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Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, California 92108-4310

CONTRACT NO. N62473-07-D-3211
CTO NO. 0007

FINAL

TECHNICAL MEMORANDUM
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION

December 2012

DCN: ECSD-3211-0007-0018

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ALAMEDA, CALIFORNIA
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TABLE OF CONTENTS

PAGE

ABBREVIATIONS AND ACRONYMS v

1.0 INTRODUCTION 1
- 1.1 Scope and Purpose 1
- 1.2 Organization of Technical Memorandum 2
- 1.3 Summary 3

2.0 SITE BACKGROUND 5
- 2.1 Site Location 5
- 2.2 Land Use 5
- 2.3 Geology 6
- 2.4 Hydrogeology 6
- 2.5 Existing Groundwater Classification 7
- 2.6 Conceptual Site Model/Source of Contamination 8
- 2.7 ROD Summary 9
- 2.8 Chronology of Key Remedial Activities 10

3.0 GROUNDWATER QUALITY 11
- 3.1 Benzene and Naphthalene 11
- 3.2 Total Dissolved Solids Distribution 11
- 3.3 Comparison to Other Groundwater Quality Criteria 13
  - 3.3.1 Sulfates 13
  - 3.3.2 Iron 13
  - 3.3.3 Alkalinity 14
- 3.4 Saline Water Intrusion and Yield 14
- 3.5 Well Construction Requirements 14
- 3.6 Potential for Off-Site Plume Migration 15
- 3.7 Groundwater Quality Summary 15

4.0 GROUNDWATER BENEFICIAL USE EVALUATION 15
- 4.1 EPA Groundwater Classification 16
- 4.2 State Water Board Beneficial Use Classifications 16
  - 4.2.1 Municipal Use 16
  - 4.2.2 Agricultural Supply 17
  - 4.2.3 Industrial Service Supply 17
- 4.3 Evaluation of Groundwater Classification for the FWBZ 18

5.0 RISK ASSESSMENT SUMMARY AND UPDATE 18
- 5.1 Summary of 2004 BHHRA 18
- 5.2 RAOs and Exposure Pathways 21
  - 5.2.1 Vapor Intrusion 22

6.0 FINDINGS AND RECOMMENDATIONS 32

7.0 REFERENCES 34

TABLE OF CONTENTS
(Continued)

TABLES

Table 1 Other Potential Beneficial Uses of Groundwater at Alameda Point

Table 2 Plume Center HydroPunch Groundwater Sampling Results

Table 3 2007 and 2008 Quarterly Groundwater Monitoring Well Sampling Results

Table 4 Vertical Groundwater Contamination Distributions at the HydroPunch Sampling Locations

Table 5 Summary of the BHHRA Tier 2 Risk Assessment Results for Nonpotable Groundwater Uses

Table 6 Summary of the BHHRA Tier 2 Risk Assessment Results for Potable Groundwater Use

FIGURES

Figure 1 OU-5/FISCA IR-02 Parcel Delineation and Site Features

Figure 2 Cross Section A-A′

Figure 3 Cross Section B-B′

Figure 4 Cross Section C-C′

Figure 5 Cross Section D-D′

Figure 6 Cross Section E-E′

Figure 7 Cross Section F-F′

Figure 8 Cross Section G-G′

Figure 9 Cross Section H-H′

Figure 10 Pilot Test Area Cross Section Location Map

Figure 11 Cross Section and Clay Distribution Location Map

Figure 12 OU-5/IR-02 Tidal Adjusted Groundwater Contours April 2007

Figure 13 Conceptual Site Model

Figure 14 Plume Center HydroPunch Groundwater Sample Locations and Benzene Results

Figure 15 Plume Center HydroPunch Groundwater Sample Locations and Naphthalene Results

Figure 16 September 2007 Groundwater Monitoring Well Quarterly Sampling Benzene/Naphthalene Results

TABLE OF CONTENTS
(Continued)

APPENDICES

Appendix A Target Remediation Zone – Background Information (on CD only)

Appendix B Additional Background Information on the Soil Gas Sampling

Appendix C Analysis of the Potential Risks Associated with the Vapor Intrusion Pathway

Appendix D Responses to Agency Comments on the Draft Technical Memorandum

ATTACHMENTS

Attachment 1 Benzene and Naphthalene Initial Mass and Pounds Removed Calculations

Attachment 2 Biosparge Area and Plume Boundary Monitoring Well Results

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ABBREVIATIONS AND ACRONYMS

µg/L	micrograms per liter
BCT	Base Realignment and Closure Cleanup Team
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSU	Bay Sediment Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
DON	Department of the Navy
DTSC	(California) Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FISCA	Fleet and Industrial Supply Center Oakland, Alameda Facility/Alameda Annex
FS	feasibility study
FWBZ	first water-bearing zone
HI	hazard index
ILCR	incremental lifetime cancer risk
IR	Installation Restoration
J&E	Johnson and Ettinger
MCL	maximum contaminant level
mg/L	milligrams per liter
OU	Operable Unit
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RD	remedial design

ABBREVIATIONS AND ACRONYMS
(Continued)

RG	remedial goals
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
SWBZ	second water-bearing zone
SWRCB	(California) State Water Resources Control Board
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
Water Board	California Regional Water Quality Control
USCG	United States Coast Guard

1.0 INTRODUCTION

This Technical Memorandum presents a focused evaluation of groundwater quality and potential human health risks associated with groundwater underlying Alameda Point Operable Unit (OU)-5 (Installation Restoration [IR] Sites 25, 30, and 31)/Fleet and Industrial Supply Center Oakland, Alameda Facility/Alameda Annex (FISCA) IR-02, in Alameda, California. OU-5/FISCA IR-02 is referred to as "the site" in this Technical Memorandum. The Record of Decision (ROD) (DON 2007) for the site was issued in 2007, and construction of the remedial system was completed in October 2009. The chemicals of concern (COCs) for the site are dissolved-phase benzene and naphthalene in the groundwater.

1.1 Scope and Purpose

The purpose of this Technical Memorandum is to provide technical support for moving toward a ROD amendment. Accordingly, this Technical Memorandum reviews the conceptual site model (CSM) in light of the additional data collected since the issuance of the ROD. Specifically, this Technical Memorandum summarizes the technical evaluations and conclusions presented in previous documents (such as the risk assessment results and conclusions presented in the Final Remedial Investigation/Feasibility Study [RI/FS] Report and the post-ROD predesign groundwater and soil stratigraphy investigation results presented in the Final Remedial Design/Remedial Action Work Plan [RD/RAWP]). This Technical Memorandum presents an evaluation of the full body of site characterization data and land-use information to assess the potential for vapor intrusion at the site.

A comprehensive review of the groundwater data collected since issuance of the ROD (DON 2007) was performed to evaluate how these new data affect the need for continued remediation at the site, particularly as these data relate to the CSM and potential risks to people resulting from direct and indirect exposure to the COCs in the groundwater (i.e., benzene and naphthalene). This Technical Memorandum was designed to assemble and present the information needed to establish an effective path forward for the groundwater at the site that is protective of human health and the environment. The groundwater data evaluation was structured to answer the following groundwater management questions and reduce or eliminate uncertainties regarding the site:

- What do these additional groundwater data tell us about the potential beneficial uses of the local groundwater?
- What do these additional data tell us about the potential direct exposures to groundwater in the first water-bearing zone (FWBZ) that would be associated with those beneficial uses?
- What do these additional data tell us about the CSM and the resulting vertical distribution of site COCs, as documented in the ROD?

- What do these additional data tell us about potential indirect exposures to COCs in the FWBZ as a result of vapor intrusion?
- What are the "next steps" to ensure protectiveness of human health regarding the shallow groundwater contamination at the site?

1.2 Organization of Technical Memorandum

Information and evaluations related to the purpose and questions in Section 1.1 are presented in Sections 2.0 through 5.0, and answers to those questions are provided in Section 6.0.

Section 2.0 of this Technical Memorandum provides background information including the site location, land use, geology, hydrogeology, the existing groundwater classification, CSM, ROD summary, and brief chronology of the key remedial activities. This information was used collectively to verify the site CSM, presented in the ROD, of the highest COC concentrations at depth and refine that CSM based on the post-ROD data evaluated in the Final RD/RAWP and also in this Memorandum.

Section 3.0 summarizes the groundwater quality data that have been collected at this site since the ROD was issued. These data are reviewed in the context of potential beneficial uses of the groundwater in the FWBZ.

Section 4.0 presents a reevaluation of the potential beneficial uses of the groundwater in the FWBZ based on the post-ROD groundwater quality data presented in Section 3.0.

Section 5.0 presents a summary of the prior baseline human health risk assessment (BHHRA) for OU-5 (focusing on the projected risks associated with both direct and indirect exposure to the FWBZ groundwater), establishing the completeness or incompleteness of the direct and indirect groundwater exposure pathways for the site, and establishing potential vapor intrusion as the appropriate focus for FWBZ groundwater. Section 5.0 also contains a summary of the prior investigations and assessments of the potential exposure to COCs in groundwater via vapor migration, and presents and summarizes the multiple lines of evidence used to evaluate the significance of this exposure pathway for the site under current and reasonably anticipated future scenarios. Section 5.0 also presents an analysis of the potential vapor intrusion risks using the currently available data and current assessment protocols and toxicity values to evaluate whether the previous RI/FS conclusions relative to vapor intrusion remain valid.

Section 6.0 summarizes the findings of the recent groundwater data evaluation and provides answers to the groundwater management questions posed in Section 1.1 and addresses many of the prior uncertainties associated with the CSM. Section 6.0 also presents recommendations for future steps to ensure protectiveness of human health in relation to shallow groundwater contamination at the site.

Section 7.0 lists the references cited in this Technical Memorandum.

Figures 1 through 16, except for Figure 13, in this Technical Memorandum are figures from previously issued OU-5/FISCA IR-02 groundwater documents. Therefore, the original documented figure numbers are retained for reference.

Appendix A provides background information from previous reports related to the target remediation zone (CD only).

Appendix B presents background information related to soil gas sampling.

Appendix C provides analysis of potential risks associated with the vapor intrusion pathway.

Appendix D presents responses to agency comments on the Draft Technical Memorandum.

1.3 Summary

Additional groundwater data were collected post-ROD as part of the predesign investigation to fill data gaps as well as support the remedial design. Both the pre- and post-ROD data are evaluated in this Technical Memorandum. The FWBZ at the site is not a source of potable water nor is it a plausible source for agricultural or industrial supply, independent of the presence of dissolved benzene and naphthalene. The overall low quality of the groundwater in the FWBZ with respect to total dissolved solids (TDS), iron, sulfates, and alkalinity causes the groundwater to be undesirable for use in even the potential nonpotable applications that were evaluated in the RI/FS risk assessment. Consequently, given this post-ROD data for the FWBZ groundwater, the only exposure pathway remaining is the potential indirect inhalation exposure to COCs in groundwater due to vapor intrusion.

The Final RI/FS risk assessment (ERRG 2004) and prior focused risk assessment of potential vapor intrusion at the U.S. Coast Guard Housing indicated that this potential exposure pathway was not significant and did not result in residential indoor air inhalation risks exceeding the risk management range. The Final RI/FS Report (ERRG 2004) concluded, "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

Post-ROD predesign investigation results identified natural barriers (clay) to upward vapor intrusion. Therefore, the vapor intrusion pathway may not be complete in these areas, and does not contribute significantly to potential indoor air inhalation risk where the pathway exists. This Technical Memorandum includes assessments of potential vapor intrusion and verifies that the previous results are still conservative and technically valid.

There have been no updates to the U.S. Environmental Protection Agency (EPA) Integrated Risk Information System toxicity values for either benzene or naphthalene since these assessments. However, as of 2004, the State of California considers naphthalene to possibly be carcinogenic to humans. The potential vapor intrusion exposure pathway was again found to not be significant

and to not result in residential indoor air inhalation risks exceeding the risk management range even with these more stringent DTSC toxicological assumptions and the updated vapor intrusion assessment protocols. Using the more recent DTSC approach and the soil gas data, vapor intrusion evaluations estimated the RME ILCRs for benzene and naphthalene to still be within the risk management range across the site.

A significant and consistent body of evidence has been developed for this site, which supports the conclusion that volatiles from the dissolved plume of benzene and naphthalene in the FWBZ are not migrating upward into potentially or currently occupied structures sufficiently to create indoor air concentrations that pose a carcinogenic or noncarcinogenic risk higher than the regulatory benchmarks and thresholds that define the risk management range (i.e., an ILCR between 10^{-4} and 10^{-6}). This evidence includes a combination of the following:

A. Direct measurements from the sampling of soil gas, groundwater, crawl space air, indoor air, and outdoor ambient air in relation to the site's residential areas
B. Results of modeling the migration of volatiles released from the groundwater or in the overlying soil gas up through the soil column into a residential building and assessment of the risk implications of the projected indoor air concentrations of the volatiles
C. Results of additional characterization of the physical features and stratigraphy of the site relative to the factors that are known to either enhance or diminish potential vapor intrusion

More specifically, these lines of evidence (presented in more detail in subsequent sections of this Technical Memorandum and in Appendix C) include: (1) direct measurements of soil gas crawl space air, indoor air and outdoor ambient air that in combination indicated that there is not a significant contribution to indoor air COC levels from a subsurface source; (2) numerous borings with associated analytical sampling at different depths that have demonstrated that there are extensive, layered clay deposits at the site that are blocking the upward migration of volatile COCs in the soil gas; (3) soil characterization in the vadose zone that showed that the conditions that are conducive to biodegradation of COCs like benzene and naphthalene are likely to be present across much of the site; (4) analytical results for multi-depth groundwater sampling performed in the absence of hydraulic pumping and mixing showed a natural vertical stratification of COC concentrations with the highest concentrations at depth at the Marsh Crust; (5) site-specific vapor intrusion modeling performed in accordance with recent studies and vapor intrusion guidance projected indoor air concentrations not indicative of significant vapor migration; (6) RI/FS risk assessment results showed RME ILCRs of 1×10^{-6} to 5×10^{-8} for residents based on use of soil gas data; and (7) the results of vapor intrusion evaluations using current DTSC criteria and the soil gas measurements from across the site (i.e., the projected benzene indoor air inhalation RME ILCRs ranged from 4.8×10^{-8} to 4.8×10^{-7}, and the projected naphthalene indoor air inhalation RME ILCRs ranged from 5.6×10^{-8} to 5.0×10^{-6}).

All the above evidence was reviewed and critically evaluated for this Technical Memorandum to assess whether the dissolved benzene and naphthalene in the FWBZ groundwater currently pose an indoor air inhalation risk to residents or a potential risk to future residents, children, or students who may routinely occupy buildings at the site. These results and further summary-level information focused on the questions in Section 1.1 are presented in Section 6.0.

2.0 SITE BACKGROUND

The following sections describe the site location, land use, geology, hydrogeology, existing groundwater classification for groundwater in the FWBZ, and the CSM. In addition, the ROD is summarized, and the key remedial activities that have been implemented since the issuance of the ROD are noted.

2.1 Site Location

The site location is shown on Figure 1 (Figure 1-2 from the Interim Remedial Action Completion Report OU-5/FISCA IR-02 Groundwater). Figure 1 also identifies the IR sites and the current site features. The OU-5/FISCA IR-02 groundwater plume, as delineated in the Remedial Design (RD)/Remedial Action Work Plan (RAWP) (TtEC 2010) and shown on Figure 1, is about 60 acres in extent. The EPA Comprehensive Environmental Response, Compensation, and Liability Information System identification number for the site, as certified in the ROD, is CA2170023236.

2.2 Land Use

The primary land use for OU-5 is residential, while land use at FISCA is mixed. OU-5 includes the following:

- IR-25: A 42-acre site, consisting of the currently unoccupied North Village Housing and the U.S. Coast Guard (USCG) Housing Maintenance Office. Future land use is expected to remain residential (DON 2007).
- IR-30: An approximately 6-acre site, consisting of the currently unoccupied Island High School and the Woodstock Child Development Center. If the future land use in this area does not return to education, it would be expected to be residential (DON 2007).
- IR-31: An approximately 24-acre site, consisting of USCG Marina Village Housing Area. Future land use is expected to remain residential (DON 2007).

FISCA includes the following:

- IR-01 is a former warehouse area located south of Site 31 on the southwest side of FISCA. Bayport Housing has since been constructed at IR-01.
- IR-02 is located on the south central side of FISCA. The Defense Logistics Agency Defense Reutilization and Marketing Office operated a screening lot and scrap yard at IR-02 until 1997. The western portion of IR-02 was used as a screening lot and for temporary equipment storage. The eastern portion of IR-02 was used as a scrap yard and

for temporary storage of discarded automobiles, stockpiled scrap metal, and surplus equipment. The Shinsei Garden Housing Development, a multi-family residential project, has been constructed on the western portion of IR-02.

- IR-03 is located in the west central portion of FISCA. It formerly consisted of an automotive drive-up maintenance rack over an asphalt-paved area. The area remains undeveloped.

IR-25, excluding the USCG housing office, and IR-30 are currently Navy property. The USCG housing office and IR-31 are USCG property. FISCA is City of Alameda property.

2.3 Geology

Surface and near-surface soil at the site consists of artificial fill placed during the historical filling of the tidal marshlands, which occurred from approximately 1900 to 1930. The artificial fill materials are believed to be dredging spoils from the surrounding San Francisco Bay and the Oakland Inner Harbor. The average fill thickness at OU-5/FISCA IR-02 is approximately 17 feet based on continuous soil cores collected during the RD/RAWP (TtEC 2010).

The following sedimentary units were identified throughout the site from the ground surface to approximately 20 feet below ground surface (bgs):

- Sand, silty sand (or gravel and cobbles in the west)
- Clay (with the clay layer being thicker to the south and west)
- Fine sand (FWBZ) (sand diminishes to the west and southwest)
- Marsh Crust (a thin layer of highly contaminated sediments)
- Top of the Bay Sediment Unit (BSU)

These sedimentary units were previously characterized by constructing a number of near-surface geological cross sections. These cross sections, labeled as AA′ through HH′, are reproduced as Figures 2 through 9. These figures are Figures 4-3, 4-4, 4-5, 4-13, 4-14, 4-15, 4-16, and 4-17 of the RD/RAWP, respectively. Figures 10 and 11 (Figures 4-2 and 4-12 of the RD/RAWP) show the locations of these cross sections.

The BSU underlying the artificial fill material ranges in thickness from 25 to 100 feet (PRC and Versar 1996), and consists of recent sediment deposited in an estuarine environment. The BSU generally consists of gray to black, high plasticity clay with occasional abundant organic material. Post-ROD drilling and coring activities were terminated once the top of the BSU was encountered.

2.4 Hydrogeology

The uppermost permeable unit at Alameda Point is referred to as the FWBZ. The FWBZ beneath OU-5 occurs in the artificial fill. The saturated thickness of the FWBZ is approximately 8 feet in

the eastern portion of OU-5 and 2 feet in the western portion of OU-5. FWBZ groundwater depth ranges from 5 to 9 feet bgs (TtEC 2010). The groundwater has a lateral flow direction that is variable, but is generally north to northwest toward Oakland's Inner Harbor as shown on Figure 12 (Figure 3-1 of the RD/RAWP). Groundwater contour maps generated during basewide sampling events indicate a high level of local variability. This local variation likely results primarily from the permeability variability of the shallow aquifer fill material (ERRG 2004).

The BSU forms an aquitard between the FWBZ and second water-bearing zone (SWBZ), the deeper, confined aquifer beneath the site (PRC and Versar 1996). BSU thicknesses of 25 to 100 feet were reported beneath the site (PRC and Versar 1996).

2.5 Existing Groundwater Classification

The 2000 beneficial use evaluation report stated that the FWBZ in the central region of Alameda Point beneath OU-5 is considered a Class II aquifer based on federal total dissolved solids (TDS) and aquifer yield criteria, and the SWBZ in this area is considered a Class III aquifer because TDS concentrations in this unit exceeded 10,000 milligrams per liter (mg/L) (TtEMI 2000). The beneficial use evaluation report also stated that the Class II groundwater in the central region (i.e., the area including OU-5 and FISCA) should not be considered a potential drinking water source for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cleanup decisions because:

- The safe yield and maximum pumping rate for the FWBZ are inadequate to support the possible common uses of water or multiple domestic users.
- Saltwater intrusion is occurring at the base of the FWBZ and would be accelerated by groundwater extraction.
- No supply wells currently exist within or downgradient of contaminated groundwater.
- There is an inability to meet state and county requirements for well construction because of a thin, shallow aquifer.

The 2000 beneficial use evaluation report identified other potential beneficial uses (including those represented in Table 1) for the groundwater beneath the central region of Alameda Point that includes OU-5.

In consideration of mitigating factors and property reuse, the Base Realignment and Closure Cleanup Team (BCT) concluded that groundwater beneath OU-5 is unlikely to be used as a drinking water source (TtEMI 2000). However, contaminant mass reduction was believed to be required to facilitate long-term contaminant attenuation and allow for other beneficial uses of groundwater (TtEMI 2000). Furthermore, the BCT concurred with setting cleanup levels at concentrations higher than drinking water standards for the central region on the condition that any contaminated groundwater beneath OU-5 would be remediated to levels such that the potential threats posed by inhalation (e.g., groundwater vapors migrating into buildings), dermal

contact, and those associated with irrigation use are eliminated, and any significant further degradation of the groundwater from contaminant migration would be prevented (TtEMI 2000).

In June 1999, the San Francisco Bay Regional Water Quality Control Board (Water Board) concurred that shallow groundwater at FISCA met the conditions for an exemption from the domestic water supply designation in State Water Resources Control Board Source of Drinking Water Policy Resolution 83-63. The Water Board exemption letter cited TDS in excess of 3,000 mg/L due to naturally occurring salt water intrusion (with an average TDS in area wells of 12,100 mg/L) as the reason for the exemption. Figure 1 shows that FISCA surrounds OU-5 on all but the west side.

There are no drinking water wells installed within the OU-5/FISCA IR-02 plume area. Water service is provided by the East Bay Municipal Utility District from a separate source outside the area, and all residences, schools, and commercial institutions are required to be connected to this supply.

2.6 Conceptual Site Model/Source of Contamination

The Final RI/FS and ROD both document the vertical stratification of COCs at the site, with the highest COC concentrations at depth. The ROD states "benzene concentrations have been found to increase with depth to the top of the Marsh Crust, with the highest concentrations detected in HydroPunch samples collected from approximately 16 to 20 feet bgs." The sources of the groundwater contamination in the FWBZ were originally believed to primarily be past point-source discharges and the contaminated fill that was used to create Alameda Point and FISCA. An objective of the predesign investigation was to verify the CSM's vertical stratification of COCs cited in the ROD, including the location and nature of the contaminant source. Based on the results of predesign continuous soil coring, additional multi-depth soil and groundwater sampling, and isotopic analysis of soil and groundwater at several locations, the RD/RAWP determined that the source of the benzene and naphthalene in the groundwater of the FWBZ is the Marsh Crust, a 0.5- to 1.0-inch thick layer of contaminated sediment located at the BSU contact. Specifically, based on extensive sampling at the site, multiple lines of evidence that verify and explain the COC concentrations increasing with depth to the top of the Marsh Crust, with the highest concentrations detected in HydroPunch samples collected from approximately 16 to 20 feet bgs, as stated in the ROD, include the following:

- Predesign hydrocarbon fingerprint and stable isotope ratio analysis results showed one common source for Marsh Crust soil and groundwater contamination and a coal-based, not petroleum-based, source for site contamination (see Final RD/RAWP, Appendices F and G). Local history confirms a nearby manufactured gas plant where coal was used. The coal carbonization process produces benzene- and naphthalene-rich waste products typically (historically) disposed of into the environment.

- Results of multi-depth soil samples collected during the predesign investigation showed that benzene and naphthalene in most soil samples collected below the water table, but above the Marsh Crust, were below detection limits and low concentrations in all samples. The results for Marsh Crust samples were one to six orders of magnitude higher than soil samples collected below the water table but above the Marsh Crust.
- Results of continuous coring geologic logging: If there were a surface or near-surface spill/source (such as a petroleum spill or a fire pit), evidence of contamination (e.g., smear zone) would be at the top of the water table since site contaminants are lighter than water. No evidence of a smear zone was observed in any continuous cores.
- The Marsh Crust is observed as a thin (approximately 0.5 to 1 inch) layer of contamination at the base of the artificial fill directly on top of the Bay Mud formation (rich in plant material). The highest contaminant concentrations in groundwater were at the Marsh Crust (see Figure 14 [Figure 3-6 of the RD/RAWP]). Therefore, the predesign HydroPunch sample results confirmed RI/FS data cited in the ROD, showing that the groundwater contamination increases with depth to the top of the Marsh Crust (Figure 14).

This determination, documented in the Final RD/RAWP, is consistent with previous multi-depth groundwater data evaluated in the RI/FS and summarized in the ROD. The Marsh Crust layer is encountered at an average depth of 17 feet bgs within the OU-5/FISCA IR-02 plume area based on the continuous core samples collected during the RD/RAWP (TtEC 2010). A more complete and detailed evaluation of the Marsh Crust and the origin of site contamination, including other sites with similar manufactured gas plant wastes, is presented in Appendices F and G of the RD/RAWP (TtEC 2010) and Appendix A of the Interim Remedial Action Completion Report (TtEC 2012). For completeness, these background data are included in Appendix A of this Technical Memorandum.

Figure 13 presents the CSM, which shows the contamination at the Marsh Crust depth, and reflects the refined understanding of the source of the benzene and naphthalene. The CSM is not reflective of any particular location. It is a general representation of the conditions encounted along cross-section E-E′ on Figure 6. Potential exposure-related implications of this CSM are discussed later in Section 5.0.

2.7 ROD Summary

The ROD declaration states:

"The DON, in coordination with the regulatory agencies, has made a risk management decision that remedial action is warranted for shallow groundwater to protect public health and the environment based on the following:

- Site histories
- Field investigations

- Laboratory analytical results
- Evaluation of potential ecological and human health risks
- Current and reasonable anticipated future land use

Results of previous investigations indicate that benzene and naphthalene in shallow groundwater at OU-5/IR-02 pose a potential risk to human health based on current and reasonably anticipated future land uses. For the current and future residential use for most of this site, the carcinogenic risk without using the groundwater for drinking water is within the risk management range. Carcinogenic and non-carcinogenic risks if the groundwater were used for drinking water exceed the risk management range. The ecological risk assessment concluded that there are no unacceptable ecological risks at the site. Additionally, the ecological risk assessment concluded that the site supports only limited habitat, the presence of terrestrial receptors is limited, and future land uses would not create additional ecological habitat."

The ROD defines benzene and naphthalene as the COCs for the site. RAOs for OU-5/FISCA IR-02 were developed to guide the identification and evaluation of remedial alternatives for the groundwater plume. The DON has taken actions to reduce contaminant concentrations in the groundwater and potential exposure media as a risk management decision that was made in coordination with the regulatory agencies. As stated in the ROD, the RAOs for groundwater are to protect human health by preventing exposure of potential residents and occupational workers to benzene and naphthalene present within the groundwater at OU-5/FISCA IR-02.

The remedial goals (RGs) are risk-based chemical concentration limits established to achieve this objective. The risk-based groundwater RGs, as presented in the ROD are:

- Benzene: 1.0 microgram per liter (µg/L)
- Naphthalene: 100 µg/L

These risk-based RGs are conservative in that they provide for unrestricted groundwater use, including the highly unlikely scenario of using the groundwater as a domestic drinking water supply.

In accordance with the RI/FS and ROD, the selected remedy is: biosparging in the plume centers, with soil vapor extraction and nutrient/microorganism enhancement as required; monitored natural attenuation for the remaining plume (and within the plume centers following completion of the active remediation); and institutional controls while the remediation is in progress.

2.8 Chronology of Key Remedial Activities

The Final ROD was issued in August 2007. Predesign investigation was conducted after the issuance of the ROD and included installation of additional plume perimeter monitoring wells, followed by the preparation of the RD/RAWP. The RD/RAWP specified the wells to be

monitored within the plume and at the plume perimeters, as well as the monitoring for the biosparging of the plume centers. The groundwater treatment system was installed between October 2008 and October 2009. Biosparging and groundwater monitoring were initiated in March 2009, and are continuing as of the writing of this Technical Memorandum. Approximately 4.33 kilograms (9.55 pounds) of benzene and 39.04 kilograms (86.07 pounds) of naphthalene have been removed. The calculations are included in Attachment 1. Semiannual biosparge area groundwater monitoring results are included in Attachment 2.

3.0 GROUNDWATER QUALITY

Groundwater samples were collected from HydroPunch and monitoring well locations along the plume center and along the plume boundary in 2007 and 2008 as part of a predesign investigation and as described in the RD/RAWP (TtEC 2010). The groundwater quality data generated by this sampling are discussed below.

3.1 Benzene and Naphthalene

Benzene and naphthalene analyses were conducted on HydroPunch and monitoring well groundwater samples (Tables 2 and 3). HydroPunch locations with benzene and naphthalene concentrations are shown on Figures 14 and 15 respectively (Figures 3-6 and 3-7 of the RD/RAWP). Samples from 48 and 45 percent of OU-5 groundwater sampling locations had benzene or naphthalene concentrations, respectively, exceeding their ROD criteria. The typical HydroPunch included a 3-foot-long well screen. The typical monitoring well was constructed with a 10-foot screen interval. Plume boundary monitoring well locations with benzene and naphthalene concentrations are shown on Figure 16 (Figure 3-12 of the RD/RAWP). Annual plume boundary monitoring well results from 2009 to 2012 are included in Attachment 2.

Pursuant to the remedial design, plume center groundwater sampling also was conducted to evaluate the vertical distribution or gradients of benzene and naphthalene concentrations across the FWBZ. Multi-depth HydroPunch groundwater samples were collected from seven locations (see Table 4). At each of the seven locations, the groundwater sample spanning the Marsh Crust had benzene and naphthalene concentrations one to four orders of magnitude greater than samples collected above the Marsh Crust. These post-ROD multi-depth groundwater sampling results correlated well with the multi-depth soil sampling results and confirm the pre-ROD investigation results that groundwater contamination increases with depth and proximity to the Marsh Crust. COC concentrations at the top of the FWBZ at the time of this sampling were near or below the respective reporting limits for benzene and naphthalene at 6 of 7 multi-depth sampling locations (see Table 4).

3.2 Total Dissolved Solids Distribution

The TDS analytical method measures the total amount of dissolved minerals in water. The solids are typically iron, chlorides, sulfates, calcium, or other minerals. The dissolved minerals can

produce an unpleasant taste or appearance and can contribute to scale deposits on pipe walls TDS levels over 1,500 mg/L are considered to be undesirable for most uses. Guidelines for TDS in irrigation water indicate that water with a TDS concentration greater than 2,000 mg/L is severely limited relative to practical uses for irrigation (Miller and Gardiner 2001). It is difficult and expensive to treat water on a scale associated with domestic or industrial use to reduce TDS levels.

OU-5 area groundwater samples were analyzed for TDS to evaluate whether the FWBZ groundwater met municipal or domestic supply criteria. The federal standard of 10,000 mg/L in the Safe Drinking Water Act of 1974 applies for making this determination. California State Water Resources Control Board (SWRCB) Resolution No. 88-63 (Sources of Drinking Water) states that groundwater is considered to be suitable, or potentially suitable, for municipal or domestic water supply with the exception of groundwater where TDS exceeds 3,000 mg/L (among other thresholds and restrictions) (SWRCB 1988).

Insufficient data had been collected during pre-ROD investigations to evaluate TDS concentrations in the OU-5 area FWBZ groundwater. TDS analysis was, therefore, conducted on HydroPunch and monitoring well samples during the predesign investigation. Table 2 provides TDS data for HydroPunch locations and Table 3 provides the data for the monitoring wells. HydroPunch and monitoring well locations are shown on Figures 14 and 16 respectively. The average TDS concentration was 16,075 mg/L in the FWBZ.

TDS concentrations above 3,000 mg/L were reported in samples collected from:

- 13 of 16 plume center HydroPunch locations (or 19 of 22 samples) with concentrations ranging from 435 to 36,300 mg/L
- 14 of 18 OU-5 area monitoring well locations (or 14 of 19 samples) with concentrations ranging from 650 to 38,300 mg/L

Samples from 80 percent of the OU-5 area groundwater sampling locations had TDS concentrations exceeding the 3,000-mg/L criterion with an average concentration across the site of 16,075 mg/L. For HydroPunch data from samples collected deeper than 15 feet bgs using shorter screen intervals, 100 percent of samples exceeded the 3,000 mg/L criterion (see Table 2).

Samples from 61 percent of OU-5 area groundwater sampling locations had TDS concentrations exceeding the federal criterion of 10,000 mg/L. For HydroPunch samples deeper than 15 feet bgs, only two samples (9,760 and 4,350 mg/L) did not exceed the criterion of 10,000 mg/L. In addition, the overall average concentration of 16,075 mg/L in the FWBZ exceeds the federal TDS criterion of 10,000 mg/L for Class III groundwater.

3.3 Comparison to Other Groundwater Quality Criteria

In addition to TDS, several other water quality parameters for the FWBZ groundwater exceed drinking water or domestic water supply suitability criteria, including sulfates, iron, and alkalinity.

3.3.1 Sulfates

Sulfates in groundwater are caused by natural deposits of magnesium sulfate, calcium sulfate, or sodium sulfate. Concentrations should be below 250 mg/L for most practical applications. Higher concentrations are undesirable for consumptive uses because of their laxative effect on people. Sulfates cannot be economically removed from drinking water. Sulfate concentrations above 250 mg/L were reported in:

- 4 of 47 plume center HydroPunch samples with concentrations as high as 736 mg/L (see Table 2)
- 8 of 24 samples from OU-5 area monitoring wells with concentrations as high as 2,780 mg/L (see Table 3)

Samples from 11 percent of the OU-5 area groundwater sampling locations had sulfate concentrations exceeding the 250 mg/L criterion, and the average sulfate concentration in the FWBZ groundwater was 133 mg/L.

3.3.2 Iron

Iron in domestic water can be objectionable because it can give a rusty color to laundered clothes and may affect taste. Frequently found in water due to large deposits in the earth's surface, iron also can be introduced into drinking water from iron pipes in the water distribution system. In the presence of hydrogen sulfide, iron causes a sediment to form that may give the water a blackish color. An iron concentration less than 0.3 mg/L is considered to be acceptable for domestic use, while concentrations greater than 1.0 mg/L are considered to be unsuitable for use.

Iron concentrations above 0.3 mg/L were reported in:

- 31 of 31 plume center HydroPunch samples with concentrations ranging from 0.6 to 10 mg/L (see Table 2)
- 85 of 92 samples from OU-5 area monitoring wells with concentrations as high as 10 mg/L (see Table 3)

Samples from 94 percent of the OU-5 area groundwater sampling locations had iron concentrations exceeding the 0.3 mg/L criterion, and the average iron concentration in the FWBZ groundwater was 3 mg/L.

3.3.3 Alkalinity

Alkalinity is a measure of the presence of bicarbonate, carbonate, or hydroxide compounds in the groundwater. Concentrations less than 100 mg/L are desirable for domestic water supplies. The recommended range for alkalinity in drinking water supplies is 30 to 400 mg/L. High alkalinity (above 500 mg/L) is usually associated with high pH values, hardness, and high dissolved solids. High alkalinity has adverse effects on plumbing systems, especially on hot water systems (e.g., water heaters, boilers, heat exchangers) where excessive scale reduces the transfer of heat to the water. This results in greater power consumption, increased costs, and more frequent replacement.

Alkalinity concentrations above 500 mg/L were reported in:

- 43 of 46 plume center HydroPunch samples with concentrations as high as 4,550 mg/L (see Table 2)
- 40 of 50 samples from OU-5 area monitoring wells with concentrations as high as 4,250 mg/L (see Table 3)

Samples from 86 percent of the OU-5 area groundwater sampling locations had alkalinity concentrations exceeding 500 mg/L, and the average alkalinity concentration in the FWBZ groundwater was 2,111 mg/L.

3.4 Saline Water Intrusion and Yield

The site groundwater typically contains moderate to high concentrations of TDS as a result of saltwater intrusion from the Oakland Inner Harbor. While the shallow aquifer may be capable of maintaining a sustained yield of 200 gallons per day in the eastern portion of OU-5 where the FWBZ aquifer averages a thickness of 6 feet, pumping-induced intrusion of saltwater would further degrade water quality (Water Board 1999). A yield of 200 gallons per day may not be possible or sustainable in the western portion of OU-5 where the FWBZ is composed of silty sand approximately 2 feet thick. Wells in these areas have very slow recharge.

3.5 Well Construction Requirements

The California Department of Water Resources has developed standard well construction requirements to prevent contamination of water supply wells by chemicals and biologic hazards related to point and non-point sources (DWR 1991). These standards require that annular sanitary seals must extend at least 50 feet bgs for community and industrial water supply wells and at least 20 feet bgs for domestic, agricultural, and other types of water supply wells. Given that the maximum artificial fill thickness (i.e., the thickness of the FWBZ) at OU-5 is 20 feet, water supply well construction requirements would result in the mandated sanitary seal extending all the way through the FWBZ and into the SWBZ. The SWBZ has already been classified as a Class III aquifer due to high TDS/saline content which makes it unsuitable for

domestic, agricultural, industrial, or municipal beneficial uses. Accordingly, a compliant well could not be installed that could be used to extract water from the FWBZ.

3.6 Potential for Off-Site Plume Migration

No off-site FWBZ groundwater production wells have been identified in the vicinity of OU-5. Off-site migration of groundwater is via the regional groundwater flow toward the nearby Oakland Inner Harbor.

3.7 Groundwater Quality Summary

Groundwater quality in the FWBZ does not meet drinking water/domestic supply criteria. In addition to the presence of benzene and naphthalene contamination associated with the Marsh Crust, there are other constituents present due to saltwater intrusion and other phenomena that have resulted in poor water quality relative to the levels of TDS, sulfates, iron, and alkalinity. Groundwater quality parameters and aquifer characteristics incompatible with drinking water/domestic supply include:

- The overall average concentration of 16,075 mg/L in the FWBZ exceeds the federal TDS criterion of 10,000 mg/L for Class III groundwater.
- 11 percent of the OU-5 area groundwater sampling locations had sulfate concentrations exceeding the 250 mg/L criterion.
- 94 percent of the OU-5 area groundwater sampling locations had iron concentrations exceeding the 0.3 mg/L criterion, and the average iron concentration was 3 mg/L.
- 86 percent of the OU-5 area groundwater sampling locations had alkalinity concentrations exceeding 500 mg/L.
- Pumping-induced intrusion of saltwater would further degrade water quality.
- Sustained yields of 200 gallons per day may not be possible in the western portion of OU-5.
- Given that the maximum thickness of the FWBZ at OU-5 is approximately 9 feet, water supply well construction requirements would result in the required sanitary seals extending all the way through the FWBZ into the SWBZ (precluding groundwater extraction form the FWBZ). The SWBZ has already been classified as a Class III aquifer due to high TDS/saline content which makes it unsuitable for domestic, agricultural, industrial, or municipal beneficial uses.

4.0 GROUNDWATER BENEFICIAL USE EVALUATION

Currently, the FWBZ in the central region of Alameda Point beneath OU-5 is considered to be a Class II aquifer based on federal TDS and yield criteria. The SWBZ in this area is considered to be a Class III aquifer because TDS concentrations exceeded 10,000 mg/L (TtEMI 2000). Additional groundwater data collected since the ROD was issued were compiled and evaluated.

This analysis indicates that the FWBZ does not meet the Class II aquifer criteria because of high TDS and high, undesirable levels of other groundwater quality parameters.

In addition to the federal and state criteria, the following criteria also were considered in evaluating the potential future use of the FWBZ groundwater:

- The geology and hydrogeology in the vicinity of OU-5
- State of California production well construction requirements regarding the length of the sanitary seal for municipal, industrial, and domestic production wells
- The current and anticipated future municipal or domestic water supply to OU-5

4.1 EPA Groundwater Classification

According to the preamble of the National Oil and Hazardous Substances Pollution Contingency Plan, site-specific factors can be evaluated to determine whether groundwater should be considered to be a potential drinking water source for CERCLA cleanup decisions. If groundwater within a region or a specific site has little or no potential as a source of drinking water, then alternate cleanup goals can be considered under CERCLA. According to EPA's Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy (EPA 1986), Class III groundwater includes groundwater that is saline, or otherwise contaminated beyond levels that would allow its use for drinking or other beneficial purposes. These include groundwater with a TDS concentration over 10,000 mg/L or groundwater that is contaminated by naturally occurring conditions or by the effects of broad-scale human activity such that it cannot be cleaned up using treatment methods reasonably employed in public water-supply systems.

4.2 State Water Board Beneficial Use Classifications

4.2.1 Municipal Use

Unless otherwise designated by the SWRCB, all groundwater is considered suitable, or potentially suitable, for municipal or domestic water supply (MUN). In making any exceptions, the Water Board must consider the exemption criteria referenced in State Water Board Resolution No. 88-63 and SWRCB Resolution No. 89-39, "Sources of Drinking Water":

Surface and groundwater where:

a. *The total dissolved solids (TDS) exceed 3,000 mg/L (5,000 microSiemens per centimeter, uS/cm, electrical conductivity) and it is not reasonably expected by Regional Boards to supply a public water system, or*

b. *There is contamination, either by natural processes or by human activity (unrelated to the specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices, or*

c. *The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day.*

Groundwater where:

The aquifer is regulated as a geothermal energy producing source or has been exempted administratively pursuant to 40 Code of Federal Regulations (CFR), Section 146.4 for the purpose of underground injection of fluids associated with the production of hydrocarbon or geothermal energy, provided that these fluids do not constitute a hazardous waste under 40 CFR, Section 261.3.

4.2.2 Agricultural Supply

Agricultural supply (AGR) includes uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

The criteria discussed under MUN also effectively protect farmstead uses. To establish water quality criteria for livestock water supply, the SWRCB must consider the relationship of water to the total diet, including water freely drunk, moisture content of feed, and interactions between irrigation water quality and feed quality. The University of California Cooperative Extension has developed threshold and limiting concentrations for livestock and irrigation water. Continued irrigation with water from poor supplies often leads to one or more of the following hazards:

- Soluble salt accumulations
- Chemical changes in the soil
- Toxicity to crops
- Potential disease transmission to humans through reclaimed water use

Irrigation water classification systems, arable soil classification systems, and public health criteria related to reuse of wastewater have been developed with consideration given to these hazards.

4.2.3 Industrial Service Supply

Uses of water for industrial activities (IND) that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization. Many industrial service supplies have essentially no water quality limitations except for gross constraints, such as freedom from unusual debris. Other applications, such as for wash water, heat transfer fluid, and landscaping irrigation, have practical limitations due to the potential effect of the water on the systems conveying or applying the water or the objects or plants to which the water is applied (see Section 3.0).

4.3 Evaluation of Groundwater Classification for the FWBZ

The current classification of the FWBZ in the OU-5 area as a potential source of drinking water (Class II or MUN) was based on a limited or incomplete evaluation of groundwater quality parameters. Data collected during the predesign investigation indicate that groundwater quality is not adequate for potable use due to average TDS concentrations in excess of both the state (3,000 mg/L) and federal (10,000 mg/L) thresholds. In addition, several other groundwater quality parameters are incompatible with domestic use, including sulfate, iron, and alkalinity (see Section 3.7). The presence of these groundwater contaminants is due in part to salt water intrusion and is not associated with any identified contaminant source. Neither TDS nor sulfate can be economically removed from domestic drinking water or small to medium-sized industrial water supplies using conventional techniques.

Agricultural supply (AGR) use was identified as a potential use for the central region groundwater (TtEMI 2000). Use of groundwater for crop irrigation or landscape watering was determined not to be feasible because of the TDS concentration. Livestock water was considered to be an improbable use, based on the assumption that TDS was less than 5,000 mg/L (TtEMI 2000). This use is also not likely to be associated with the reasonably anticipated future use of this site. Acceptable TDS concentrations for turf grass irrigation range from 200 to 500 mg/L. TDS concentrations higher than 2,000 mg/L can damage turf grasses (PennState 2012). As the average TDS concentration in the groundwater (16,075 mg/L) significantly exceeds acceptable levels for crop irrigation or livestock watering (i.e., below 5,000 mg/L) or landscape watering (i.e., below 2,000 mg/L), agricultural supply is not a potential beneficial use of the FWBZ groundwater.

Industrial supply (IND) was determined to not be a potential beneficial use of the FWBZ groundwater due to TDS concentrations greater than 1,000 mg/L and insufficient sustainable yield (TtEMI 2000).

Based on an evaluation of the groundwater quality information presented in Section 3.0 in the context of the federal and state beneficial use criteria, the FWBZ at this site is not a potential source of drinking water and, therefore, should be considered Class III groundwater instead of Class II groundwater. This evaluation also found that the FWBZ groundwater was not suitable for uses like wash water for a car wash or water for irrigating crops or landscaping on a routine basis.

