre-design investigation data:

- The A-Zone comprises primarily fine-grained soils, mostly silts with fine sands and clays. Coarser-grained sand stringers with high VOC concentrations within the A-Zone were not observed in this area.
- As shown in Figure 4-2, the B-Zone sands are typically found at depths between 50 and 80 feet bgs. Along the eastern flank of the test alignment (in the vicinity of CPT-44, -45, and –46), the B-Zone sands are slightly more shallow, starting at approximately 37 feet bgs.
- Based on MIP and chemical concentration data, the shallow ground water within the A-Zone is generally more impacted along the western portion of the investigation alignment compared with the eastern portion of the alignment. For example, in ground water samples collected from A-Zone silts beneath Len Hester Park (CPT-36 through CPT-41), TCE concentrations ranged from 240 to 2,900 µg/L, whereas A-Zone ground water samples collected beneath Hookston Road (CPT-42 through CPT-46) ranged in concentration from 20 to 95 µg/L. The core of the TCE plume in A-Zone ground water appears to be centered on CPT-41. These findings are generally consistent with prior interpretations of ground water chemical distribution and the results of indoor air samples collected within the downgradient area.
- The vertical distribution of contaminants based on MIP responses is generally consistent with monitoring well and ground water grab samples collected from this area. The MIP tools indicate there are chemical impacts in deeper portions of the A-Zone that are not being monitored by the current monitoring network. For example, in the vicinity of CPT-40 and CPT-41, low MIP responses were found at the water table (approximately 20 feet bgs), which is consistent with the results of the adjacent wells MW-15A and MW-27A (both of which are screened from approximately 15 to 25 feet bgs). However, the MIP results show that ground water concentrations in these silts increase at approximately 30 feet bgs. Ground water samples collected from CPT-40 and CPT-41 at approximately 35 to 40 feet bgs contained TCE concentrations ranging from 860 to 2,900 µg/L, while TCE was detected in nearby water table wells MW-15A and MW-27A at concentrations of 230 and 110 µg/L, respectively, during the First

Quarter 2007 monitoring event. These deeper, impacted silt intervals will be addressed by the PRB, as they are not part of the deeper B-Zone sand unit.

4.2 SCREENING OF APPLICABLE CONSTRUCTION ALTERNATIVES

Two construction methods for PRBs were screened for use at the Hookston Station Parcel.

4.2.1 Biopolymer Slurry Trench

One of the most cost-effective PRB construction methods has been biopolymer (BP) trenching. Installation of a treatment zone of granular iron using BP is similar to constructing a conventional impermeable slurry wall. As the trench is excavated, BP is added as liquid shoring to provide stability to the trench walls. The BP used is typically guar gum-based. With the addition of BP to the trench, the excavation can continue without the need for dewatering. Granular iron (or iron-sand mixture) is added to the trench and BP by tremie pipe. Recirculation wells are spaced along the length of the trench. After placement of the granular iron is complete, an enzyme is circulated through these wells. The enzyme initiates the breakdown of the BP, thereby allowing ground water to flow through the granular iron PRB. At least 25 full-scale iron walls have been constructed with the BP method. The maximum depth for a granular iron PRB completed to date is 70 feet bgs.

There are, however, several technical and administrative issues regarding the use of this method for the Hookston Station Parcel:

- Trenching through fine-grained soils, such as the silts, fine sands, and clays of the A-Zone in this area, can potentially cause smearing of the excavation sidewalls that reduce the localized permeability of those soils, thereby reducing the ability of ground water to flow through the PRB. Although many PRBs have demonstrated that the iron or iron/sand mixtures are more permeable than the surrounding soils, several sites have observed water level buildup on the upgradient side of a PRB, suggesting some restrictions in flow due to smearing of the excavation sidewalls.

- Continuous trenching from the ground surface may require the temporary relocation of underground utilities. In the vicinity of the proposed Hookston Station PRB, water lines, natural gas lines, and sewer lines may be affected.

- There is a relatively high level of activity in the local community during construction, as this method requires the use of large excavation machinery and generates significant truck and heavy equipment traffic.
- Because soils would be completely removed from the trench, this emplacement method generates a significant amount of waste that must be temporarily stored near the trench, characterized, and later disposed of.
- Because there is significant soil movement and stock piling, trenched construction methods are generally not performed during the rainy season due to storm water runoff and safety issues.