5.0 RISK ASSESSMENT SUMMARY AND UPDATE

5.1 Summary of 2004 BHHRA

The RI BHHRA for OU-5/FISCA IR-02 evaluated potential risks from direct and indirect exposures to chemicals in groundwater associated with potential future beneficial uses that involve bringing groundwater to the surface and using it in commercial and/or industrial

activities. The BHHRA identified potential beneficial uses of groundwater based on the 1995 Basin Plan for the San Francisco Bay Region (Water Board 1995), which identified beneficial water uses for the aquifer that included irrigation water, commercial water, and industrial service supply water. Additionally, the BHHRA quantitatively assessed potential health risks associated with the migration of dissolved groundwater and soil gas constituents into indoor air at a current or future school that would be located at the site.

The BHHRA considered several hypothetically possible direct exposure scenarios associated with groundwater use, including:

- Exposure to workers and the public associated with groundwater use at a commercial car wash
- Exposure to workers associated with groundwater use for industrial cooling or process cooling
- Exposure to workers using groundwater for an industrial emergency shower
- Exposure to workers using groundwater for janitorial activities
- Exposure to workers and the public using groundwater for irrigation purposes (lawn, landscaping, or vegetation)
- Exposure to workers and residents associated with future hypothetical use of the groundwater beneath the property as a potable water supply

These hypothetical receptors were identified through the performance of a qualitative human health evaluation conducted as part of the BHHRA (NewFields 2000). Of these various hypothetical beneficial groundwater use scenarios, the following two were quantitatively assessed in the BHHRA:

- A worker theoretically exposed to chemicals of potential concern (COPCs) in groundwater during the operation of a commercial car wash
- A worker hypothetically exposed to COPCs in the groundwater through landscaping irrigation activities

The BHHRA also considered indirect exposures to COPCs in the FWBZ groundwater due to potential vapor intrusion:

- A school exposure scenario (school children and adult workers) was evaluated based on the assumption of theoretical exposure to volatile COPCs migrating upward from the groundwater into the indoor air of an existing or future school.
- Vapor intrusion into occupied or potentially occupied residential buildings at the site also was evaluated.

For the hypothetical worker beneficial groundwater use exposure scenarios, the potential inhalation of COPCs volatilized from groundwater brought to the surface and released during the

operation of spray jets and sprinklers and the dermal absorption of COPCs during contact with this water were assessed. Use of groundwater as a potable water supply also was assessed. For the school scenario, theoretical inhalation of adult workers and children resulting from vapor migration from groundwater into the indoor school air was estimated using the Johnson and Ettinger (J&E) vapor migration model (EPA 2000). Lastly, for the residential scenario, theoretical inhalation exposures resulting from vapor migration from groundwater into the indoor air and exposures associated with use of groundwater as a potable water supply were evaluated.

The BHHRA conservatively used the maximum detected concentration in groundwater for all COPCs as the exposure point concentrations (EPCs) for both its Tier 1 and Tier 2 risk evaluations, except for benzene and naphthalene. Tier 2 EPCs for benzene and naphthalene were calculated from kriged groundwater concentrations for a 500-foot and 725-foot radius around the monitoring well with the highest detected concentration of benzene. The RI/FS risk assessment (Final RI/FS Report, Section 6, page 6-1) included use of HydroPunch data from samples collected at approximately 20 feet bgs (ERRG 2004). The Final RI/FS Report further documented (Section 6.4, page 6-6) that in both Tier 1 and Tier 2 analysis, exposure point concentration data included data from all depths at both Alameda Point and FISCA.

Two different approaches were used to calculate EPCs for vapor intrusion, one based on groundwater monitoring results and one based on soil gas measurements. The first approach used the Tier 2 groundwater EPCs as input to the J&E vapor migration modeling. The second approach used the measured soil gas concentrations as the driver inputs to the J&E modeling. For soil gas, four exposure areas were defined based on current land use. They were the OU-5 – IR-25, IR-30, IR-31, and FISCA. FISCA was not used for residential purposes at the time the BHHRA was prepared, but the IR-02 area is currently occupied by the Shinsei Garden Housing Development, which was constructed with sub-slab depressurization and vapor barriers. Land use controls dictate that any other new construction in FISCA IR-02 must include engineering controls similar to those now in place. OU-5 IR-31 is currently used for residential housing (USCG Marina Village Housing). IR-30 includes a school that is no longer in use and the Woodstock Child Development Center. IR-25 is abandoned USCG housing. The maximum benzene soil gas concentrations were used as the Tier 2 EPCs for each of these four locations. The Tier 2 evaluation included both Central Tendency and Reasonable Maximum Exposure (RME) factors. The RME noncarcinogenic Hazard Indices (HIs) based on the soil gas data ranged from 0.0076 to 0.0092 across all locations. These values were all well below the acceptable HI threshold of 1.0. The RME results for the incremental lifetime cancer (carcinogenic) risk (ILCR) based on the soil gas data ranged from 5×10^{-8} to 1×10^{-6}. Table 6-2 of the Final RI/FS is included in Appendix C.

The results of this BHHRA demonstrate that for non-potable water beneficial use scenarios involving the FWBZ groundwater, the projected upper-bound Incremental Lifetime Cancer Risks (ILCRs) did not exceed a probability of 1×10^{-4} (1 in 10,000) for any current or future receptors.

Use of the multi-depth groundwater data yielded slightly higher risk than the risk using the soil gas data summarized above, but risks were still in the risk management range. The RME ILCR without potable water usage ranges from 10^{-5} to 10^{-8} for workers, residents, and school children (ERRG 2004). In addition, projected non-cancer Hazard Indices (HIs) were below 1.0 for all receptors. The calculated HI and ILCR for the RME case for each receptor group are summarized in Table 5. The 725-foot kriged radius results are not presented as these HIs and ILCRs were consistently lower than the results based on the 500-foot kriged radius. Therefore, the BHHRA non-consumptive uses of the FWBZ groundwater associated with the commercial worker scenarios were projected to have risks within the risk management range.

The hypothetical use of the FWBZ groundwater as a potable water supply also was evaluated. The BHHRA noted that groundwater at the site is currently not used as a potable water supply. The calculated HI and ILCR for the RME case for each receptor group are summarized in Table 6. These results are seen to be higher than the risk management range, reflecting potentially unacceptable risks for drinking the groundwater.

5.2 RAOs and Exposure Pathways

The ROD states:

"RAOs for OU-5/IR-02 were developed to guide the development and evaluation of remedial alternatives for the groundwater plume. The DON proposes to reduce contaminant concentrations as a risk management decision, which was made in coordination with the regulatory agencies (DON 2006). The RAOs for groundwater are to protect human health by preventing exposure of potential residents and occupational workers to benzene and naphthalene present within groundwater at OU-5/IR-02."

The ROD RAO of ensuring "to protect human health by preventing exposure of potential residents and occupational workers to benzene and naphthalene present within groundwater at OU-5/IR-02" is still intact given the evaluation of the post-ROD data herein. In light of the additional post-ROD groundwater quality data described in the RD/RAWP and as detailed in Sections 3.0 and 4.0 of this Technical Memorandum, the FWBZ is not a potential source of potable water nor is it a plausible source for agricultural or industrial supply, independent of the presence of dissolved benzene and naphthalene. As discussed above, the overall low quality of the groundwater in the FWBZ with respect to TDS, iron, sulfates, and alkalinity causes the groundwater in the FWBZ to be undesirable for use in even these nonpotable applications that were evaluated in the BHHRA. This is especially true for the use of the groundwater at a car wash where the high dissolved solids, sulfates, and iron contents would likely lead to the water causing significant staining and spotting of the vehicles being washed (Water Laundry News 2009). The quality of the groundwater also would practically limit if and when it could be used for irrigation or watering lawns (Miller and Gardiner 2001).

Consequently, the only exposure pathway remaining for the FWBZ groundwater is the potential indirect inhalation exposure to COCs in groundwater due to vapor intrusion. The vapor intrusion pathway in the context of the FWBZ groundwater is discussed in more detail in Section 5.2.1.

5.2.1 Vapor Intrusion

5.2.1.1 Features and Characteristics of the Site Relevant to Potential Vapor Intrusion

Possible vapor intrusion into a residence, school, or day care has been a focus for this site for over a decade. This is due to the presence of a number of residential housing and public buildings overlying the groundwater plume that contains dissolved benzene and naphthalene. These structures include (see Figure 1):

- The unoccupied North Village Housing Area (including the Kollman Circle Housing Area) – A set of formerly used housing units with crawl spaces
- The USCG Marina Village Housing Area – A set of slab-on-grade housing units that is still in use and occupied
- The Shinsei Gardens Housing Development – A new apartment complex that was constructed with a vapor barrier and sub-slab depressurization (Note: Land use controls that have already been implemented require any new construction in IR-02 to include similar engineering controls.)
- The Island High School – A former high school and elementary school that is no longer in use
- The Woodstock Child Development Center – An active slab-on-grade child day-care center

Vapor intrusion of subsurface contamination into the breathing spaces of houses and occupied public structures can occur as a result of the release of volatile constituents that are dissolved in the shallow groundwater and their migration up through the soil column by diffusion and convection. Once at the building foundation or flooring of the structure, the volatile constituents can be drawn into the structure through cracks and openings and mixed with the indoor air. This upward migration of volatiles from the groundwater is most significantly affected by:

- The length of the soil column between the bottom of the foundation or the floor of the occupied structure and the surface of the groundwater table
- The type(s) of soil making up this soil column and their properties (e.g., density, porosity, moisture content, soil vapor permeability)
- The thicknesses and juxtaposition of the soil layers in the vadose zone between the groundwater table and the building foundation or floor of the structure
- The degree to which conditions in the soil column either promote or limit biodegradation of the volatile organic contaminants

5.2.1.2 Evidence Regarding the Completeness and Significance of the Vapor Intrusion Exposure Pathway

A significant and consistent body of evidence supports the conclusion that volatiles from the dissolved plume of benzene and naphthalene in the FWBZ are not migrating upward into potentially or currently occupied structures sufficiently to create indoor air concentrations that pose a carcinogenic or noncarcinogenic risk higher than the regulatory benchmarks and thresholds that define the risk management range (i.e., an ILCR between 10^{-4} and 10^{-6}). This evidence includes a combination of the following:

A. Direct measurements from the sampling of soil gas, groundwater, crawl space air, indoor air, and outdoor ambient air in relation to the site's residential areas

B. Results of modeling the migration of volatiles released from the groundwater or in the overlying soil gas up through the soil column into a residential building and assessment of the risk implications of the projected indoor air concentrations of the volatiles

C. Results of additional characterization of the physical features and stratigraphy of the site relative to the factors that are known to either enhance or diminish potential vapor intrusion

More specifically, these lines of evidence (presented in more detail below) include: (1) direct measurements of soil gas crawl space air, indoor air and outdoor ambient air that in combination indicated that there is not a significant contribution to indoor air COC levels from a subsurface source; (2) numerous borings with associated analytical sampling at different depths that have demonstrated that there are extensive, layered clay deposits at the site that are blocking the upward migration of volatile COCs in the soil gas; (3) soil characterization in the vadose zone that showed that the conditions that are conducive to biodegradation of COCs like benzene and naphthalene are likely to be present across much of the site; (4) analytical results for multi-depth groundwater sampling performed in the absence of hydraulic pumping and mixing showed a natural vertical stratification of COC concentrations with the highest concentrations at depth at the Marsh Crust; (5) site-specific vapor intrusion modeling performed in accordance with recent studies and vapor intrusion guidance projected indoor air concentrations not indicative of significant vapor migration; (6) RI/FS risk assessment results showed RME ILCRs of 1×10^{-6} to 5×10^{-8} for residents based on use of soil gas data; and (7) the results of additional vapor intrusion evaluations using current DTSC criteria that were recently performed and added as Appendix C of this Technical Memorandum. The additional evaluations were performed using the soil gas measurements from across the site, and the RME results for the projected benzene indoor air inhalation ILCRs ranged from 4.8×10^{-8} to 4.8×10^{-7}. The RME results from the additional evaluations had projected naphthalene indoor air inhalation ILCRs ranging from 5.6×10^{-8} to 5.0×10^{-6}.

All the above evidence was reviewed to assess whether the dissolved benzene and naphthalene in the FWBZ groundwater currently pose an indoor air inhalation risk to residents or a potential risk

to future residents, children, or students who may routinely occupy buildings at the site. A more detailed summary of this evidence is presented below.

5.2.1.2.1 Evidence Based on Direct Soil Gas, Groundwater, and Air Sampling

Three lines of direct evidence relative to the potential completeness and significance of the vapor intrusion pathway at the site are associated with the results of the sampling of the site soil gas, groundwater, and air (including indoor, outdoor, and crawl space air).

A-1. Soil gas measurements (active and passive) have been taken multiple times across the study area. Sampling has typically been performed at locations above the groundwater plume and above and below the clay layer. The results of this sampling showed that the soil gas has consistently had relatively low concentrations of benzene and naphthalene even at locations directly above where the highest groundwater concentrations of these constituents were measured. These measurements indicate that the upward migration of volatiles through the soil column is being limited or restricted. An examination of the site conditions (see Section 5.2.1.2.3) suggests that soil gas migration is being limited by the clay layer, which is acting as a relatively effective barrier to upward vapor diffusion and the occurrence of some amount of natural biodegradation of benzene and naphthalene in the vadose zone. In combination, these mechanisms appear to be acting to prevent the benzene and naphthalene soil gas concentrations near the ground surface from becoming measurably elevated. (Further information on the soil gas sampling performed at the site is presented in Appendix B, Section B-1.)

A-2. Indoor air sampling was performed at a number of unoccupied and occupied residential structures of different design and construction styles, in combination with colocated ambient air and/or crawl space air sampling. The results indicated that the concentrations of benzene, naphthalene, and other volatile in the crawl space air (at the houses with crawl spaces) did not differ from their concentrations in the indoor (or outdoor) air. In addition, the measurements showed that the indoor air volatiles concentrations were generally very comparable to the outdoor ambient air concentrations. Together, these findings support the conclusion that there was no significant contribution of volatiles to the crawl space or indoor air from a subsurface source. (Further information on the air sampling performed at the site is presented in Appendix B, Section B-2.)

A-3. An evaluation of the pre-operations soil gas and groundwater data compared to the conservative default screening levels presented in the 2002 EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (EPA 2002) suggested that subsurface volatile contamination could potentially pose an indoor air inhalation risk relative to the threshold carcinogenic and noncarcinogenic risk levels of 1×10^{-6} and 1, respectively, when the maximum detected study areawide concentrations were used in the screening. However, most of the comparisons showed that the measured pre-operations soil gas and groundwater concentrations did not exceed these default screening levels for risk goals within the risk management range. (Further

information on the comparison of the site data to the default EPA vapor intrusion screening levels is presented in Appendix B, Section B-3.)

Therefore, the best predictor of potential indoor air impacts (i.e., properly placed soil gas measurements) indicated that potential inhalation risks were within the risk management range. Second, direct air measurements did not indicate that a subsurface source of volatiles contamination was contributing detectably to the concentrations of these constituents in indoor air or crawl space air. Third, only a very conservative screening level analysis of the maximum measured soil gas and groundwater concentrations assuming minimal resistance to upward vapor migration and no biodegradation gave an indication that there was the potential for vapor intrusion. This indication was associated with potential projected inhalation risk at the most stringent end of the risk management range.

5.2.1.2.2 Evidence Based on Vapor Intrusion Modeling and Risk Assessment

Two indirect lines of evidence relative to the potential completeness and significance of the vapor intrusion pathway involve analyses to project indoor air concentrations by modeling vapor migration from measured subsurface conditions and comparing the projected indoor air concentrations to risk-based thresholds.

B-1. Soil gas to indoor air modeling performed as part of the BHHRA using both the "EPA Methodology" (i.e., modeling vapor intrusion using the VLEACH model and a box model for air mixing inside the residence) and the "Cal/EPA Methodology" (i.e., simulating the vapor migration and indoor air mixing using the DTSC-modified J&E vapor intrusion model) projected indoor air concentrations of the site volatiles that were associated with potential indoor air inhalation carcinogenic and noncarcinogenic risks that were within the risk management range. These analyses of potential residential exposures used conservative pretreatment operations soil gas concentrations and conservative modeling inputs relative to the site vadose zone and representative residential structure design parameters. Similar J&E modeling performed for the USCG Alameda Housing Indoor Air Assessment using the soil gas measurements as the driver reached the same conclusion that the projected indoor air inhalation risks from vapor intrusion were within the risk management range.

B-2. Two designs of groundwater to indoor air modeling were developed for the USCG Alameda Housing Indoor Air Assessment using the J&E vapor intrusion model. The first design used the groundwater quality measured in a series of HydroPunch borings of the shallow groundwater extracted from just below the groundwater table. The second design used the groundwater quality measured in a series of monitoring wells that were screened across the width of the FWBZ and in contact with the Marsh Crust. The projected indoor air concentrations from the first design (using the contaminant concentrations measured near the groundwater table) were lower than were predicted using the monitoring well data with higher concentrations. The projected indoor air concentrations for all modeled volatiles using the HydroPunch data were below their respective EPA ambient air PRGs (risk-based thresholds associated with a contaminant-specific residential inhalation cancer risk level of

1×10^{-6} or a noncarcinogenic HI of 1). The projected indoor air concentrations for all modeled volatiles except benzene using the monitoring well data were below their respective EPA ambient air PRGs. The projected benzene indoor air concentration was associated with a potential inhalation cancer risk of approximately 3.8×10^{-6}, which is within the risk management range. This vapor migration modeling also conservatively used the pretreatment operations groundwater concentrations from the HydroPunch borings and the monitoring wells, conservative site characteristic modeling inputs, and residential exposure assumptions.

Projections of the potential indoor air concentrations of the site-related volatiles due to vapor intrusion and their associated inhalation risks were developed for multiple scenarios using mechanistic vapor migration modeling. As was noted, the soil types and soil column characteristics were conservatively selected such that minimal resistance to upward vapor migration was assumed. In addition, but no less significant, is that the modeling was driven by soil gas and groundwater measurements made prior to the start of the biosparging treatment operations. These pre-operations concentrations reflect the highest levels of these volatiles detected in these media. The vapor intrusion modeling and indoor air risk assessments that have been performed indicate that the vapor intrusion to indoor air exposure pathway is not likely to become significant at this site unless the dissolved groundwater concentrations near the groundwater table would increase to levels 1 to 2 orders of magnitude higher than they were in the pre-operations baseline HydroPunch and monitoring well measurements.

5.2.1.2.3 Evidence Associated with Better Defined Site Characteristics that Affect Vapor Migration

A considerable amount of additional site characterization has been performed since the OU-5 BHHRA and the follow-up vapor intrusion assessments at the site. This additional characterization work was performed primarily as part of the remedial design of the biosparging treatment system. The sampling, coring, and other characterization activity have produced a more complete description of the subsurface conditions at the site and have allowed the CSM to be refined. Some of this newer information relates to conditions or features that would be expected to have a direct effect on the volatilization of benzene and naphthalene from the groundwater or their migration up through the soil column to the area beneath a possible house or public building.

C-1. There is a competent, fairly continuous clay layer in the vadose zone across the site at or above the groundwater table that has been shown through soil gas measurements above and below the layer to be effectively limiting the upward migration of benzene and naphthalene volatilized out of the groundwater into the soil gas. The clay layer typically is just over 2 feet thick but is considerably thinner in some portions of the site (see the geologic cross sections presented in Figures 2 through 9). The migration-limiting effect of this clay layer was not accounted for in any of the prior conservative vapor migration modeling performed using the DTSC-modified J&E or VLEACH models. Had the presence of this clay layer been reflected in the modeling,

even lower benzene and naphthalene indoor air concentrations and associated potential inhalation risks would have been projected than were previously reported. (Further information on the characteristics of the clay layer and the associated stratigraphy is presented in Appendix B, Section B-4.)

C-2. Benzene and naphthalene are known to naturally biodegrade in the environment under the right conditions. Sand and sandy soil in the vadose zone can create conditions that are very conducive to biodegradation and constituent attenuation. This is due, in part, to the combination of the ability of the sand to allow oxygen to penetrate deeper into the soil column and the sand providing a suitable matrix on which microbes can grow. The rate of biodegradation is typically greatest for compounds like benzene and naphthalene under aerobic conditions in the soil column (i.e., in the presence of oxygen). Under these conditions, biodegradation can be an effective mechanism for benzene and naphthalene elimination in the vadose zone and can lead to reductions of concentrations of up to two orders of magnitude (Davis 2010). No direct measurements have been made of the degree to which biodegradation was occurring or would be occurring naturally at the site in the absence of the biosparging. However, the near surface vadose zone soil types and stratigraphy (being largely associated with poorly graded sand, silty sand, and some gravel) promote the penetration of oxygen deeper into the soil column. The presence of oxygen that has penetrated deeper into the soil allows biodegradation to occur over a larger fraction of the vapor migration path and residence time.

C-3. When the FWBZ is not disturbed by groundwater pumping or air injection, the concentrations of benzene and naphthalene have tended to stratify with the concentrations of the dissolved constituents two to four orders of magnitude higher near the bottom of the water column nearer the Marsh Crust and concentrations below or near detection limits near the surface of the groundwater table. As volatilization and upward vapor migration is driven by the dissolved concentrations of benzene and naphthalene present at the surface of the groundwater table, this stratification leads to reduced soil gas concentrations of these constituents above the groundwater table. Lower soil gas concentrations at the bottom of the soil column would then be associated with lower indoor air concentrations in structures located above. (Further information on the potential stratification of the dissolved groundwater concentrations in the FWBZ is presented in Appendix B, Section B-5.)

C-4. Several recent studies indicate that vapor intrusion of petroleum hydrocarbons (including benzene) is much less significant than previously thought (CSWRCB 2010). The main reason for this is that benzene and other petroleum hydrocarbons readily degrade in the vadose zone, and the models historically used to evaluate this pathway (including the models used at OU-5) did not account for this degradation. Using sets of colocated and contemporaneous groundwater, soil gas, indoor air, and outdoor air measurements from a large number of petroleum contamination sites across the country with different soil stratigraphies and building construction styles, certain combinations of site characteristics were identified where subsurface volatile contamination did not result in significant vapor intrusion or projected indoor air inhalation risks. These conditions described a site that was characterized as a “low strength dissolved groundwater source” of volatiles

contamination (CSWRCB 2010, API 2009, Davis 2010). The combination of characteristics that in general never produced vapor intrusion concerns was: 1) there were only dissolved constituents in groundwater (i.e., no free product or LNAPL); 2) the concentrations reflected <1,000 µg/L of benzene and <10,000 µg/L of TPH; and 3) the impacted groundwater is overlain by 5 feet of clean soil in the vadose zone. The California State Water Resources Control Board has included this finding in its current Draft Leaking Underground Fuel Tank Guidance manual, (SWRCB 2010) as a vapor intrusion risk screening tool for quickly identifying sites that "present no unacceptable risk for vapor intrusion." Upon comparison of these specifications to the site conditions and the pre-operations groundwater data, these specifications were seen to be met. This similarity would lead to the expectation that this site would not create vapor intrusion concerns because these conditions did not create vapor intrusion concerns when they were found to exist at other similar sites. (Further information on the "rule of thumb" for screening potential vapor intrusion sites with petroleum-related contaminants is presented in Appendix B, Section B-6.)

Analyses of potential vapor intrusion that were performed nearly a decade ago made very conservative assumptions about the site that did not address site features that may effectively limit or mitigate upward vapor migration. The modeling analyses performed did not account for the presence of the clay layer in the vadose zone and the natural biodegradation that is likely to be occurring to some degree. In addition, the vapor migration modeling analyses were generally performed using the maximum detected groundwater concentrations from monitoring well data collected across the FWBZ and not the groundwater concentrations near the groundwater table (which are typically two to four orders of magnitude lower than the concentrations found near the Marsh Crust source). Even though the prior analyses concluded that vapor intrusion was not creating conditions that were outside the risk management range, the refined site characterization would suggest that these modeling results were even more conservative than was possibly first thought. The recently derived "low strength source" paradigm would indicate that the modeling and measurement evidence for this site is what should be anticipated for a site with these known characteristics and features.

5.2.1.2.4 Summary of Verification Evaluation of the Potential for Vapor Intrusion with Better Defined Site Characteristics and RI/FS Risk Assessment Results

Evaluation of the potential for vapor intrusion was performed using the data collected to date in combination with current DTSC and EPA vapor intrusion assessment methodologies and toxicity criteria. All results are less than or within the risk management range. The details of this evaluation and the RI/FS risk evaluations can be found in Appendix C. Key results are summarized below.

The RI/FS risk assessment evaluated multiple pathways, including vapor intrusion, using groundwater data from multiple depths down to 20 feet bgs and soil gas data (ERRG 2004). All HQs were less than 1 for all evaluations. Using soil gas data, the RI/FS vapor intrusion risk assessment estimated RME ILCRs ranging from 5×10^{-8} to 1×10^{-6} for residents and from

5×10^{-8} to 8×10^{-7} for school receptors. Using groundwater data from all depths, the RI/FS RME ILCR results were in the risk management range. The Final RI/FS Report (ERRG 2004) concluded "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

The findings of the RI/FS risk assessment of potential vapor intrusion are supported by subsequent evaluations performed using the current DTSC approach and the collected crawl space air and soil gas data from multiple depths over a widespread area. Using the more recent DTSC approach and the soil gas data, subsequent vapor intrusion evaluations presented in Appendix C estimated the RME ILCR for benzene to range from 4.8×10^{-8} to 4.8×10^{-7} and for naphthalene to range from 5.6×10^{-8} to 5.0×10^{-6} across the site.

Additional evaluations presented in Appendix C were performed using groundwater data collected near the water table, which is recommended for use in vapor intrusion evaluations by current guidance. The groundwater at these depths shows much lower benzene and naphthalene concentrations than the data used in the RI/FS vapor intrusion risk assessment that were from depths considerably below the water table. Benzene and naphthalene were both detected at only 7 of 37 locations in the more recent water table data. Four of these locations were chosen for further vapor intrusion evaluation because they had the characteristics most likely to promote vapor migration and higher potential indoor air concentrations. Using IRIS toxicity criteria, the projected RME ILCRs for benzene at these locations were 10^{-7} except at one location, where the ILCR was 1.6×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for benzene at these individual locations ranged from 6.9×10^{-7} to 6.0×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for naphthalene at these individual locations ranged from 7.9×10^{-8} to a maximum of 3.6×10^{-5}. All HQs were less than 1 for all evaluations based on groundwater. These results serve as another line of evidence for verifying the RI/FS risk assessment results.

Therefore, in summary, these additional analyses of the pretreatment subsurface conditions at the site provide additional support for the conclusion that there are no unacceptable potential risks to the residents, school workers, or students at the site as the result of vapor intrusion.

5.2.1.2.5 Findings Relative to the Vapor Intrusion Exposure Pathway

In consideration of the series of direct measurements, modeling analyses, and risk assessments conducted with an explicit focus on the potential vapor intrusion pathway relative to the dissolved benzene and naphthalene contamination plume in the FWBZ, the weight of evidence supports the finding that vapor intrusion and subsequent indoor air inhalation exposure to volatiles released from the groundwater do not currently pose a risk to members of the public in exceedance of the risk management range and are not likely to pose an inhalation risk in exceedance of the risk management range in the future:

1. **There is a consistent body of evidence that supports the conclusion that volatiles from the FWBZ are not migrating upward into potentially or currently occupied structures sufficiently to create indoor air concentrations posing a carcinogenic or noncarcinogenic risk level in exceedance of the risk management range.**

This evidence includes the inhalation risk assessments performed for the OU-5 RI, the Residential Risk Evaluation for the USCG Housing, and the BHHRA conducted for residences and the school as part of the Groundwater RI/FS. These assessments were performed using conservative source term concentrations (typically the maximum detected pre-biosparging system operation groundwater and soil gas concentrations); conservative exposure parameters (typically residential or unrestricted access exposure parameters applicable to the most sensitive potential receptor – a child); and vapor migration modeling using conservative default site parameters (typically permeable sand or silty sand making up the entire vadose zone soil column and taking no credit for the presence of the competent clay layer as an impediment to upward migration or for biodegradation of the benzene or naphthalene during migration). The only indoor air modeling results that indicated a potential inhalation risk were those using the full water column groundwater quality as the modeling source term, and no results using the measured soil gas concentrations as the modeling driver. Modeling indoor air concentrations all the way from groundwater concentrations using the J&E model does not account for any biodegradation during the upward migration process. Modeling indoor air concentrations from soil gas measurements made above the clay layer would be expected to provide a more realistic estimate of vapor migration that is less prone to uncertainties or inaccuracies as less of the overall migration path must be modeled (i.e., part of the migration and environmental chemistry is captured empirically) and the effect of the clay layer and part of any biodegradation that will occur has already taken place and affected the soil gas composition. In addition, the groundwater concentrations that actually drive or affect the vapor migration process are at the top of the groundwater table, not the well-mixed dissolved groundwater concentrations or the higher groundwater concentrations that existed pre-operations deeper in the aquifer due to stratification.

The vapor migration modeling and risk estimates developed from crawl space and soil gas measurements have consistently indicated no significant risks from vapor intrusion, even when the maximum detected preoperations soil gas concentrations were used to drive the modeling. An evaluation of the potential for vapor intrusion that was performed using the data collected to date, in combination with current DTSC and EPA vapor intrusion assessment methodologies and toxicity criteria presented in Appendix C, also supports this finding. The passive soil gas survey and baseline soil gas sampling performed as part of the design of the biosparging system provided further evidence that soil gas concentrations are much lower above the clay layer than below it. The site characterization data show that this clay layer is over 2 feet thick throughout the area of interest and indicated that this clay layer is acting as an effective barrier to upward vapor migration.

2. **Measurements of the indoor air concentrations in residences and structures with potentially sensitive receptors taken to address uncertainties associated with the vapor migration modeling revealed that benzene and naphthalene were not present in the indoor air at concentrations that were demonstrably higher than in the colocated ambient air.**

This appears to be, in part, because the dissolved concentrations of benzene and naphthalene in the shallow groundwater have not been extraordinarily high, which limits the amount of volatile contaminant being released into the soil column. The shallow groundwater was not seen to be grossly contaminated with dissolved volatiles, even before operation of the biosparging system began. Again, it should be emphasized that the findings of no projected potential indoor air inhalation risk in exceedance of the risk management range noted in the assessments above were obtained assuming the groundwater and soil gas contaminant concentrations associated with pre-operation conditions.

Recent published results of extensive data analyses for sites with respect to natural attenuation of subsurface petroleum hydrocarbons and their potential to create vapor intrusion concerns have indicated that vapor intrusion is very unlikely to be a complete pathway given a certain set of conditions (Davis 2010). An extensive Petroleum Vapor Database of paired groundwater and soil gas sampling results for over 100 locations (focusing primarily on benzene and TPH constituents like naphthalene) was analyzed to identify trends in the empirical attenuation of these constituents during upward migration under different conditions. A "low strength source" scenario (as described in Section 5.2.1.2.3 bullet C-4) was defined in which the vapor intrusion pathway for these constituents was empirically determined to not be complete (Davis 2010, CSWRCB 2010). This case reflects a source that is dissolved constituents in groundwater with <1,000 micrograms per liter (µg/L) of benzene and <10,000 µg/L of TPH that is overlain by 5 feet of clean soil in the vadose zone.

A detailed evaluation was made of data for sites with buildings with slab-on-grade construction and sites where sampling was performed very near and adjacent to the structures. The results showed that sand in the vadose zone created the good conditions for biodegradation and constituent attenuation, followed by silt and silty clay in the vadose zone. This is due, in part, to the combination of the ability of the sand to allow oxygen to penetrate deeper into the soil column and the sand providing a suitable matrix on which microbes can grow. Significant biodegradation rates for benzene in the soil column were seen from the data (leading to attenuation by approximately two orders of magnitude). Pre-operational conditions at OU-5 match the conditions specified for a "low strength dissolved groundwater source" at almost all locations, which would suggest that the vapor intrusion pathway for benzene and naphthalene would not be complete for the majority of the site. Those locations that would not meet the "low strength dissolved groundwater source" definition based on the pre-operations characterization data are clustered in the area of the Shinsei Gardens Housing Development, which was constructed with a vapor barrier and sub-slab depressurization foundation design. As such, the

recently published research on vapor intrusion pathway completeness appears to be borne out by the characterizations and assessments performed for this site.

3. **The vapor intrusion exposure pathway is not significant at this site.**

The Residential Risk Evaluation for the USCG Housing projected that an increase in the dissolved groundwater concentrations of benzene and naphthalene of one or two orders of magnitude above the maximum preoperational levels considered in those indoor air inhalation risk assessments would be required for vapor intrusion to contribute enough contaminant to the indoor air for a change relative to ambient conditions to be noticeable. An increase in benzene and naphthalene to such levels is highly unlikely. In addition, predesign investigation results identified natural barriers (clay) to upward vapor intrusion. Therefore, the vapor intrusion pathway may not be complete in these areas, and does not contribute significantly to potential indoor air inhalation risk where the pathway exists. Biosparging has been actively remediating the site for over 3 years. During this time, an increase in the dissolved oxygen content of FWBZ groundwater has resulted in the destruction of approximately 4.33 kilograms (9.55 pounds) of benzene and 39.04 kilograms (86.07 pounds) of naphthalene.

6.0 FINDINGS AND RECOMMENDATIONS

As outlined in Section 1.1, this groundwater data evaluation was designed to answer a number of basic groundwater management questions. The answers to these questions were addressed in some detail in the body of this report and are summarized below:

- **What do these additional groundwater data tell us about the potential beneficial uses of the local groundwater?** The analysis of the groundwater quality measurements made over time at the site indicates that the FWBZ does not meet the specifications of a potential source of drinking water (Class II or MUN). The level of TDS in the FWBZ was the primary factor in this determination. However, several other groundwater quality parameters also were found to be incompatible with domestic use, including the characteristic levels of sulfate, iron, and alkalinity. Neither TDS nor sulfate can be economically removed from domestic water supplies using conventional techniques. Further evaluation of the FWBZ groundwater characteristics revealed that the groundwater in the FWBZ is sufficiently impaired relative to multiple quality parameters (including TDS) that even the nonpotable beneficial uses evaluated in the BHHRA (i.e., as a water supply for a car wash or for landscaping or irrigation) are not likely to be realistic given operational and aesthetic constraints to using the groundwater. In addition, the California well standards require that annular sanitary seals extend at least 50 feet bgs for community and industrial water supply wells and at least 20 feet bgs for domestic, agricultural, and other types of water supply wells. Given that the maximum artificial fill thickness that defines the bottom of the FWBZ at OU-5 is approximately 20 feet, water supply well construction requirements would preclude the installation of water supply wells in the FWBZ. As such, no practical beneficial uses of the groundwater in the FWBZ (consumptive or nonconsumptive) were identified.

- **What do these additional data tell us about the potential direct exposures to groundwater in the FWBZ that would be associated with those beneficial uses?** Based on the analysis of this data, no direct exposure pathways relative to this groundwater (i.e., ingestion/drinking, incidental ingestion, dermal absorption or inhalation of volatiles released during use) were identified to be complete.
- **What do these additional data tell us about the CSM and the resulting vertical distribution of site COCs, as documented in the ROD?** Based on borings and groundwater sampling from different depth horizons in the FWBZ, the highest groundwater COC concentrations are confirmed at the Marsh Crust depth, which along with other multiple lines of evidence indicates the source of the benzene and naphthalene dissolved in the groundwater is the Marsh Crust, a thin layer underlying the FWBZ. This conclusion is supported by multiple lines of evidence including continuous soil coring, additional soil and groundwater sampling, and isotopic analysis. The additional data are described in detail in Appendix A. An examination of the pre-operations groundwater data (i.e., data collected prior to the start of biopsarging) collected at multiple depth intervals shows clear concentration gradients for these constituents upward in the direction away from the Marsh Crust layer. The concentrations of dissolved benzene and naphthalene are two to four orders of magnitude higher near the bottom of the water column nearer the Marsh Crust and below or near analytical detection limits near the surface of the groundwater table. In a few cases where multiple depth groundwater samples were collected below the apparent Marsh Crust layer, concentrations of the contaminants were seen to decrease at the deeper samples (i.e., further from the Marsh Crust layer). The clearer role of the concentration gradient has been reflected in the refined CSM.
- **What do these additional data tell us about potential indirect exposures to COCs in the FWBZ as a result of vapor intrusion?** A systematic review of the compiled data and the findings of the sequence of analyses performed to assess the potential for vapor intrusion at the site revealed that vapor intrusion is not currently and is not projected to be an indirect exposure pathway that could lead to potential indoor air inhalation risks in the future that would exceed the risk management range. This conclusion was supported using multiple lines of evidence that included: 1) the results of the direct sampling of soil gas, groundwater, and air at the site; 2) conservative modeling of the potential migration of volatiles from the groundwater and soil gas into residential structures and assessments of the risk implications of their projected concentrations in the indoor air; 3) a verification that there has been no change in the EPA Integrated Waste Management System toxicity values for benzene and naphthalene since the prior risk assessments; 4) the further characterization of the site and the updated CSM that identified features and conditions that would naturally act as barriers to vapor migration and natural processes that would mitigate the amount of vapor intrusion that could occur; and further evaluation using recent DTSC criteria that show potential risk to be less than or within the risk management range. These data and their analysis support the conclusion that the indirect vapor intrusion/indoor air inhalation exposure pathway is not significant at this site. Previous assessments indicate that this pathway would not potentially become significant unless the dissolved groundwater concentrations of benzene and naphthalene were to increase to levels one to two orders of magnitude higher than they were at the pre-

operations levels. Since the source of the contamination has been in place for approximately 100 years, biosparging has been actively remediating the site for over 3 years, and approximately 12,000 pounds of benzene and 335,000 pounds of naphthalene have been destroyed, such an increase is highly unlikely.

- **What are the "next steps" to ensure protectiveness of human health in relation to the shallow groundwater contamination at the site?** Based on the evaluation presented in this Technical Memorandum, the questions and answers presented above frame a series of "next steps" to ensure protectiveness of human health in relation to the groundwater in the FWBZ:

  1. Document that the actual groundwater uses appropriate for the FWBZ do not include the occupational nonpotable groundwater uses or potable groundwater use evaluated in previous risk assessments. The uses of the shallow groundwater for car washing or landscaping/irrigation were shown in this Technical Memorandum to be very unlikely because of the impaired quality of the FWBZ groundwater relative to a number of parameters (i.e., not just its concentrations of dissolved benzene and naphthalene). Elimination of these potential groundwater beneficial uses leaves no practical groundwater uses and no corresponding potential for direct exposure of people to the FWBZ groundwater contaminants. This leaves only vapor intrusion into indoor air with subsequent potential inhalation exposure as a potential pathway for consideration.
  2. Adopt the findings of the prior vapor intrusion investigations and risk assessments that do not show unacceptable risk for residents and other potential receptors when the groundwater is not used for drinking water. Site conditions without groundwater treatment are protective of people living or working above the plume from the potential intrusion of benzene and naphthalene vapors into their indoor air.
  3. Shut down the biosparging operation. Turning off the biosparging system would allow the subsurface environment to re-equilibrate without the unnatural injection of oxygen/air, the artificial pressure gradients and forced vapor movement associated with biosparging.

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TABLES

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TABLE 1
OTHER POTENTIAL BENEFICIAL USES OF GROUNDWATER AT ALAMEDA POINT
(Summarized from TTEMI 2000)

Non-Enforceable Criteria	**Central Region**
Livestock (TDS below 5,000 mg/L)	Yes, but low probability
Crop Irrigation (TDS: 700–2,000 mg/L)	No, pretreatment not economical
Ability to Meet Agricultural Yield Requirement	Yes
Retain Agricultural Supply Use?	**Yes, but limited because of low probability of use for livestock watering**
Industrial Supply (TDS below 1,000 mg/L)	No, pretreatment not economical
Ability to meet Industrial Yield Requirements	No
Retain Industrial Supply Use?	**No**

Notes:
Bold text indicates decision summary.

Abbreviations and Acronyms:
mg/L – milligrams per liter
TDS – total dissolved solids
TTEMI – Tetra Tech EM, Inc.

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TABLE 2
PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLING RESULTS

Location Code	Start Depth	End Depth	Collected	Sample ID	EPA Method 8260B		EPA Method 160.1	EPA Method 300	EPA Method 300	EPA Method 310.1	EPA Method 350.2	Field Parameters
					BENZENE	NAPHTHALENE	TDS	NITRATE	SULFATE	ALKALINITY	AMMONIA AS N	FE+2
	(ft)	(ft)			µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L	mg/L
Screening Criteria					1	100 HA	3000 CalEPA/500 SMCL	10,000 MCL	250000 SMCL	>500 "Hard water"	30 MCL	0.3 SMCL
PC1-1	12	15	8/6/2007	11-3146	**170**	**2800**	**15200**	188	601	**2300**	20.4	**4.8**
PC1-1	16	19	8/6/2007	11-3147	0.46 J	6.8	**26500**	191	823	**2250**	26.8	**5.3**
PC1-2	11	14	8/1/2007	11-3130	**82**	**4300**	**24600**	200 U	1090	**3500**	**43.6**	**4.6**
PC1-3	12	15	7/31/2007	11-3124	**540**	**5,100 J**	--	500 U	5760	**4450**	**72.4**	--
PC1-3A	12	15	8/21/2007	11-3173	**460**	**2000**	--	--	--	--	--	--
PC1-3B	12	15	8/21/2007	11-3174	**73**	**4300**	--	500 UJ	17300	--	**47.8**	--
PC1-3C	12	15	8/21/2007	11-3175	**150**	**330**	--	--	--	--	--	--
PC1-3D	12	15	8/24/2007	11-3179	**18**	64	--	--	--	--	--	--
PC1-3E	12	15	8/29/2007	11-3182	0.21 J	7.1	--	--	--	--	--	--
PC1-4	12	15	8/21/2007	11-3171	**1000**	**3900**	--	978 J	7500	**3850**	**46**	--
PC1-4	15	18	8/21/2007	11-3172	**700**	**3300**	--	1,000 UJ	9140	**4550**	**49.8**	--
PC1-4A	12	15	9/11/2007	11-3216	**200**	**2000**	**20200**	500 U	1,710 J	**2650**	**37.4**	**5.4**
PC1-4A	15	18	9/11/2007	11-3217	0.45 J	13	**22800**	120	754	**1700**	22.6	**5.8**
PC1-4B	12	15	9/11/2007	11-3218	**190**	**4300**	**25500**	500 U	1,440 J	**3300**	25.3	**5**
PC1-4B	15	18	9/11/2007	11-3219	**39**	**490**	--	--	--	--	--	**8**
PC2-1	14.5	17.5	7/26/2007	11-3104	**580**	**9600**	**11800**	100 U	925	**1620**	18.9	**4.3**
PC2-1	6.5	9.5	7/31/2007	11-3121	**1.7**	1.2 J	435	126	84100	240	2.99	**3.4**
PC2-1	12	15	7/31/2007	11-3122	**170**	**1,500 J**	1950	64.2 J	1190	**695**	0.925	**2.2**
PC2-2	15	18	7/26/2007	11-3105	**180**	**5700**	**9760**	105	475 J	**1420**	15.4	**4**
PC2-2A	15	18	8/2/2007	11-3135	**870**	**9500**	**4350**	116	1390	**1180**	6.94	**3.4**
PC2-3	8	11	7/27/2007	11-3109	0.50 U	0.64 J	1420	89.9 J	**730000**	408	1.81	**3.6**
PC2-3	11	14	7/27/2007	11-3110	**1800**	**6,100 J**	**8770**	100 U	1090	**1460**	19.3	**4.6**
PC2-4	12	15	8/31/2007	11-3186	0.50 U	2.0 U	--	109	**603000**	**2500**	14.1	**0.8**
PC2-4	16	19	8/31/2007	11-3188	**160**	**1800**	--	100 U	**736000**	**3200**	**33.2**	**10**
PC2-5	18	21	7/30/2007	11-3118	**2600**	**5500**	**36300**	500 U	172000	**4450**	**63**	**7.6**
PC2-5A	18	21	8/20/2007	11-3168	**78**	**420**	--	--	--	--	--	--
PC2-6	11.5	14.5	8/1/2007	11-3127	0.50 U	2.3	**11400**	492 J	76200	**3250**	13.5	--
PC2-6	15	18	8/1/2007	11-3129	**490**	**4400**	**31800**	200 U	28800	**4150**	**42.2**	**6.5**
PC2-6A	4.5	17.5	8/29/2007	11-3184	**300**	**5300**	--	1340	17000	**3050**	25.1	**10**
PC2-7	14	17	7/30/2007	11-3114	**740**	**5800**	**30400**	100 U	2350	**4000**	**45.2**	**8**
PC2-7A	14	17	8/6/2007	11-3144	**420**	**3500**	**30900**	100 U	974	**3550**	**48.3**	--
PC2-8	16.5	19.5	7/30/2007	11-3115	**680**	**4000**	**29200**	100 U	814	**3600**	**53.2**	**7.5**
PC2-8	16.5	19.5	7/30/2007	11-3116 (FD)	**680**	**5500**	--	--	--	--	--	--
PC2-9	15	18	7/27/2007	11-3111	**710**	**4,100 J**	**28400**	100 U	826	**3600**	**38.8**	**9.6**
PC2-10	13	16	8/6/2007	11-3142	**31**	**770**	**20600**	138	11200	**2030**	23.3	**4.4**
PC3-1	18	21	7/19/2007	11-3074	**4500**	**17000**	--	180	229000	**3250**	**32.4**	--
PC3-1A	18	21	7/24/2007	11-3088	**1600**	**6200**	--	176	683	**1700**	14.5	**4.2**
PC3-2	18	21	7/19/2007	11-3075	**1300**	**5500**	--	204	1400	**3450**	**46.8**	--
PC3-2A	18	21	7/24/2007	11-3089	**1200**	**3100**	--	200 U	1070	**3600**	**39.2**	**5.6**
PC3-3	17	20	7/19/2007	11-3076	**1600**	**5300**	--	237	1640	**2750**	29	--
PC3-3A	17	20	7/24/2007	11-3090	**1900**	**8400**	--	162	1040	**1620**	20.1	**3.6**
PC3-3B	17	20	8/24/2007	11-3180	**10**	**1500**	**20500**	337	6730	**3000**	**34.4**	--

TABLE 2
PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLING RESULTS

Location Code	Start Depth	End Depth	Collected	Sample ID	EPA Method 8260B		EPA Method 160.1	EPA Method 300	EPA Method 300	EPA Method 310.1	EPA Method 350.2	Field Parameters
					BENZENE	NAPHTHALENE	TDS	NITRATE	SULFATE	ALKALINITY	AMMONIA AS N	FE+2
	(ft)	(ft)			µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L	mg/L
Screening Criteria					1	100 HA	3000 CalEPA/500 SMCL	10,000 MCL	250000 SMCL	>500 "Hard water"	30 MCL	0.3 SMCL
PC3-4	12.5	13.5	7/20/2007	11-3079	0.50 U	0.68 J	--	1,000 U	**323000**	**1760**	16.2	--
PC3-4	14.5	17.5	7/20/2007	11-3080	**1300**	**5800**	--	1,000 U	86500	**3000**	29.8	--
PC3-4A	14.5	17.5	7/25/2007	11-3098	**310**	**780**	--	100 U	52700	**3050**	**38.1**	--
PC3-5	16.5	19.5	7/20/2007	11-3081	**400**	**12000**	--	1,000 U	7090	**1910**	26.9	--
PC3-5A	17	20	7/25/2007	11-3096	**28**	**2100**	--	100 U	1060	**3450**	**46.5**	**4.3**
PC3-5A	17	20	7/25/2007	11-3097 (FD)	**14**	**1600**	--	--	--	--	--	--
PC3-6	17	19	7/23/2007	11-3083	**15**	**3600**	--	100 U	1690	**2020**	23.1	--
PC3-6	17	19	7/23/2007	11-3084 (FD)	**14**	**2200**	--	--	--	--	--	--
PC3-7A	20	23	7/23/2007	11-3085	**360**	**5100**	--	100 U	1410	**3850**	**54.4**	--
PC3-8	17	20	7/24/2007	11-3091	**230**	**2700**	--	100 U	1070	**3100**	**36.5**	**6.4**
PC3-9	12	15	7/24/2007	11-3092	**5.1**	12	--	--	--	--	--	--
PC3-10	14	17	7/25/2007	11-3099	**84**	**1600**	--	100 U	1290	**3900**	**63.2**	--
PC3-11	12	15	7/25/2007	11-3100	**410**	**1300**	--	--	--	--	--	--
PC3-12	13	16	8/2/2007	11-3134	**34**	33	--	--	--	--	--	--
PC3-13	12	15	8/3/2007	11-3137	**8.1**	**660**	--	192 J	73600	**870**	4.98	**1.4**
PC3-13	12	15	8/3/2007	11-3138 (FD)	**6.7**	**500**	--	--	--	--	--	--
PC3-13	15	18	8/3/2007	11-3139	**730**	**7300**	--	200 U	2150	**2750**	25.6	**4.4**
PC3-14	6	9	8/7/2007	11-3150	0.50 U	2.0 U	--	290	48400	230	0.472	**0.6**
PC3-14	12.5	15.5	8/7/2007	11-3151	**90**	**390**	--	--	--	--	--	--

Notes:
Table summarized from Table 3-3 of RD/RAWP (TTEC 2010).
Bolded text indicates exceedance of criteria.
dash – not analyzed

Abbreviations and Acronyms:
µg/L – micrograms per liter
CalEPA – California Environmental Protection Agency
EPA – U.S. Environmental Protection Agency
FD – field duplicate
FE – ferrous iron
ft – feet
HA – U.S. Environmental Protection Agency Drinking Water Health Advisories
ID – identification
J – estimated value
MCL – maximum contamination level
mg/L – milligrams per liter
N – nitrogen
SMCL – secondary maximum contamination level
TDS – total dissolved solids
U – analyte not detected above project reporting limit

TABLE 3
2007 AND 2008 QUARTERLY GROUNDWATER MONITORING WELL SAMPLING RESULTS

Location Code	Start Depth	End Depth	Collected	Client Sample ID	EPA Method 8260B		EPA Method 160.1	EPA Method 300	EPA Method 300	EPA Method 310.1	EPA Method 350.2	Field Parameters
					BENZENE	NAPHTHALENE	TDS	NITRATE	SULFATE	ALKALINITY	AMMONIA AS N	FE+2
	(ft)	(ft)			µg/L	µg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L
Screening Criteria					1	100 HA	3000 CaLEPA/500 SMCL	10,000 MCL	250000 SMCL	>500 "Hard water"	30 MCL	0.3 SMCL
M07A-10	5	10	9/14/2007	11-3246	0.50 U	2.0 U	--	183	34600	**970**	17.5	**3.4**
M07A-10	5	10	12/11/2007	11-3307	0.50 U	0.73 J	--	185	11900	**710**	--	**2.1**
M07A-10	5	10	12/11/2007	11-3308 (FD)	0.50 U	2.0 U	--	123	12100	**640**	--	n/a
M07A-10	5	10	3/11/2008	11-3407	0.50 U	2.0 U	--	--	--	--	--	**3.3**
M07A-10	5	10	3/11/2008	11-3408 (FD)	0.50 U	2.0 U	--	--	--	--	--	n/a
M07A-10	5	10	6/17/2008	11-3507	0.50 U	2.0 U	--	--	--	--	--	**2.4**
M07A-11	2.5	10.5	9/17/2007	11-3252	0.50 U	2.0 U	--	244	**2780000**	**2000**	27.3	**5**
M07A-11	2.5	10.5	12/11/2007	11-3309	2.5 U	5.4 J	--	204	2540	**3300**	--	**2**
M07A-11	2.5	10.5	3/12/2008	11-3409	0.50 UJ	2.0 UJ	--	--	--	--	--	**4**
M07A-11	2.5	10.5	6/17/2008	11-3508	0.50 U	2.0 U	--	--	--	--	--	**3.6**
M07A-11	2.5	10.5	6/17/2008	11-3509 (FD)	0.50 U	2.0 U	--	--	--	--	--	n/a
M25-01	10	20	9/13/2007	11-3239	**330 J**	**4300 J**	**25400**	548 J	3200	**3200**	**38.2**	**4.8**
M25-01	10	20	12/12/2007	11-3313	**320**	**5500**	--	144 J	780 J	**2900**	--	**2.6**
M25-01	10	20	3/12/2008	11-3413	**320 J**	**3100 J**	--	--	--	--	--	**4**
M25-01	10	20	6/17/2008	11-3513	**410 J**	**2200 J**	--	--	--	--	--	**0.6**
M25-02	10	20	9/11/2007	11-3212	0.50 U	0.83 J	**4760**	114	62300	**1090**	6.02	**1.1**
M25-02	10	20	9/11/2007	11-3207 (FD)	0.50 U	0.84 J	--	--	--	--	--	n/a
M25-02	10	20	12/10/2007	11-3315	0.50 U	1.4 J	--	110	9960	**1020**	--	**0.7**
M25-02	10	20	3/11/2008	11-3415	0.50 U	0.91 J	--	--	--	--	--	**1**
M25-02	10	20	6/16/2008	11-3515	0.50 U	2.6 J	--	--	--	--	--	**1**
M25-04	10.49	20.49	9/13/2007	11-3234	0.50 UJ	2.0 UJ	650	500 R	48700	218	0.74	**3**
M25-04	10.49	20.49	12/10/2007	11-3321	0.50 U	0.89 J	--	141	48000	205	--	0.2
M25-04	10.49	20.49	3/11/2008	11-3421	0.50 U	2.0 U	--	--	--	--	--	**1**
M25-04	10.49	20.49	6/16/2008	11-3521	0.50 U	2.0 UJ	--	--	--	--	--	**2.6**
M25-05	10	20	9/14/2007	11-3247	**180**	**1200**	--	232	1660	**3500**	**50.7**	**5.8**
M25-05	10	20	12/11/2007	11-3324	**140**	**810**	--	115 J	37800	**3400**	--	0.1
M25-05	10	20	3/12/2008	11-3424	**150**	**700**	--	--	--	--	--	0.2
M25-05	10	20	6/17/2008	11-3524	**190**	**1500**	--	--	--	--	--	**1.2**
M25-06	10	19.5	9/12/2007	11-3226	**1.1**	1.3 J	**38300**	602	31100	**3950**	**68.6**	**0.4**
M25-06	10	19.5	12/12/2007	11-3311	**1.8**	8.7	--	176 J	5450	**4250**	--	**0.6**
M25-06	10	19.5	3/11/2008	11-3411	0.21 J	2.0 UJ	--	--	--	--	--	**1**
M25-07	10	19.5	9/12/2007	11-3222	0.30 J	2.0 U	**20200**	551	3240	**2250**	22	**10**
M25-07	10	19.5	12/12/2007	11-3310	0.31 J	1.1 J	--	94.5 J	1320 J	**1750**	--	**1.7**
M25-07	10	19.5	3/11/2008	11-3410	0.50 U	0.87 J	--	--	--	--	--	**4**
M25-07	10	19.5	6/17/2008	11-3510	0.50 U	0.58 J	--	--	--	--	--	**2**
M25-08	10	19.5	9/11/2007	11-3214	0.50 U	2.0 U	**19700**	500 U	5550	**2400**	**33.2**	**1.4**
M25-08	10	19.5	12/10/2007	11-3312	2.5 UJ	10 UJ	--	200 U	12700	**2380**	--	**1.6**
M25-08	10	19.5	3/11/2008	11-3412	0.50 U	2.0 U	--	--	--	--	--	**3**
M25-08	10	19.5	6/16/2008	11-3512	0.50 U	2.0 U	--	--	--	--	--	**1.4**

TABLE 3
2007 AND 2008 QUARTERLY GROUNDWATER MONITORING WELL SAMPLING RESULTS

Location Code	Start Depth	End Depth	Collected	Client Sample ID	EPA Method 8260B		EPA Method 160.1	EPA Method 300	EPA Method 300	EPA Method 310.1	EPA Method 350.2	Field Parameters
					BENZENE	NAPHTHALENE	TDS	NITRATE	SULFATE	ALKALINITY	AMMONIA AS N	FE+2
	(ft)	(ft)			µg/L	µg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L
Screening Criteria					1	100 HA	3000 CaLEPA/500 SMCL	10,000 MCL	250000 SMCL	>500 "Hard water"	30 MCL	0.3 SMCL
M25-09	10	19.5	9/13/2007	11-3238	0.50 UJ	1.4 J	**4300**	499 J	34500	**960**	11.4	**7.8**
M25-09	10	19.5	12/13/2007	11-3314	0.50 U	0.76 J	--	164	112000	463	--	**2.2**
M25-09	10	19.5	3/12/2008	11-3414	0.50 U	2.0 U	--	--	--	--	--	**4**
M25-09	10	19.5	6/16/2008	11-3514	0.50 U	2.0 UJ	--	--	--	--	--	**4**
P181-MW45	16	18.5	9/10/2007	11-3202	**58**	**160**	**26100**	93.9 J	713	**2280**	**41.7**	**3**
P181-MW45	16	18.5	12/12/2007	11-3316	**59**	**520 J**	--	295 J	1510 J	**1210**	--	**3**
P181-MW45	16	18.5	3/12/2008	11-3416	**94 J**	**880 J**	--	--	--	--	--	**5**
P181-MW45	16	18.5	6/17/2008	11-3516	**82**	**710**	--	--	--	--	--	**7.8**
P181-MW45	16	18.5	6/17/2008	11-3516A (FD)	**66**	**230**	--	--	--	--	--	n/a
P181-MW46	9	19	9/10/2007	11-3206	**10**	67	**9570**	180	51200	**1270**	19.3	**1**
P181-MW46	9	19	12/12/2007	11-3317	**5.1**	**120**	--	178	19200	**900**	--	**1.6**
P181-MW46	9	19	3/12/2008	11-3417	**30 J**	**440 J**	--	--	--	--	--	**1.3**
P181-MW46	9	19	6/17/2008	11-3517	**25**	**370**	--	--	--	--	--	**3.6**
P181-MW47	13.5	18.5	9/13/2007	11-3232	**260 J**	**830 J**	**14800**	543 J	46100	**2040**	21.3	**3.6**
P181-MW47	13.5	18.5	12/10/2007	11-3318	**270**	**690**	--	173	54300	**1920**	--	**1**
P181-MW47	13.5	18.5	12/10/2007	11-3319 (FD)	**240**	**1000**	--	200 U	52900	**2040**	--	n/a
P181-MW47	13.5	18.5	3/12/2008	11-3418	**400**	**460**	--	--	--	--	--	**1.1**
P181-MW47	13.5	18.5	3/12/2008	11-3419 (FD)	**400 J**	**480 J**	--	--	--	--	--	n/a
P181-MW47	13.5	18.5	6/17/2008	11-3518	**390**	**190**	--	--	--	--	--	**0.6**
PMW1	9.1	19.1	9/10/2007	11-3203	0.24 J	3.5	2150	162	14300	**560**	3.32	**3**
PMW1	9.1	19.1	12/12/2007	11-3300	0.63	16 J	--	153	22800	500	--	**1**
PMW1	9.1	19.1	3/11/2008	11-3400	0.43 J	7.5	--	--	--	--	--	**2**
PMW1	9.1	19.1	6/16/2008	11-3500	0.71	9.0 J	--	--	--	--	--	**2.4**
PMW2	8.6	18.6	9/10/2007	11-3205	0.50 U	1.1 J	2560	108	30900	**730**	5.36	**1**
PMW2	8.6	18.6	12/11/2007	11-3301	0.50 U	1.0 J	--	159	45900	**600**	--	**1.9**
PMW2	8.6	18.6	12/11/2007	11-3302 (FD)	0.50 U	0.99 J	--	149	46100	**570**	--	n/a
PMW2	8.6	18.6	3/11/2008	11-3401	0.50 U	0.57 J	--	--	--	--	--	**2**
PMW2	8.6	18.6	3/11/2008	11-3402 (FD)	0.50 U	2.0 UJ	--	--	--	--	--	n/a
PMW2	8.6	18.6	6/16/2008	11-3501	0.50 U	0.77 J	--	--	--	--	--	**3.6**
PMW3	6.6	16.6	9/14/2007	11-3243	0.50 U	2.0 U	--	100 U	**720000**	310	1.21	**1.2**
PMW3	6.6	16.6	12/11/2007	11-3303	0.50 U	20	--	104	**668000**	320	--	**1**
PMW3	6.6	16.6	3/12/2008	11-3403	0.50 U	11	--	--	--	--	--	0.1
PMW3	6.6	16.6	6/17/2008	11-3502	**10**	71	--	--	--	--	--	**1.2**
PMW3	6.6	16.6	6/17/2008	11-3503 (FD)	**17**	**170**	--	--	--	--	--	n/a
PMW4	5.1	15.1	9/12/2007	11-3223	**1.8**	0.76 J	**26200**	576	133000	**2950**	**30.8**	**4.6**
PMW4	5.1	15.1	12/12/2007	11-3304	**2.4**	1.4 J	--	168 J	71500	**1260**	--	**2.4**
PMW4	5.1	15.1	3/11/2008	11-3404	0.63	2.0 U	--	--	--	--	--	**4**
PMW4	5.1	15.1	6/17/2008	11-3504	0.49 J	0.65 J	--	--	--	--	--	**3.8**
PMW5	3.1	13.1	9/11/2007	11-3213	0.50 U	2.0 U	1010	100 U	23800	**630**	1.47	**0.8**
PMW5	3.1	13.1	12/11/2007	11-3305	0.50 U	2.0 U	--	140	47700	**550**	--	0.3
PMW5	3.1	13.1	3/11/2008	11-3405	0.50 U	0.55 J	--	--	--	--	--	**1**
PMW5	3.1	13.1	6/16/2008	11-3505	0.50 U	2.0 U	--	--	--	--	--	**3**

TABLE 3
2007 AND 2008 QUARTERLY GROUNDWATER MONITORING WELL SAMPLING RESULTS

Location Code	Start Depth	End Depth	Collected	Client Sample ID	EPA Method 8260B		EPA Method 160.1	EPA Method 300	EPA Method 300	EPA Method 310.1	EPA Method 350.2	Field Parameters
					BENZENE	NAPHTHALENE	TDS	NITRATE	SULFATE	ALKALINITY	AMMONIA AS N	FE+2
	(ft)	(ft)			µg/L	µg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L
Screening Criteria					1	100 HA	3000 CaLEPA/500 SMCL	10,000 MCL	250000 SMCL	>500 "Hard water"	30 MCL	0.3 SMCL
PMW6	8	18	9/14/2007	11-3242	0.27 J	2.0 U	**3760**	99.6 J	**1560000**	415	8.91	0
PMW6	8	18	12/13/2007	11-3306	0.23 J	0.94 J	--	159	**1060000**	365	--	**2.2**
PMW6	8	18	3/11/2008	11-3406	0.50 U	2.0 U	--	--	--	--	--	**2.3**
PMW6	8	18	6/16/2008	11-3506	0.30 J	2.0 U	--	--	--	--	--	**3.8**
PW-12	12	17	9/13/2007	11-3236	**2.2 J**	0.93 J	**28700**	553 J	**369000**	**3450**	**46.6**	**1**
PW-12	12	17	9/13/2007	11-3237 (FD)	**2.3 J**	1.0 J	--	--	--	--	--	n/a
PW-12	12	17	12/13/2007	11-3320	0.27 J	2.2	--	100 U	**588000**	**3600**	--	**0.5**
PW-12	12	17	3/11/2008	11-3420	0.50 U	2.0 U	--	--	--	--	--	**1**
PW-12	12	17	6/16/2008	11-3520	0.62	0.52 J	--	--	--	--	--	**0.6**
S-16-R	9.11	20.07	9/14/2007	11-3244	**1.2**	6.9	--	573	97100	**3950**	**73.2**	**0.9**
S-16-R	9.11	20.07	12/11/2007	11-3325	**1.9 J**	7.2 J	--	209	3000	**2200**	--	**0.6**
S-16-R	9.11	20.07	3/11/2008	11-3425	0.53	3.4	--	--	--	--	--	**0.4**
S-16-R	9.11	20.07	6/17/2008	11-3525	0.40 J	1.3 J	--	--	--	--	--	**0.8**
S-35R	10	20	8/7/2007	11-3153	0.50 U	2.0 U	**13400**	100 U	51900	**2270**	13.1	**5.6**
S-35R	10	20	8/7/2007	11-3154 (FD)	0.50 U	2.0 U	--	--	--	--	--	n/a
S-35R	10	20	9/10/2007	11-3208	0.50 U	2.0 U	1650	109	243000	208	0.0879 U	**3**
S-35R	10	20	12/10/2007	11-3322	0.50 U	2.0 U	--	100 U	232000	220	--	**0.7**
S-35R	10	20	3/11/2008	11-3422	0.50 U	2.0 U	--	--	--	--	--	**1**
S-35R	10	20	6/16/2008	11-3522	0.50 U	2.0 U	--	--	--	--	--	**1**
S-35R-2	7.67	19.55	9/13/2007	11-3233	**6.9 J**	**240 J**	**3060**	509 J	6980	**850**	3.31	**2.7**
S-35R-2	7.67	19.55	12/10/2007	11-3323	**9.6**	**360**	--	106	20600	**700**	--	**2.3**
S-35R-2	7.67	19.55	3/11/2008	11-3423	**6.5**	**210**	--	--	--	--	--	0
S-35R-2	7.67	19.55	6/16/2008	11-3523	**1.7**	45	--	--	--	--	--	**1.6**

Notes:

Table summarized from Table 3-5 of RD/RAWP (TTEC 2010).

Bolded text indicates exceedance of criteria.

dash – not analyzed

Abbreviations and Acronyms:

µg/L – micrograms per liter
CaEPA – California Environmental Protection Agency
EPA – U.S. Environmental Protection Agency
FD – field duplicate
FE – ferrous iron
ft – feet
HA – U.S. Environmental Protection Agency Drinking Water Health Advisories
ID – identification
J – estimated value
MCL – maximum contamination level
mg/L – milligrams per liter
N – nitrogen
n/a – not applicable
SMCL – secondary maximum contamination level
TDS – total dissolved solids
TKN – total Kjeldahl nitrogen
U – analyte not detected above project reporting limit

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TABLE 4
VERTICAL GROUNDWATER CONTAMINATION DISTRIBUTIONS AT THE HYDROPUNCH SAMPLING LOCATIONS

Location	Soil Sample Depth	Soil Benzene	Soil Naphthalene	Water Sample Depth	Water Benzene	Water Naphthalene
	(ft bgs)	(µg/kg)	(µg/kg)	(ft bgs)	(µg/L)	(µg/L)
PC2–1	8–8.5	5.5 U	5.5 UJ	6.5–9.5	1.7	1.2 J
PC2–1	13–13.5	5.8 U	11 J	12–15	170	1,500 J
PC2–1	15–15.5	1,300 J	640,000	14.5–17.5	580	9,600
PC2–3	9.5–10	5.7 U	5.7 UJ	8–11	0.50 U	0.64 J
PC2–3	13–13.5	4,600 J	830,000	11–14	1,800	6,100 J
PC2–4	9.5–10	9.4 U	9.4 U	8–11	no water	no water
PC2–4	13–13.5	5.8 U	4.9 J	12–15	0.50 U	2.0 U
PC2–4	18.5–19	29,000 J	2,700,000 J	16–19	160	1,800
PC2-6	13–13.5	5.5 U	5.5 U	11.5–14.5	0.50 U	2.3
PC2-6	16.5–17	15,000J	5,100,000	15–18	490	4,400
PC3–4	13–13.5	5.4 U	3.0 J	12.5–13.5	0.50 U	0.68 J
PC3–4	16–16.5	1,000	120,000	14.5–17.5	1,300	5,800
PC3–10	7–7.5	7.1 U	7.1 U	(clay)	no sample	no sample
PC3–10	13.75–14.25	9.7 U	9.7 U	(clay)	no sample	no sample
PC3–10	15–16	610 J	340,000	14–17	84	1,600
PC3–12	9.5–10	10 U	10 U	(clay)	no sample	no sample
PC3–12	13–13.5	310 J	42,000	(clay)	no sample	no sample
PC3–12	15–15.5	2,100	800,000	13–16	34	33
PC3–13	9.5–10	9.1 U	9.1 U	7.5–10.5	no water	no water
PC3–13	13–13.5	7.9 U	7.9 U	12–15	8.1	660
PC3–13	16.5–17	5,000 J	1,800,000	15–18	730	7,300
PC3–14	7.5–8	6.0 U	6.0 U	6–9	0.50 U	2.0 U
PC3–14	11–11.5	11 U	11 U	(clay)	no sample	no sample
PC3–14	13.5–14	8.7	1,800 J	12.5–15.5	90	390
PC3–14	15.5–16	31,000 J	4,100,000 J	(silt and clay)	no sample	no sample

Notes:
Highlighted cells show multi-depth groundwater sample locations and results

Abbreviations and Acronyms:

µg/kg – micrograms per kilogram
µg/L – micrograms per liter
bgs – below ground surface
ft – feet
J – estimated value
U – analyte not detected above project reporting limit

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TABLE 5

SUMMARY OF THE BHHRA TIER 2 RISK ASSESSMENT RESULTS FOR NONPOTABLE GROUNDWATER USES

Receptor	Exposure Pathway	RME HI	RME ILCR
Car Wash Worker	Inhalation and dermal contact with water	0.99	2×10^{-5}
Landscape (Irrigation) Worker	Inhalation and dermal contact with water	0.98	3×10^{-5}
Resident	Inhalation (modeled from groundwater[a])	0.29	1×10^{-5}
School Worker	Inhalation (modeled from groundwater[a])	0.29	7×10^{-6}
School Student	Inhalation (modeled from groundwater[a])	0.29	2×10^{-6}
Resident	Inhalation (modeled from soil gas; Sites IR-25, IR-30, IR-31)	0.0076	5×10^{-8}
School Worker	Inhalation (modeled from soil gas; Sites IR-25, IR-30, IR-31)	0.0076	5×10^{-8}
School Student	Inhalation (modeled from soil gas; Sites IR-25, IR-30, IR-31)	0.0076	5×10^{-8}

Notes:

[a] These risk contributions calculated for the vapor intrusion pathway in the BHHRA were conservatively based on the groundwater sampling results from all investigated depths, not just those near the water table.

Abbreviations and Acronyms:

BHHRA – Baseline Human Health Risk Assessment
HI – hazard index
IR – Installation Restoration (Program)
ILCR – incremental lifetime cancer risk
RME – reasonable maximum exposure

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TABLE 6
SUMMARY OF THE BHHRA TIER 2 RISK ASSESSMENT RESULTS FOR POTABLE GROUNDWATER USE

Receptor	Exposure Pathway	RME HI	RME ILCR
Car Wash Worker	Ingestion, inhalation and dermal contact with water	9.8	2×10^{-3}
Landscape (Irrigation) Worker	Ingestion, inhalation and dermal contact with water	9.8	3×10^{-3}
Resident	Ingestion of groundwater; inhalation modeled from groundwater	145	2×10^{-2}

Source: (ERRG 2004.) Final Groundwater Remedial Investigation/Feasibility Study, Alameda Point Site 25/ Alameda Annex IR-02. October.

Abbreviations and Acronyms:

BHHRA – Baseline Human Health Risk Assessment

HI – hazard index

ILCR – incremental lifetime cancer risk

RME – reasonable maximum exposure

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FIGURES

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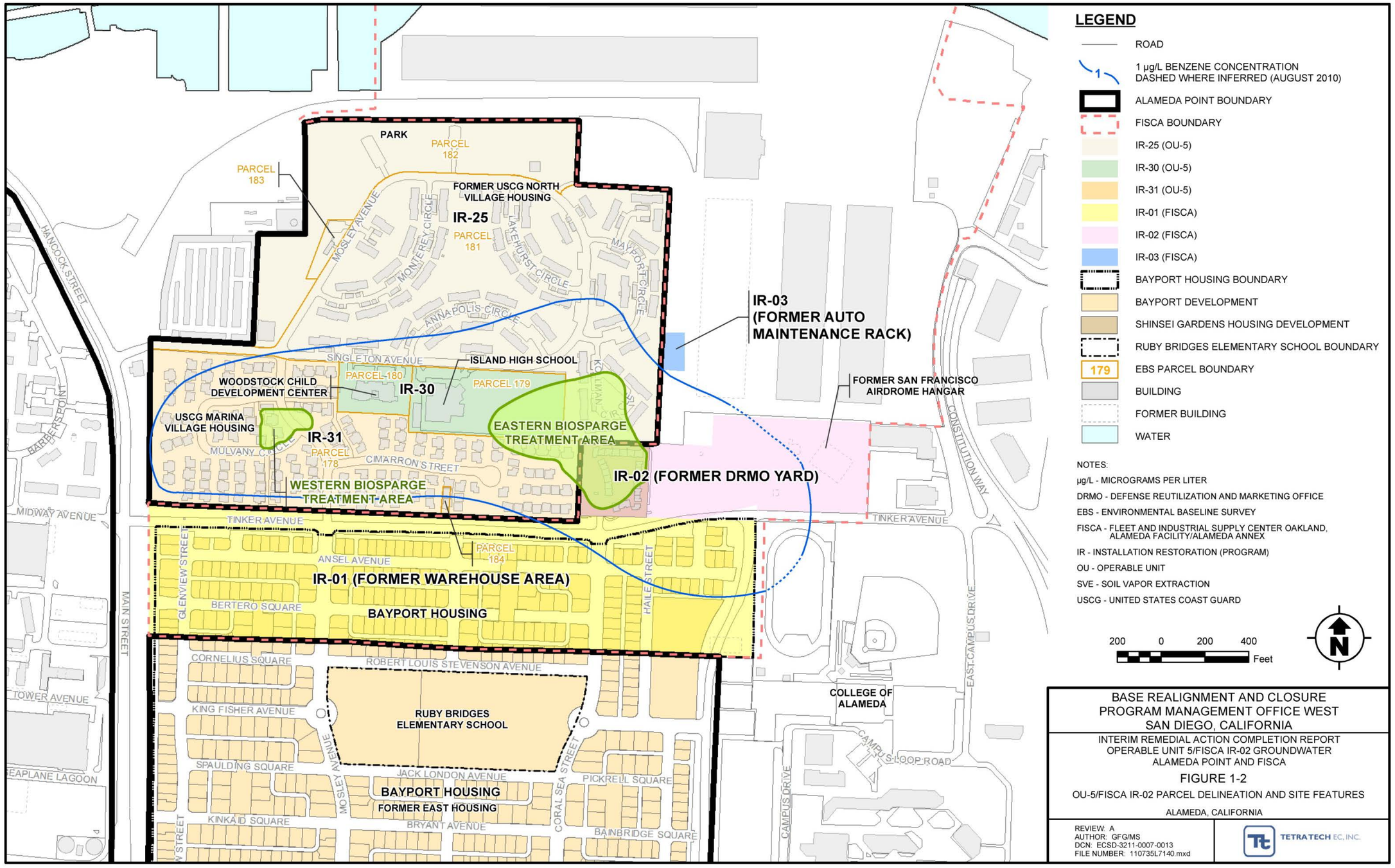
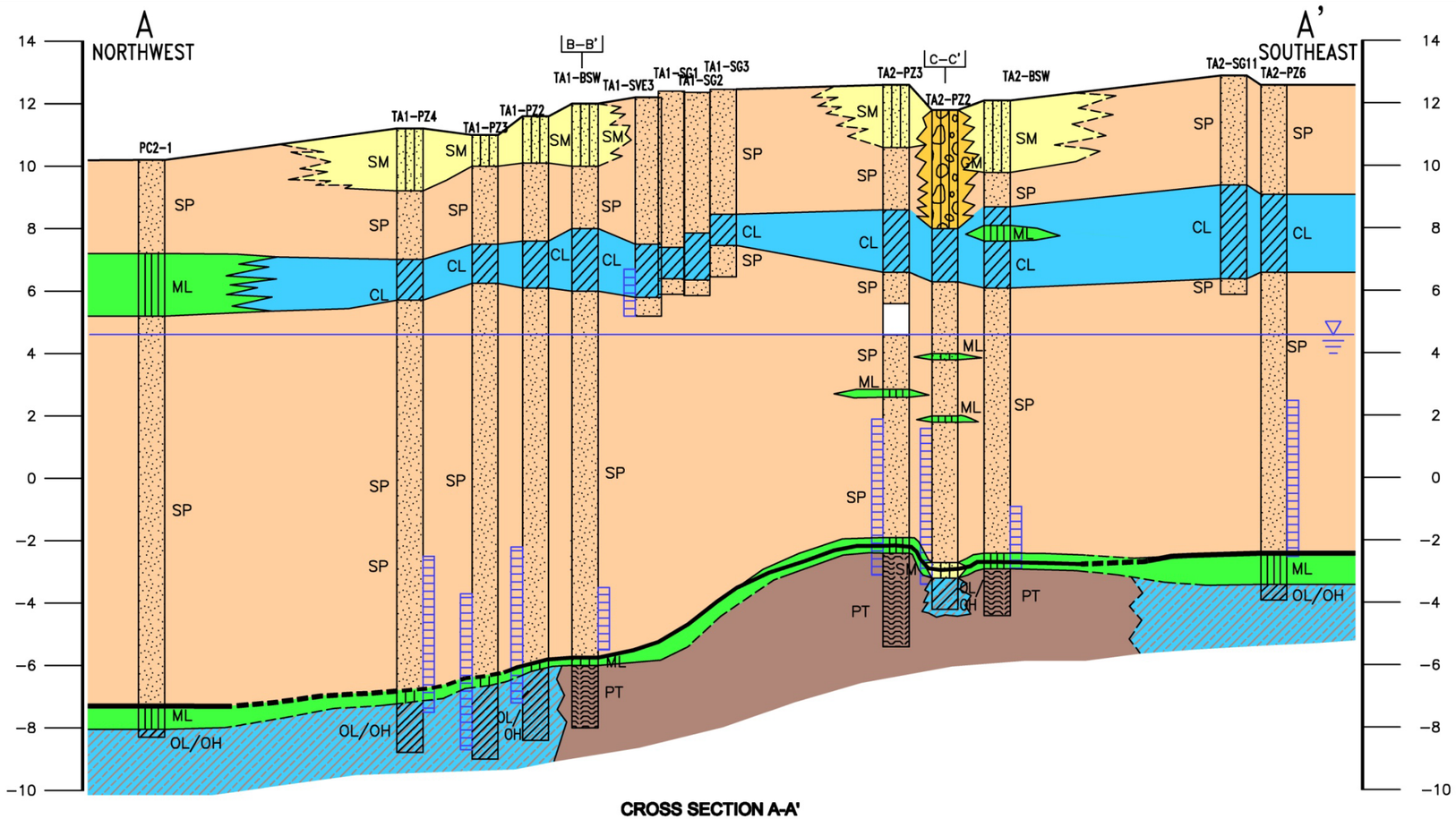

LEGEND
ROAD
1 µg/L BENZENE CONCENTRATION DASHED WHERE INFERRED (AUGUST 2010)
ALAMEDA POINT BOUNDARY
FISCA BOUNDARY
IR-25 (OU-5)
IR-30 (OU-5)
IR-31 (OU-5)
IR-01 (FISCA)
IR-02 (FISCA)
IR-03 (FISCA)
BAYPORT HOUSING BOUNDARY
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
179 EBS PARCEL BOUNDARY
BUILDING
FORMER BUILDING
WATER
NOTES:
µg/L - MICROGRAMS PER LITER
DRMO - DEFENSE REUTILIZATION AND MARKETING OFFICE
EBS - ENVIRONMENTAL BASELINE SURVEY
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR - INSTALLATION RESTORATION (PROGRAM)
OU - OPERABLE UNIT
SVE - SOIL VAPOR EXTRACTION
USCG - UNITED STATES COAST GUARD
200 0 200 400 Feet
N
PARK
PARCEL 182
PARCEL 183
FORMER USCG NORTH VILLAGE HOUSING
IR-25
PARCEL 181
MOSLEY AVENUE
MONTEREY CIRCLE
LAKEHURST CIRCLE
MAYPORT CIRCLE
ANNAPOLIS CIRCLE
IR-03 (FORMER AUTO MAINTENANCE RACK)
SINGLETON AVENUE
ISLAND HIGH SCHOOL
PARCEL 180
PARCEL 179
WOODSTOCK CHILD DEVELOPMENT CENTER
IR-30
USCG MARINA VILLAGE HOUSING
IR-31
MULVANY CIRCLE
PARCEL 178
CIMARRON STREET
EASTERN BIOSPARGE TREATMENT AREA
WESTERN BIOSPARGE TREATMENT AREA
IR-02 (FORMER DRMO YARD)
FORMER SAN FRANCISCO AIRDROME HANGAR
CONSTITUTION WAY
TINKER AVENUE
PARCEL 184
ANSEL AVENUE
IR-01 (FORMER WAREHOUSE AREA)
BERTERO SQUARE
BAYPORT HOUSING
GLENVIEW STREET
HAILEY STREET
HANCOCK STREET
BARBERS POINT
MIDWAY AVENUE
MAIN STREET
TOWER AVENUE
SEAPLANE LAGOON
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
RUBY BRIDGES ELEMENTARY SCHOOL
SPAULDING SQUARE
JACK LONDON AVENUE
PICKREL SQUARE
BAYPORT HOUSING
FORMER EAST HOUSING
KINKAID SQUARE
BRYANT AVENUE
BAINBRIDGE SQUARE
CORAL SEA STREET
COLLEGE OF ALAMEDA
EAST CAMPUS DRIVE
CAMPUS LOOP ROAD
CAMPUS DRIVE
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
INTERIM REMEDIAL ACTION COMPLETION REPORT
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 1-2
OU-5/FISCA IR-02 PARCEL DELINEATION AND SITE FEATURES
ALAMEDA, CALIFORNIA
REVIEW: A
AUTHOR: GFG/MS
DCN: ECSD-3211-0007-0013
FILE NUMBER: 110735L7140.mxd
TETRA TECH EC, INC.

FIGURE 1

P:\CAD Terp\CAD - GIS\Alarreda\Alarreda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alarreda A_A xsec FIG 4-3_081508.dwg,



CROSS SECTION A-A'

LEGEND

CL	CLAY
ML	SILT
SM	SILTY SANDS
GM	SILTY GRAVELS, GRAVEL–SILT MIXTURE
SP	POORLY GRADED SAND
OL/OH	ORGANIC SOIL
PT	PEAT
	NO RECOVERY

FORMATION CONTACT (DASHED WHERE INFERRED)

PETROLEUM CONTAMINATED SEDIMENTS – MARSH CRUST (DASHED WHERE INFERRED)

WELL SCREEN

C–C' INTERSECTING CROSS SECTION

WATER TABLE (APPROXIMATE)

FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR INSTALLATION RESTORATION

50' 0 50' 100'
HORIZONTAL SCALE

4' 0 4' 8'
VERTICAL SCALE

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

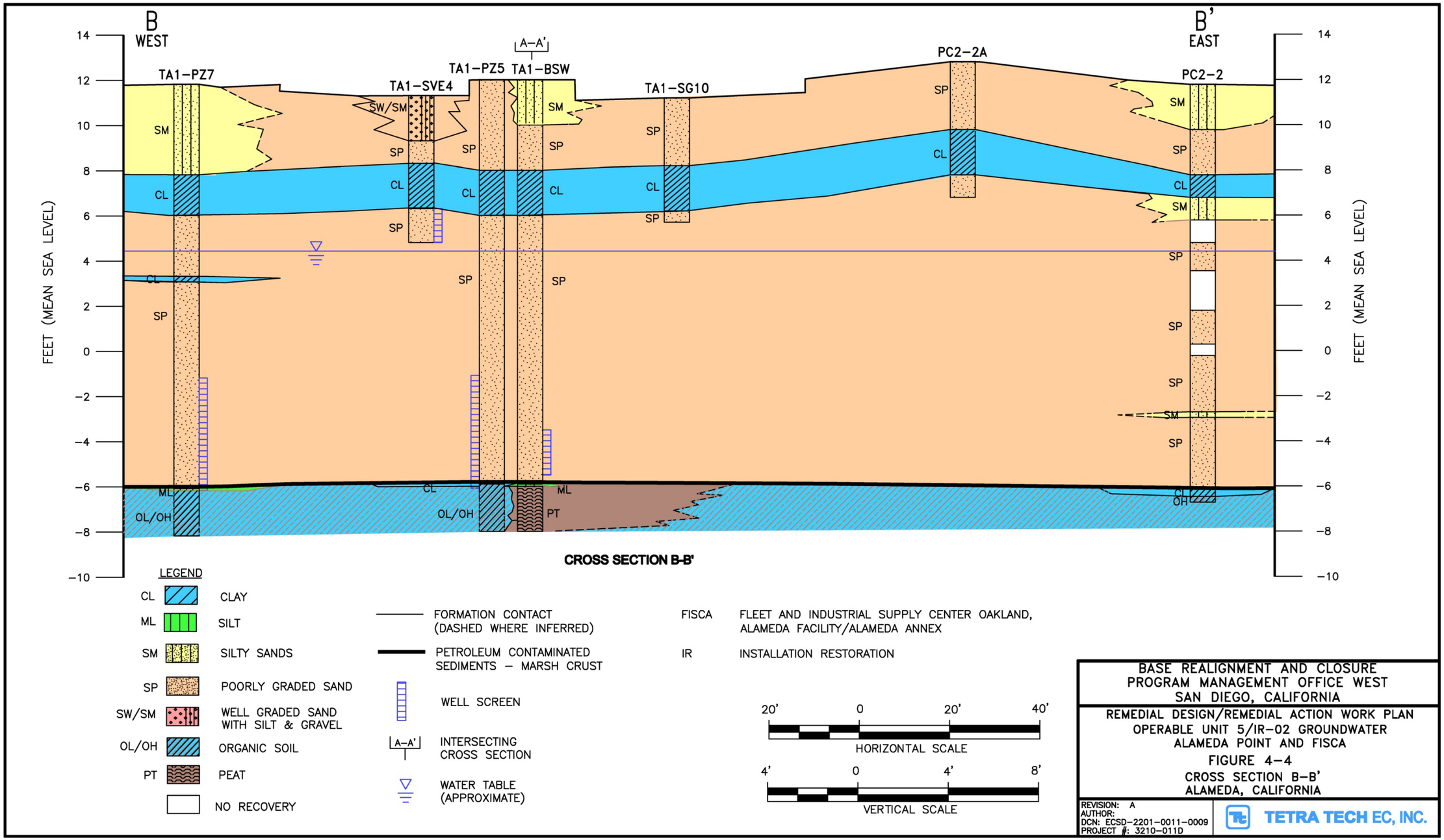
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 4-3
CROSS SECTION A-A'
ALAMEDA, CALIFORNIA

REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D

TETRA TECH EC, INC.