4.2.2 *Vertical Hydraulic Fracturing*

Continuous PRBs can be injected into the subsurface using vertical hydraulic fracturing (VHF). Boreholes that are spaced 15 feet apart along the length of the PRB alignment are advanced to the required depth for the PRB. Specialized tooling is then inserted into two boreholes and oriented to control the direction and fracture pathway for what will become the PRB treatment zone. The vertical interval for fracturing and injection is isolated in the borehole by packers. Iron filings of medium sand size (approximately –80 to +15 mesh size) are mixed with biodegradable slurry. Immediately before injection of the slurry, a special breaker enzyme is included in the slurry mixture, which is then cross-linked to form a highly viscous gel containing approximately 16 pounds of iron filings per gallon. This highly viscous iron filings carrier is then injected under low pressure (25 psi) through the down-hole tooling to propagate the fracture and form the PRB treatment zone. The gel carrier follows the fracture pathway causing the soil to separate, creating the iron treatment zone.

The enzyme breaks the gel within an hour or two, reducing it to water and harmless sugars, leaving a clean zone of iron filings. The PRB is built from the bottom up by coalescing injections from each borehole to form a continuous treatment zone (i.e., a continuous vertical interval of iron filings). This construction method offers several advantages over BP trenching:

- Hydraulic fracturing does not cause clay smearing along the PRB. No reduction in permeability is anticipated. A pre- and post-construction hydraulic test is completed to confirm this.
- There is no excavation, so no significant wastes are generated and no underground utilities will need to be removed from service.

- This installation method is minimally invasive, requiring only the drilling of 6-inch-diameter boreholes on 15-foot spacings.
- VHF enables placement of PRBs far deeper than possible by conventional construction methods. Continuous PRB treatment zones as deep as 300 feet and up to 9 inches thick can be injected into subsurface using VHF.
- The overall impact to the local community is relatively small. The largest piece of machinery is a mud-rotary drilling rig for installing the fracture casings. There will be a pump trailer and several support vehicles, but there is very little traffic associated with this operation.
- This type of work can be completed during any season in Northern California.

Because of the above advantages, the installation of a zero-valent iron PRB within the A-Zone using VHF methods has been selected for the Hookston Station site.

4.3 PRB DESIGN PARAMETERS

The location, depth, height, and thickness of the proposed PRB alignment are described below.

4.3.1 PRB Location

The PRB will be approximately 380 feet long, and will be installed in a northwest-to-southeast orientation, perpendicular to ground water flow (Figure 4-4). Locations of underground utilities near the proposed PRB alignment are shown on Figure 4-5. Approximately 220 feet of the PRB will be installed beneath Len Hester Park. The remaining 160 feet will be installed beneath portions of Hookston Road and the sidewalk and driveway areas within the Colony Park Townhomes complex. This configuration is slightly different than that proposed in the FS for the following reasons:

- The previously-proposed alignment included a long portion of the PRB to be constructed within (and parallel to) Hookston Road. This was originally proposed to allow for space necessary to construct the PRB using a BP trenching method.
- The hydraulic fracturing installation method does not require a large easement for construction. The largest rig needed over the PRB alignment will be the drill rig necessary to install the fracture casings.

The installation technique will therefore have greater flexibility where the PRB can be installed.

- The proposed alignment is now entirely perpendicular to ground water flow, which increases the efficiency of the PRB. This new alignment is possible because of the increased flexibility using an injected installation method.

4.3.2 PRB Depth and Height

The PRB will be constructed to a depth of approximately 19 feet above mean sea level (msl), which is approximately 44 to 48 feet bgs (adjusting for topographic changes along the proposed alignment), as shown on Figure 4-6. The top of the PRB will be constructed approximately 51 feet msl, which is approximately 11 to 15 feet bgs. Historical well gauging data from nearby well MW-15A show water levels normally fluctuate between approximately 47 and 49.5 feet msl, with one high point of 50.59 feet msl in March 2006, during one of the wettest periods in recent history. The top of the PRB will therefore be above the historical seasonal high water levels. The bottom of the PRB will be generally above the top of the B-Zone sands, which typically begin at approximately 50 feet bgs. The eastern portion of the PRB may encounter sand lenses as observed in boring CPT-42 (at approximately 42 feet bgs) and borings CPT-44 through CPT-46 (between approximately 37 and 46 feet bgs).