FIGURE 2



P:\CAD Temp\CAD – GIS\Alameda\Alameda cross sections –Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alameda B_B' xsec FIG 4-4_08

FIGURE 3

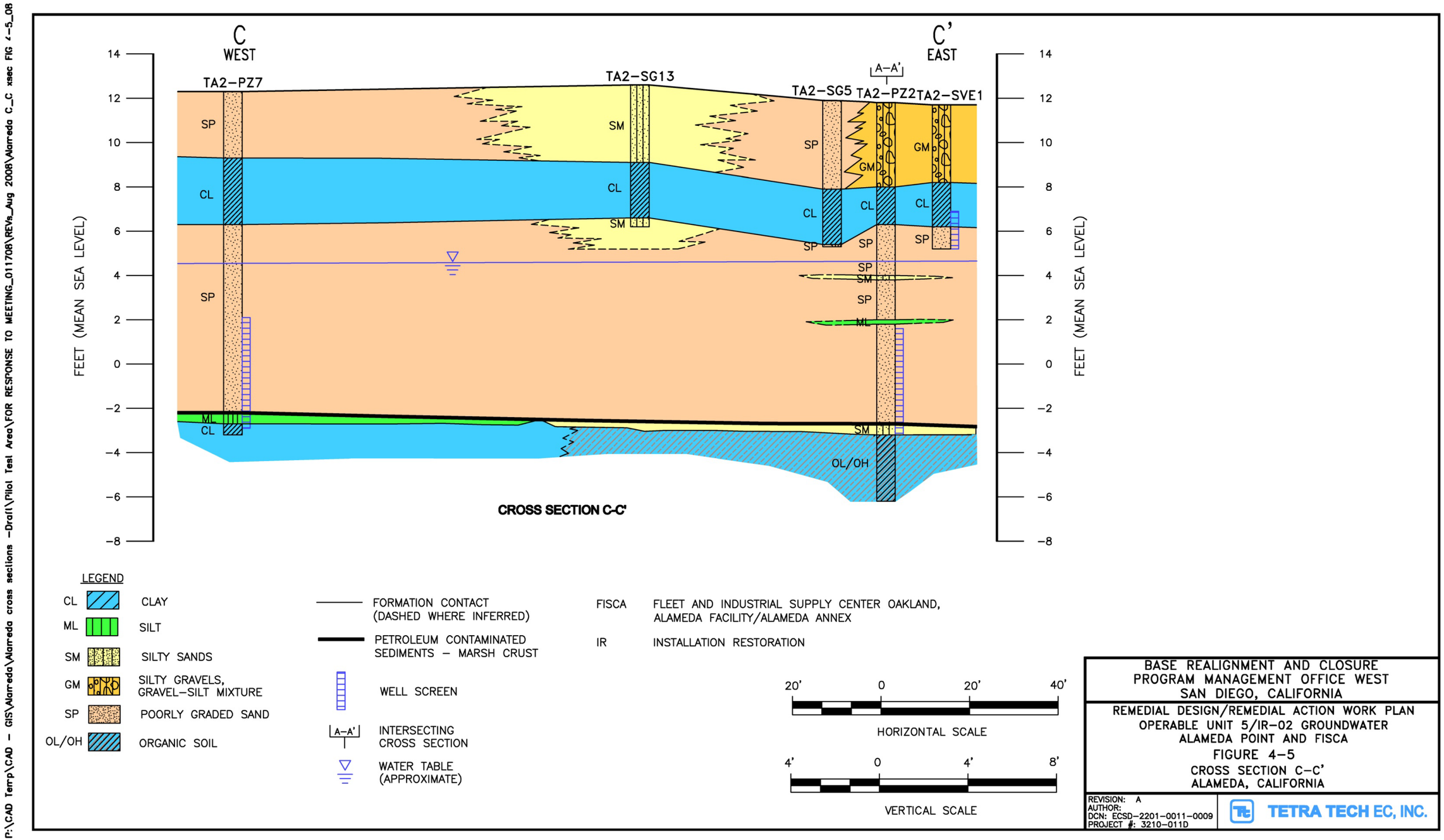

C
WEST
C'
EAST
TA2-PZ7
TA2-SG13
TA2-SG5
A-A'
TA2-PZ2
TA2-SVE1
SP
SM
CL
GM
ML
OL/OH
FEET (MEAN SEA LEVEL)
14
12
10
8
6
4
2
0
-2
-4
-6
-8
CROSS SECTION C-C'
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
SP POORLY GRADED SAND
OL/OH ORGANIC SOIL
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST
WELL SCREEN
A-A' INTERSECTING CROSS SECTION
WATER TABLE (APPROXIMATE)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
20' 0 20' 40'
HORIZONTAL SCALE
4' 0 4' 8'
VERTICAL SCALE
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-5
CROSS SECTION C-C'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Temp\CAD - GIS\Alameda\Alameda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alameda C_C xsec FIG 4-5_08

FIGURE 4

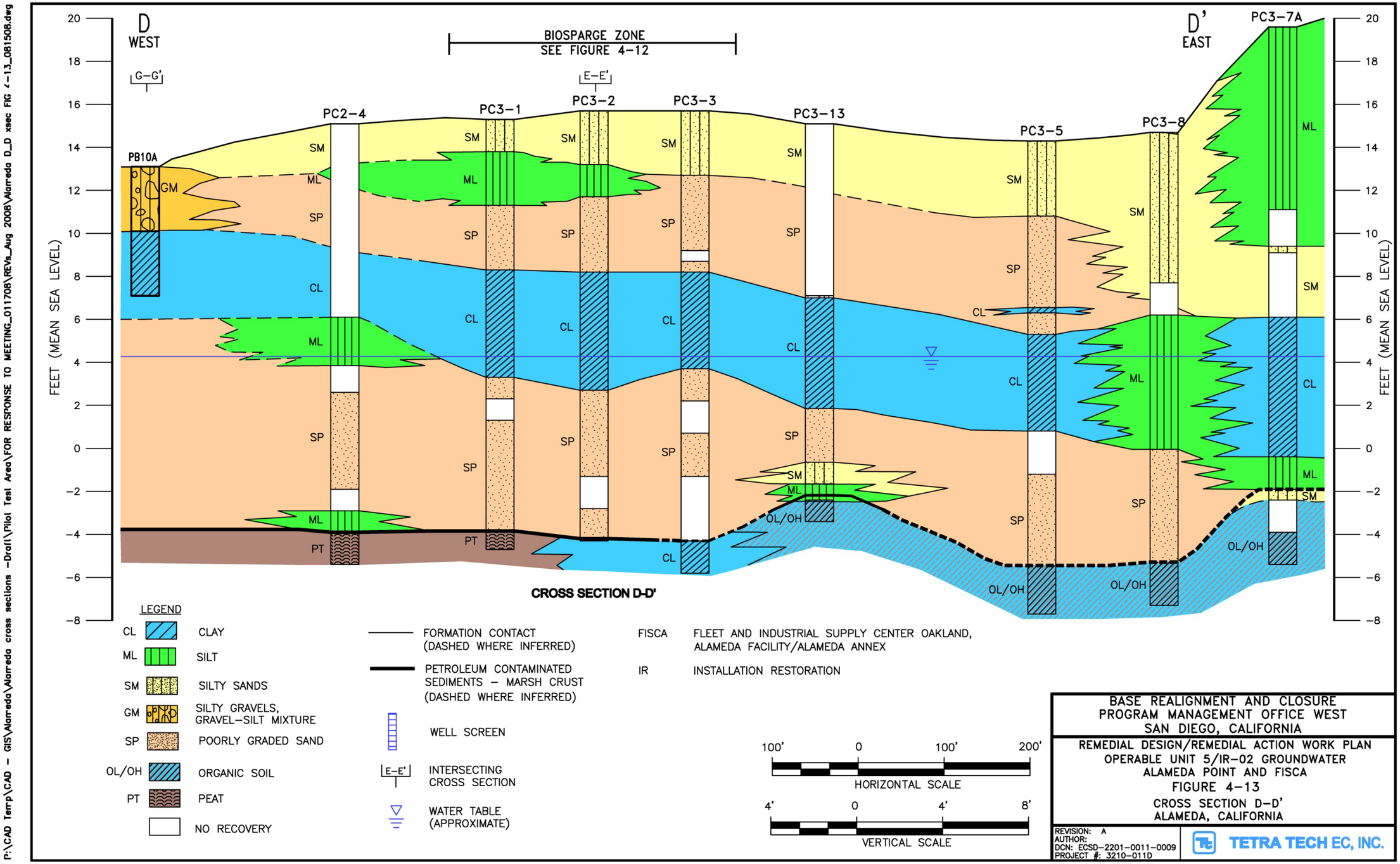

D
WEST
D'
EAST
BIOSPARGE ZONE
SEE FIGURE 4-12
G-G'
E-E'
PB10A
PC2-4
PC3-1
PC3-2
PC3-3
PC3-13
PC3-5
PC3-8
PC3-7A
FEET (MEAN SEA LEVEL)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
GM
SM
ML
SP
CL
PT
OL/OH
CROSS SECTION D-D'
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
SP POORLY GRADED SAND
OL/OH ORGANIC SOIL
PT PEAT
NO RECOVERY
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST (DASHED WHERE INFERRED)
WELL SCREEN
E-E' INTERSECTING CROSS SECTION
WATER TABLE (APPROXIMATE)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
100' 0 100' 200'
HORIZONTAL SCALE
4' 0 4' 8'
VERTICAL SCALE
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-13
CROSS SECTION D-D'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Terrp\CAD - GIS\Alarreda\Alarreda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alarreda D_D xsec FIG 4-13_081508.dwg

FIGURE 5

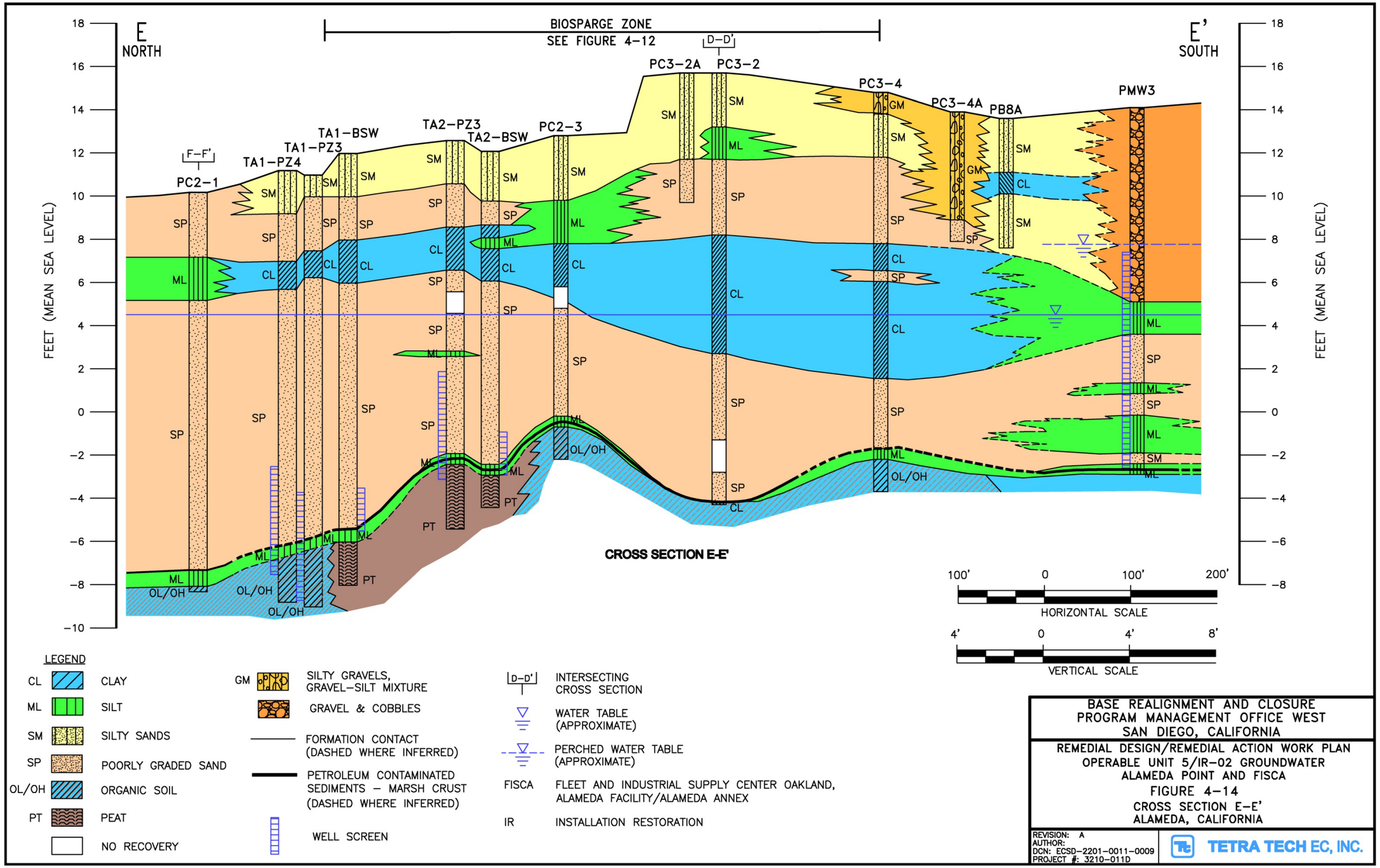

E
NORTH
E'
SOUTH
BIOSPARGE ZONE
SEE FIGURE 4-12
D-D'
F-F'
PC2-1
TA1-PZ4
TA1-PZ3
TA1-BSW
TA2-PZ3
TA2-BSW
PC2-3
PC3-2A
PC3-2
PC3-4
PC3-4A
PB8A
PMW3
FEET (MEAN SEA LEVEL)
CROSS SECTION E-E'
100' 0 100' 200'
HORIZONTAL SCALE
4' 0 4' 8'
VERTICAL SCALE
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
SP POORLY GRADED SAND
OL/OH ORGANIC SOIL
PT PEAT
NO RECOVERY
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
GRAVEL & COBBLES
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST (DASHED WHERE INFERRED)
WELL SCREEN
D-D' INTERSECTING CROSS SECTION
WATER TABLE (APPROXIMATE)
PERCHED WATER TABLE (APPROXIMATE)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-14
CROSS SECTION E-E'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Temp\CAD - GIS\Alameda\Alameda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alameda E_E xsec FIG 4-14_081508.dwg

FIGURE 6

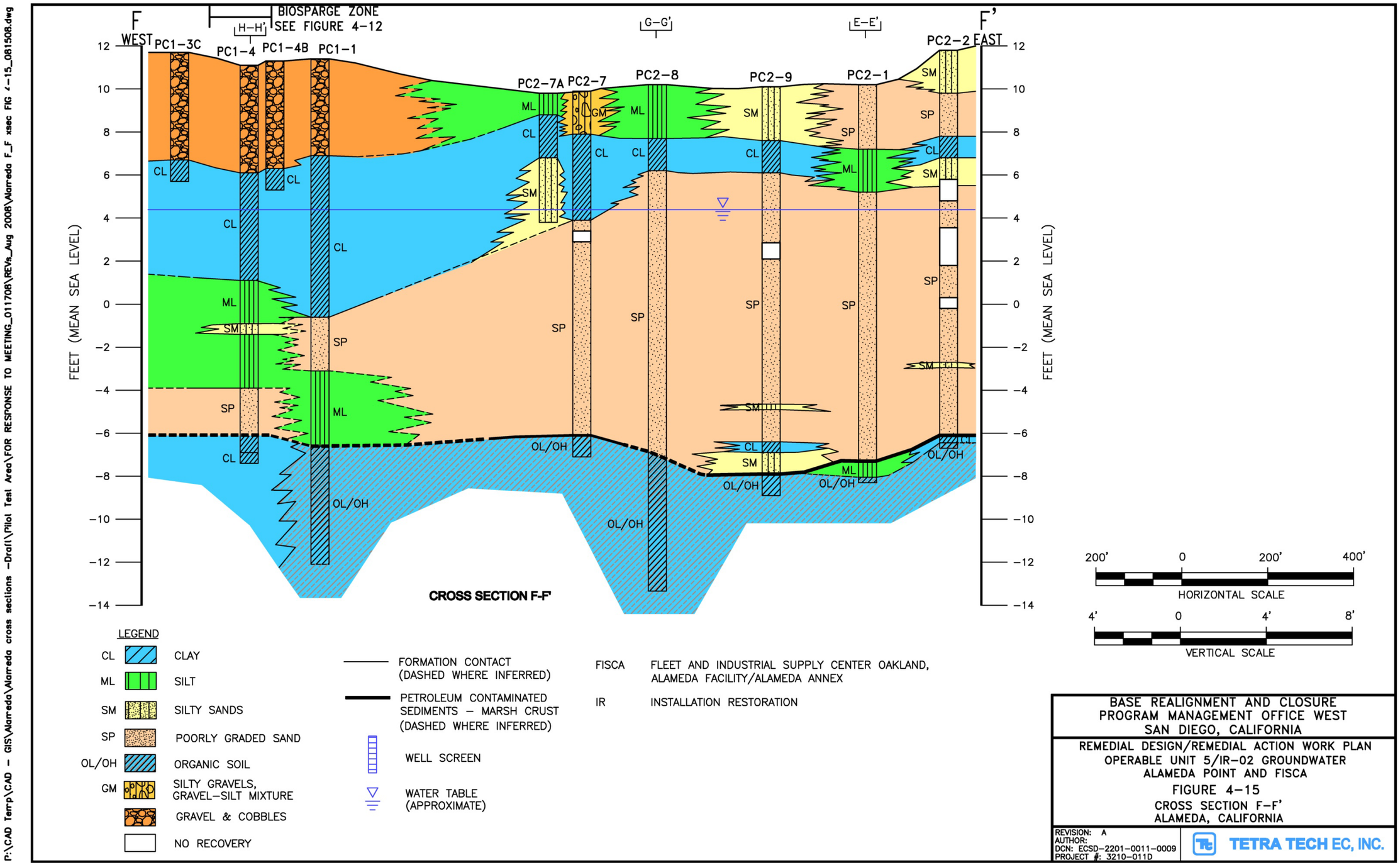

F
WEST
F'
EAST
BIOSPARGE ZONE
SEE FIGURE 4-12
H-H'
G-G'
E-E'
PC1-3C
PC1-4
PC1-4B
PC1-1
PC2-7A
PC2-7
PC2-8
PC2-9
PC2-1
PC2-2
FEET (MEAN SEA LEVEL)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
CL
ML
SM
SP
GM
OL/OH
CROSS SECTION F-F'
200'
0
200'
400'
HORIZONTAL SCALE
4'
0
4'
8'
VERTICAL SCALE
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
SP POORLY GRADED SAND
OL/OH ORGANIC SOIL
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
GRAVEL & COBBLES
NO RECOVERY
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST (DASHED WHERE INFERRED)
WELL SCREEN
WATER TABLE (APPROXIMATE)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-15
CROSS SECTION F-F'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Terrp\CAD - GIS\Alarreda\Alarreda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alarreda F_F xsec FIG 4-15_081508.dwg

FIGURE 7

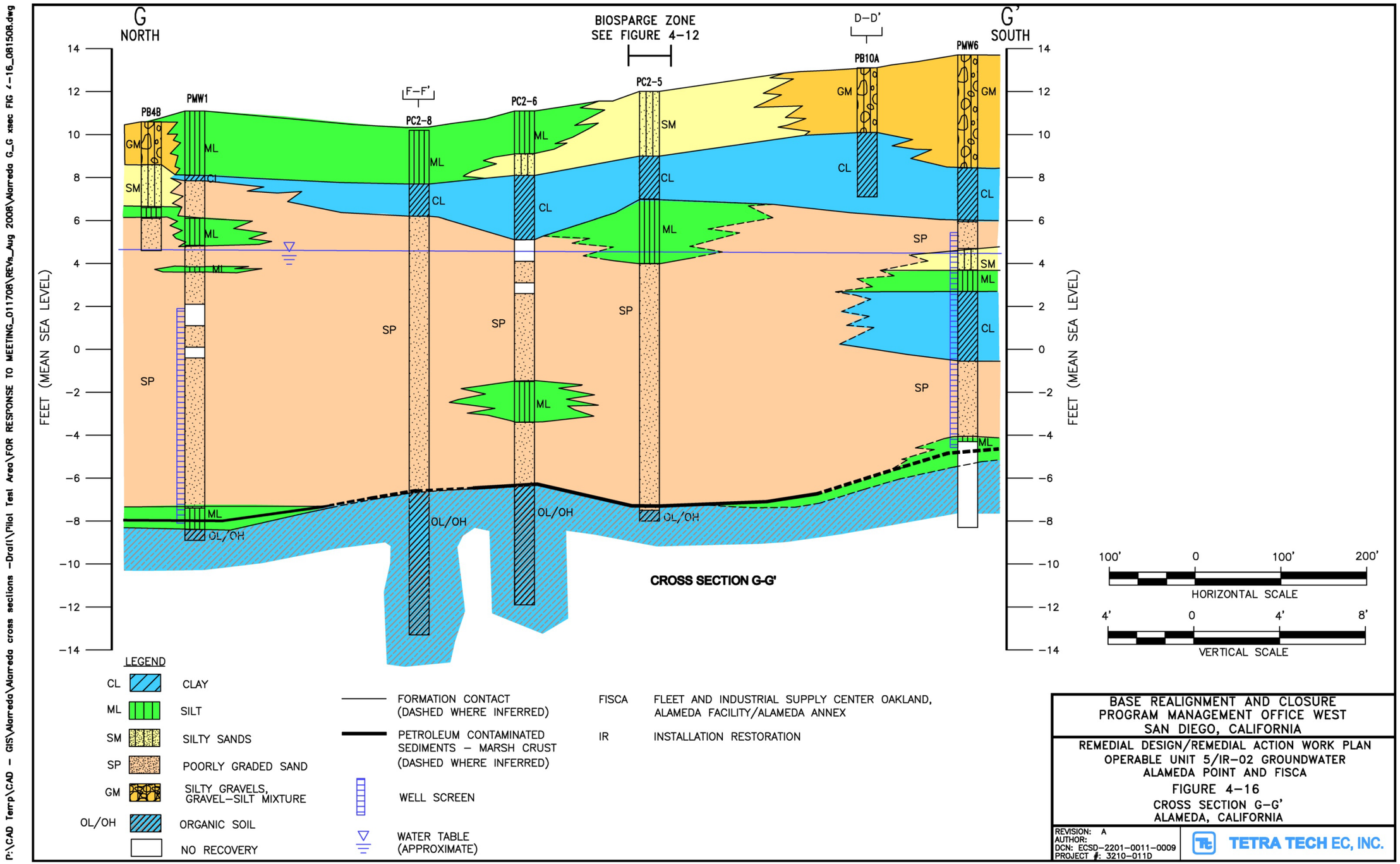

G
NORTH
G'
SOUTH
BIOSPARGE ZONE
SEE FIGURE 4-12
D-D'
F-F'
PB4B
PMW1
PC2-8
PC2-6
PC2-5
PB10A
PMW6
FEET (MEAN SEA LEVEL)
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
GM
SM
ML
CL
SP
OL/OH
CROSS SECTION G-G'
100' 0 100' 200'
HORIZONTAL SCALE
4' 0 4' 8'
VERTICAL SCALE
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
SP POORLY GRADED SAND
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
OL/OH ORGANIC SOIL
NO RECOVERY
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST (DASHED WHERE INFERRED)
WELL SCREEN
WATER TABLE (APPROXIMATE)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-16
CROSS SECTION G-G'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Terrp\CAD - GIS\Alarreda\Alarreda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alarreda G_G xsec FIG 4-16_081508.dwg

FIGURE 8

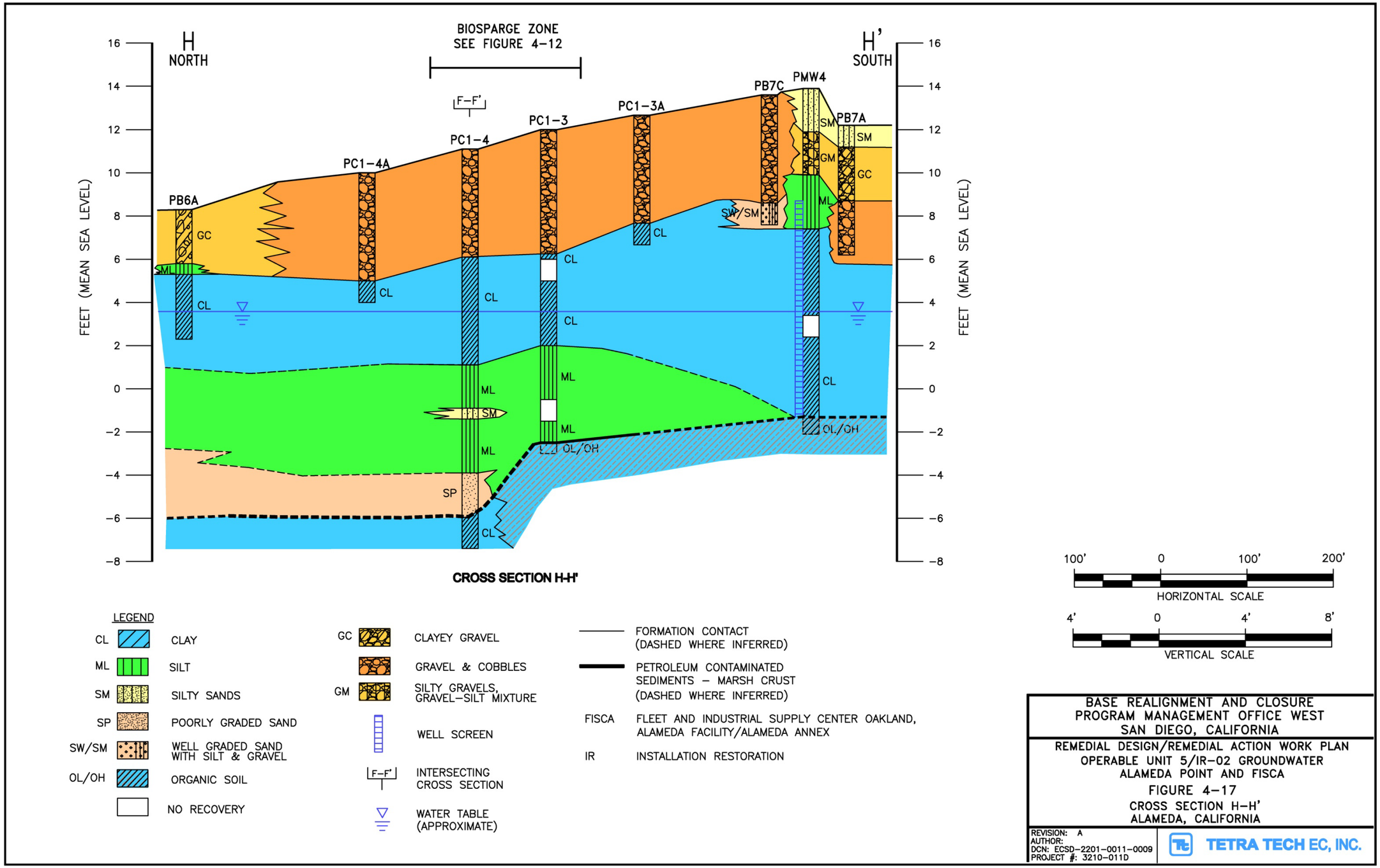

H
NORTH
H'
SOUTH
BIOSPARGE ZONE
SEE FIGURE 4-12
F-F'
PB6A
PC1-4A
PC1-4
PC1-3
PC1-3A
PB7C
PMW4
PB7A
GC
ML
CL
SM
SP
SW/SM
GM
OL/OH
FEET (MEAN SEA LEVEL)
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
CROSS SECTION H-H'
LEGEND
CL CLAY
ML SILT
SM SILTY SANDS
SP POORLY GRADED SAND
SW/SM WELL GRADED SAND WITH SILT & GRAVEL
OL/OH ORGANIC SOIL
NO RECOVERY
GC CLAYEY GRAVEL
GRAVEL & COBBLES
GM SILTY GRAVELS, GRAVEL-SILT MIXTURE
WELL SCREEN
INTERSECTING CROSS SECTION
WATER TABLE (APPROXIMATE)
FORMATION CONTACT (DASHED WHERE INFERRED)
PETROLEUM CONTAMINATED SEDIMENTS - MARSH CRUST (DASHED WHERE INFERRED)
FISCA FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR INSTALLATION RESTORATION
100' 0 100' 200'
HORIZONTAL SCALE
4' 0 4' 8'
VERTICAL SCALE
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-17
CROSS SECTION H-H'
ALAMEDA, CALIFORNIA
REVISION: A
AUTHOR:
DCN: ECSD-2201-0011-0009
PROJECT #: 3210-011D
TETRA TECH EC, INC.
P:\CAD Temp\CAD - GIS\Alameda\Alameda cross sections -Draft\Pilot Test Area\FOR RESPONSE TO MEETING_011708\REVs_Aug 2008\Alameda H_H' xsec FIG 4-17_081508.dw

FIGURE 9

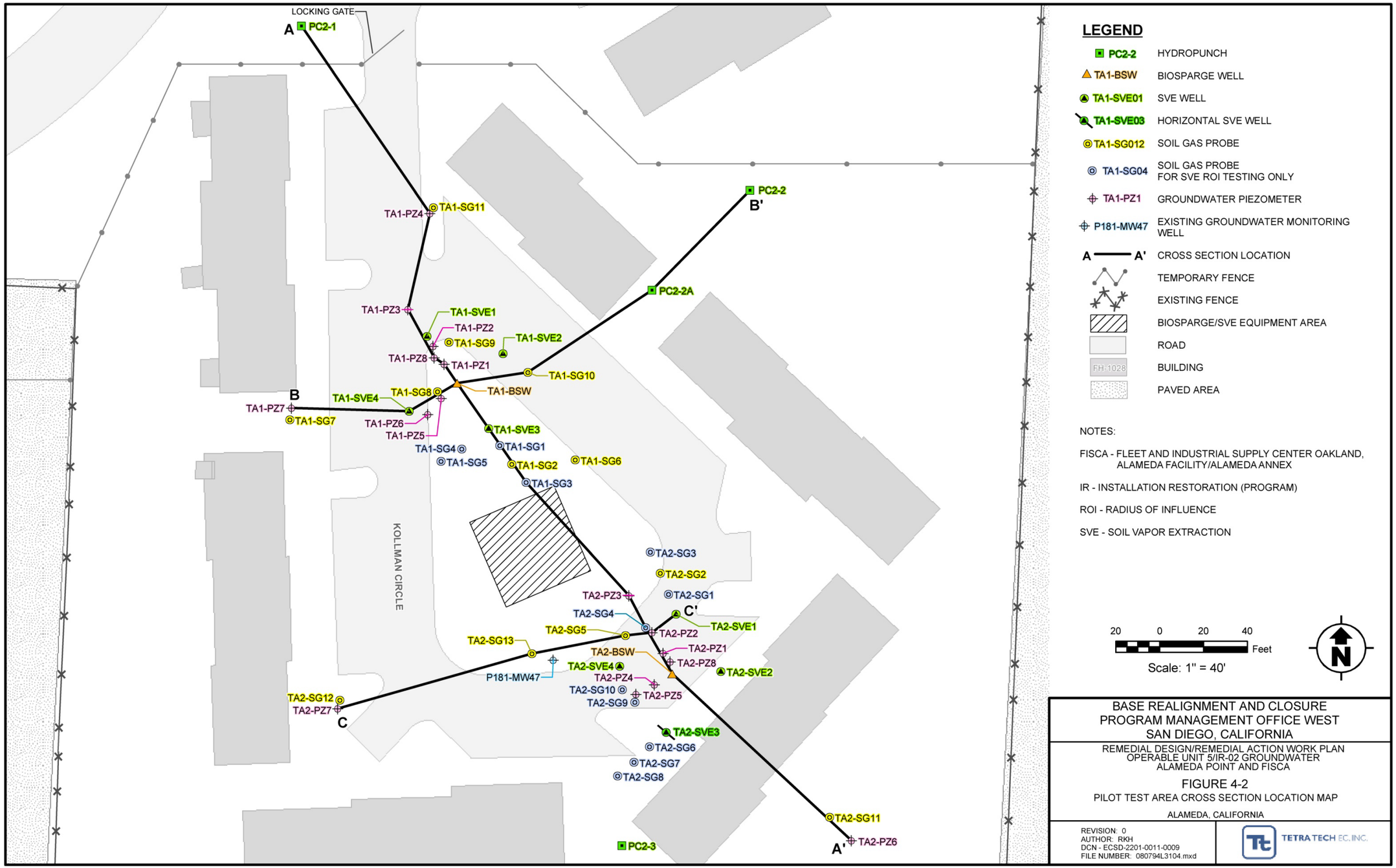

LOCKING GATE
A
PC2-1
PC2-2
B'
PC2-2A
TA1-PZ4
TA1-SG11
TA1-PZ3
TA1-SVE1
TA1-PZ2
TA1-SG9
TA1-SVE2
TA1-PZ8
TA1-PZ1
TA1-SG10
TA1-BSW
B
TA1-SVE4
TA1-SG8
TA1-PZ7
TA1-SG7
TA1-PZ6
TA1-PZ5
TA1-SVE3
TA1-SG4
TA1-SG1
TA1-SG5
TA1-SG2
TA1-SG6
TA1-SG3
KOLLMAN CIRCLE
TA2-SG3
TA2-SG2
TA2-PZ3
TA2-SG1
C'
TA2-SG4
TA2-SVE1
TA2-SG5
TA2-PZ2
TA2-SG13
TA2-PZ1
TA2-BSW
TA2-PZ8
TA2-SVE4
TA2-SVE2
P181-MW47
TA2-PZ4
TA2-SG10
TA2-PZ5
TA2-SG9
TA2-SG12
TA2-PZ7
C
TA2-SVE3
TA2-SG6
TA2-SG7
TA2-SG8
TA2-SG11
TA2-PZ6
A'
PC2-3
LEGEND
PC2-2 HYDROPUNCH
TA1-BSW BIOSPARGE WELL
TA1-SVE01 SVE WELL
TA1-SVE03 HORIZONTAL SVE WELL
TA1-SG012 SOIL GAS PROBE
TA1-SG04 SOIL GAS PROBE FOR SVE ROI TESTING ONLY
TA1-PZ1 GROUNDWATER PIEZOMETER
P181-MW47 EXISTING GROUNDWATER MONITORING WELL
A A' CROSS SECTION LOCATION
TEMPORARY FENCE
EXISTING FENCE
BIOSPARGE/SVE EQUIPMENT AREA
ROAD
FH-1028 BUILDING
PAVED AREA
NOTES:
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR - INSTALLATION RESTORATION (PROGRAM)
ROI - RADIUS OF INFLUENCE
SVE - SOIL VAPOR EXTRACTION
20 0 20 40 Feet
Scale: 1" = 40'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-2
PILOT TEST AREA CROSS SECTION LOCATION MAP
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN - ECSD-2201-0011-0009
FILE NUMBER: 080794L3104.mxd
TETRA TECH EC, INC.

FIGURE 10

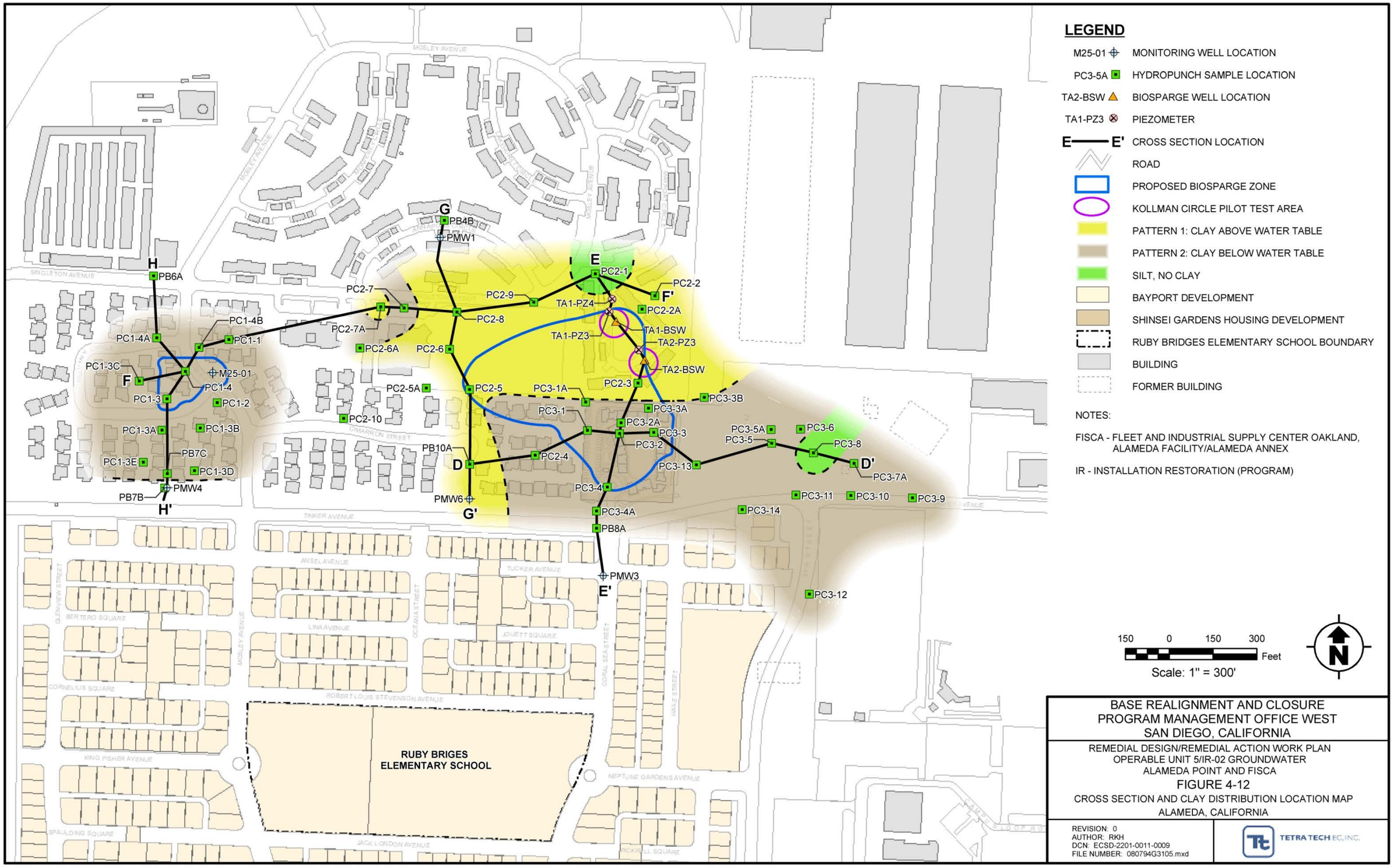

LEGEND
M25-01 MONITORING WELL LOCATION
PC3-5A HYDROPUNCH SAMPLE LOCATION
TA2-BSW BIOSPARGE WELL LOCATION
TA1-PZ3 PIEZOMETER
E E' CROSS SECTION LOCATION
ROAD
PROPOSED BIOSPARGE ZONE
KOLLMAN CIRCLE PILOT TEST AREA
PATTERN 1: CLAY ABOVE WATER TABLE
PATTERN 2: CLAY BELOW WATER TABLE
SILT, NO CLAY
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR - INSTALLATION RESTORATION (PROGRAM)
150 0 150 300 Feet
Scale: 1" = 300'
N
RUBY BRIGES ELEMENTARY SCHOOL
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 4-12
CROSS SECTION AND CLAY DISTRIBUTION LOCATION MAP
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794G3105.mxd
TETRA TECH EC, INC.

FIGURE 11

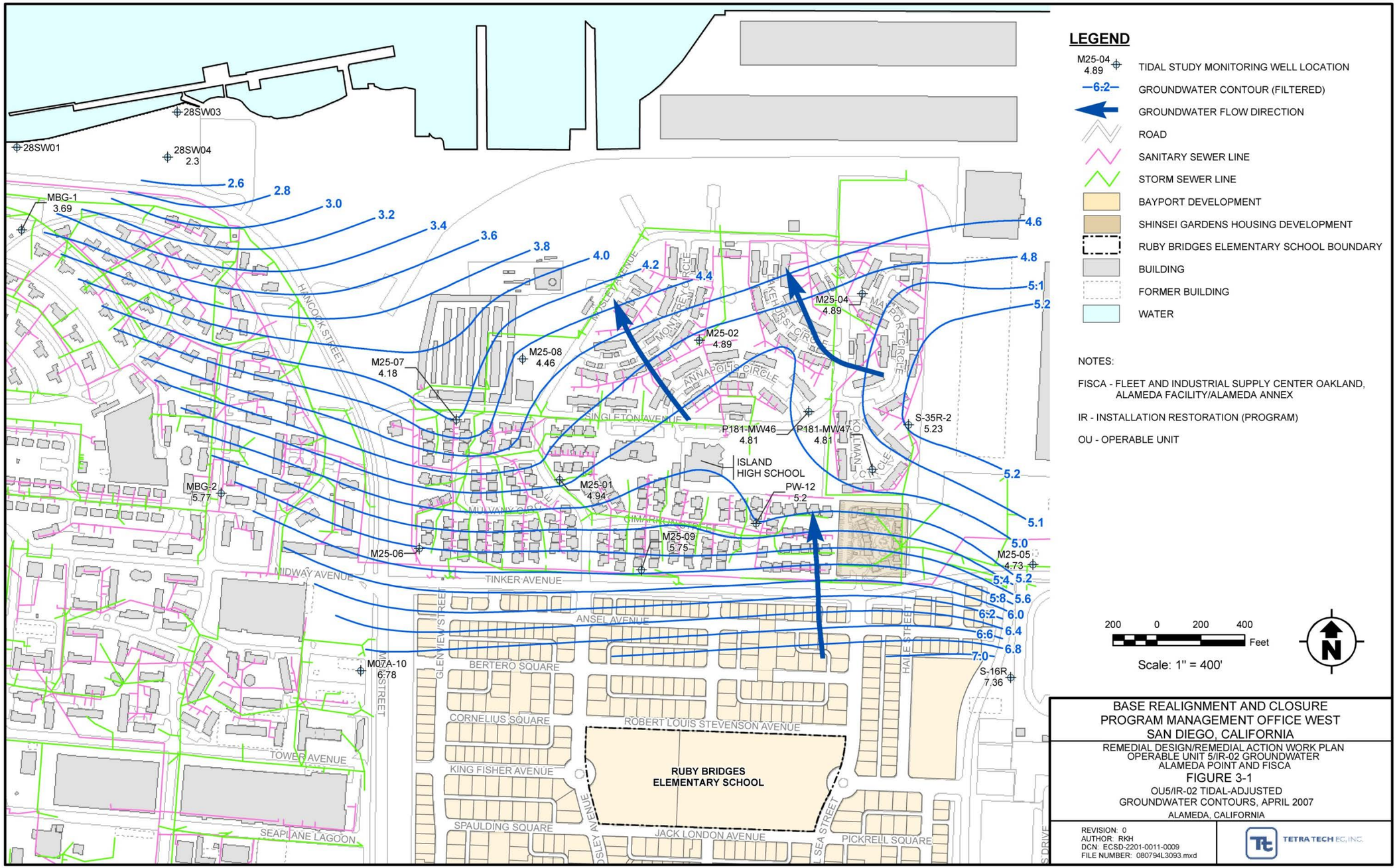
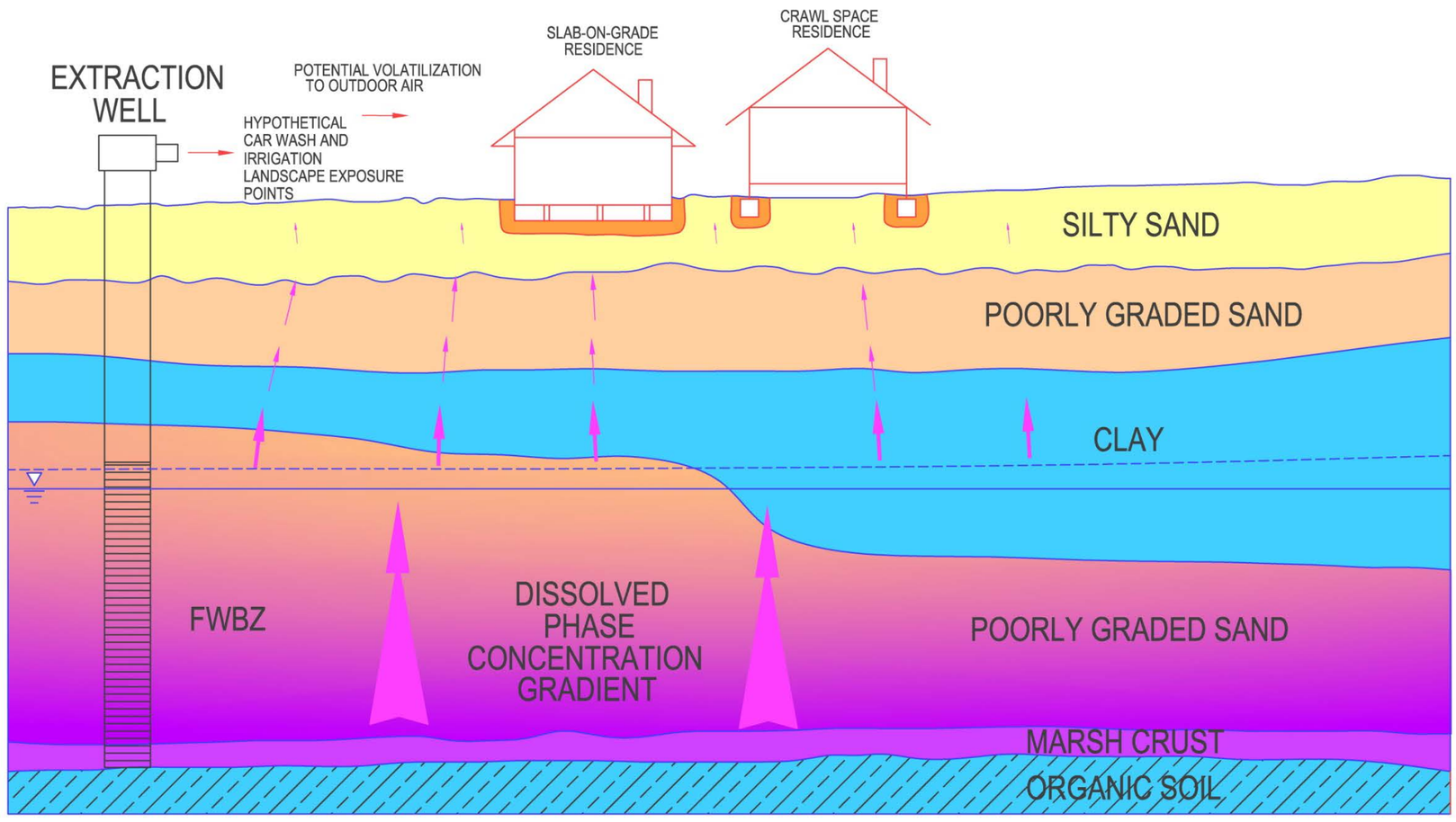

LEGEND
M25-04 4.89 TIDAL STUDY MONITORING WELL LOCATION
6.2 GROUNDWATER CONTOUR (FILTERED)
GROUNDWATER FLOW DIRECTION
ROAD
SANITARY SEWER LINE
STORM SEWER LINE
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
WATER
NOTES:
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
IR - INSTALLATION RESTORATION (PROGRAM)
OU - OPERABLE UNIT
200 0 200 400 Feet
Scale: 1" = 400'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-1
OU5/IR-02 TIDAL-ADJUSTED
GROUNDWATER CONTOURS, APRIL 2007
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3093.mxd
TETRA TECH EC, INC.
28SW03
28SW01
28SW04 2.3
MBG-1 3.69
MBG-2 5.77
M07A-10 6.78
M25-07 4.18
M25-08 4.46
M25-02 4.89
M25-04 4.89
M25-01 4.94
M25-09 5.75
M25-06
M25-05 4.73
P181-MW46 4.81
P181-MW47 4.81
S-35R-2 5.23
PW-12 5.2
S-16R 7.36
ISLAND HIGH SCHOOL
RUBY BRIDGES ELEMENTARY SCHOOL
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.1
5.2
5.0
5.4
5.8
6.2
6.6
7.0
6.0
6.4
6.8
HANCOCK STREET
MOSELEY AVENUE
MONTGOMERY CIRCLE
HIGHHURST CIRCLE
BAYPORT CIRCLE
ANNAPOLIS CIRCLE
SINGLETON AVENUE
KOLLMAN CIRCLE
MULVANEY CIRCLE
SIMARRONES
MIDWAY AVENUE
TINKER AVENUE
ANSEL AVENUE
GLENVIEW STREET
BERTERO SQUARE
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
SPAULDING SQUARE
JACK LONDON AVENUE
PICKRELL SQUARE
HALE STREET
TOWER AVENUE
SEAPLANE LAGOON

FIGURE 12



LEGEND

- CLAY
- SILTY SANDS
- POORLY GRADED SAND
- ORGANIC SOIL
- HYDROCARBON CONTAMINATION FROM MARSH CRUST
- GRAVEL AND COBBLES
- WATER TABLE
- CAPILLARY FRINGE

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TECHNICAL MEMORANDUM
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 13
CONCEPTUAL SITE MODEL

ALAMEDA, CALIFORNIA

REVISION: A
AUTHOR:

TETRA TECH EC, INC.

FIGURE 13

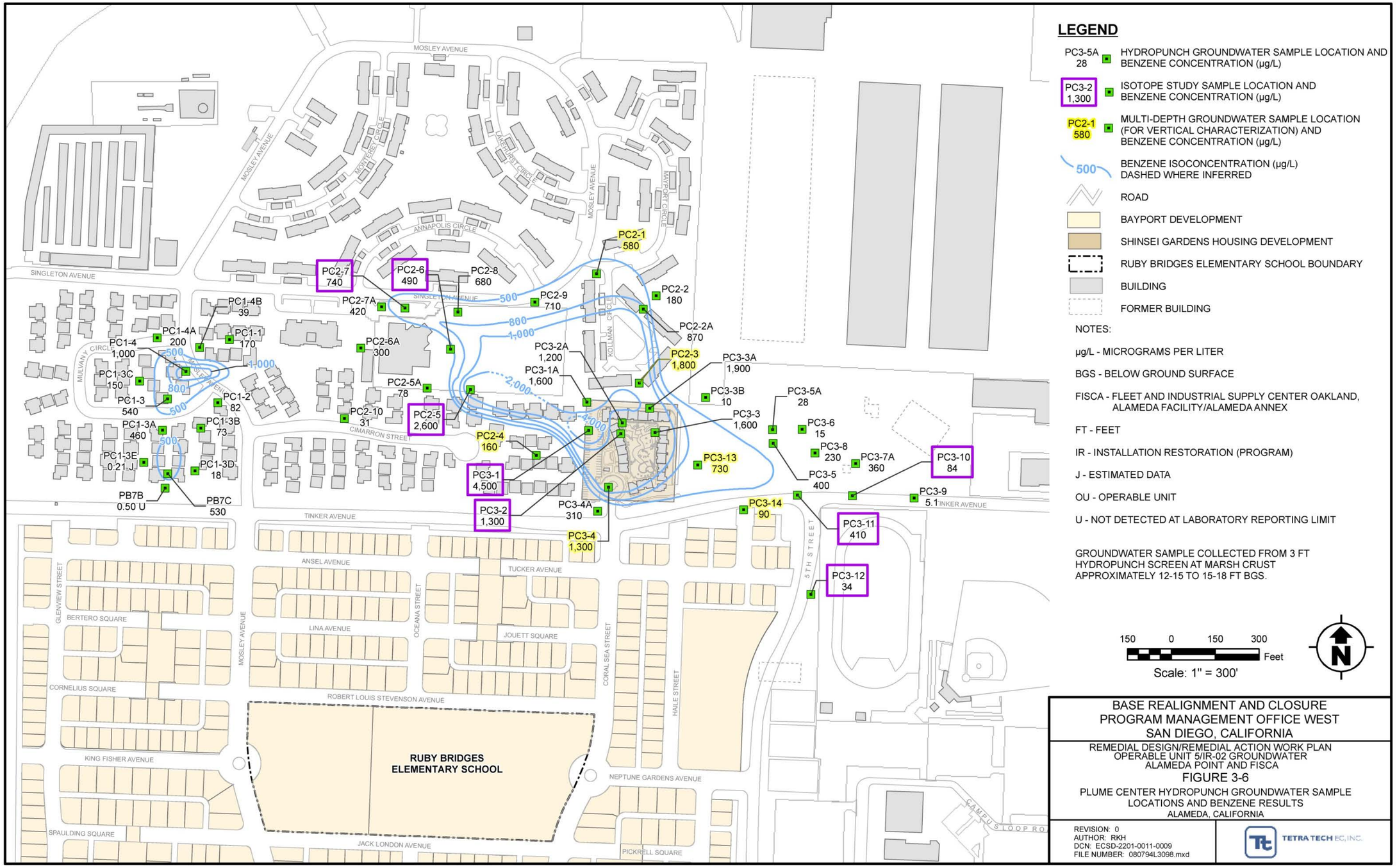

LEGEND
PC3-5A 28 HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC3-2 1,300 ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC2-1 580 MULTI-DEPTH GROUNDWATER SAMPLE LOCATION (FOR VERTICAL CHARACTERIZATION) AND BENZENE CONCENTRATION (µg/L)
500 BENZENE ISOCONCENTRATION (µg/L) DASHED WHERE INFERRED
ROAD
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
µg/L - MICROGRAMS PER LITER
BGS - BELOW GROUND SURFACE
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
FT - FEET
IR - INSTALLATION RESTORATION (PROGRAM)
J - ESTIMATED DATA
OU - OPERABLE UNIT
U - NOT DETECTED AT LABORATORY REPORTING LIMIT
GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.
150 0 150 300 Feet
Scale: 1" = 300'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-6
PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLE LOCATIONS AND BENZENE RESULTS
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3098.mxd
TETRA TECH EC, INC.
MOSLEY AVENUE
SINGLETON AVENUE
ANNAPOLIS CIRCLE
MONTEREY CIRCLE
CAPELLA CIRCLE
MAYPORT CIRCLE
KOLLMAN CIRCLE
MULVANEY CIRCLE
CIMARRON STREET
TINKER AVENUE
ANSEL AVENUE
TUCKER AVENUE
GLENVIEW STREET
BERTERO SQUARE
LINA AVENUE
OCEANA STREET
JOUETT SQUARE
CORAL SEA STREET
HALE STREET
5TH STREET
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
RUBY BRIDGES ELEMENTARY SCHOOL
NEPTUNE GARDENS AVENUE
SPAULDING SQUARE
JACK LONDON AVENUE
PICKRELL SQUARE
CAMPUS LOOP RO
PC2-7 740
PC2-6 490
PC2-8 680
PC2-7A 420
PC2-9 710
PC2-1 580
PC2-2 180
PC2-2A 870
PC2-3 1,800
PC2-6A 300
PC2-5A 78
PC2-5 2,600
PC2-10 31
PC2-4 160
PC1-4B 39
PC1-4A 200
PC1-1 170
PC1-4 1,000
PC1-3C 150
PC1-3 540
PC1-2 82
PC1-3A 460
PC1-3B 73
PC1-3E 0.21 J
PC1-3D 18
PB7B 0.50 U
PB7C 530
PC3-2A 1,200
PC3-1A 1,600
PC3-3A 1,900
PC3-3B 10
PC3-5A 28
PC3-3 1,600
PC3-6 15
PC3-8 230
PC3-7A 360
PC3-13 730
PC3-5 400
PC3-10 84
PC3-9 5.1
PC3-1 4,500
PC3-2 1,300
PC3-4A 310
PC3-4 1,300
PC3-14 90
PC3-11 410
PC3-12 34
500
800
1,000
2,000
4,000

FIGURE 14

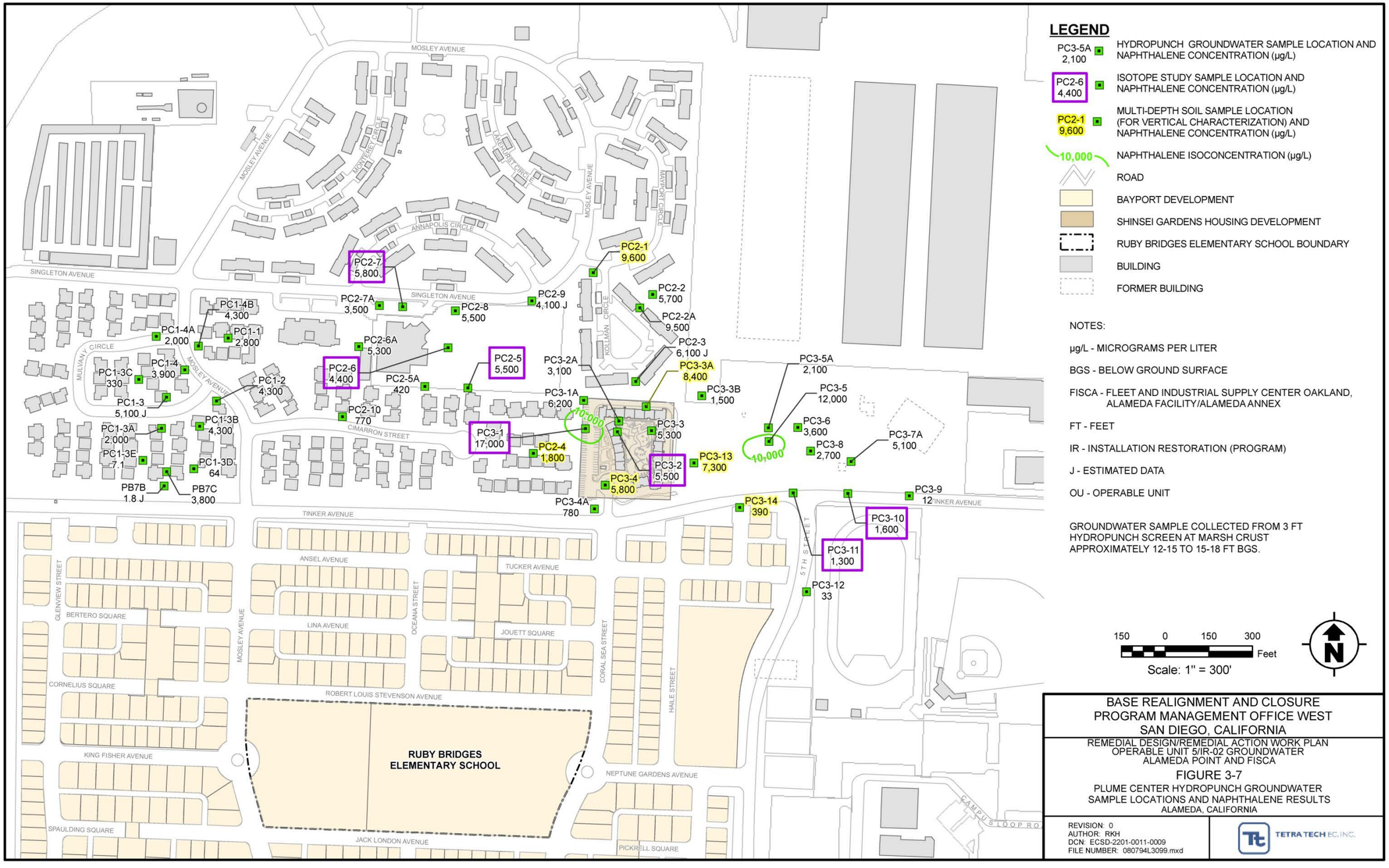

LEGEND
PC3-5A 2,100 HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND NAPHTHALENE CONCENTRATION (µg/L)
PC2-6 4,400 ISOTOPE STUDY SAMPLE LOCATION AND NAPHTHALENE CONCENTRATION (µg/L)
PC2-1 9,600 MULTI-DEPTH SOIL SAMPLE LOCATION (FOR VERTICAL CHARACTERIZATION) AND NAPHTHALENE CONCENTRATION (µg/L)
10,000 NAPHTHALENE ISOCONCENTRATION (µg/L)
ROAD
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
µg/L - MICROGRAMS PER LITER
BGS - BELOW GROUND SURFACE
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
FT - FEET
IR - INSTALLATION RESTORATION (PROGRAM)
J - ESTIMATED DATA
OU - OPERABLE UNIT
GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.
150 0 150 300 Feet
Scale: 1" = 300'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-7
PLUME CENTER HYDROPUNCH GROUNDWATER
SAMPLE LOCATIONS AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3099.mxd
TETRA TECH EC, INC.
MOSLEY AVENUE
SINGLETON AVENUE
MONTEREY CIRCLE
LAKEHURST CIRCLE
ANNAPOLIS CIRCLE
MAYPORT CIRCLE
KOLLMAN CIRCLE
MULVANY CIRCLE
CIMARRON STREET
TINKER AVENUE
ANSEL AVENUE
TUCKER AVENUE
GLENVIEW STREET
BERTERO SQUARE
LINA AVENUE
OCEANA STREET
JOUETT SQUARE
CORAL SEA STREET
HALE STREET
5TH STREET
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
RUBY BRIDGES ELEMENTARY SCHOOL
NEPTUNE GARDENS AVENUE
SPAULDING SQUARE
JACK LONDON AVENUE
PICKRELL SQUARE
CAMPUS LOOP RO
PC2-7 5,800
PC2-1 9,600
PC2-2 5,700
PC2-2A 9,500
PC2-3 6,100 J
PC3-3A 8,400
PC3-3B 1,500
PC2-7A 3,500
PC2-8 5,500
PC2-9 4,100 J
PC1-4B 4,300
PC1-4A 2,000
PC1-1 2,800
PC2-6A 5,300
PC1-3C 330
PC1-4 3,900
PC2-6 4,400
PC2-5 5,500
PC3-2A 3,100
PC3-5A 2,100
PC1-2 4,300
PC2-5A 420
PC3-1A 6,200
PC3-5 12,000
PC1-3 5,100 J
PC2-10 770
PC3-3 5,300
PC3-6 3,600
PC1-3B 4,300
PC3-1 17,000
PC2-4 1,800
PC3-13 7,300
PC3-8 2,700
PC3-7A 5,100
PC1-3A 2,000
PC1-3E 7.1
PC1-3D 64
PC3-2 5,500
PC3-4 5,800
PB7B 1.8 J
PB7C 3,800
PC3-4A 780
PC3-14 390
PC3-9 12
PC3-10 1,600
PC3-11 1,300
PC3-12 33

FIGURE 15

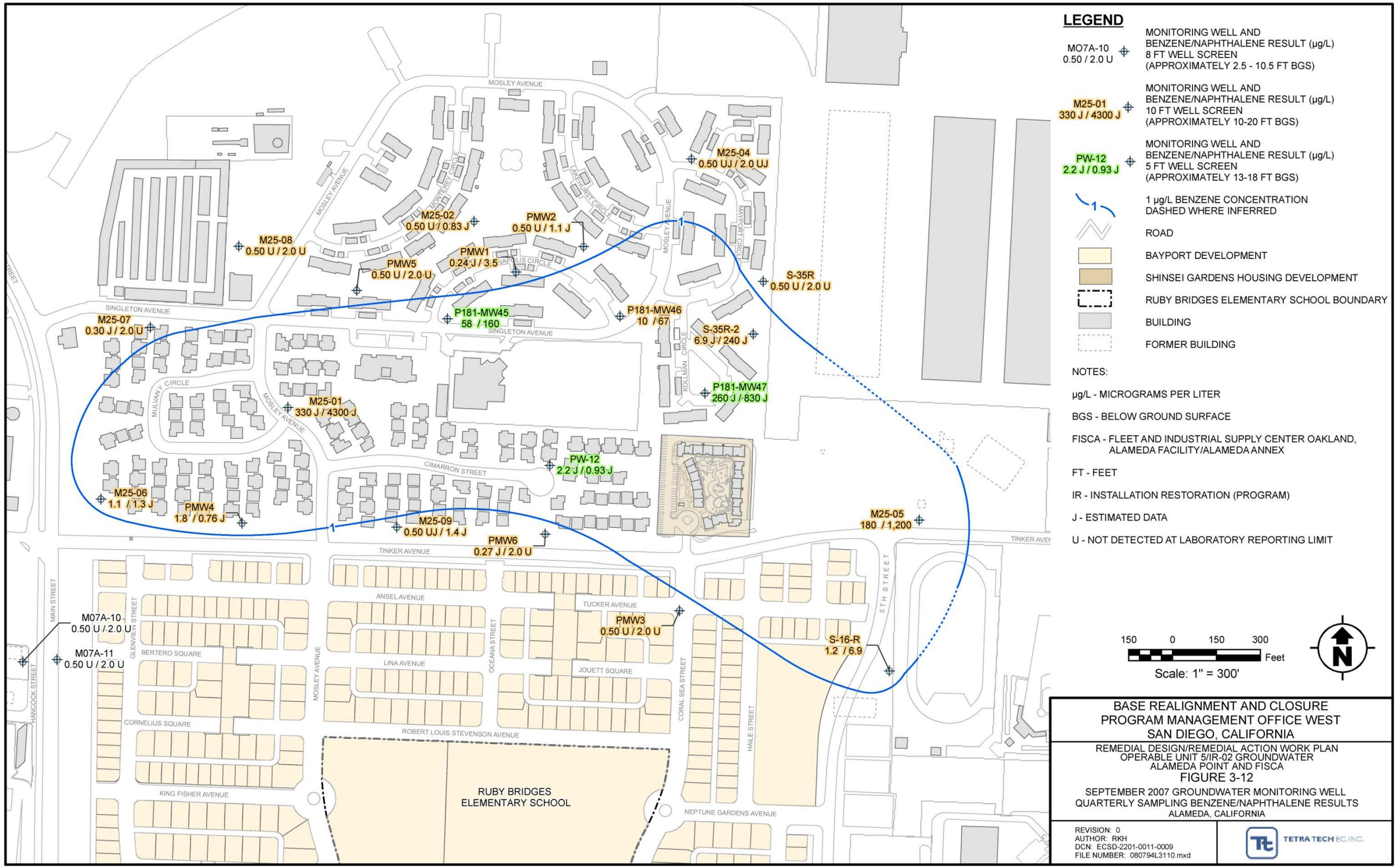

LEGEND
MO7A-10
0.50 / 2.0 U
MONITORING WELL AND
BENZENE/NAPHTHALENE RESULT (µg/L)
8 FT WELL SCREEN
(APPROXIMATELY 2.5 - 10.5 FT BGS)
M25-01
330 J / 4300 J
MONITORING WELL AND
BENZENE/NAPHTHALENE RESULT (µg/L)
10 FT WELL SCREEN
(APPROXIMATELY 10-20 FT BGS)
PW-12
2.2 J / 0.93 J
MONITORING WELL AND
BENZENE/NAPHTHALENE RESULT (µg/L)
5 FT WELL SCREEN
(APPROXIMATELY 13-18 FT BGS)
1 µg/L BENZENE CONCENTRATION
DASHED WHERE INFERRED
ROAD
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
µg/L - MICROGRAMS PER LITER
BGS - BELOW GROUND SURFACE
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
FT - FEET
IR - INSTALLATION RESTORATION (PROGRAM)
J - ESTIMATED DATA
U - NOT DETECTED AT LABORATORY REPORTING LIMIT
150 0 150 300
Feet
Scale: 1" = 300'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-12
SEPTEMBER 2007 GROUNDWATER MONITORING WELL
QUARTERLY SAMPLING BENZENE/NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3110.mxd
TETRA TECH EC, INC.
MOSLEY AVENUE
SINGLETON AVENUE
CIMARRON STREET
TINKER AVENUE
ANSEL AVENUE
TUCKER AVENUE
LINA AVENUE
JOUETT SQUARE
BERTERO SQUARE
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
NEPTUNE GARDENS AVENUE
RUBY BRIDGES
ELEMENTARY SCHOOL
MAIN STREET
HANCOCK STREET
GLENVIEW STREET
OCEANA STREET
CORAL SEA STREET
HALE STREET
5TH STREET
MULVANEY CIRCLE
KOLLMAN CIRCLE
MAYPORT CIRCLE
LAKEHURST CIRCLE
M25-08
0.50 U / 2.0 U
M25-02
0.50 U / 0.83 J
PMW2
0.50 U / 1.1 J
PMW1
0.24 J / 3.5
PMW5
0.50 U / 2.0 U
M25-04
0.50 UJ / 2.0 UJ
S-35R
0.50 U / 2.0 U
M25-07
0.30 J / 2.0 U
P181-MW45
58 / 160
P181-MW46
10 / 67
S-35R-2
6.9 J / 240 J
P181-MW47
260 J / 830 J
M25-01
330 J / 4300 J
PW-12
2.2 J / 0.93 J
M25-06
1.1 / 1.3 J
PMW4
1.8 / 0.76 J
M25-09
0.50 UJ / 1.4 J
PMW6
0.27 J / 2.0 U
M25-05
180 / 1,200
M07A-10
0.50 U / 2.0 U
M07A-11
0.50 U / 2.0 U
PMW3
0.50 U / 2.0 U
S-16-R
1.2 / 6.9

FIGURE 16

APPENDIX A

TARGET REMEDIATION ZONE – BACKGROUND INFORMATION (on CD only)

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APPENDIX A

TARGET REMEDIATION ZONE – BACKGROUND INFORMATION FROM THE DRAFT FINAL INTERIM REMEDIAL ACTION COMPLETION REPORT OPERABLE UNIT 5/ FISCA IR-02 GROUNDWATER

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TARGET REMEDIATION ZONE – BACKGROUND INFORMATION

To understand the distribution of benzene and naphthalene in site groundwater, it is important to understand the Marsh Crust. An analysis was performed in the final Remedial Design (RD)/Remedial Action Work Plan (RAWP) (TtEC 2010) to answer the following questions regarding the Marsh Crust at OU-5/FISCA IR-02 and the origin of site contamination:

- What is the Marsh Crust?
- Where did the Marsh Crust come from?
- How did the Marsh Crust get here?
- Why is the Marsh Crust not a continuous layer?
- Why is the contaminant distribution variable throughout the Marsh Crust?

The Marsh Crust was originally defined in 1969 by Lee and Praszker in the California Division of Mines and Geology Special Report 97 (Lee and Praszker 1969) and in 1979 (Lee and Praszker 1979) when they performed a geotechnical investigation at Alameda. They defined the Marsh Crust as the peat layer that was the historic marshlands. The marshlands were filled in with dredge material between 1900 and 1940. By 2000, the definition of the Marsh Crust had changed to a layer of refinery by-products and sludges deposited within tidal channels and up to the high water mark on the tidal marsh (TtEMI 2000). A similar definition can be found in the Remedial Investigation (RI)/Feasibility Study (FS) Report (ERRG 2004) as "A layer of petroleum-related contamination on the historic shoreline, marshland and tidal channels underlying the Site, referred to as the Marsh Crust."

The Marsh Crust beneath OU-5/IR-02 originated from residues associated with the Oakland Gas Works, a manufactured gas plant (MGP) in Oakland that was active in the 1800s. The hydrocarbon fingerprint and stable isotopic ratio analysis (see attached RD/RAWP, Appendix F, TtEC 2010) determined that the Marsh Crust contaminants are consistent with MGP residues from a coal carbonization process. No petroleum derived residues are present, confirming the Marsh Crust contaminants are not from a more recent petroleum or fuel release. The Oakland Gas Works was formerly located across San Antonio Creek at the present-day Jack London Square, approximately 1 mile from the site (Figure A.1). This facility processed coal only from 1866 to 1904 (consistent with the isotope analysis).

Based on the MGP location, residuals were probably discharged to San Antonio Creek. Once discharged into an estuarine environment, such as San Antonio Creek and adjacent tidelands/marshes on Alameda, dissolved-phase coal tar residuals (primarily benzene, toluene, ethylbenzene, xylenes [BTEX], and/or naphthalene), suspended microglobules of coal tar polycyclic aromatic hydrocarbons (PAHs), and/or suspended sediment particulates with PAHs adsorbed to their surface would migrate with the tidal currents and become adsorbed to the

surface of the tidal marsh organic matter/sediment. This would typically be restricted to a thin layer due to the highly adsorptive nature of the marshes/tidal flats organic peat and/or fine-grained sediments. Once incorporated in the sediment, these contaminants will typically remain there and serve as a localized source to adjacent surface water. If subsequently covered with fill, the impacted sediment would occur as a relatively thin subsurface layer that serves as a localized source to adjacent groundwater.

The Marsh Crust is not a uniform, continuous layer because natural estuarine processes as well as construction/development activities were not static during its formation. Estuarine marshes are dynamic landforms that are continually in a state of flux due to water-mediated sediment transport, erosion/accretion, and/or other depositional events that constantly shape and reshape tidally influenced wetland areas. Other major erosional and/or depositional events such as storms or the differential filling (placement of dredge spoils) of the marsh over time also have a significant impact on the reshaping of the tidally influenced wetland areas and the subsequent distribution of impacted marshland sediments referred to as the Marsh Crust.

In addition to the Marsh Crust not being a uniform, continuous layer for reasons described above, contaminants within the Marsh Crust also vary in concentration. For example, high concentrations of benzene and naphthalene are collocated in some areas; however, there are other areas with high naphthalene and low benzene. Three processes can contribute to this variability:

- The estuarine environment and related construction/development activities described in the previous paragraph.
- The differences in the way benzene and naphthalene react when released into the environment due to differing chemical characteristics. Differences in solubility, adsorption, volatility, and other chemical characteristics may cause attenuation of one compound but not another.
- The MGP coal carbonization process produces two different waste product streams: coal tar, which includes naphthalene, and benzol, which consists primarily of benzene. Manufacturing, by-product segregation, and disposal practices at the MGPs typically resulted in differential distributions of different MGP wastes. For example, the benzol may be discharged at different rates or different times than the coal tar, which would affect the distribution of benzene and naphthalene.

Because of these processes, a uniform MGP residual (i.e., uniform Marsh Crust) does not exist and thus uniform groundwater contamination does not exist. This type of contaminant variability is routinely seen at other MGP sites (TtEC 2010).

Another important fact to consider when evaluating the origins of site contamination is the lack of evidence of a source, or sources, other than the Marsh Crust. Had site contamination originated from a surface or near surface release, a zone of contamination along the shallow clay layer or a smear zone at the water table would be expected. Near-surface sourced hydrocarbons

would migrate downward through the soil column until contacting an impermeable clay layer (common throughout the site) or the water table. Such contamination would then migrate horizontally along the clay contact or, in the case of the water table, create a smear zone as the water table fluctuated between wet and dry months. Such conditions were not observed. Instead, site characterization activities confirm increasing contamination with depth, and maximum concentrations at the Marsh Crust.

Previous site characterization activities include

- Over 70 HydroPunch (2001 data) groundwater samples and 12 shallow (approximately 10 to 20 feet bgs) groundwater monitoring wells (2003 data) previously sampled to analyze contamination distribution (presented in 2004 RI/FS, see attached RD/RAWP Figure 2-4 and RI/FS Figures 4-5, 4-6 and 4-8)
- Contaminant concentrations are higher at deeper (16-20 ft) interval vs. shallower (12-16 ft) interval at all 35 HydroPunch locations where contamination was detected and where multi-depth samples were collected (Figures 4-5 and 4-6).
- RI/FS data were used as starting point to further evaluate plume centers. The need for further refinement was stated in the RI/FS and ROD and was accomplished in the 2007 pre-design investigation
- 2007 pre-design investigation included:
  - 28 continuously cored soil sample locations –Marsh Crust observed as 0.5 to 1 inch layer of contamination at the base of the FWBZ (approximately 13 to 21 ft throughout site) at 26 of 28 locations. Highest contamination concentrations were at Marsh Crust (see RD/RAWP Figure 3-4).
  - Multi-depth soil sample locations at 8 of 28 locations –Results for most soil samples above the Marsh Crust were below detection limits; results for Marsh Crust samples were one to 6 orders of magnitude higher than samples collected above Marsh Crust
  - HydroPunch groundwater samples collected adjacent to, and at the same depth as, soil samples. Additional step-out HydroPunch samples (total of 46) were also collected to establish 500 ug/L benzene isoconcentration contour. HydroPunch sample results confirmed RI/FS data that the contamination increases with depth (see RD/RAWP Figure 3-6). HydroPunch data were used to establish biosparge treatment areas (see RD/RAWP Figure 3-8).
  - Hydrocarbon fingerprint and stable isotope ratio analysis results showed one common source for soil and groundwater contamination and a coal, not petroleum, based source for site contamination (RD/RAWP Appendix F and G)
  - Soil sampling to investigate “dark colored areas” (see RD/RAWP Figures 3-16 and 3-17). All benzene and naphthalene results were below detection limits.

- 18 continuously cored wells and piezometer locations installed for the biosparge/SVE pilot tests (including 9 locations drilled through the dark colored areas observed on the 1968 aerial photograph shown on Figure A-2)
- 6 continuously cored plume boundary well locations (PMW1 through PMW6) (The degree of observable contamination was much compared to plume center locations. The Marsh Crust was often observed as only a slight staining or slight-to-moderate hydrocarbon odor in sediments at the base of the FWBU)
- 7 continuously cored biosparge area monitoring wells (BZMW1 through BZMW7) where the Marsh crust was observed at the base of the FWBZ.
- Approximately 17 additional plume center step-out location and 31 additional pilot test probe locations not included in the above totals that were hand augured to 6 feet bgs. The cuttings were logged and, in most cases, field screened with a PID. Field evidence of contaminated was not observed at any of these locates.

The site is well characterized. There are multiple lines of evidence that the Marsh Crust is the only source of site contamination.

- If there were a surface or near surface spill/source (such as a fire pit, burn area, pipeline, UST, AST, etc) signs of contamination (e.g. smear zone) would be at the top of the water table since site contaminants are lighter than water. In the 60 continuously cored borings, there was no sign of contamination (e.g. smear zone) at the top of the water table. In the 48 additional hand auger locations there was no sign of contamination on top of the clay layer
- Marsh Crust observed as a thin (approx. 0.5 to 1 inch) layer of contamination at the base of the FWBZ directly on top of the plant material rich native Bay Mud formation
- Soil and groundwater "fingerprint analysis" indicates one common source for soil and groundwater.
- Isotope ratio analysis indicates coal based, not petroleum based, hydrocarbon.
- Coal carbonization process produces benzene and naphthalene rich waste products typically (historically) disposed of into the environment.
- Local history confirms nearby MGP where coal was used.
- Differing distribution and concentrations of benzene and naphthalene are consistent with dynamic costal environment, MGP waste disposal practices, and as seen at other MGP sites
- Soil sample results and continuous soil cores collected to the base of the FWBZ in the "dark colored area" show no evidence of spill, burn pit, or any other contamination source
- Benzene and naphthalene are flammable and are not used in fire retardants
- There is no history of any other source areas

A detailed evaluation of Marsh Crust and the origin of site contamination, including other sites with similar MGP wastes, were presented in Appendix F and G originally included in the RD/RAWP (TtEC 2010). These two appendices are attached.

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ERRG (Engineering Remediation Resources Group, Inc.). 2004. Final Groundwater Remedial Investigation/Feasibility Study, Alameda Point Site 25 and Alameda Annex IR-02, Alameda, California. October.

Lee and Praszker. 1969. California Division of Mines and Geology Special Report 97.

——————. 1979. Geotechnical Investigation, Defense Property Disposal Office. Alameda, California.

TtEMI (Tetra Tech EM, Inc.). 2000. Final Feasibility Study for the Marsh Crust and Groundwater at FISCA and Feasibility Study for the Marsh Crust and Former Subtidal Area of Alameda Point. March.

TtEC (Tetra Tech EC, Inc.). 2010. Final Remedial Design/Remedial Action Work Plan, Operable Unit 5/IR-02 Groundwater, Alameda Point and FISCA, Alameda, California. December.

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FIGURES

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LEGEND

- OU-5 BOUNDARY
- ALAMEDA BASE BOUNDARY
- MODERN COASTLINE

NOTES:

MGP - MANUFACTURED GAS PLANT

OU - OPERABLE UNIT

ALAMEDA 1908 HISTORICAL MAP

N

1,000 0 1,000 2,000 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

INTERIM REMEDIAL ACTION COMPLETION REPORT
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

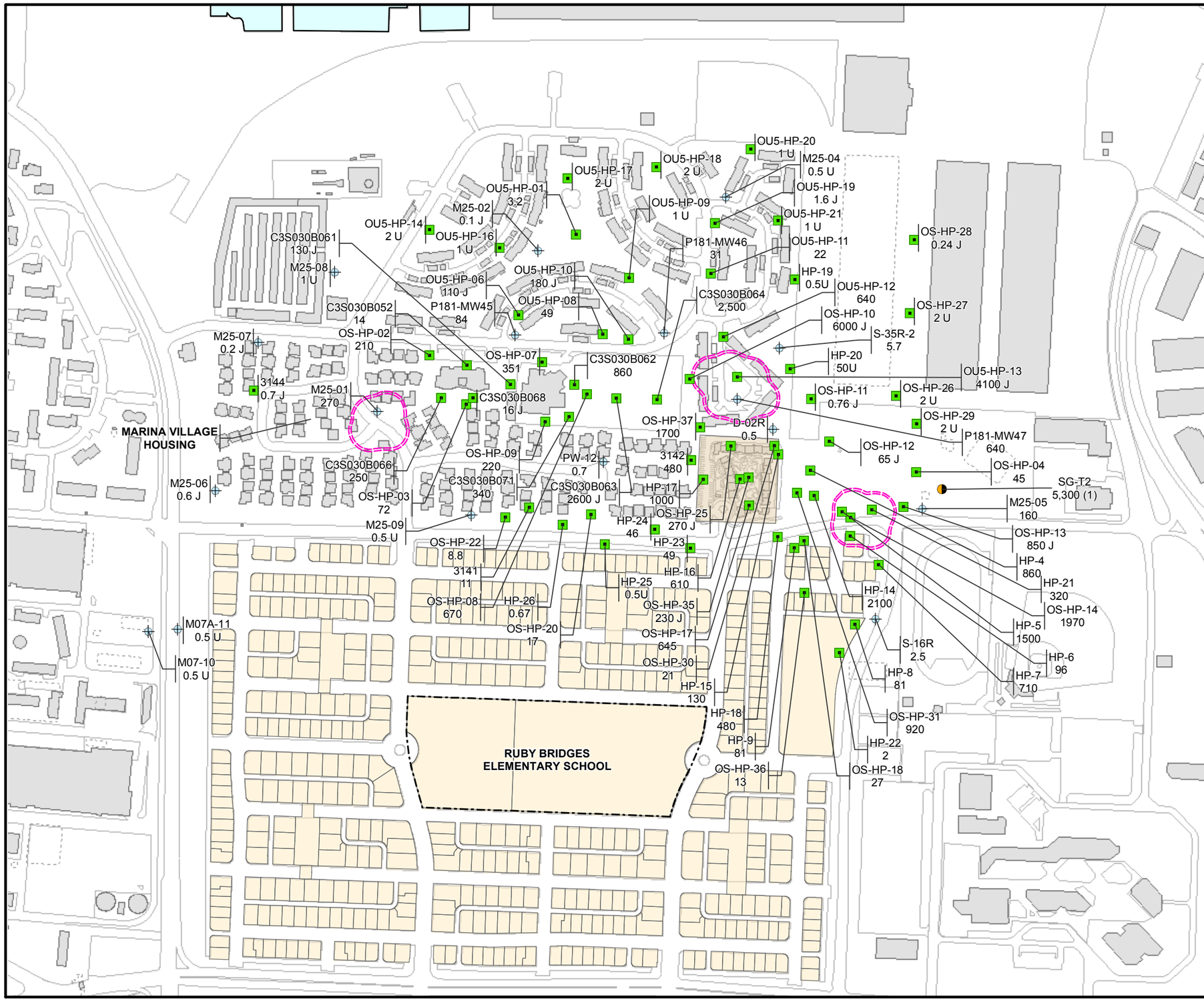
FIGURE A.1

MGP SITE LOCATION MAP

ALAMEDA, CALIFORNIA

REVISION: A
AUTHOR: GFG/MS
DCN: ECSD-3211-0007-0011
FILE NUMBER: 110735L7141.mxd

TETRA TECH EC, INC.



LEGEND

SG-T2 5,300	SOIL GAS PROBE AND BENZENE CONCENTRATION (PPBV)
OU5-HP-14 2 U	PREVIOUS HYDROPUNCH LOCATION AND BENZENE CONCENTRATION (µg/L)
M25-05 160	EXISTING MONITORING WELL AND BENZENE CONCENTRATION (µg/L)
	FEASIBILITY STUDY BIOSPARGE ZONE
	ROAD
	BAYPORT DEVELOPMENT
	SHINSEI GARDENS HOUSING DEVELOPMENT
	RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
	BUILDING
	FORMER BUILDING
	WATER

NOTES:

(1) - SOIL GAS CONCENTRATION IN PPBV DETECTED IN 1996

µg/L - MICROGRAMS PER LITER

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FS - FEASIBILITY STUDY

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

PPBV - PARTS PER BILLION VOLUME

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

SOURCE: ITSI, 2006

200 0 200 400 Feet

Scale: 1" = 400'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

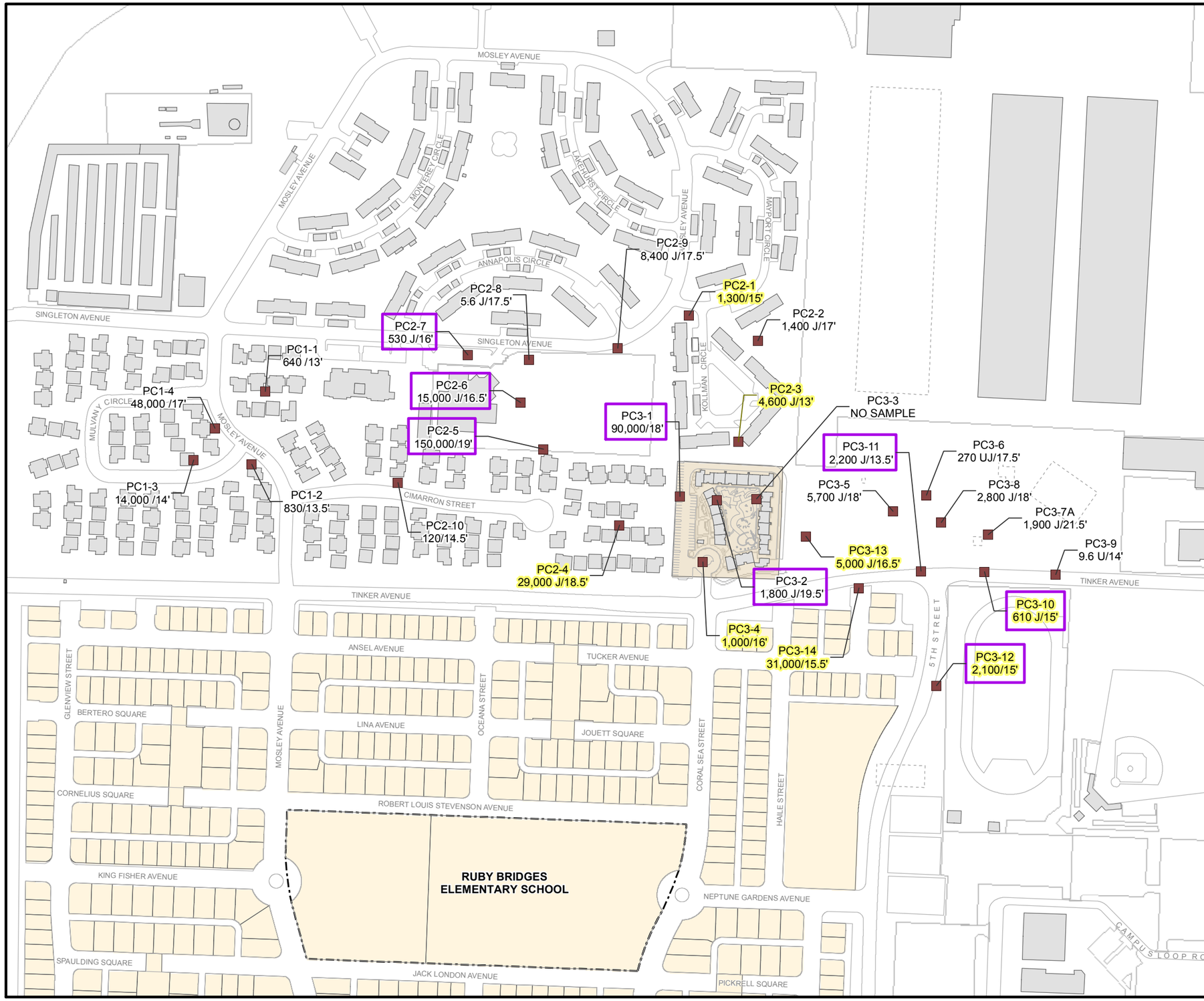
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 2-4

PREVIOUS SAMPLING LOCATIONS
AND PROPOSED FS BIOSPARGE ZONES
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3092.mxd

TETRA TECH EC, INC.



LEGEND

PC1-2 830 /13.5' — SOIL SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH BASED ON HIGHEST CONCENTRATION INDICATED BY FIELD SCREENING)

PC2-6 15,000 J/16.5' — ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH IS MARSH CRUST)

PC2-1 1,300/15' — MULTI-DEPTH SOIL SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (RESULTS LISTED ARE HIGHEST OF SAMPLES ANALYSED FROM 3 DEPTHS AT EACH LOCATION)

ROAD

BAYPORT DEVELOPMENT

SHINSEI GARDENS HOUSING DEVELOPMENT

RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY

BUILDING

FORMER BUILDING

NOTES:

µg/kg - MICROGRAMS PER KILOGRAM

BGS - BELOW GROUND SURFACE

FT - FEET

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

150 0 150 300 Feet

Scale: 1" = 300'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

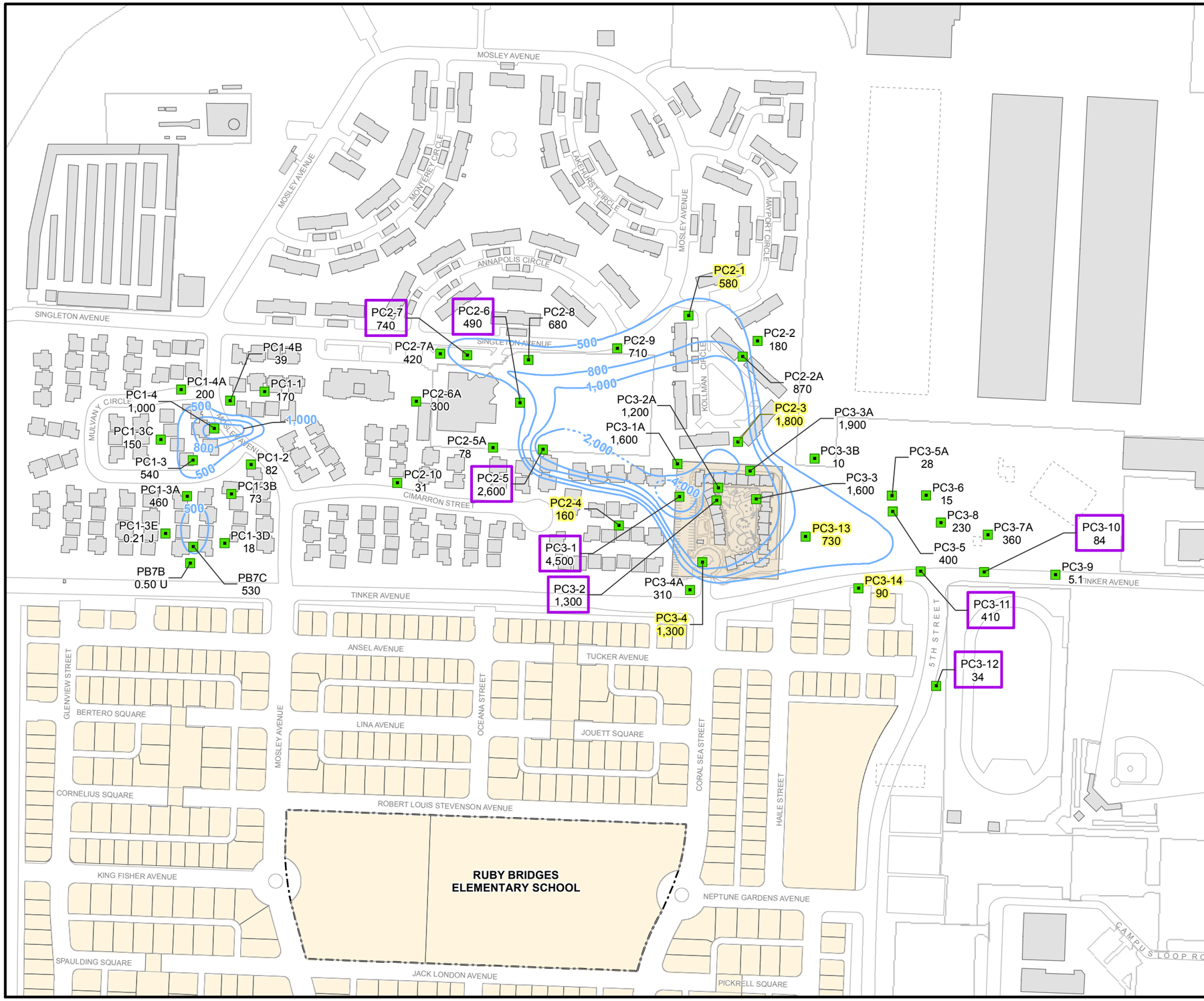
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 3-4

PLUME CENTER SOIL SAMPLE
LOCATIONS AND BENZENE RESULTS
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3096.mxd

TETRA TECH EC, INC.