4.3.3 PRB Thickness

The thickness of the PRB will be refined following additional bench-scale treatability tests that are currently underway. Based on the chemical concentrations that will be treated by the PRB, the ground water flow data, variations in the subsurface lithology, and experience at other sites, it is expected that the PRB thickness will vary from approximately 3 to 6 inches to provide uniform treatment across the entire length of the PRB. The results of the supplemental treatability test and the final design specifications, including the proposed PRB thickness, will be submitted to the RWQCB as an addendum to this RDIP.

5.0 IMPLEMENTATION PLAN

This section provides the implementation plan for the PRB, which includes pre-construction activities, construction management, an effectiveness-monitoring program, data evaluation and reporting, and an implementation schedule.

5.1 PRE-CONSTRUCTION ACTIVITIES

The pre-construction activities that will be conducted prior to constructing the PRB are described below.

5.1.1 Contractor Selection and Submittals

Bids will be obtained from PRB construction contractors that are capable of installing PRBs with VHF. Once the bids are reviewed, the Contractor will be selected.

The Contractor will provide a submittal package that will document the final construction details for the PRB for approval from ERM. The submittal package will include, but not be limited to, the following information:

- Final location for the PRB alignment, including length, depth, thickness, and orientation;
- Final locations and spacing for the boreholes;
- Material specifications and sources for the iron filings and guar gum enzyme;
- Identification and size of staging areas to be used during the PRB construction;
- Plans for PRB construction confirmation tests (additional information provided further below); and
- Final implementation and construction schedule.

5.1.2 Permitting and Private Property Access Agreement

The Contractor will conduct all work in accordance with applicable local, state, and federal laws and regulations. ERM will obtain all necessary permits from the appropriate agencies. The anticipated permits and notifications are:

- Soil boring permits from Contra Costa County;
- Traffic control plan from the City of Concord; and
- Encroachment permit from the City of Concord.

Copies of these and any other permits and notifications necessary to execute the work will be maintained on site by the Contractor during execution of the work.

A private property access agreement will also be necessary with Colony Park Townhomes to complete the southeastern portion of the PRB.

5.1.3 Utility Clearance

All proposed PRB injection locations would be cleared for utilities prior to concrete coring, drilling or other invasive activity. Underground Services Alert will be notified at least 48 hours prior to beginning work. A private utility locator will be retained to provide utility clearance at each location. The utility locator will identify the locations of water, gas, fuel, electrical, communication, storm sewer, and sanitary sewer lines. Invasive work will not be initiated until all stages of utility clearance described above are completed. In addition, the upper 5 feet of all borings will be hand-augered or air-vacuumed prior to drilling.

5.2 CONSTRUCTION MANAGEMENT

Construction management details, including equipment and materials staging areas, traffic control, and waste characterization, storage, and disposal are described below.

It should be noted that because the PRB construction work is completed completely underground, there are no dust or vapor controls that will be necessary during construction. Local residents and Fair Oaks Elementary School will be notified prior to any construction activities.

5.2.1 Equipment and Materials Staging Area

Temporary facilities, project-control setup, and site access and security are necessary so each component of the remediation work can be performed. These include:

- A location established for a field office, equipment, storage containers, materials, and sanitary facilities. The Contractor is responsible for any utility connections and disconnections that may be required.

- A parking area for workers' personal vehicles. The parking area will be at a location on site such that the work will not be hindered.
- Fencing and signs around specific work areas to prevent unauthorized entrance. An entry/exit point to the project site will be established. At the entry/exit point, signs will be placed to direct visitors and vendors to either a field office or designated area where they can check in with the site superintendent.
- The Contractor will be responsible for site security 24 hours a day, 7 days a week. Measures may include, but not necessarily be limited to, perimeter fence installation, site lighting, construction of a safety fence around potential site hazards (if any), gate locks, equipment storage vaults, and off-hours security personnel.

We anticipate that one of the County-owned vacant lots immediately northwest or southwest of the Hookston Road/Bancroft Road intersection, may be used for equipment staging during the construction process. We will make every effort to restrict contractor vehicle parking to these staging areas to minimize the traffic impacts in this area.

5.2.2 *Traffic Control*

Due to the location of the proposed PRB, it will be necessary to close at least one lane of Hookston Road when the PRB is being constructed beneath Hookston Road. The easiest method for implementing traffic control for the PRB installation would be to close Hookston Road between Bancroft Road and Hampton Drive and implement a detour into the community via Stimel Drive off Bancroft Road. In the event this is not possible, a traffic control plan will be prepared to direct traffic around the project work along Hookston Road. The plan will be submitted to the City Engineer for approval prior to implementation. All residents will have the ability to access their homes throughout construction, although traffic detours may be in place for a brief time.

The southern portion of Len Hester Park will also be closed during construction. Pedestrian traffic will be re-routed as appropriate through the park to ensure the safety of individuals using the park during construction.

5.2.3 *Waste Characterization, Storage, and Disposal*

While it is not anticipated that a significant amount of waste material will be generated during the project activities, drill cuttings and a small quantity of wastes associated with the injection process are expected. All waste materials will be placed in 55-gallon drums or roll-off bins, appropriately labeled, and stored at the equipment staging area.

The generated waste materials will be sampled for waste disposal profiling. Once profiling is completed, the wastes will be disposed of at an appropriate landfill facility.

5.2.4 *Site Restoration*

All project work areas will be restored to pre-construction conditions. Street sections and portions of the walkway within Len Hester Park that need to be repaired will conform to all applicable City standard plans. Ruts and damage to the park will first be filled with clean soil to provide an even surface prior to surface restoration. Damaged grass areas will be seeded or new sod will be placed to repair these areas.

5.3 *CONSTRUCTION CONFIRMATION TESTS*

Once the PRB has been installed, the Contractor will conduct tests to confirm that the PRB was installed according to the design specifications. These tests will include hydraulic conductivity pulse tests, PRB imaging tests, and PRB thickness verification tests. These tests will be designed and conducted by the Contractor, and are briefly described below.

Hydraulic pulse interference tests will be conducted prior to and after the PRB construction is installed. The tests will be conducted to verify the local ground water flow characteristics (primarily related to the hydraulic conductivity of the surrounding formation) are not reduced by the installation of the PRB.

Geophysical imaging tests will be conducted along the entire length of the PRB during construction to verify the width and depth of the PRB. The Contractor will also collect core samples through the PRB to confirm its thickness; these samples will be collected from angled boreholes advanced through the PRB in designated areas.

5.4 *EFFECTIVENESS MONITORING PLAN*

While there are no operational or maintenance requirements for the PRB, ground water monitoring is a critical component for the long-term evaluation of PRB system effectiveness. This section describes the monitoring proposed to evaluate the effectiveness of the remedial action at achieving remedial action objectives for A-Zone ground water. The key elements of the ground water monitoring program include evaluating ground water chemistry and ground water hydraulics relative to the design criteria of the PRB system. Ground water monitoring will evaluate the direct effectiveness of the PRB for destroying VOCs in the A-Zone ground water, as well as evaluate the ability of natural degradation processes to reduce VOCs. In addition, air quality monitoring will be performed to ensure the effectiveness of the vapor intrusion prevention.

The following sections present the various ground water monitoring activities that will be performed to demonstrate PRB effectiveness.

5.4.1 *Monitoring Well Installation*

Monitoring wells will be installed at 25 new locations; 12 immediately upgradient of the PRB, and 13 immediately downgradient of the PRB (Figure 4-4). It is anticipated that these wells can be installed within 3 to 5 feet of the PRB, except one well, which will be installed near the MW-15A/B/C well cluster. Based on the CPT/MIP data collected during the pre-design investigation, seven of the new monitoring wells will be installed in a deeper portion of the A-Zone (from approximately 30 to 40 feet bgs) to monitor the higher concentrations found in this depth interval. For the purposes of identifying the differences between the water table wells (with an "A" designation, e.g., MW-15A) and these deeper well screens, the deeper intervals will be labeled with "A2" designations (e.g., MW-15A2).