LEGEND

PC3-5A 28 — HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)

PC3-2 1,300 — ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)

PC2-1 580 — MULTI-DEPTH GROUNDWATER SAMPLE LOCATION (FOR VERTICAL CHARACTERIZATION) AND BENZENE CONCENTRATION (µg/L)

500 — BENZENE ISOCONCENTRATION (µg/L) DASHED WHERE INFERRED

ROAD

BAYPORT DEVELOPMENT

SHINSEI GARDENS HOUSING DEVELOPMENT

RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

OU - OPERABLE UNIT

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.

150 0 150 300 Feet

Scale: 1" = 300'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

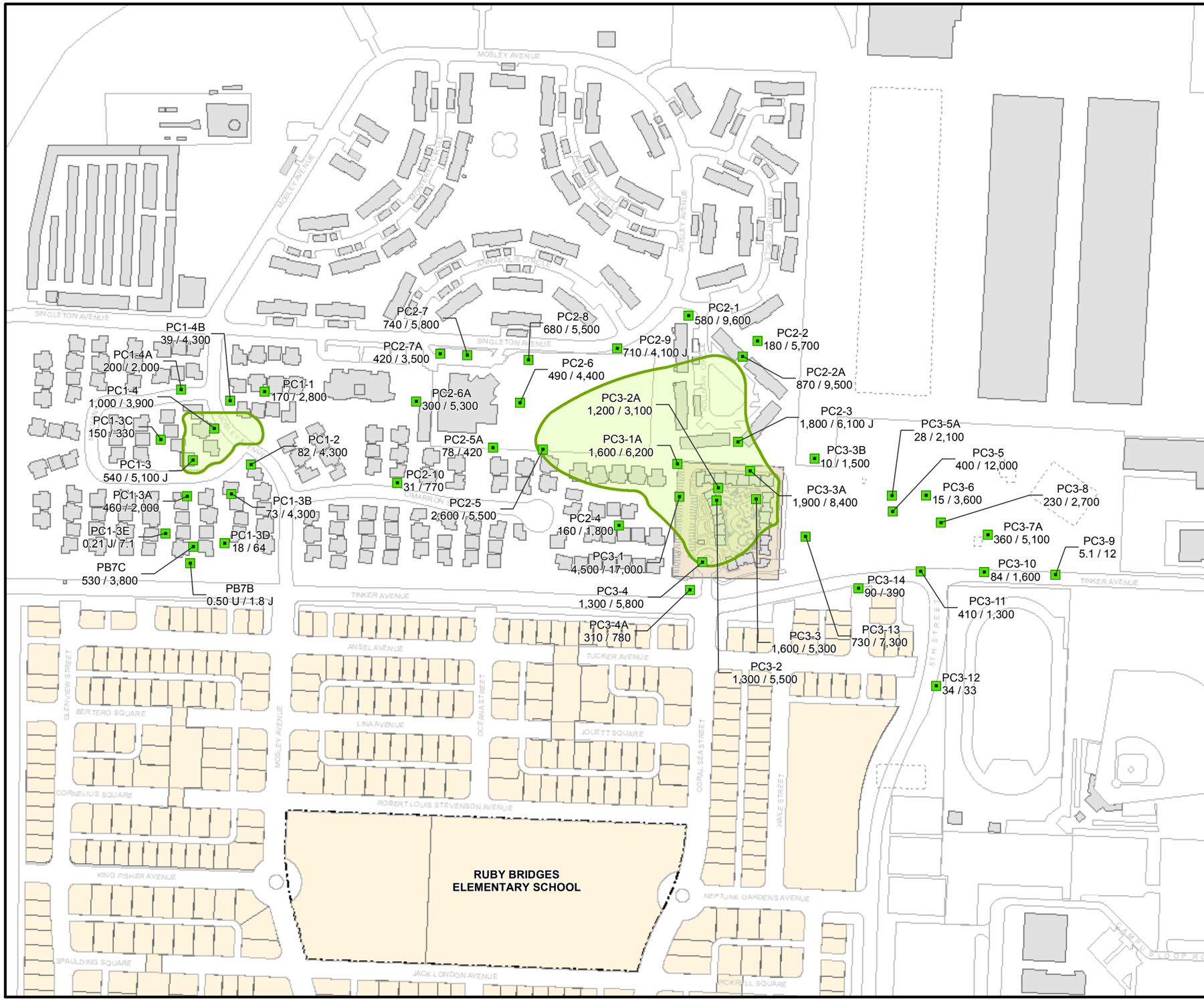
FIGURE 3-6

PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLE LOCATIONS AND BENZENE RESULTS

ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3098.mxd

TETRA TECH EC, INC.



LEGEND

PC3-5A 28 / 2,100 — HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND BENZENE/NAPHTHALENE CONCENTRATION (µg/L)

ROAD

PROPOSED BIOSPARGE ZONE

BAYPORT DEVELOPMENT

SHINSEI GARDENS HOUSING DEVELOPMENT

RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

OU - OPERABLE UNIT

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.

150 0 150 300 Feet

Scale: 1" = 300'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

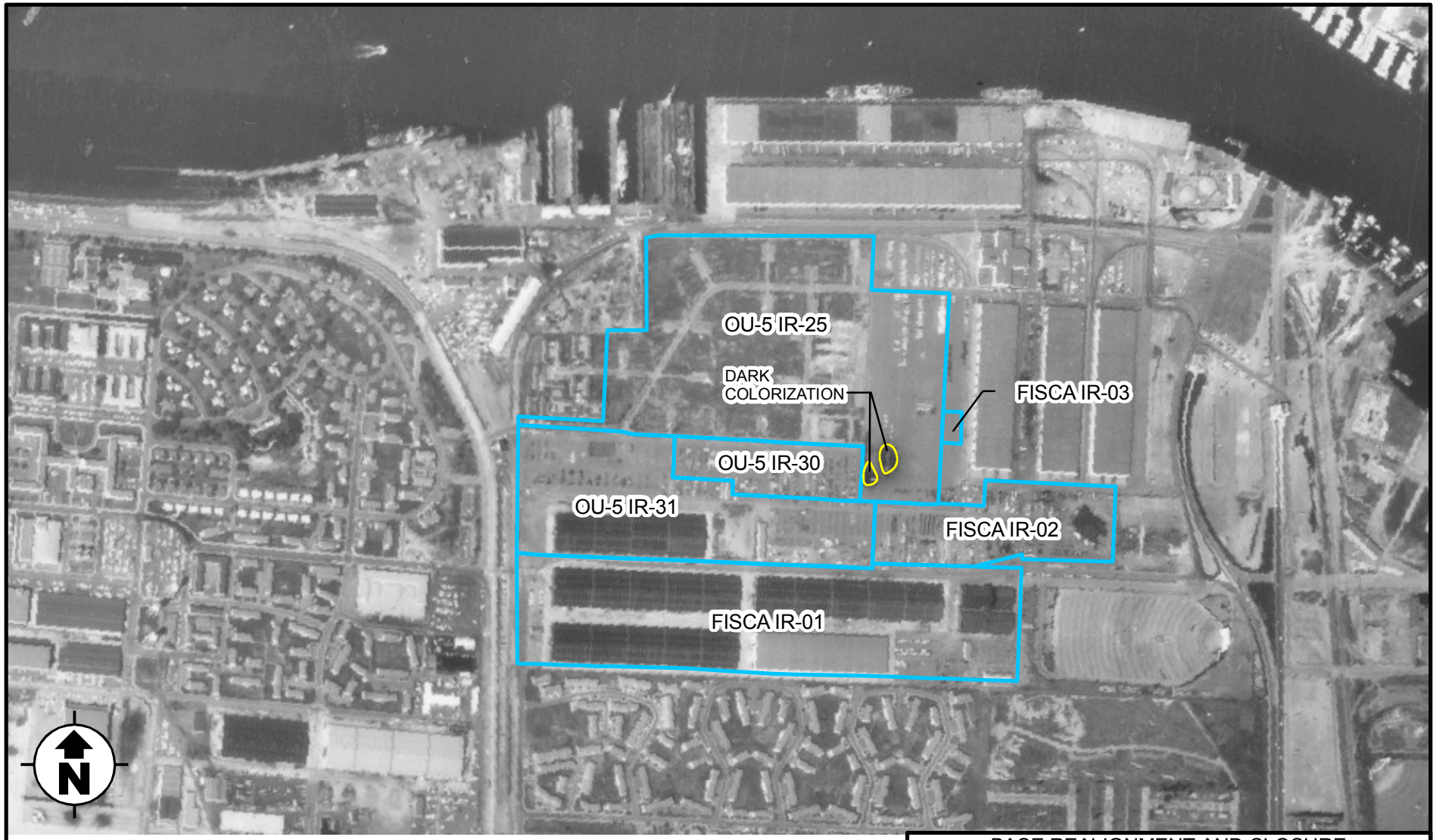
FIGURE 3-8

PROPOSED BIOSPARGE ZONE

ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3100.mxd

TETRA TECH EC, INC.



LEGEND

- OU-5/FISCA IR SITE
- DARK COLORED AREA

NOTES:

FISCA - FORMER FLEET INDUSTRIAL SUPPLY CENTER, OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

OU - OPERABLE UNIT

400 0 400 800 Feet

Scale: 1" = 800'

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 3-16

1968 AERIAL PHOTOGRAPH WITH
UNIDENTIFIED DARK COLORED AREAS
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3111.mxd

TETRA TECH EC, INC

LEGEND

NAS2-10 ND/ND — SOIL SAMPLE LOCATION AND AND BENZENE/NAPHTHALENE RESULTS

ROAD

EXISTING FENCE

BLOCK WALL

TEMPORARY FENCE

IR SITE 25 DARK COLORATION ON HISTORIC AIR PHOTO

BUILDING

50 0 50 100 Feet

Scale: 1" = 100'

N

NOTES:

FISCA - FORMER FLEET INDUSTRIAL SUPPLY CENTER, OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

ND - NON-DETECT

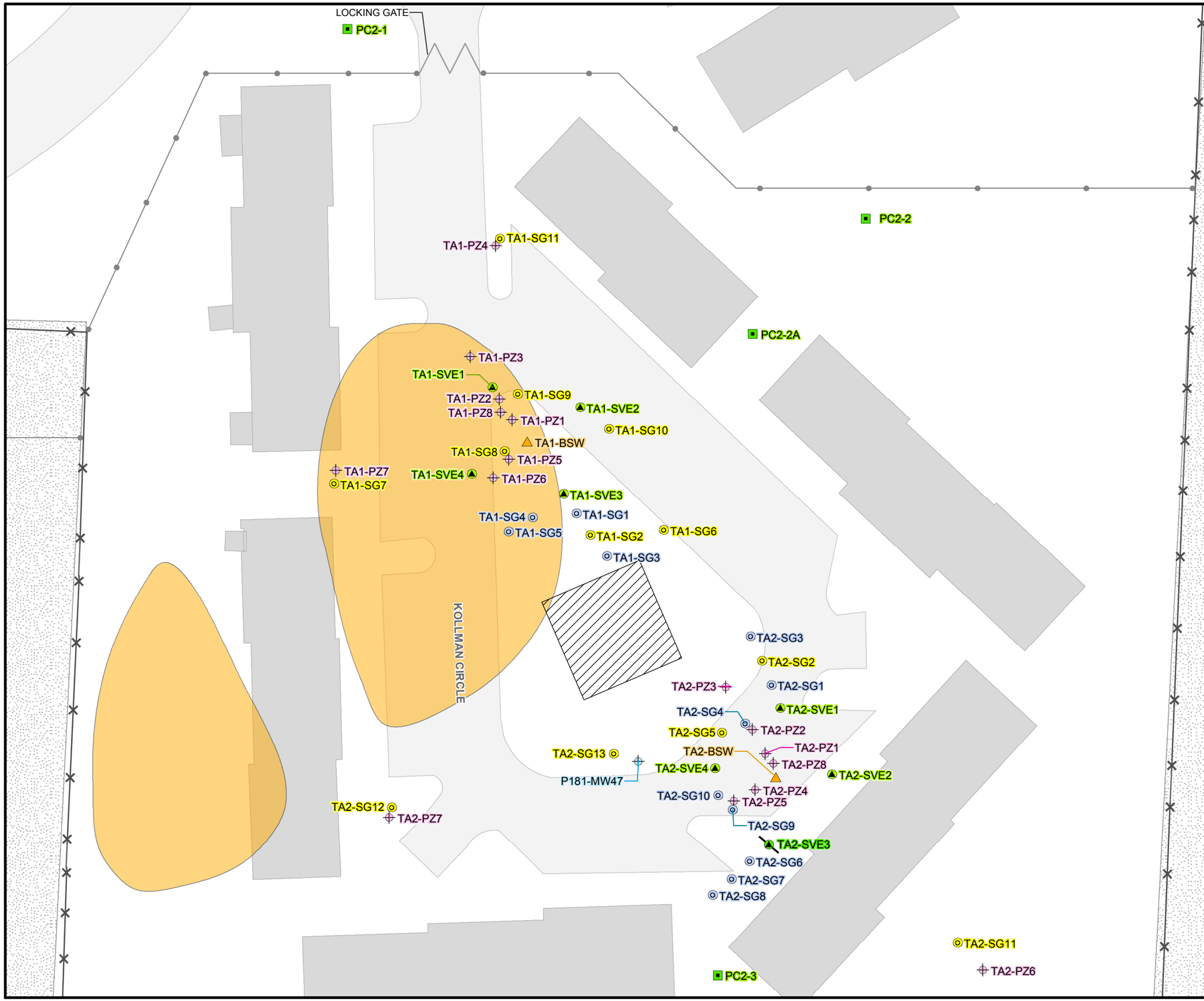
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 3-17
SURFACE AND NEAR SURFACE SOIL SAMPLING LOCATIONS AND BENZENE/NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3112.mxd

TETRA TECH EC, INC.



LEGEND

PC2-2	HYDROPUNCH
TA1-BSW	BIOSPARGE WELL
TA1-SVE01	SVE WELL
TA1-SVE03	HORIZONTAL SVE WELL
TA1-SG012	SOIL GAS PROBE
TA1-SG04	SOIL GAS PROBE FOR SVE ROI TESTING ONLY
TA1-PZ1	GROUNDWATER PIEZOMETER
P181-MW47	EXISTING GROUNDWATER MONITORING WELL
	TEMPORARY FENCE
	EXISTING FENCE
	BIOSPARGE/SVE EQUIPMENT AREA
	ROAD
	BUILDING
	PAVED AREA
	IR SITE 25 DARK COLORATION ON HISTORIC AIR PHOTO

NOTES:

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

ROI - RADIUS OF INFLUENCE

SVE - SOIL VAPOR EXTRACTION

20 0 20 40 Feet

Scale: 1" = 40'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02
GROUNDWATER DATA EVALUATION

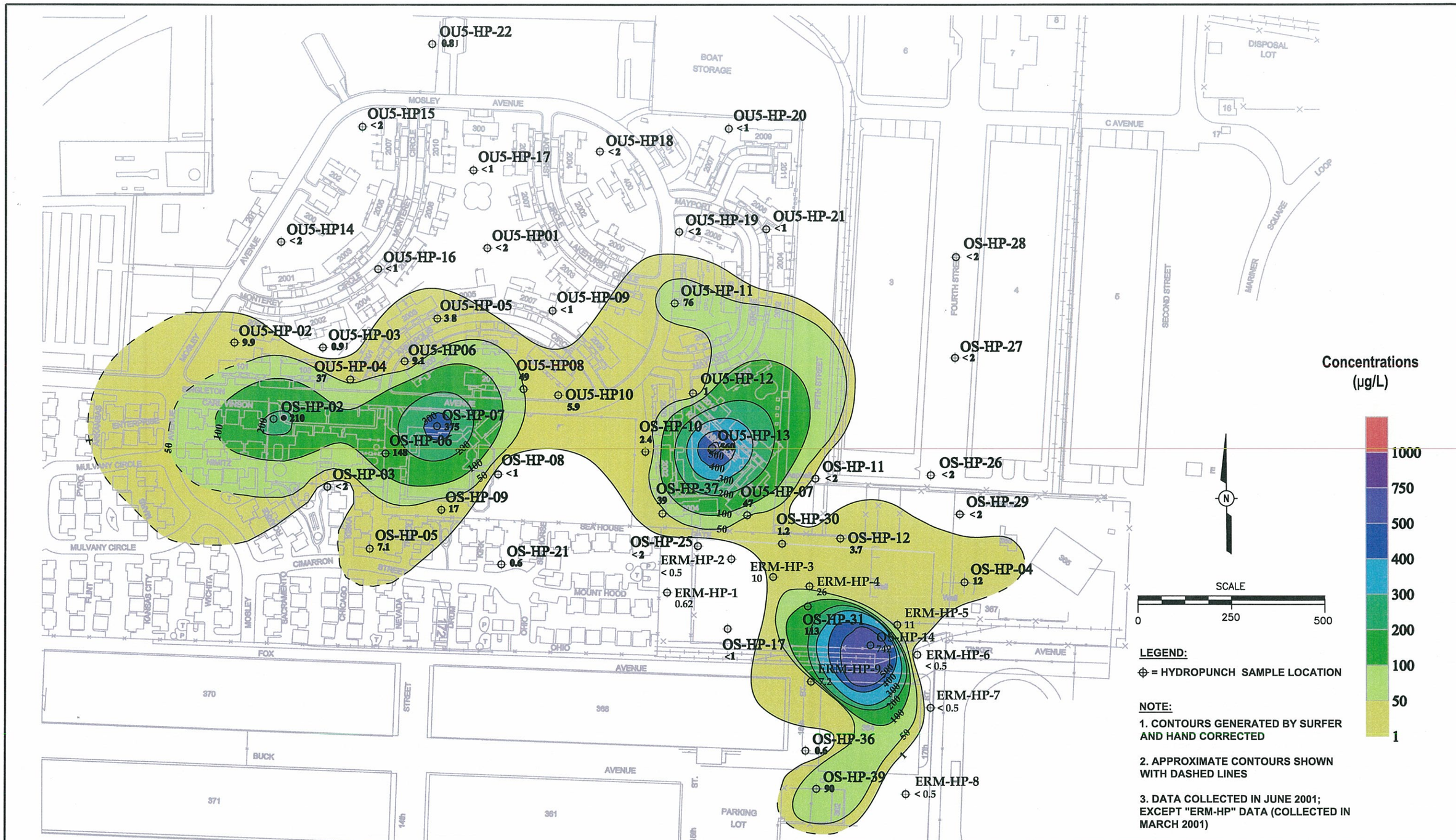
FIGURE A.2

ADDITIONAL SAMPLE LOCATIONS IN DARK COLORED AREA

ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: MS
FILE NUMBER: IR25L7650.mxd

TETRA TECH EC, INC.



LEGEND:

⊕ = HYDROPUNCH SAMPLE LOCATION

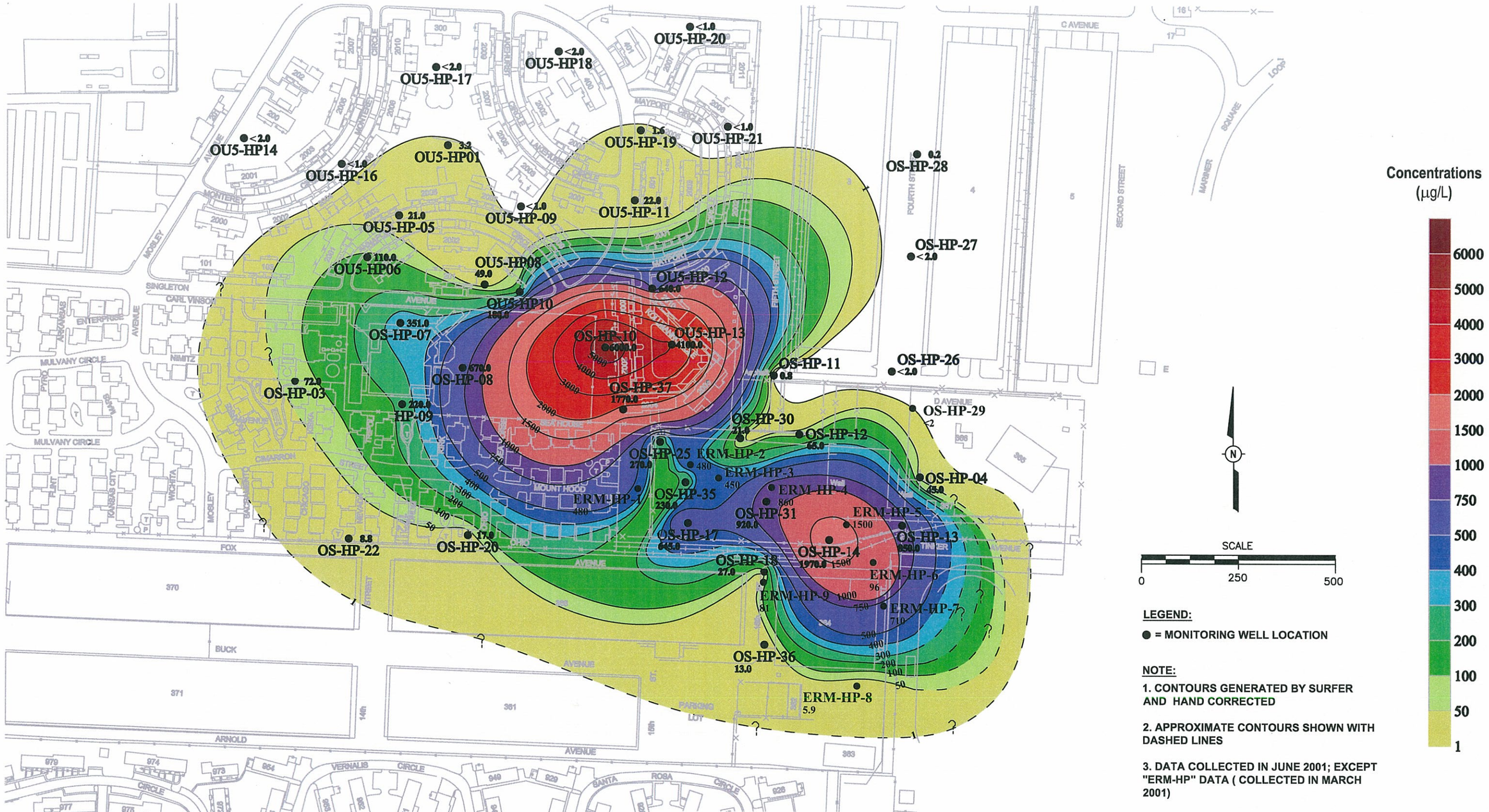
NOTE:

1. CONTOURS GENERATED BY SURFER AND HAND CORRECTED
2. APPROXIMATE CONTOURS SHOWN WITH DASHED LINES
3. DATA COLLECTED IN JUNE 2001; EXCEPT "ERM-HP" DATA (COLLECTED IN MARCH 2001)

ERRG
Engineering/Remediation Resources Group, Inc.
185 Mason Circle, Suite A
Concord, California 94520
(925) 969-0750

DRAWN BY: R.W. 6/15/04	2001 BENZENE CONTOUR MAP 12'-16' bgs HYDROPUNCH DATA	
DESIGNED BY: C.L. 6/15/04	CLIENT: NAVY SWDIV	FIGURE: 4-5
CHECKED BY: P.F. 6/15/04	DWG. NO. 22-052-FIGURE 4-5	

FILE: P:\2002 Projects\22-052 RI FS Alameda Point\Figures\Draft version\Jun 04\Revised Session 4\Fig 4-5 2001 Benzene 12-16 ft HP.dwg USER: rwong Aug 11, 2004 1:16pm



LEGEND:

● = MONITORING WELL LOCATION

NOTE:

1. CONTOURS GENERATED BY SURFER AND HAND CORRECTED
2. APPROXIMATE CONTOURS SHOWN WITH DASHED LINES
3. DATA COLLECTED IN JUNE 2001; EXCEPT "ERM-HP" DATA (COLLECTED IN MARCH 2001)

ERRG
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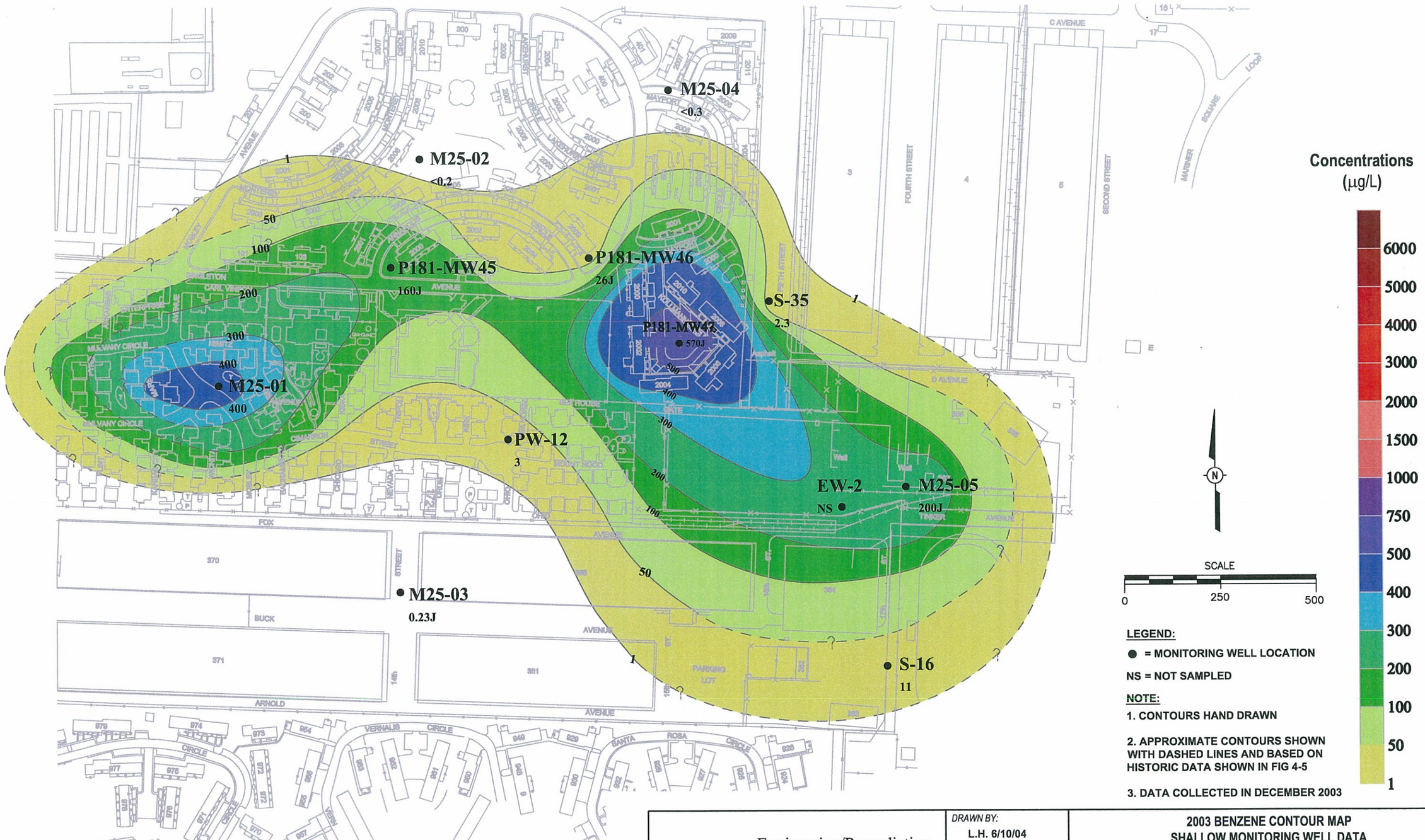
DRAWN BY: R.W. 6/16/04	2001 BENZENE CONTOUR MAP 16'-20' bgs HYDROPUNCH DATA	
DESIGNED BY: C.L. 6/16/04	CLIENT: NAVY SWDIV	FIGURE: 4-6
CHECKED BY: P.F. 6/22/04	DWG. NO. 22-052-FIGURE 4-6	

FILE: P:\2002 Projects\22-052 RI FS Alameda Point\Figures\Draft version\Jun 04\Revised Session 4\Fig 4-6 2001 Benzene 16-20 ft HP.dwg USER: rwong Aug 11, 2004 1:20pm



ERRG

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DRAWN BY: L.H. 6/10/04	2003 BENZENE CONTOUR MAP SHALLOW MONITORING WELL DATA	
DESIGNED BY: C.L. 6/10/04	CLIENT: NAVY SWDIV	FIGURE: 4-8
CHECKED BY: P.F. 6/16/04	DWG. NO. 22-052-FIGURE 4-8	

FILE: P:\2002 Projects\22-052 RI FS Alameda Point\Figures\Draft version\Jun 04\Revised Session 4\Fig 4-8 2003 Benzene Shallow MW.dwg USER: rwong Aug 11, 2004 1:32pm

APPENDIX F
HYDROCARBON FINGERPRINTS AND STABLE ISOTOPE RATION ANALYSIS FROM THE FINAL REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN

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APPENDIX F

HYDROCARBON FINGERPRINTS AND STABLE ISOTOPE RATIO ANALYSIS

Contaminant source evaluation consisted of assessing expanded gas chromatograph (GC)/flame ionization detector (FID) "fingerprints" and compound-specific stable isotope ratio data for groundwater and soil samples. Stable isotope analysis is extremely useful in determining whether polycyclic aromatic hydrocarbons (PAHs) and benzene in an environmental sample may have originated from a single or multiple sources even when the patterns of individual compounds in a GC/FID fingerprint in those samples are essentially the same or similar.

1.0 ANALYTICAL METHODS

Soil and groundwater samples from the site were received by the analytical laboratory in good condition. Samples and extracts were stored at 4 °Celsius (C) ± 2 °C prior to extraction and analysis. Soil and groundwater samples were extracted within 7 days of sample receipt, and the extracts were analyzed within 40 days of sample preparation.

Soil samples were prepared by solvent extraction (U.S. Environmental Protection Agency [EPA] Method 3570) using dichloromethane, and aqueous samples were prepared using EPA Method 3511 for fingerprinting. The extracts were spiked with internal standard and analyzed by GC/FID (EPA Method 8100M) for fingerprinting of hexane (C_6) to tetracosane (C_{40}). A 5-liter (L) aliquot of each aqueous sample was extracted using EPA Method 3510, and the extracts were combined and reduced to a final volume of 1.0 milliliter (mL) for compound-specific stable isotope ratios (CSIR) of volatile organic compounds. A portion of each fingerprinting soil extract was submitted for PAH CSIR analysis. Compound specific stable isotope analysis consisted of GC/isotope ratio mass spectrometry (IRMS) for stable isotope ratios of carbon ($^{13}C/^{12}C$) and hydrogen ($^{2}H/^{1}H$) using standard practice for these analyses. No deviations of quality control (QC) parameters occurred during analysis to compromise the integrity of the reported values.

2.0 DATA INTERPRETATION

GC/FID Fingerprinting

Individual GC/FID chromatograms are presented in Attachment A. An interpretive synopsis is provided below.

Groundwater Samples

See Work Plan Figures 3-6 and 3-7 for sample locations.

PC3-1 – Volatile aromatic compounds and light-weight PAHs present with a relatively high concentration of naphthalene compared to other compounds present in the chromatogram.

PC3-2 – Volatile aromatic compounds and light-weight PAHs present similar to PC3-1.

PC3-10 – A relatively high concentration of naphthalene with lower concentrations of other light to mid-weight PAHs (methylnaphthalenes to phenanthrene) compared to other compounds present in the chromatogram.

PC2-7 – Volatile aromatic compounds and light-weight PAHs present similar to PC3-1 with relatively high concentrations of naphthalene compared to other compounds present in the chromatogram.

PC2-5 – Volatile aromatic compounds and light-weight PAHs present similar to PC3-1 with relatively high concentrations of naphthalene compared to other compounds present in the chromatogram.

PC2-6 – Volatile aromatic compounds and light-weight PAHs present similar to PC3-1.

Soil Samples

See Work Plan Figures 3-4 and 3-5 for sample locations.

PC3-1 – Pyrogenic material with a wide range of PAHs from naphthalene to benzo(g,h,i)perylene, with high concentrations of naphthalene and lower concentrations of light-to-heavy PAHs. Fluoranthene-to-pyrene ratio approximately 0.85.

PC3-2 – Pyrogenic material similar to PC3-1 with naphthalene, phenanthrene, fluoranthene, and pyrene present at similar concentrations indicating some weathering. Fluoranthene-to-pyrene ratio approximately 0.85.

PC3-10 – Pyrogenic material similar to PC3-1, with the lower concentration of naphthalene in the sample compared to that in PC3-1 indicating some weathering. Fluoranthene-to-pyrene ratio approximately 0.90.

PC3-11 – Pyrogenic material with a wide range of PAHs at relatively low concentrations, with naphthalene, phenanthrene, fluoranthene, and pyrene present at similar concentrations indicating some weathering. Fluoranthene-to-pyrene ratio approximately 0.85.

PC2-7 – Pyrogenic material similar to PC3-2, with naphthalene, phenanthrene, fluoranthene, and pyrene present at similar concentrations indicating some weathering. Fluoranthene-to-pyrene ratio approximately 0.85.

PC2-6 – Pyrogenic material similar to PC3-1, with naphthalene and phenanthrene present at similar concentrations indicating some weathering. Fluoranthene-to-pyrene ratio approximately 0.90.

PC-12 – Pyrogenic material similar to PC3-1 with concentrations of light-weight and heavy-weight PAHs similar to the mid-weight PAHs present at higher concentrations indicating weathering. Fluoranthene-to-pyrene ratio approximately 0.95.

Discussion

Soil samples PC3-1, PC3-2, PC3-11, PC2-7, and PC2-6 (Work Plan Figures 3-4 and 3-5) had relatively high concentrations of naphthalene and lower concentrations of heavier PAHs through benzo(g,h,i)perylene with no or little aromatic volatile compounds present.

Soil samples PC3-10 and PC-12 had a wide range of PAHs, present with higher concentrations of the mid-weight PAHs relative to the lighter and heavier-weight compounds. No or little volatile aromatic compounds were present in the samples. The materials in the samples appeared to be heavily weathered.

Soil sample PC2-5 had mid-weight PAHs present at relatively low concentrations.

Groundwater samples PC3-1, PC3-2, PC2-7, PC2-5 and PC2-6 (Work Plan Figures 3-6 and 3-7) had very high concentrations of naphthalene with low concentrations of methylnaphthalenes and acenaphthylene. Volatile aromatic compounds were also present at low concentrations relative to naphthalene.

Groundwater sample PC3-10 had high concentrations of naphthalene with lower concentrations of mid-weight PAHs up to phenanthrene.

All samples have pyrogenic material present with varying degrees of some weathering evident in the soil samples. The groundwater samples have the water soluble components of the pyrogenic material present. The PAH pattern present is similar to that from an oil-gas (i.e., manufactured gas plant [MGP]) process.

Compound Specific Isotope Ratio Results

Stable isotope results are presented in Attachment B, and PAH and stable isotope concentrations and calculated ratios are provided in Table F-1 (attached). An interpretive synopsis is provided below. See Work Plan Figures 3-4 and 3-5 for soil sample locations. See Work Plan Figures 3-6 and 3-7 for groundwater sample locations.

Discussion

Soil samples had average carbon isotope values of -21.9 ‰ to -23.0 ‰ for benzene, toluene, ethylbenzene, and xylenes (BTEX) and -21.8 ‰ to -23.0 ‰ for PAH compounds (Attachment B for isotope values). Groundwater samples had average carbon isotope ratios for BTEX and PAHs from -21.9 ‰ to -22.7 ‰ and -21.7 ‰ to -22.4 ‰, respectively. Average hydrogen isotope values were between -62 ‰ and -101 ‰ for benzene and between -44 ‰ and -82 ‰ for naphthalene. These values are typical for coal ($\delta^{13}C$ of -23 ‰ to -25 ‰; $\delta^{2}H$ of -60 to -120 ‰) and MGP residuals from a coal carbonization process, which typically exhibits $\delta^{13}C$ values between -21.0 ‰ and -24.0 ‰.

As the plots in Attachment B illustrate, stable isotope signatures ($\delta^{13}C$ and $\delta^{2}H$) for benzene and naphthalene are all consistent and similar within and among groundwater and soil across the site area sampled, indicating a common source material. Multiple sources are not indicated (i.e., no separate, distinct clusters of isotope values are evident), and isotopic enrichment was noted (i.e., more positive isotope values indicative of an increase in the proportion of heavier isotopes as biodegradation enzyme systems preferentially degrade the lighter isotopes), especially in the $\delta^{13}C$ isotope plots for naphthalene and benzene across the site in soil and groundwater, and also for the $\delta^{2}H$ plots for naphthalene and benzene within groundwater and soil.

The stable isotope data ($\delta^{13}C$ and $\delta^{2}H$ isotope enrichment) indicate that biodegradation of benzene and naphthalene is occurring. The enrichment of the carbon stable isotopes along a biodegradation kinetic isotope effect enrichment line and more enriched isotope value in the water sample compared to its companion soil isotope ratio (see Attachment B) indicate that biodegradation is occurring on a common source material. Also indicated is that biodegradation is proceeding fairly uniformly (i.e., the biodegradation kinetic isotope effect enrichment line is linear) across the site area sampled for each compound.

Stable isotope signatures ($\delta^{13}C$ and $\delta^{2}H$) and GC/FID hydrocarbon fingerprinting results for the soil and groundwater samples collected indicate that the benzene and naphthalene present in groundwater originate from contaminants within the Marsh Crust.

The fluoranthene-to-pyrene ratios and stable isotope signatures in the Marsh Crust soil samples are consistent with those from a pyrogenic oil-gas (i.e., MGP) coal carbonization process, which typically exhibits fluoranthene-to-pyrene ratios between 0.70 and 1.00 and $\delta^{13}C$ values between -21.0 ‰ and -24.0 ‰. Petrogenic (i.e., crude oil, #2 fuel oil, Bunker C, etc.) material is not indicated, which typically exhibits fluoranthene-to-pyrene ratios between 0.0 and 0.20 and $\delta^{13}C$ values between -25.0 ‰ and -35.0 ‰.

3.0 SUMMARY CONCLUSIONS

- Hydrocarbon fingerprints are consistent and similar in the soil and groundwater samples across the site, suggesting a common source material.
- Stable isotope signatures (^{13}C and ^{2}H) for benzene and naphthalene are consistent and similar in soil and groundwater samples at the College of Alameda property line and across the site indicating a common source material. Multiple contaminant sources are not indicated.
- The stable isotope data indicate that biodegradation of benzene and naphthalene is occurring.
- Stable isotope signatures and hydrocarbon fingerprint results are consistent with MGP residues from a coal carbonization process. Petroleum residues are not indicated.
- Stable isotope signatures and hydrocarbon fingerprint results indicate that the benzene and naphthalene present in groundwater originate from the Marsh Crust.

Glossary

Pyrogenic substances are complex mixtures of primarily hydrocarbons produced from organic matter subjected to high temperatures but with insufficient oxygen for complete combustion. Pyrogenic materials are produced by fires, internal combustion engines, and furnaces. They also are formed when coke or gas are produced from coal or oil. Coal-tar based products, such as roofing, pavement sealers, waterproofing, pesticides, and some shampoos contain pyrogenic materials.

Petrogenic substances include crude oil and crude oil derivatives such as gasoline, diesel, heating oil, and asphalt.