5.4.2 *Water Level Monitoring*

Water levels will be measured in each of the monitoring wells along the PRB alignment (MW-30A through MW-43A2) monthly for the first year following installation. These data will be used to verify that no significant hydraulic buildup behind the PRB is occurring throughout all seasons. Following this initial year of well gauging, water levels will be collected semiannually in accordance with the existing Self-Monitoring Program.

5.4.3 *Baseline Water Quality Monitoring*

Baseline groundwater data will be collected from MW-15A and MW-27A prior to PRB installation. Because of the hydraulic nature of the PRB installation method, performance-monitoring wells immediately upgradient and downgradient of the PRB (MW-30A through MW-43A) cannot be installed until after the PRB is constructed. Once these new wells are installed, baseline ground water samples will be collected from each new well for laboratory analysis of VOCs. Three of the wells on the upgradient side of the PRB will also be sampled for additional baseline ground water sampling parameters. These data will be used for future evaluation of the PRB performance. The additional baseline ground water samples will be analyzed for the following parameters:

- pH
- Ground water temperature
- Oxidation-reduction potential
- Dissolved oxygen
- Specific conductance
- Turbidity
- Salinity
- Metals (K, Na, Ca, Mg, Fe, Al, Mn, and Ba)
- Anions (SO_4, Cl, Br, F, and NO_3)
- Alkalinity
- Total dissolved solids
- Total suspended solids
- Total organic carbon
- Dissolved organic carbon.

5.4.4 Post-Construction Water Quality Monitoring

To ensure ground water remedial action objectives are achieved, water quality monitoring will be conducted following construction of the PRB. Approximately 3 months following PRB construction, all monitoring wells along the PRB alignment (MW-30A through MW-43A2) will be sampled and analyzed for VOCs. At the locations where baseline ground water sampling was completed in wells upgradient of the PRB, the new wells immediately downgradient of the PRB will be analyzed for the same suite of chemical parameters listed above (Section 5.4.3). This will allow for the comparison of chemical changes following PRB installation.

All wells installed as part of the performance monitoring program will be analyzed for VOCs quarterly for the first year. Following the first year of operation, the Hookston RPs will evaluate the data to determine the appropriate sampling frequency and locations.

5.5 DATA EVALUATION AND REPORTING

Data collected during the baseline ground water sampling, system installation, and hydraulic conductivity pulse tests will be tabulated and evaluated to document the effectiveness of the PRB. These data will be presented in a technical report, which is required by Task 6 of Order No. R2-2007-0009; that report will also document completion of PRB installation and the initial data for performance monitoring by 28 September 2008. Task 9 of Order No. R2-2007-0009 requires status reports documenting the remedy effectiveness; these reports are due on 31 December 2009, 31 December 2012, and every 5 years thereafter. Additional performance monitoring data will be presented in the Semiannual Monitoring Reports, which are prepared in accordance with the Self-Monitoring Program described in the Order.

5.6 IMPLEMENTATION SCHEDULE

The schedule for the components of this Implementation Plan is shown in Table 5-1.

6.0 CLOSURE AND POST-CLOSURE ACTIVITIES

The PRB system does not require any closure or post-closure activities. The PRB may remain in place indefinitely, as its materials of construction do not represent a potential for any deleterious impact or risk to human health or the environment.

7.0 HEALTH AND SAFETY

Activities described in this RDIP will be performed in accordance with the current site-specific *Health and Safety Plan*, which is included in the *Phase I Remedial Investigation Sampling and Analysis Plan* (ERM 2000). The procedures described by the plan will be implemented and enforced by a health and safety representative during site work. Compliance with the *Health and Safety Plan* will be required of all persons who enter restricted areas for the project. The Contractor will also be required to prepare and follow a site-specific health and safety plan that the employees of the Contractor and visitors to the project area will be required to follow.

8.0 REFERENCES

ERM-West, Inc. (ERM). 2000. *Phase I Remedial Investigation Sampling and Analysis Plan, Hookston Station Site, Pleasant Hill, California*. December 2000.

ERM. 2004. *Remedial Investigation Report, Hookston Station Site, Pleasant Hill, California.* August 2004.

ERM 2006a. *Feasibility Study, Hookston Station Site, Pleasant Hill, California.* 10 July 2006.

ERM. 2006b. *Indoor Air Sampling Report, Hookston Station Site, Pleasant Hill, California.* 23 January 2006.

ERM. 2006c. *2006 Annual Indoor Air Monitoring Report, Hookston Station Site, Pleasant Hill, California.* 30 November 2006.

CTEH. 2006. *Baseline Risk Assessment, Hookston Station Site, Pleasant Hill, California*. February 2006.

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

United States Code of Federal Regulations. *National Oil and Hazardous Substance Pollution Contingency Plan* (Title 40, Part 435).

United States Environmental Protection Agency (USEPA). 1995a. *Guidance for Scoping the Remedial Design.* Office of Solid Waste and Emergency Response. 1995.

USEPA. 1995b. *Remedial Design/Remedial Action Handbook.* Office of Solid Waste and Emergency Response. 1995.

Tables

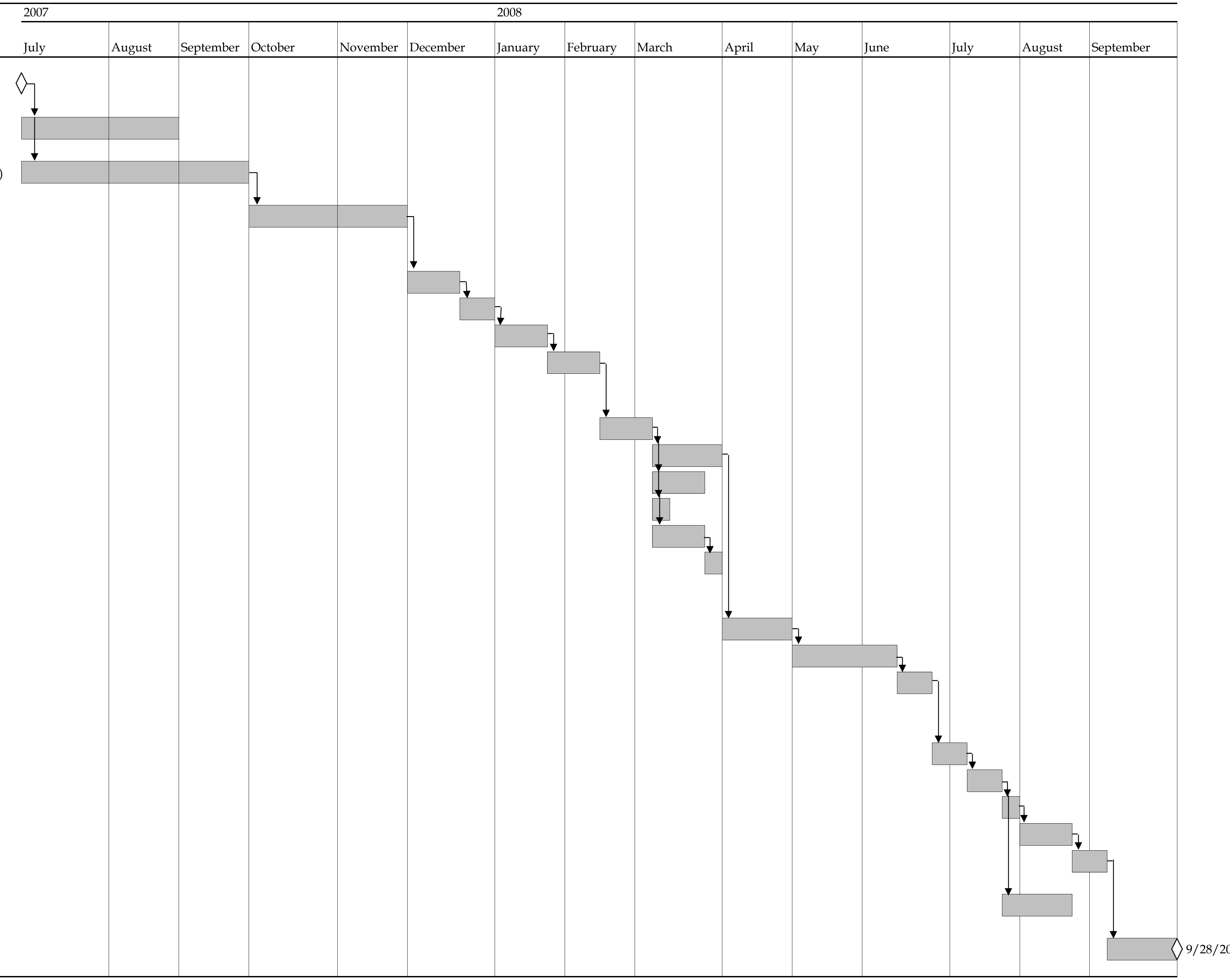
Sample Location	Sample Depth (feet)	Sample Date	PCE (µg/L)	TCE (µg/L)	c-1,2-DCE (µg/L)	t-1,2-DCE (µg/L)	1,1-DCE (µg/L)	VINYL CHLORIDE (µg/L)	1,1,1-TCA (µg/L)	1,1-DCA (µg/L)	1,1,2-TCA (µg/L)	1,2-DCA (µg/L)	BENZENE (µg/L)	TOLUENE (µg/L)	ETHYLBENZENE (µg/L)	XYLENES (µg/L)	MTBE (µg/L)	ACETONE (µg/L)	CHLOROFORM (µg/L)	DCM (µg/L)
California State MCL:			*5*	*5*	*6*	*10*	*6*	*0.5*	*200*	*5*	*5*	*0.5*	*1*	*150*	*700*	*20*	*5*	*n/a*	*n/a*	*5*
Hookston Station Ground Water Cleanup Standard:			*n/a*	*5*	*6*	*10*	*6*	*0.5*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Hookston Station Ground Water Cleanup Standard (for vapor intrusion):			*n/a*	*530*	*6,200*	*6,700*	*6,300*	*3.8*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
CPT-36	34	2/23/2007	**0.68**	**280**	**23**	**0.91**	**8**	<0.50	<0.50	**2.1**	**0.57**	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	**5.6**	<0.50	<5.0
CPT-36	73	2/23/2007	**0.82**	**920**	**5.6**	**0.61**	**55**	<0.50	<0.50	**3.2**	**1.1**	0.53	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-37	34	2/23/2007	**1.2**	**440**	**18**	**0.97**	**28**	**0.69**	<0.50	**3.7**	**0.73**	<0.50	<0.50	<0.50	<0.50	<1.0	**0.51**	<5.0	<0.50	<5.0