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TABLE F-1

ALAMEDA FORENSIC EVALUATION DATA

Sample Location ID	Field ID	Lab Sample ID	Matrix	Parameter	Benzene	Toluene	Ethylbenzene	m,p-Xylenes	Styrene	o-Xylene	Naphthalene	2-Methyl Naphthalene	1-Methyl Naphthalene	Fluoranthene	Pyrene	Fluoranthene/ Pyrene Ratio	Dibenzofuran	Fluorene	Dibenzofuran/ Fluorene Ratio
PC3-1 (18-18.5)	11-1045	TT070723-01	Soil	delta-13C	-23.1	-22.1	-22.1	-22.0	-19.5	-22.8	-22.9	-22.3	-23.3						
				delta-2H	-88	-71	-127	-94	-74	-108	-46								
				Concentration (ug/Kg)	90000	647	930	1594	1302	776	11000000	15712	9232	35386	41631	0.85	1376	11392	0.12
PC3-1	11-3074	TT070723-03	GW	delta-13C	-22.9	-21.8	-21.9	-21.7	-18.8	-22.3	-22.5								
				delta-2H	-87	-67	-170	-113	-98	-122	-44								
				Concentration (ug/L)	4500	490	196	327	277	168	170000	237	162						
PC3-2 (19.5-20)	11-1046	TT070723-04	Soil	delta-13C	-22.6	-21.9	-21.0	-22.5		-23.5	-22.8	-22.3	-22.3						
				delta-2H		-58	-148	-103		-111	-58								
				Concentration (ug/Kg)	1800	202	413	531	189	283	170000	10610	7016	52343	61580	0.85	1413	11275	0.13
PC3-2	11-3075	TT070723-05	GW	delta-13C	-22.6	-21.8	-21.2	-21.5	-18.1	-22.3	-22.7	-21.9	-23.2						
				delta-2H	-101	-98	-170	-112		-123	-82								
				Concentration (ug/L)	1300	67	52	52	11	39	5500	66	55						
PC3-10	11-3099	TT070726-02	GW	delta-13C	-23.4	-22.7	-20.9	-21		-22	-22.4	-21.9	-22.3						
				delta-2H	-62	-96	-108			-88	-51								
				Concentration (ug/L)	84	10	16	11	7	15	1600	84	69						
PC3-10 (15-16)	11-1056	TT070726-03	Soil	delta-13C	-24.3	-22.4	-20.8	-21.5	-18.8	-22.9	-22.7	-21.6	-22.8						
				delta-2H							-62								
				Concentration (ug/Kg)	610	48	83	97	88	79	340000	2895	1834	19836	22039	0.90	357	3803	0.09
PC3-11 (13.5-14.5)	11-1057	TT070726-04	Soil	delta-13C	-23.0	-21.2	-21.2	-21.8	-18.8	-22.3	-22.8	-22.3	-23.2						
				delta-2H	-75	-47	-101	-72	-34	-77	-55								
				Concentration (ug/Kg)	2200	44	89	58	29	26	440000	365	328	4749	5587	0.85	63	320	0.20
PC2-7 (14-17)	11-3114	TT070801-02	GW	delta-13C	-24	-23.0	-21.8	-22.1	-19.4	-22.7	-23	-22.5	-23.4						
				delta-2H	-87	-58	-113	-84	-64	-97	-60								
				Concentration (ug/L)	740	66	89	79	57	72	5800	101	98						
PC2-5 (18-21)	11-3118	TT070801-03	GW	delta-13C	-22.9	-22.5	-21.7	-21.9	-19.4	-22.6	-22.6	-22.2	-23.8						
				delta-2H	-81	-76	-123	-92	-72	-105	-58								
				Concentration (ug/L)	2600	105	63	105	100	78	5500	99	89						
PC2-7 (16-16.5)	11-1065	TT070801-04	Soil	delta-13C		-27.9	-19.6	-22.1		-22.3	-23.1	-22.7	-23.6						
				delta-2H							-77								
				Concentration (ug/Kg)	530	0.15	0.24	0.27	0.07	0.14	47000	4	3	16	19	0.85	0	3	0.10
PC2-5 (19-19.5)	11-1067	TT070801-05	Soil	delta-13C	-23.1	-23.3	-22.1	-22.4	-18.6	-22.8	-22.8	-22.65	-24.1						
				delta-2H	-93	-70	-62	-89	-48	-93	-69								
				Concentration (ug/Kg)	150000	0.781					11000000.00	0.12	0.16						
PC2-6 (16.5-17)	11-1070	TT070802-01	Soil	delta-13C	-23.7	-24.8	-21.5	-22.1	-19.8	-22.8	-23	-21.9	-23.3						
				delta-2H		-75	-120	-96	-69	-96	-47								
				Concentration (ug/Kg)	15000	0.09	0.23	0.57	0.51	0.36	5100000	10	6	26	29	0.90	1	7	0.09
PC2-6 (15-18)	11-3129	TT070802-02	GW	delta-13C	-23.47	-23.1	-21.2	-21.5	-19.1	-22.2	-22.8	-22.05	-23.6						
				delta-2H	-65	-0.06	-122	-70	-47	-80	-53								
				Concentration (ug/L)	490	NA	NA	NA	NA	NA	4400	NA	NA						
PC-12 (15-15.5)	11-1074	TT070803-01	Soil	delta-13C	-23.3	-25.1	-20.9	-21.4	-18.6	-22.5	-22.4	-21.9	-22.8						
				delta-2H							-79								
				Concentration (ug/Kg)	2100	0.64	0.08	0.11		0.07	800000	3	3	22	23	0.95	0	5	0.08
#6 Fuel Oil																0.02			0.47
Bunker C																0.14			0.44
Gas Oil																0.09			0.43
#4 Fuel Oil																0.03			0.42
Carbureted Water Gas MGP Tar-1																0.72			0.11
Carbureted Water Gas MGP Tar-2																0.70			0.11
Carbureted Water Gas MGP Tar-3																0.73			0.18
Coal Carbonization MGP Tar-1																1.00			0.72
Coal Carbonization MGP Tar-2																1.27			0.86
Coke Oven Tar-1																1.39			0.84
Coke Oven Tar-2																1.34			0.58
Coke Oven Tar-3																1.27			0.75

Except where noted below, all data cited for petrogenic and pyrogenic material if from:
Saber, D., D. Mauro and T. Sirivedhin. 2006. Environmental forensics investigation in sediments near a former manufactured gas plant site. Environmental Forensics, 7:1, 65-75.
delta -^{12}C and delta-^{2}H Ranges for Naphthenic PAHs in Petroleum Based Products from:
Snape, C. 2006. Storch Award Symposium, 231st Am. Chem. Soc. National Meeting, Div. of Fuel Chemistry, Atlanta, Georgia, 29 March 2006
delta -^{12}C and delta-^{2}H Ranges for Naphthalene in Pyrogenic Coal Carbonization MGP Residue from:
Steinbach A. and Michaelis W. 2003. Combined ^{13}C and ^{2}H monitoring of in situ biodegradation of aromatic hydrocarbons in a contaminated aquifer. In Geochemical Processes in Soil and Groundwater, Measurement - Modelling - Upscaling, pp. 169-181

	δ ^{13}C (‰, PDB)	δ ^{2}H (‰, SMOW)
Crude oil & Derived products	-27 ~ -35‰	-90 ~ -180
Coal:	-23 ~ -25‰	-60 ~ -120
MGP Residue:	-21 ~ -25‰	-60 ~ -90

ATTACHMENT A

GC/FID CHROMATOGRAMS

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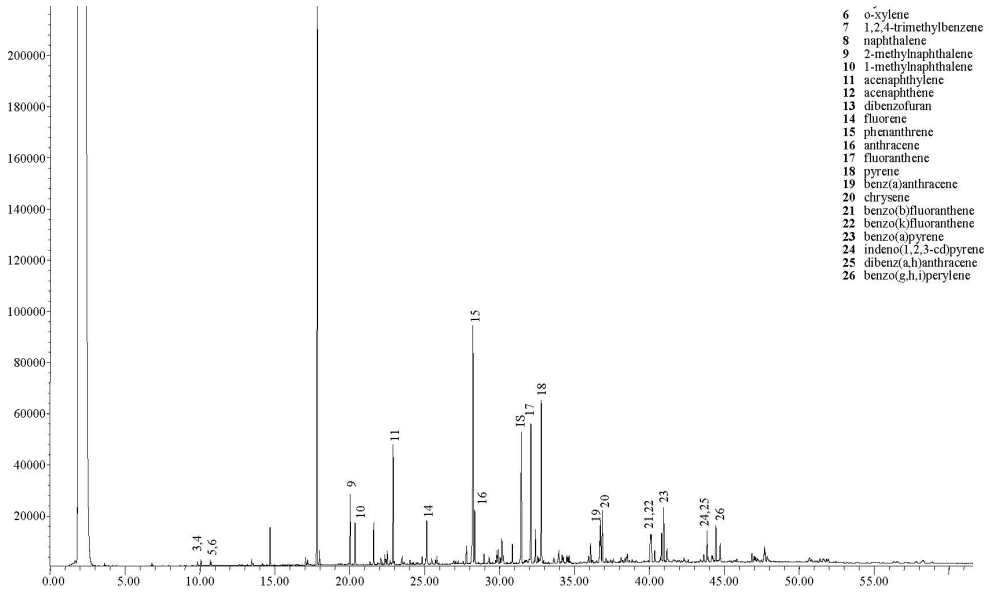
SOIL PC3-1 - 11-1045



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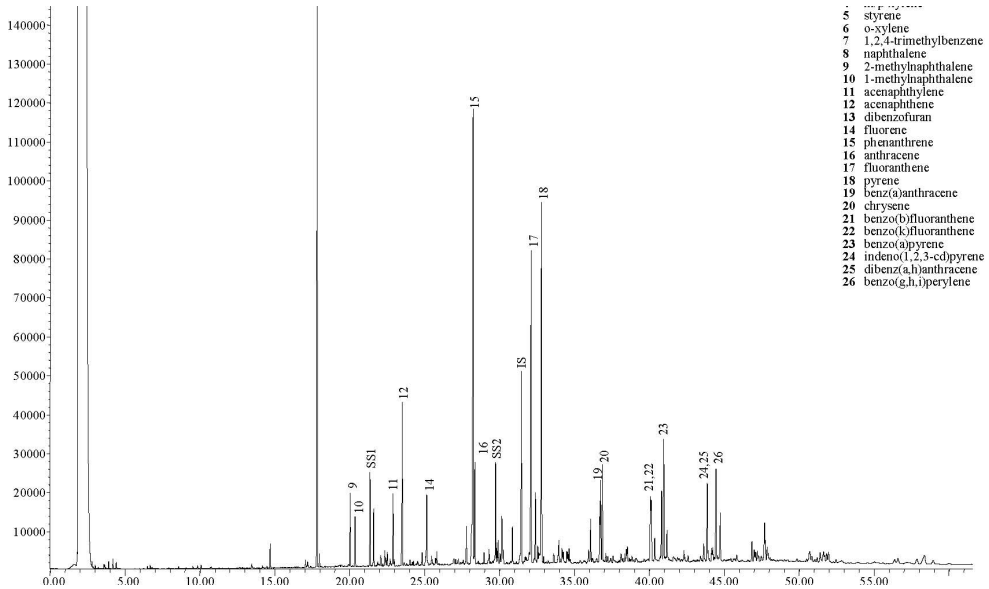
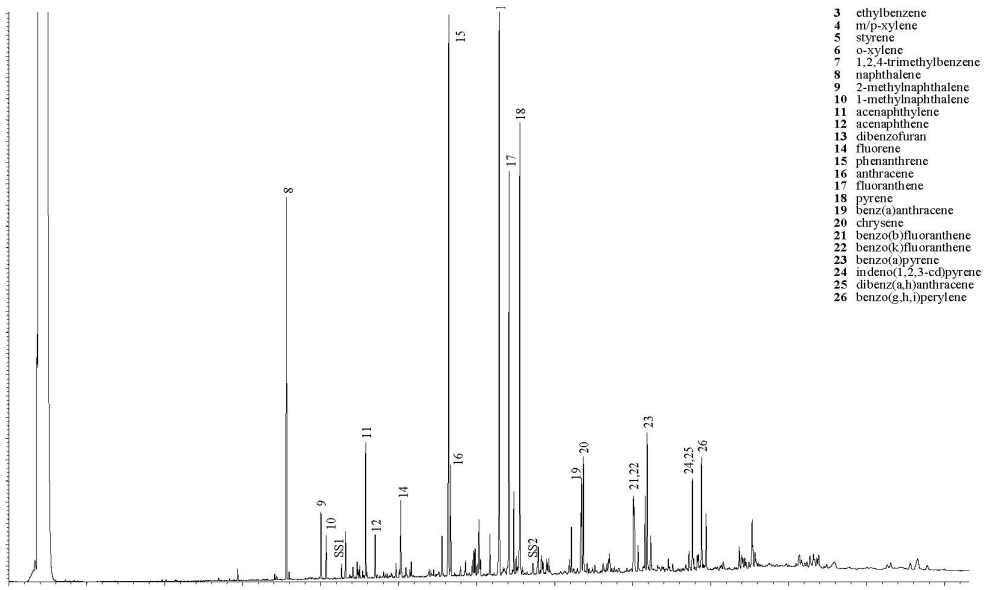


SOIL PC3-10 - 11-1056



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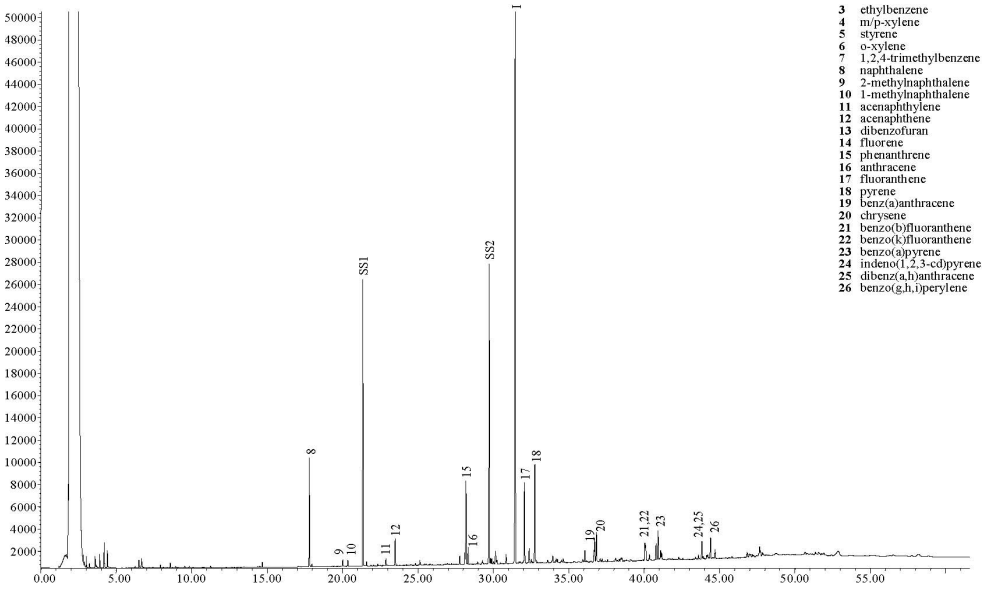

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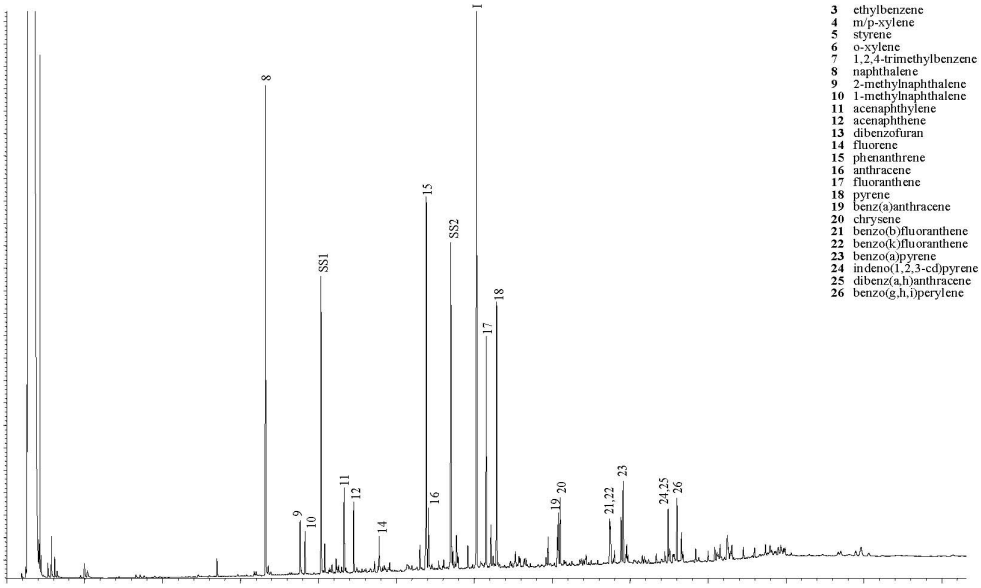

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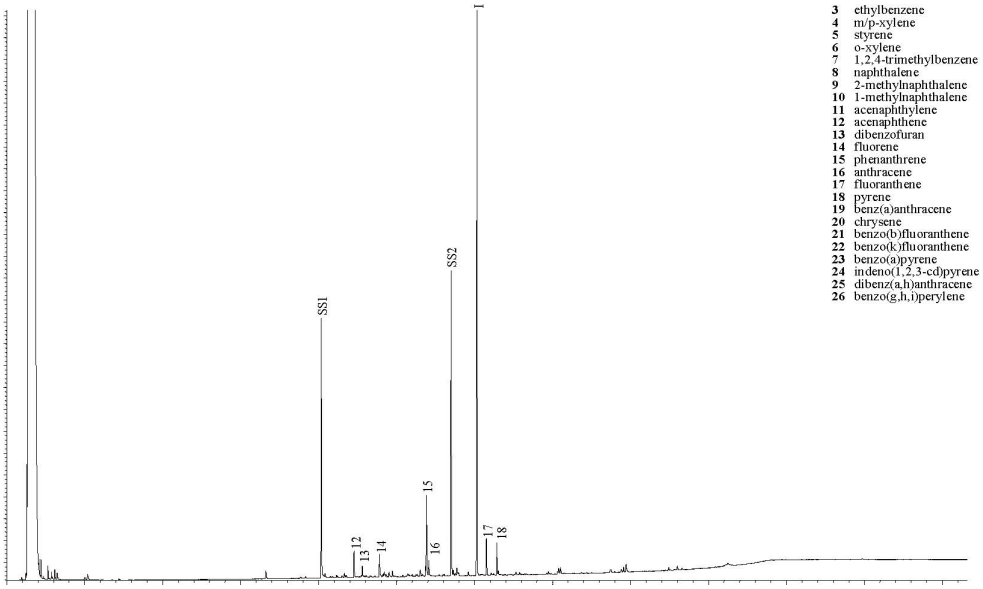
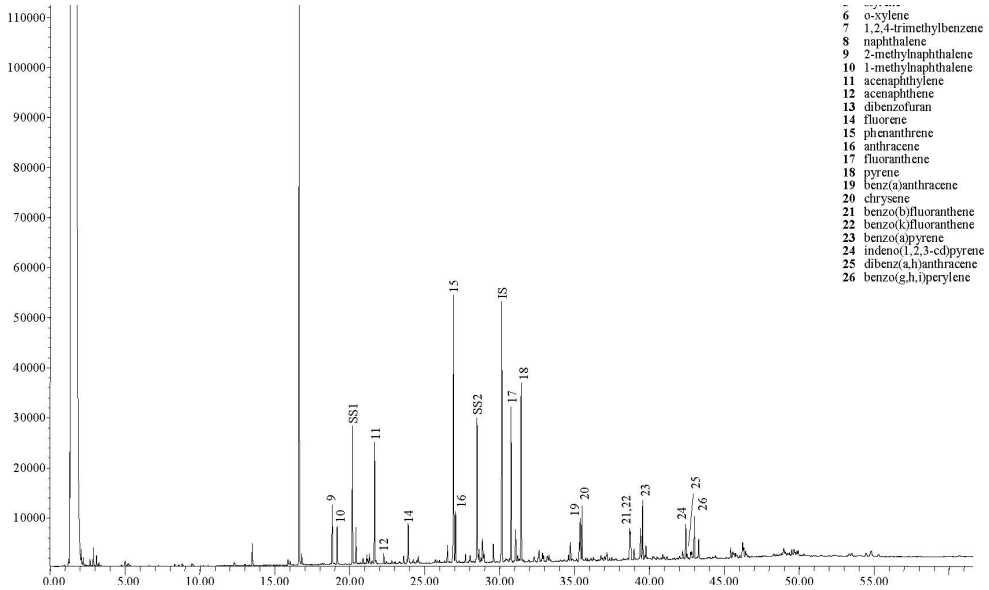
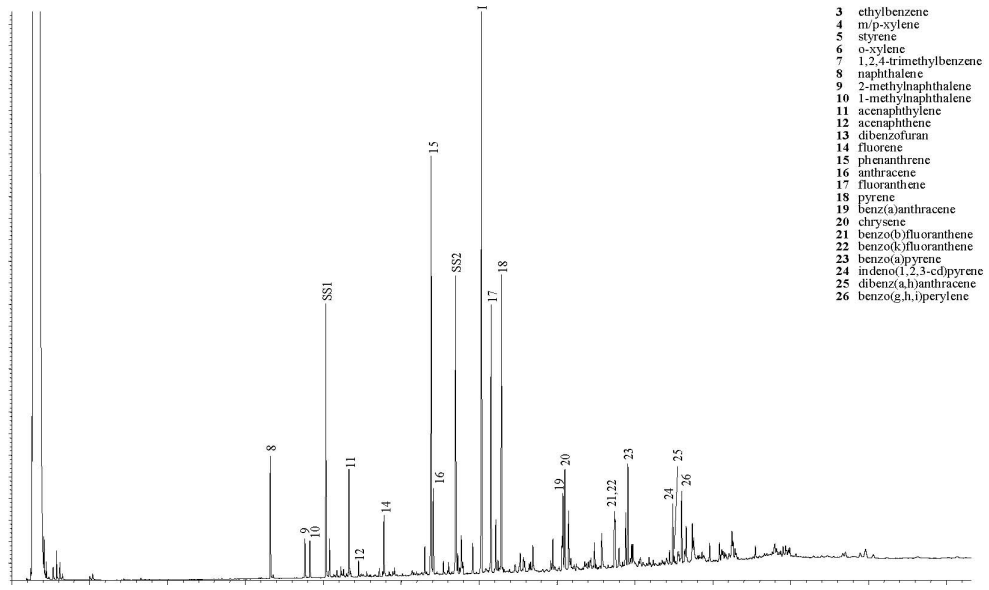


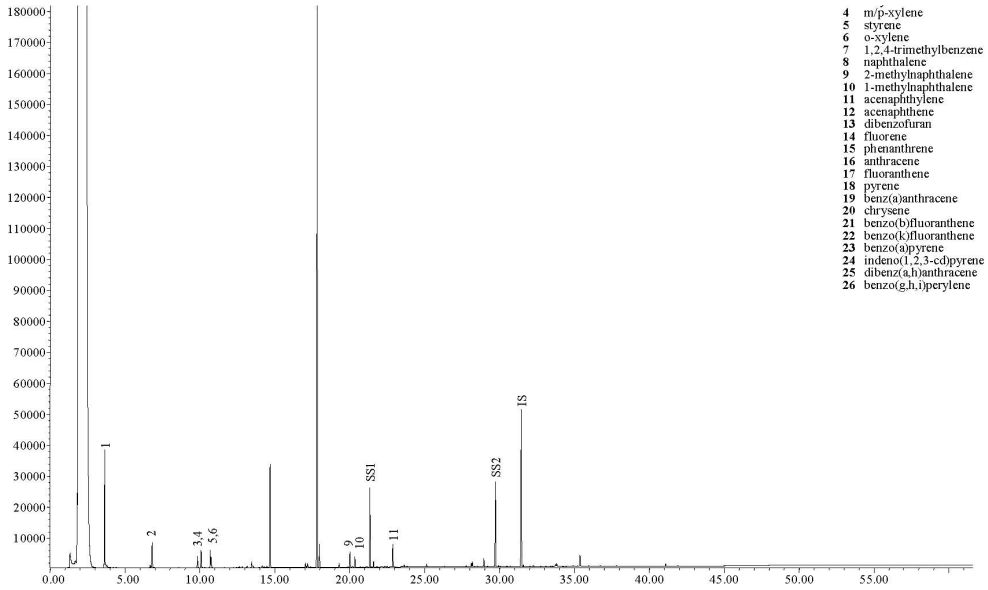
SOIL – PC2-6 - 11-1070



SOIL PC-12 - 11-1074



GROUNDWATER PC3-1 - 11-3074



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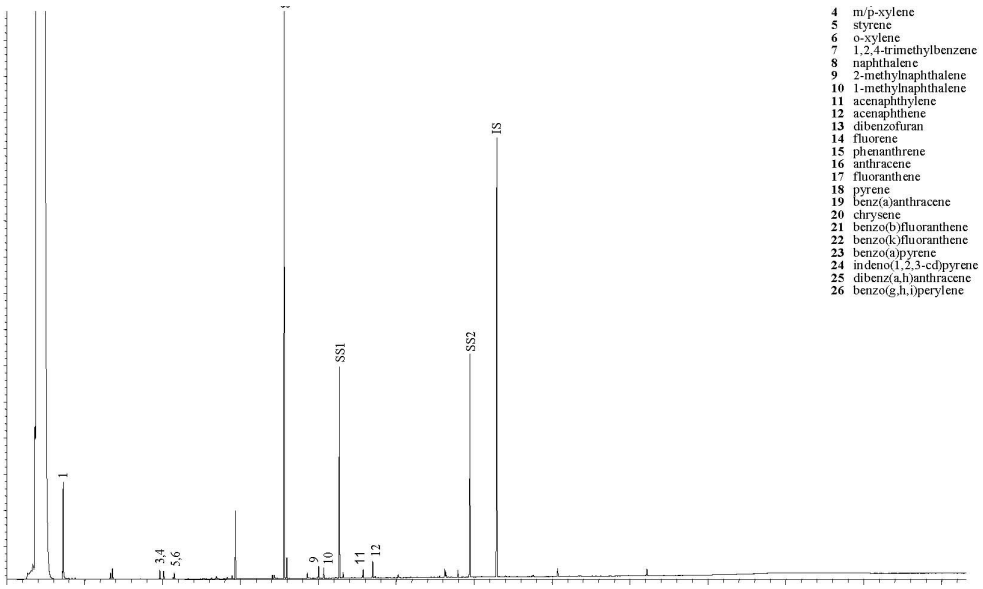
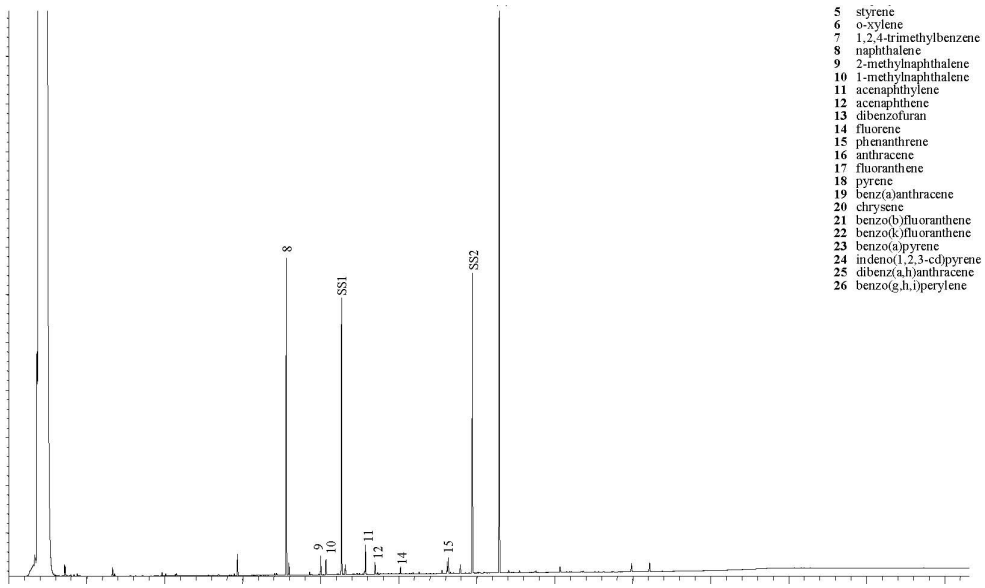
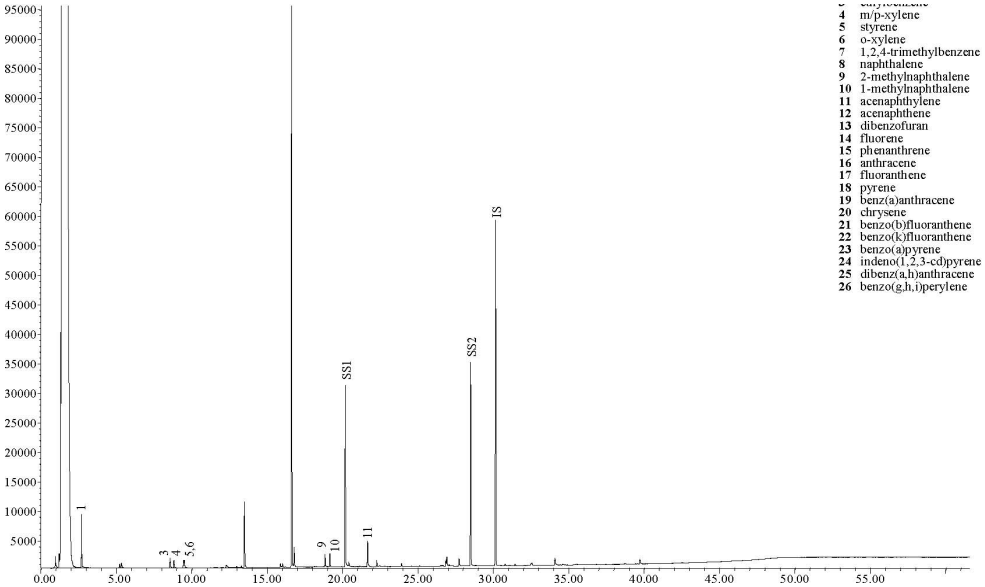


GROUNDWATER PC3-10 - 11-3099



GROUNDWATER PC2-7 - 11-3114



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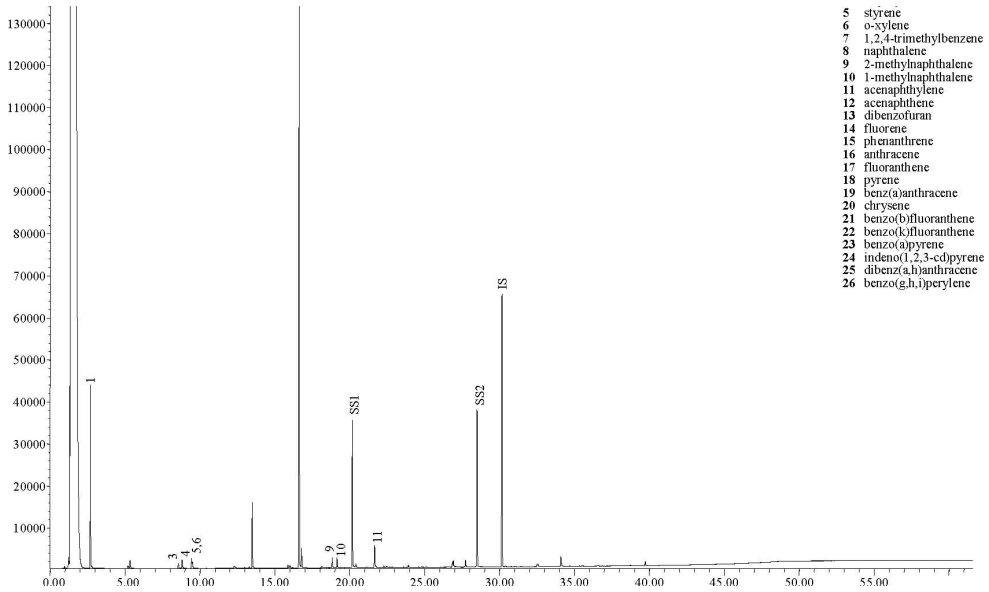

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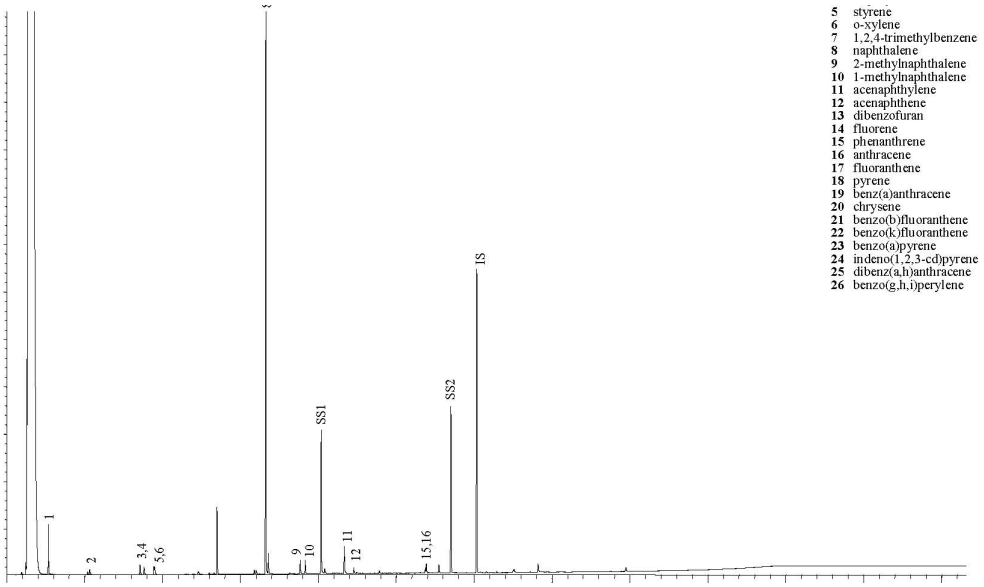

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ATTACHMENT B

STABLE ISOTOPE PLOTS

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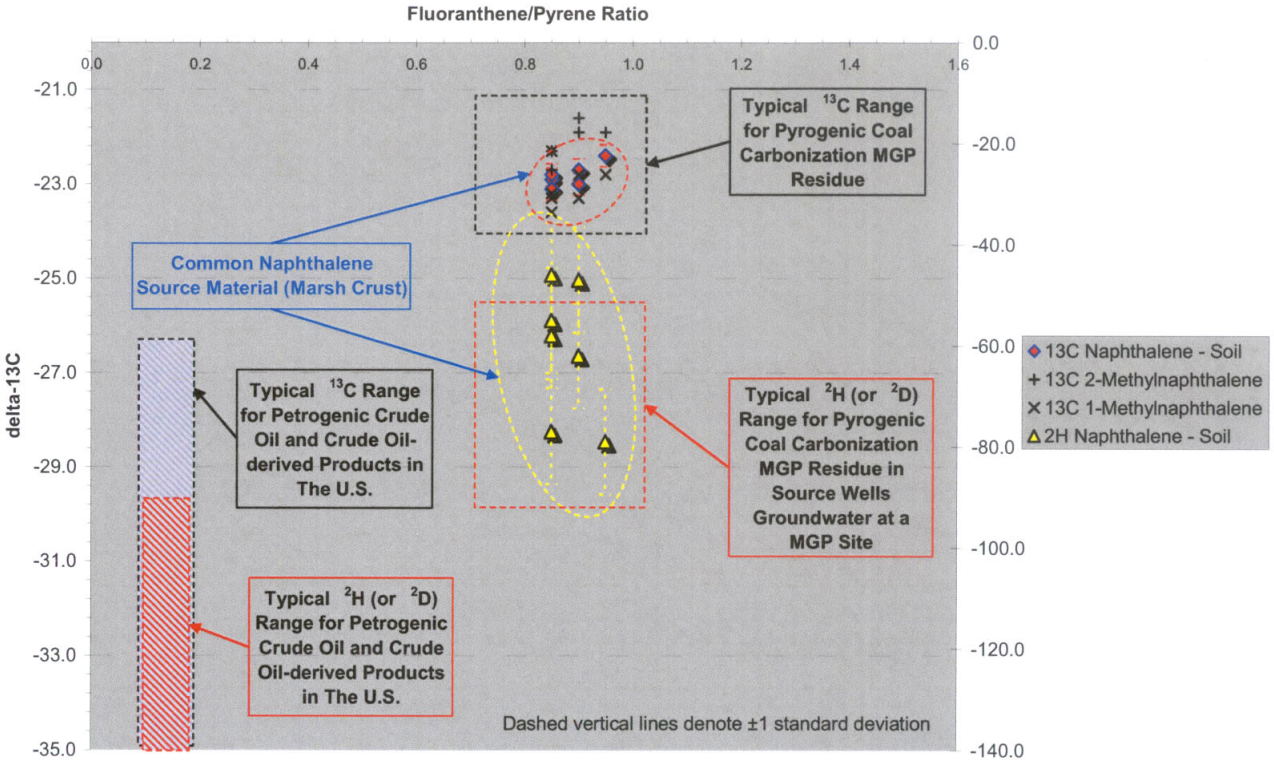
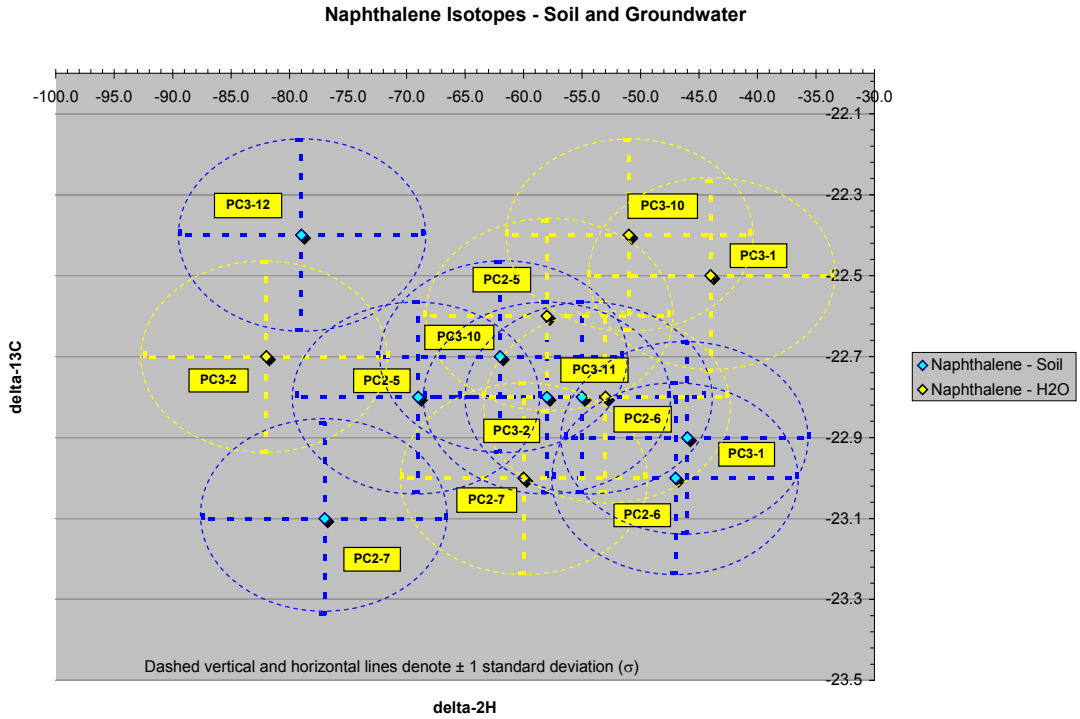
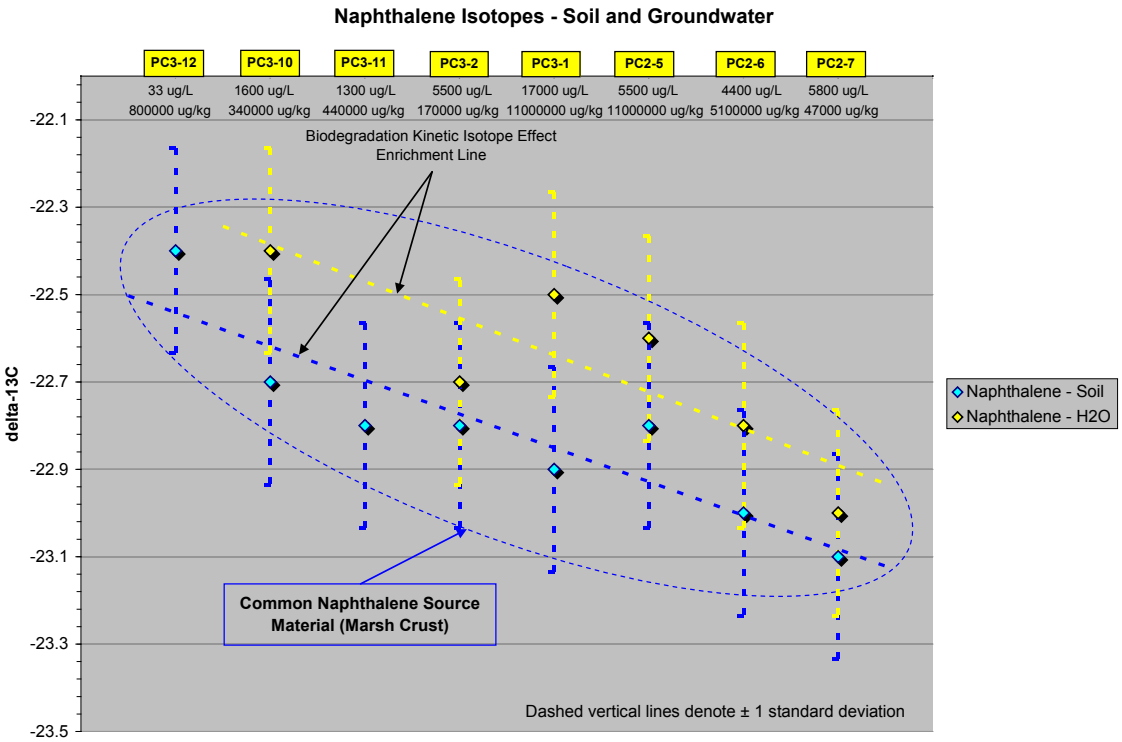
Naphthalene δ^2H and $\delta^{13}C$ Isotopes versus Fluoranthene/Pyrene Ratio – Soil



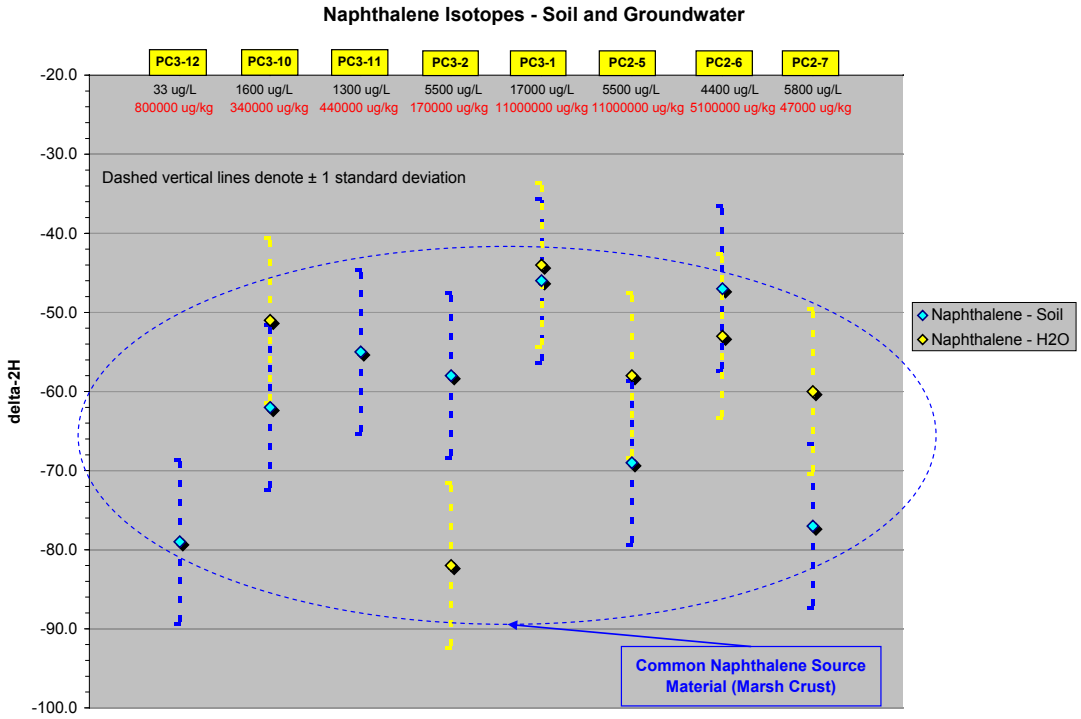
Naphthalene δ^2H and $\delta^{13}C$ Isotopes – Soil and Groundwater



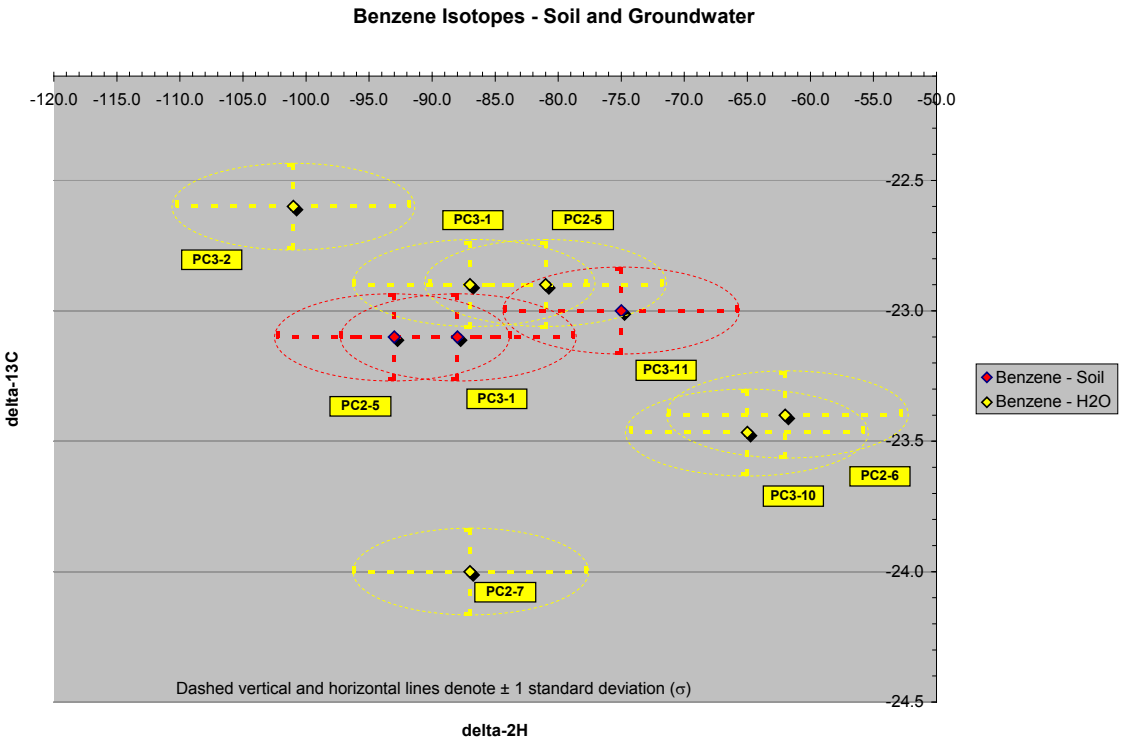
Naphthalene $\delta^{13}C$ Isotopes– Soil and Groundwater



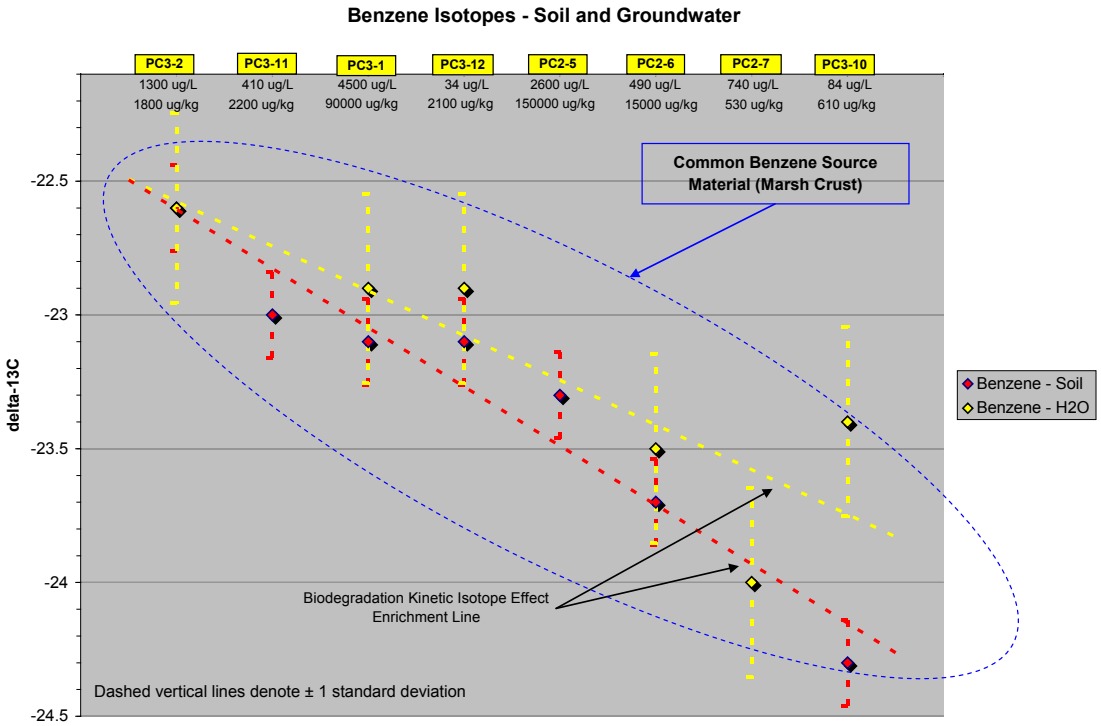
Naphthalene $\delta^{2}H$ Isotopes– Soil and Groundwater