CPT-37	65	2/23/2007	**1.3**	**980**	**5.3**	**0.85**	**81**	<0.50	<0.50	**4.6**	**1.8**	**0.82**	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-38	20	2/23/2007	**1.1**	**240**	**24**	**0.79**	**4.7**	<0.50	<0.50	**0.99**	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	**6.3**	<0.50	<5.0
CPT-38	54	2/23/2007	**1**	**1,100**	**4.7**	**0.72**	**81**	<0.50	<0.50	**4.2**	**1.6**	**0.66**	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-39	54	2/22/2007	**1**	**820**	**5**	**0.62**	**73**	<0.50	<0.50	**3.9**	**1.6**	**0.66**	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-40	39	2/28/2007	<2.5	**860**	**3.4**	<2.5	**93**	<2.5	<2.5	**3.8**	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<25	<2.5	**25**
CPT-41	34	2/28/2007	**0.87**	**2,900**	**10**	**1.8**	**250**	<0.50	<0.50	**9.3**	**6.2**	**2.5**	**0.57**	<1.0	<0.50	<1.0	<0.50	<5.0	**0.6**	<5.0
CPT-41	48	2/28/2007	**0.73**	**1,100**	**4.3**	**0.71**	**91**	<0.50	<0.50	**4.1**	**2.1**	**0.71**	<0.50	<1.0	<0.50	<1.0	<0.50	**7**	<0.50	<5.0
CPT-42	23	2/27/2007	<0.50	**93**	**18**	**0.73**	**6.3**	**0.6**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-42	45	2/27/2007	**1.4**	**2,000**	**12**	**1.9**	**170**	<0.50	<0.50	**6.8**	**3.6**	**2.1**	**0.62**	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-42	54	2/27/2007	**0.82**	**390**	**4.6**	**0.56**	**21**	<0.50	<0.50	**1.7**	**0.73**	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-43	20	2/26/2007	<0.50	**95**	**45**	**2.1**	**7.2**	**1.1**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-44	20	2/27/2007	<0.50	**75**	**57**	**3.6**	**4.7**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-44	41	2/22/2007	<0.50	**160**	**25**	**2**	**6.2**	**0.94**	<0.50	**0.55**	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-45	20	2/27/2007	<0.50	**20**	**27**	**1.6**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0
CPT-45	39	2/26/2007	<2.5	**1,200**	**28**	**3.4**	**61**	<2.5	<2.5	**4.2**	<2.5	<2.5	<2.5	<2.5	<2.5	<5.0	<2.5	<25	**5.4 B**	**26**
CPT-46	44	2/22/2007	<0.50	**170**	**5.9**	**0.51**	**8.8**	<0.50	<0.50	**0.63**	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<5.0	<0.50	<5.0

Notes:
All samples analyzed by USEPA method 8260B at Test America in Sacramento, California.
(µg/L) = Micrograms per Liter.
n/a = Not applicable.
< = Analyte not detected at or above the reporting limit.
B= Analyte was detected in the associated Method Blank.

Chemicals:
PCE = Tetrachloroethene
TCE = Trichloroethene
c-1,2-DCE = cis-1,2-Dichloroethene
t-1,2-DCE = trans-1,2-Dichloroethene
1,1-DCE = 1,1-Dichloroethene
1,1,1-TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
1,1,2-TCA = 1,1,2-Trichloroethane
1,2-DCA = 1,2-Dichloroethane
MTBE = Methyl tert-butyl ether
DCM = Methylene chloride

Table 5-1
Tentative PRB Implementation Schedule
Hookston Station
Pleasant Hill, California

Task #	Task Description	Anticipated Duration (Completion Date)
1	Submittal of the 90% Complete Remedial Design and Implementation Plan	Milestone (29 June 2007)
2	RWQCB Review and Approval of 90% Complete Remedial Design Implementation Plan	60 days (28 August 2007)
3	Submittal of Final Remedial Design and Implementation Plan	90 days[A] (27 September 2007)
4	Final RWQCB Approval of Final Remedial Design and Implemenation Plan	60 days (26 November 2007)
5	PRB Procurement	9 weeks
	Bid Package Preparation	3 weeks (17 December 2007)
	Contractor Bidding	2 weeks (31 December 2007)
	Bid Award and Contract Negotiation	3 weeks (21 January 2008)
	Contractor Submittals and Construction Schedule	3 weeks (11 February 2008)
6	Pre-Construction Activities	7 weeks
	Encroachment Permits	3 weeks (3 March 2008)
	Utility Clearance	4 weeks (31 March 2008)
	Drilling Permits	3 weeks (24 March 2008)
	Baseline Sampling Event	1 day (3 March 2008)
	Laboratory Analysis	3 weeks (24 March 2008)
	Data Evaluation	1 week (31 March 2008)
7	PRB Construction	12 weeks
	Contractor Mobilization/Equipment Staging	4 weeks (28 April 2008)
	PRB Installation	6 weeks (9 June 2008)
	Construction Confirmation Testing	2 weeks (23 June 2008)
8	PRB Effectiveness Monitoring	10 weeks
	Performance Monitoring Well Installations	2 weeks (7 July 2008)
	Monitoring Well Development	2 weeks (21 July 2008)
	Initial System Effectiveness Sampling Event	1 week (28 July 2008)
	Laboratory Analysis	3 weeks (18 August 2008)
	Data Analysis	2 weeks (1 September 2008)
9	Site Restoration	4 weeks (18 August 2008)
10	PRB Completion and Initial Effectiveness Report Submittal	4 weeks (28 September 2008)



Notes:
Anticipated Durations are estimates shown in calendar days.
A - Duration assumes comments for the Draft RDIP are received within 60 days of submittal
Schedule is tentative and will be finalized during the PRB Procurement phase.