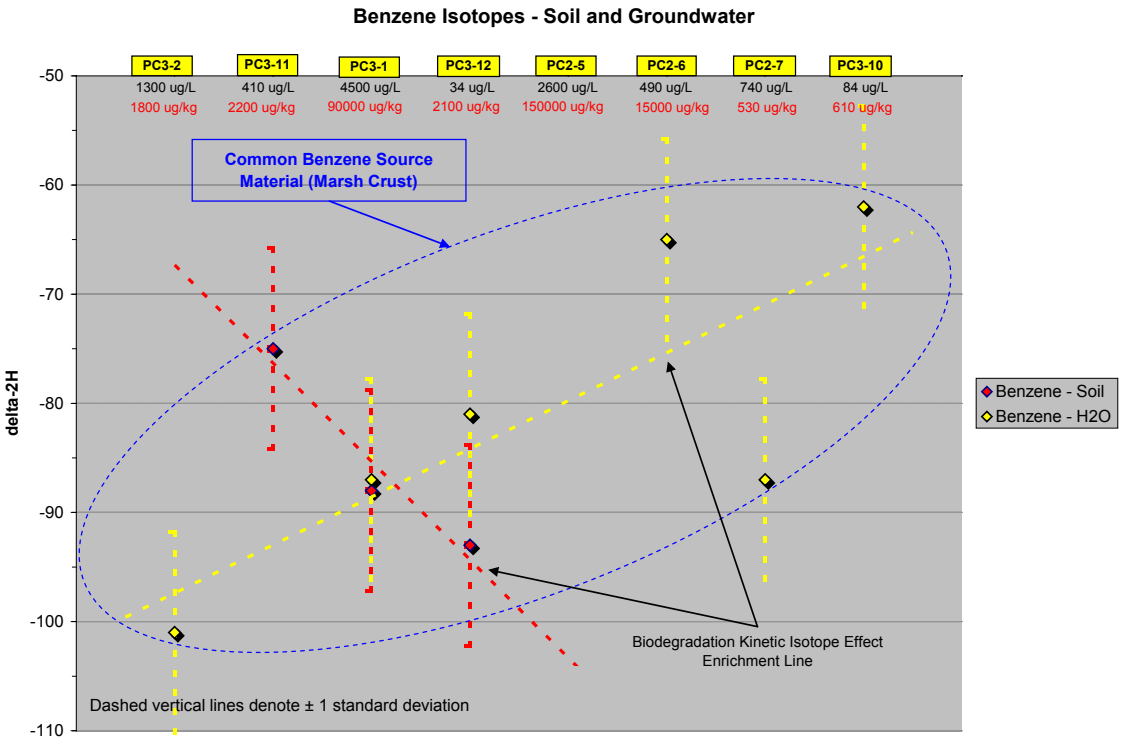
Benzene δ^2H and $\delta^{13}C$ Isotopes – Soil and Groundwater



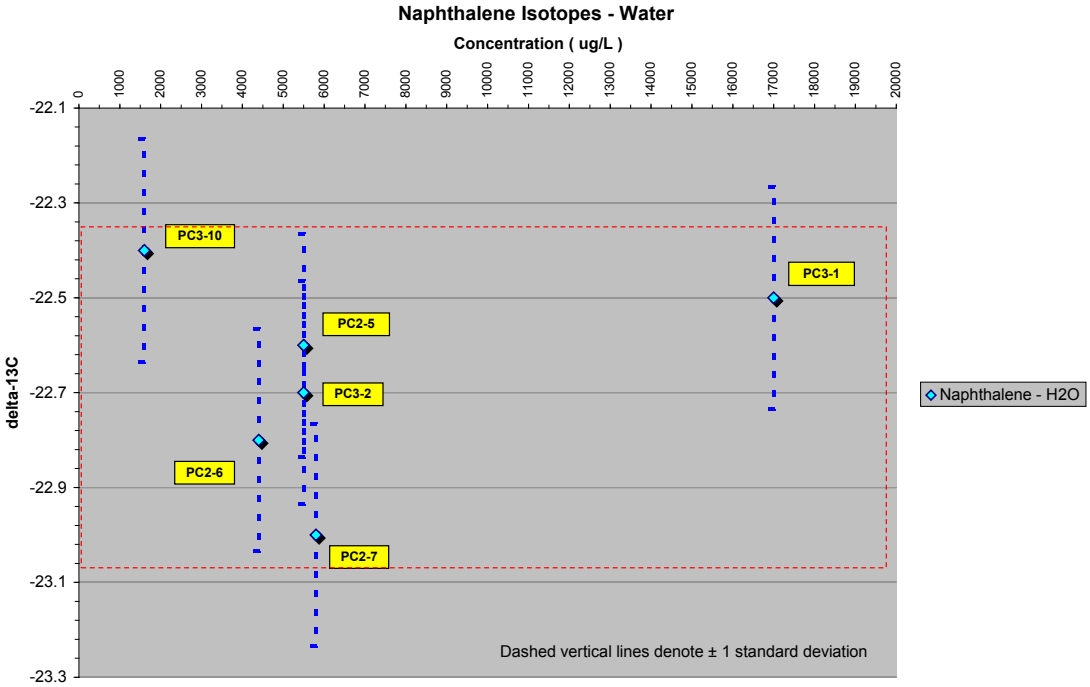
Benzene $\delta^{13}C$ Isotopes– Soil and Groundwater



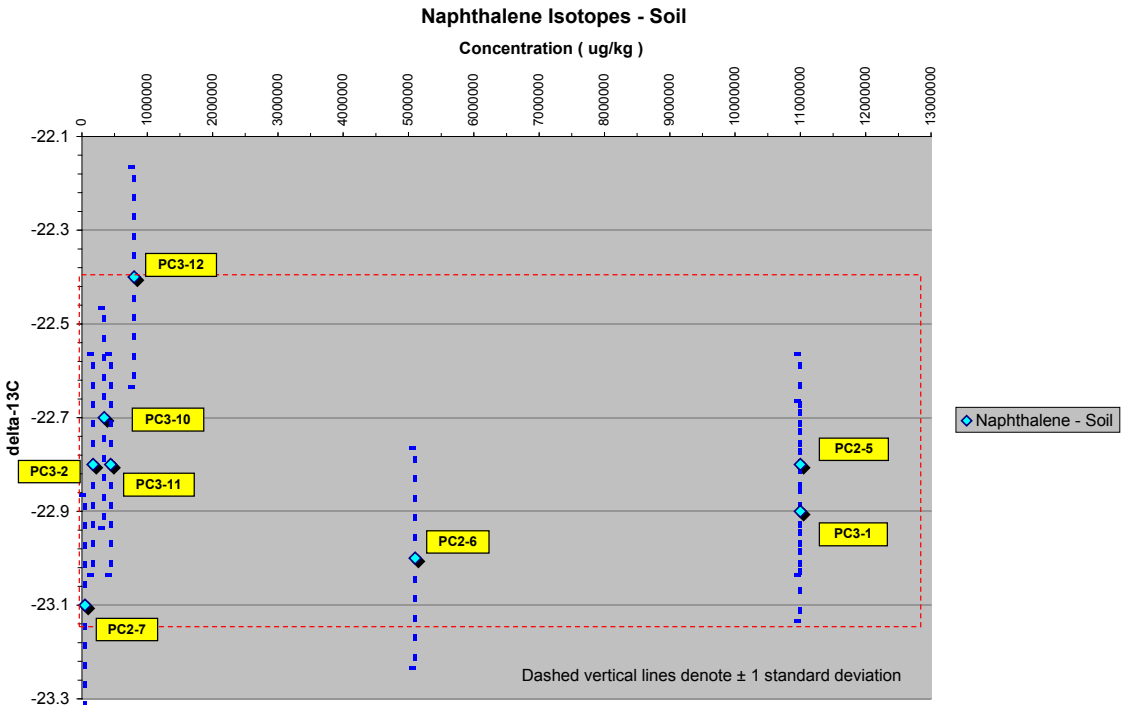
Benzene δ^2H Isotopes– Soil and Groundwater



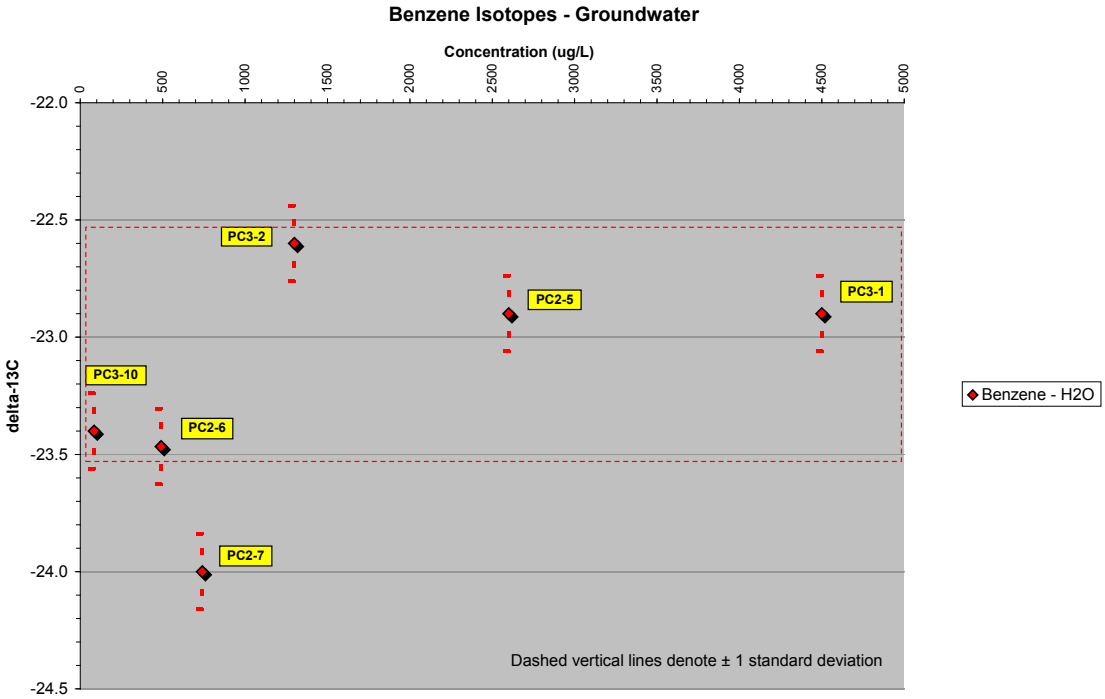
Naphthalene δ^{13}C Isotopes vs Concentration – Groundwater Only



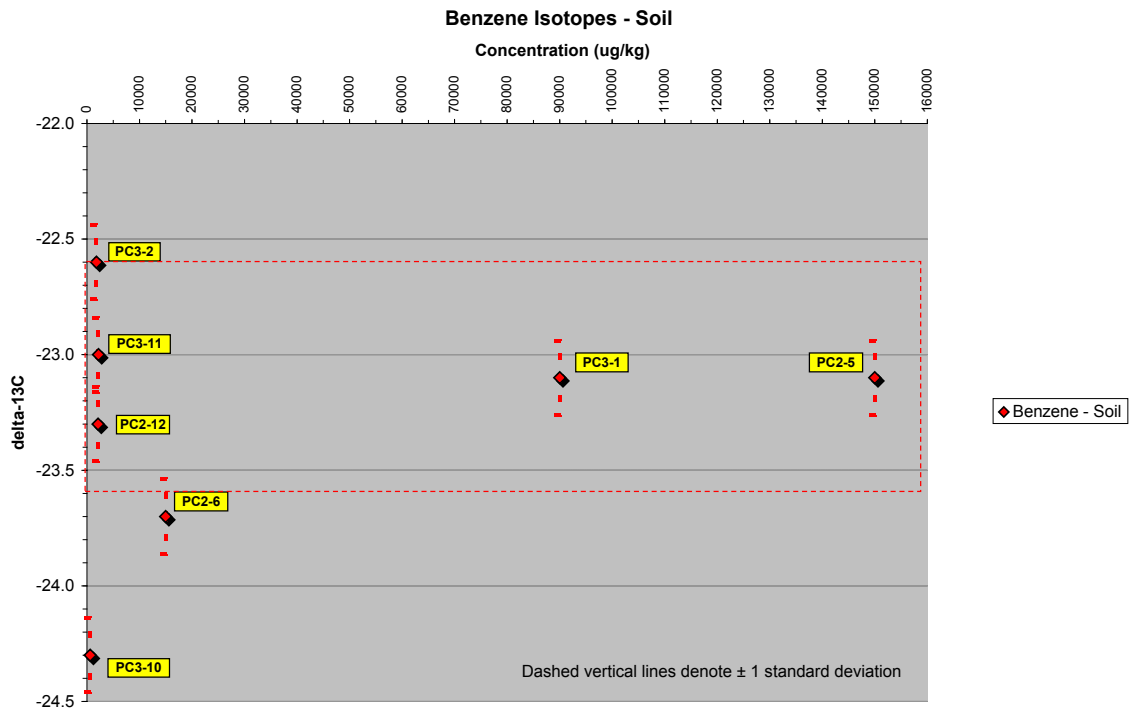
Naphthalene $\delta^{13}C$ Isotopes vs Concentration – Soil Only



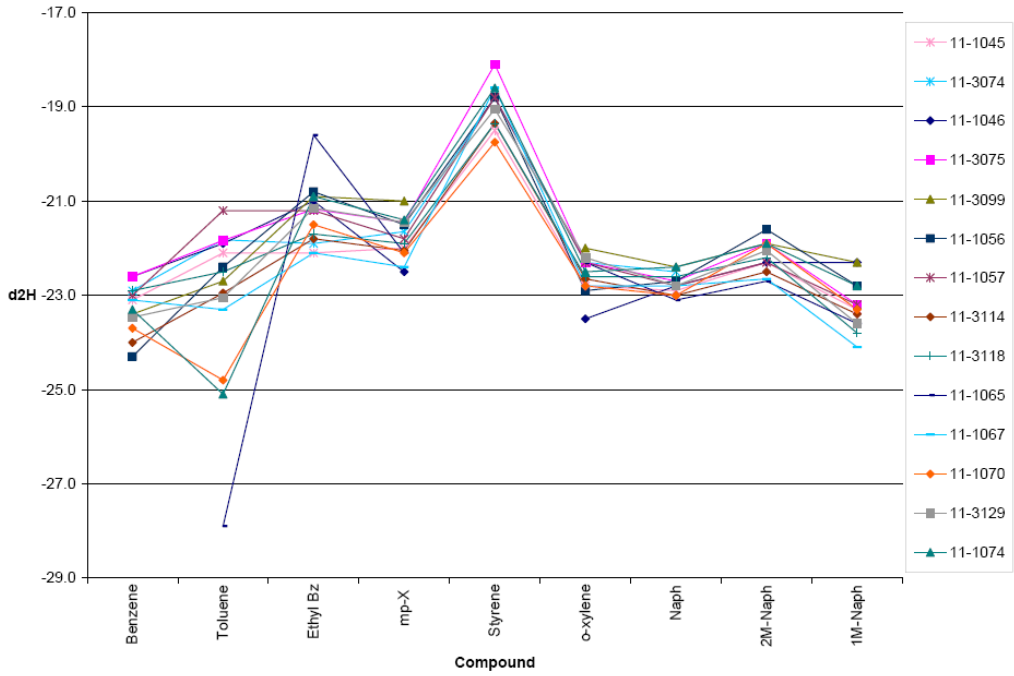
Benzene $\delta^{13}C$ Isotopes vs Concentration – Groundwater Only



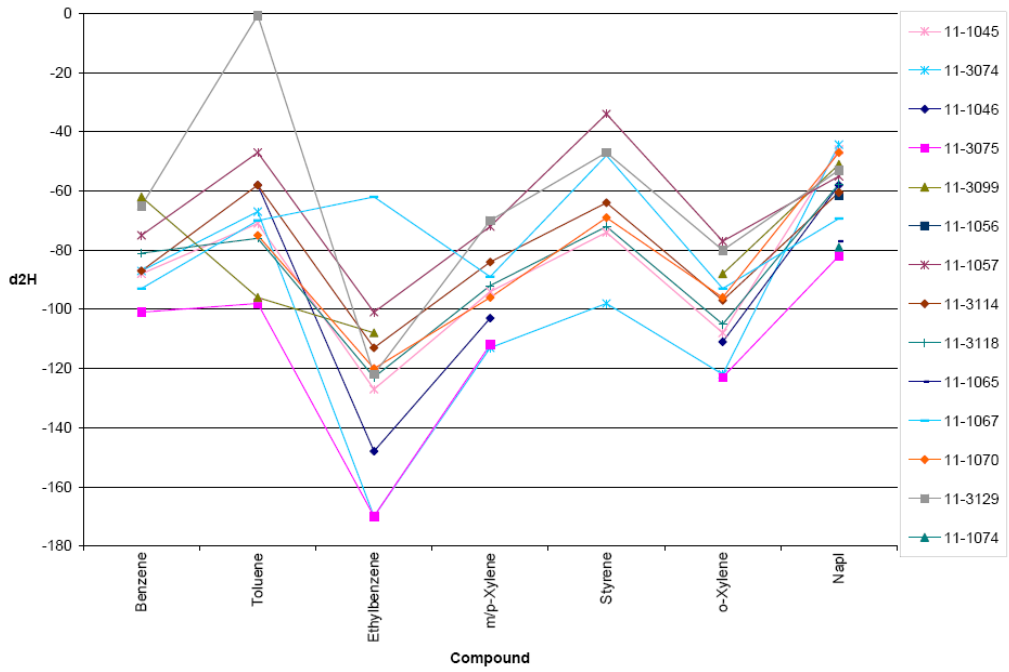
Benzene $\delta^{13}C$ Isotopes vs Concentration – Soil Only



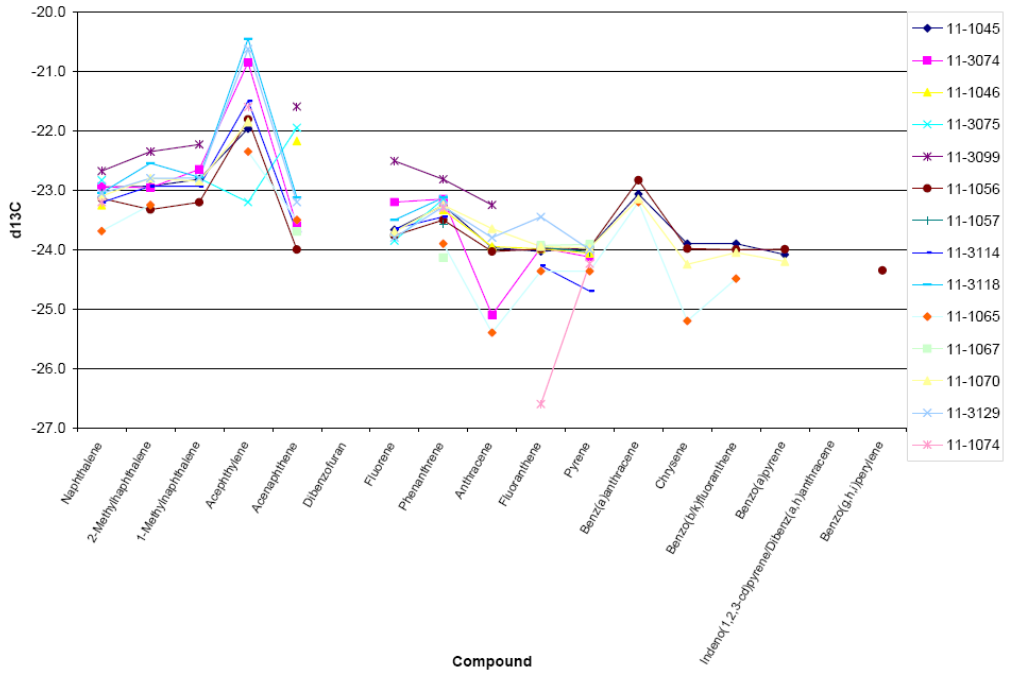
Carbon CSIR Results for 9 Individual Volatile Analytes (Benzene, Toluene, Ethylbenzene, m,p-Xylenes, o-Xylene, Styrene, Naphthalene, 1-Methylnaphthalene and 2-Methylnaphthalene)



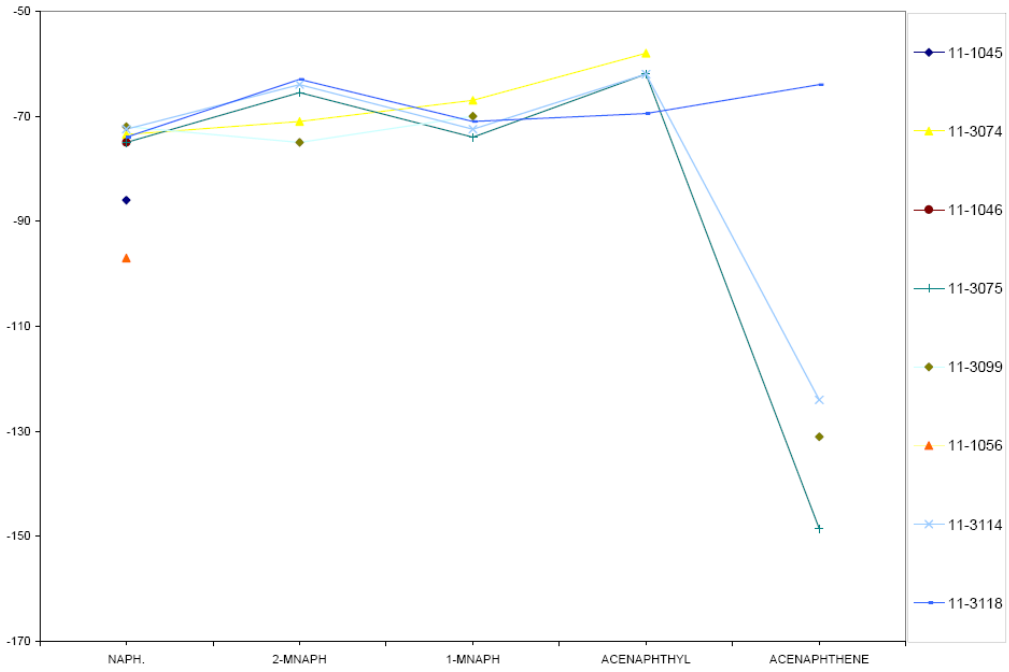
Hydrogen CSIR Results for 7 Individual Volatile Analytes (Benzene, Toluene, Ethylbenzene, m,p-Xylenes, o-Xylene, Styrene and Naphthalene)



Carbon CSIR Results for 17 Individual PAH Compounds



Hydrogen CSIR Results for 5 Individual PAH Compounds (Naphthalene, 1-Methylnaphthalene, 2-Methylnaphthalene, Acenaphthylene and Acenaphthene)



APPENDIX G
MARSH CRUST AND THE ORIGINS OF SITE CONTAMINATION FROM THE FINAL REMEDIAL DESIGN/ REMEDIAL ACTION WORK PLAN

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APPENDIX G

MARSH CRUST AND THE ORIGINS OF SITE CONTAMINATION

1.0 INTRODUCTION

The sporadic occurrences of elevated concentrations of benzene and/or naphthalene in the groundwater at Operable Unit (OU)-5/Installation Restoration (IR)-02 have been attributed to point-source discharges at the site. The following information will illustrate that these areas of elevated concentrations of benzene and/or naphthalene are originating from the Marsh Crust, which is historical contamination originating from a former manufactured gas plant (MGP). Such a distribution is expected considering 1) the character of the Marsh Crust; 2) the source material and where it was generated; 3) processing waste/by-products and/or practices at the point of generation; 4) fate and transport characteristics and probable scenarios of the source material; and 5) man-made reclamation/filling, natural marsh accretion/depositional, and/or erosion processes affecting contaminant source distributions over time. The following evaluation is specific to OU-5/IR-02 and not intended to be applicable to other Marsh Crust areas in Alameda.

2.0 CHARACTER OF THE MARSH CRUST

The Marsh Crust was originally defined in 1969 by Lee and Praszker in the California Division of Mines and Geology Special Report 97 (Lee and Praszker, 1969) and in 1979 (Lee and Praszker, 1979) when they performed a geotechnical investigation at Alameda Point. They defined the Marsh Crust as the peat layer that was the historic marshlands. The marshlands were filled in with dredge material between 1900 and 1940. By 2000, the definition of the Marsh Crust had changed to a layer of refinery by-products and sludges deposited within tidal channels and up to the high water mark on the tidal marsh (Tetra Tech EM, Inc. [TtEMI], 2000). A similar definition can be found in the Final Groundwater Remedial Investigation (RI)/Feasibility Study (FS), Alameda Point Site 25 and Alameda Annex IR-02 (Engineering Remediation Resources Group, Inc. [ERRG], 2004) – "A layer of petroleum-related contamination on the historic shoreline, marshland and tidal channels underlying the Site, referred to as the Marsh Crust."

The contaminated Marsh Crust sediments lie on top of organic matter or highly organic clay (the top of the Bay Sediment Unit). Although a few exceptions occur, beneath the former East Housing Area, the Marsh Crust occurs as a fairly contiguous layer 13 to 19 feet below ground surface (bgs) and is generally 0.5- to 1.0-inches thick.

3.0 SOURCE MATERIAL AND POINT OF GENERATION

Stable isotope signatures and hydrocarbon fingerprint results indicate that the source material for the Marsh Crust is MGP residues from a coal carbonization process. These data also show that the benzene and naphthalene present in groundwater originate from the Marsh Crust. No petroleum-derived residues are present.

The historical industrial operation (Oakland Gas Works) that released coal carbonization residues to the environment was located directly across San Antonio Creek in Oakland at the present-day Jack London Square (see Figures G-1 to G-7), approximately 1 mile from the site. The operation included an MGP on the waterfront that used coal from 1866 to 1904 (Jones, 1909). Modernization of the Oakland plant in 1880 introduced the Lowe process for "water gas" production. Although coal or oil can be used as the carbon source in the water gas production process, historic records indicate that coal was the source material used at the site. The site was used for gas manufacturing until 1904 when the gas works were relocated three blocks north to the adjacent properties (Howard Terminal).

A second possible contributing site is at block 206 on Clement Avenue between Minturn and Union Streets on Alameda Island at the present-day Alameda Marina on San Antonio Creek. No information is available for this former facility except that gas storage holders are shown on the 1897 Sanborn map, and the facility is named “Oakland Gas, Light and Heat, Co.”

Two other historic operations had been considered potential sources of the Marsh Crust. However, they were petroleum- (not coal-) based operations, so they cannot be considered potential sources. The operations in question were an adjacent waterfront MGP (Howard Terminal) on the waterfront in Oakland that used oil (most active from 1903 through 1930) and an oil refinery (Pacific Coast Oil Works – Figure G-8) on the western tip of pre-fill Alameda, active from about 1864 to 1899.

4.0 PROCESSING WASTE/BY-PRODUCTS AND/OR PRACTICES AT THE POINT OF GENERATION

Coal gasification was the primary commercial mode of manufacturing gas from approximately 1816 to 1875. After 1875, newer processes and technologies gradually replaced coal carbonization; however, the switch to these newer technologies was gradual and dictated by economic factors. At the MGP on the waterfront in Oakland, coal was used from 1866 to 1904 exclusively, until more modern, cost-efficient MGPs that used oil (petroleum) came on-line in Oakland in 1902 (Howard Terminal).

Coal gas was produced through the distillation of bituminous coal in heated, anaerobic vessels called retorts. The liquids produced consisted of (contaminated) water and coal tar. The associated wastes, most notably "light oil" or as it was usually referred to as "benzol," are primarily a mixture of benzene, toluene, ethylbenzene, xylenes (BTEX), and naphthalene. Until the demand was created by early motorcars in the early 1900s for benzol as a fuel (aka "motor spirits") and/or as an octane-boosting additive to gasoline, or for naphthalene as a solvent, BTEX and naphthalene were primarily unwanted by-product wastes to be disposed of. The principal purpose of the MGP was to generate large quantities of gas, not benzol.

Large volumes of wastes required disposal, particularly as production increased due to rising consumer demand. While uses for the by-products were continually sought, such as in dye formulation, explosives manufacture, wood treating (i.e., creosote), or shipment to tar distillers, in many instances, improper disposal practices occurred. As a consequence, since the MGP was on San Antonio Creek, improper disposal along with reoccurring spills over time of unwanted by-products/residuals into soil/ditches and low lying areas, or even directly into San Antonio Creek, resulted in MGP-related constituents entering the adjacent creek.

Manufacturing, by-product segregation, and disposal practices at an MGP typically resulted in differential distributions of the various MGP waste products. Thus, a "uniform" MGP residual (i.e., "uniform" Marsh Crust) in on-site or near-site MGP soils does not exist. For example, some soils will contain only polycyclic aromatic hydrocarbons (PAHs) (from coal tar), while others only BTEX and naphthalene (from light oil or benzol). Others will have a mixture dependent on the ratio of light oil to coal tar present. Examples of this variability from two separate MGPs are illustrated on Figures G-9 and G-10, and Figures G-11 and G-12. Figure G-9 illustrates the location of visible tar or PAHs above 500 mg/kg in soils on a former MGP site in Troy, New York. Figure G-10 illustrates the areas of elevated benzene concentrations in groundwater. The highest concentrations of benzene are in an area where there is no visible tar or elevated PAH concentrations in the soil. Figure G-11 illustrates the distribution of dense nonaqueous phase liquid (DNAPL) in the fill of a former MGP facility in Washington State. Figure G-12 shows the benzene concentrations in the shallow groundwater in the fill. The high benzene concentrations are only in a small fraction of the DNAPL contaminated area.

5.0 FATE AND TRANSPORT CHARACTERISTICS OF THE SOURCE MATERIAL

Excluding cyanides, waste material at MGP plant sites is primarily coal tar and light oil (benzol). Naphthalene and BTEX are the main constituents of light oil, whereas coal tar is a complex mixture of PAHs.

Naphthalene and BTEX are more water soluble and mobile in the environment, whereas coal tar has low water solubility and strongly adsorbs to organic matter (i.e., marsh peat) and fine grained sediments (i.e., as found in estuaries). However, if elevated concentrations of BTEX/naphthalene and coal tar are together, the BTEX/naphthalene acts as a cosolvent and increases the solubility of coal tar in water, facilitating its transport. Microglobules of coal tar (tar-water emulsions) are also a main component in process wastewater from coal tar plants (Hatheway, 2006) and can be transported to the environment via this medium. Additionally, if mixed together, the BTEX/naphthalene will dissolve into the coal tar and stay associated with it, particularly in water-logged sediment (both are hydrophobic and lypophillic). Once in an estuarine environment such as San Antonio Creek and adjacent tidelands/marshes on Alameda, dissolved-phase coal tar residuals, primarily BTEX and/or naphthalene, and suspended microglobules of coal tar will migrate with the tidal currents and become adsorbed to the tidal marsh organic matter/sediment. This will typically be restricted to a thin layer (i.e., a fraction of an inch to a few inches) due to the highly adsorptive nature of the marshes/tidal flats organic peat and/or fine-grained sediments. Once incorporated in the sediment, it will typically remain there and serve as a localized contaminant source to adjacent surface water. If impacted sediment is subsequently covered with fill and becomes a subsurface soil, such as at Site 25, this impacted soil occurs as a thin subsurface layer that serves as a localized source of contaminants to adjacent groundwater.

This process is substantiated by recent investigative forensic data from the OU-5/IR-02 pre-design investigation including hydrocarbon fingerprints and stable isotope signatures (^{13}C and ^{2}H) for benzene and naphthalene. The hydrocarbon fingerprint and stable isotope signatures are consistent and similar in the soil and groundwater samples across the site. This indicates a single, common source material (see Appendix F for isotope analysis). Additionally, the stable isotope signatures and hydrocarbon fingerprint results indicate that the benzene and naphthalene present in groundwater originate from the Marsh Crust.

6.0 ACCRETION/DEPOSITIONAL AND/OR EROSION PROCESSES AFFECTING CONTAMINANT SOURCE DISTRIBUTIONS

Estuarine marshes are dynamic landforms that are continually in a state of flux due to water mediated sediment transport, erosion/accretion, and/or other depositional events (i.e., dredge spoils) that constantly shape and reshape tidally influenced wetland areas. This is evident in the marshlands/tidal flats areas in historical maps/figures presented on Figures G-1 through G-7, from years 1859, 1878, 1905, 1908, 1910, 1915, and 1941, respectively. The importance of this to differential occurrences of BTEX/naphthalene versus PAHs concentrations is apparent when considering that as marsh/tidal drainage areas shift and different areas are now exposed to creek water containing dissolved/suspended coal tar contaminants, distinct areas can be impacted by different light oil versus coal tar ratios adsorbing to the surficial marsh/tidal flats sediments. This combination of erosion/accretion shifts contaminant distributions in marshlands/tidal flats areas.

Other major erosional and/or depositional events such as storms or the differential filling (placement of dredge spoils) of the marsh over time also have a significant impact on the reshaping of the tidally influenced wetland areas (i.e., contrast Figures G-4 and G-5 from 1908 to 1915, respectively).

Different distributions of BTEX/naphthalene to PAHs across Alameda are expected when erosional/depositional processes are combined with the potential variability (i.e., differing ratios of BTEX/naphthalene to PAHs) of coal MGP wastes discharged to the San Antonio Creek during its period of operation, and the remobilization of potentially variable coal tar waste impacted sediment to the estuarine waters of San Antonio Creek during dredging and fill operations with subsequent transport to and adsorption by exposed marsh tidal flats. Considering that filling of the marsh/tidal flats on Alameda began during the 1890s (Global Security, 2008) prior to the shutdown of the coal MGP in Oakland in 1904 (see attached 1919 picture [Figure G-13] of filling of more northern locations from the park and across from Jack London Square), the remobilization of impacted sediments in the historic San Antonio Creek/surrounding estuary is a viable scenario.

These dynamic erosional/depositional processes continued until all the west end marshlands and intertidal areas on Alameda were filled in. After this, the former coal gas plant derived wastes of varying spatial distributions with regard to their BTEX/naphthalene versus PAHs ratio became entrapped in the subsurface, creating what is now referred to as the Marsh Crust at approximately 15 to 20 feet bgs. As shown on Figure G-7, the fill was completely in place in 1941 and most of the fill, particularly in the northern part of the site, was in place by 1919 (see Figure G-13 for a photograph of dredging adjacent to the Webster Street Bridge).

7.0 CONCLUSIONS

- The Marsh Crust is defined as a layer of MGP coal carbonization by-products deposited within tidal channels and up to the high water mark on the tidal marsh.
- The Marsh Crust at the site came from a former MGP using the coal carbonization process from 1866 to 1904 located across the San Antonio Creek in Oakland at the present day Jack London Square, approximately 1 mile from the site.
- The MGP produced coal tar and light oil (BTEX and naphthalene) waste streams.
- Waste production and discharge at MGP plants are not uniform. Coal tar and light oil would be released at different times and sometimes together. Therefore, the Marsh Crust is not uniform in composition.
- The different transport mechanisms for the coal tar versus the light oil leads to further heterogeneities in the composition and distribution of the Marsh Crust.
- Accretion, deposition, and erosional processes also lead to further heterogeneities in the composition and distribution of the Marsh Crust.

- The heterogeneities in the Marsh Crust causing variability of benzene concentrations in the groundwater are common at MGP sites.
- The benzene and naphthalene present in groundwater originate from the Marsh Crust.

8.0 REFERENCES

Engineering Remediation Resources Group, Inc. (ERRG). 2004. Final Groundwater Remedial Investigation/Feasibility Study. Alameda Point Site 25/Alameda Annex IR-02, Alameda, California.

Global Security. 2008. http://www.globalsecurity.org/military/facility/alameda.htm.

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Jones, E. C. 1909. The History of Gas Lighting in Oakland. *Pacific Service Magazine* 1(4), pp 125-129.

Lee and Praszker. 1969. California Division of Mines and Geology Special Report 97.

Lee and Praszker. 1979. Geotechnical Investigation Defense Property Disposal Office. Alameda, California.

Sanborn, 1897. Sanborn Fire Insurance Fire Insurance Map.

Tetra Tech EM, Inc. (TtEMI). 2000. Final Feasibility Study for the Marsh Crust and Groundwater at FISCA and Feasibility Study for the Marsh Crust and Former Subtidal Area of Alameda Point. March

Figure G-1 – 1859 Historic map showing extent of marshlands/tidal areas –

Base from http://www.alamedainfo.com/alameda_antique_maps.htm

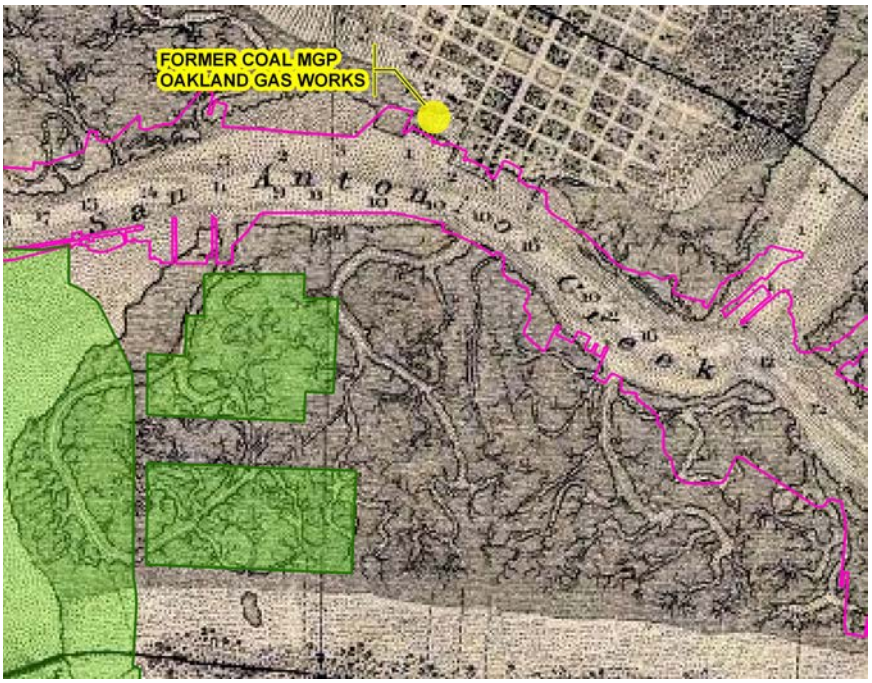

Figure G-2 – 1878 Historic map showing extent of marshlands/tidal areas –

Base from http://www.alamedainfo.com/alameda_antique_maps.htm

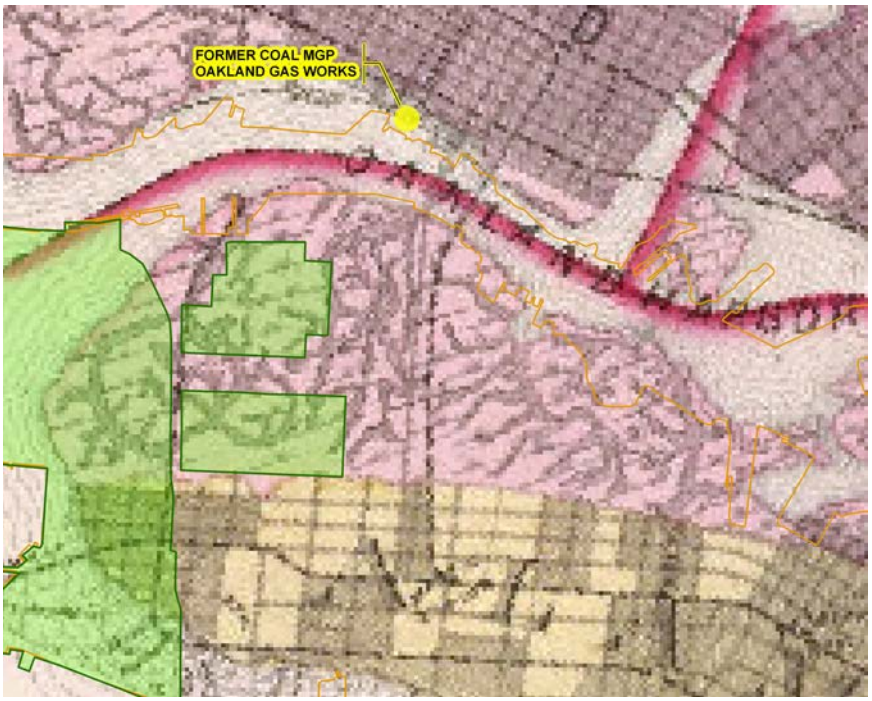

Figure G-3 – 1905 Historic map showing extent of filling of marshlands/tidal areas –

Base from http://www.alamedainfo.com/alameda_antique_maps.htm

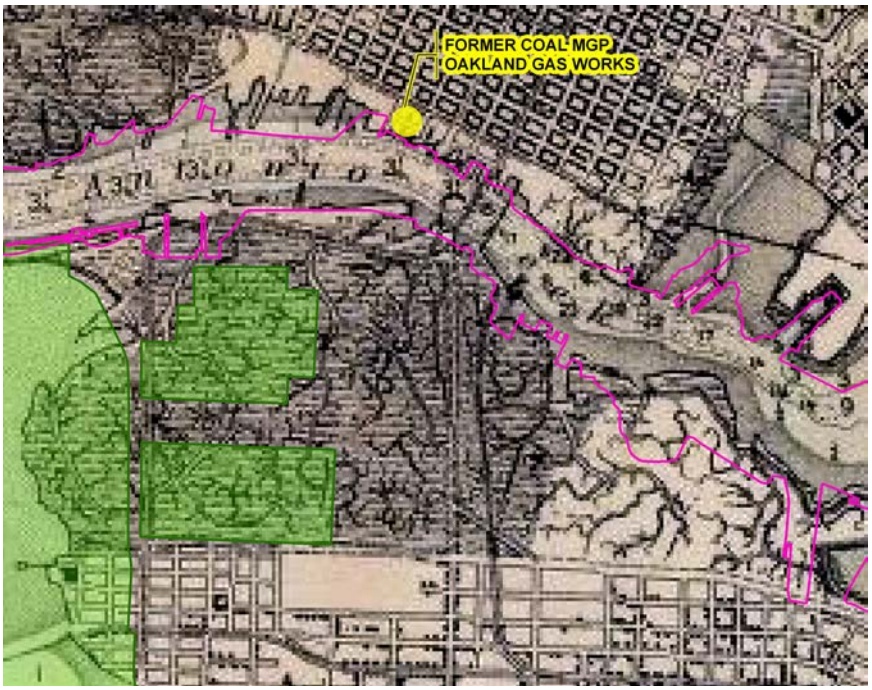

Figure G-4 – 1908 Historic map showing former coal MGP and refinery locations

Base from http://www.alamedainfo.com/alameda_antique_maps.htm

Figure G-5 – 1915 Historic map showing former coal MGP, borax plant, brick/tile/pipe works, and refinery locations
Base from http://www.alamedainfo.com/alameda_antique_maps.htm

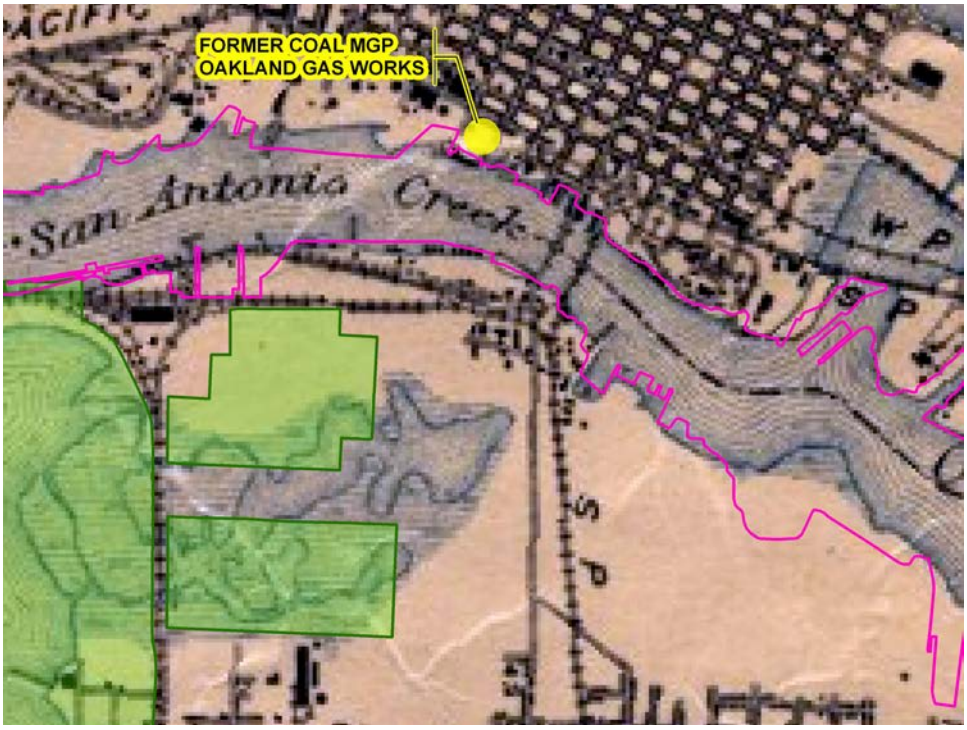

Figure G-6 – ca 1910 Postcard showing Alameda west end and town of Oakland
from http://www.alamedainfo.com/

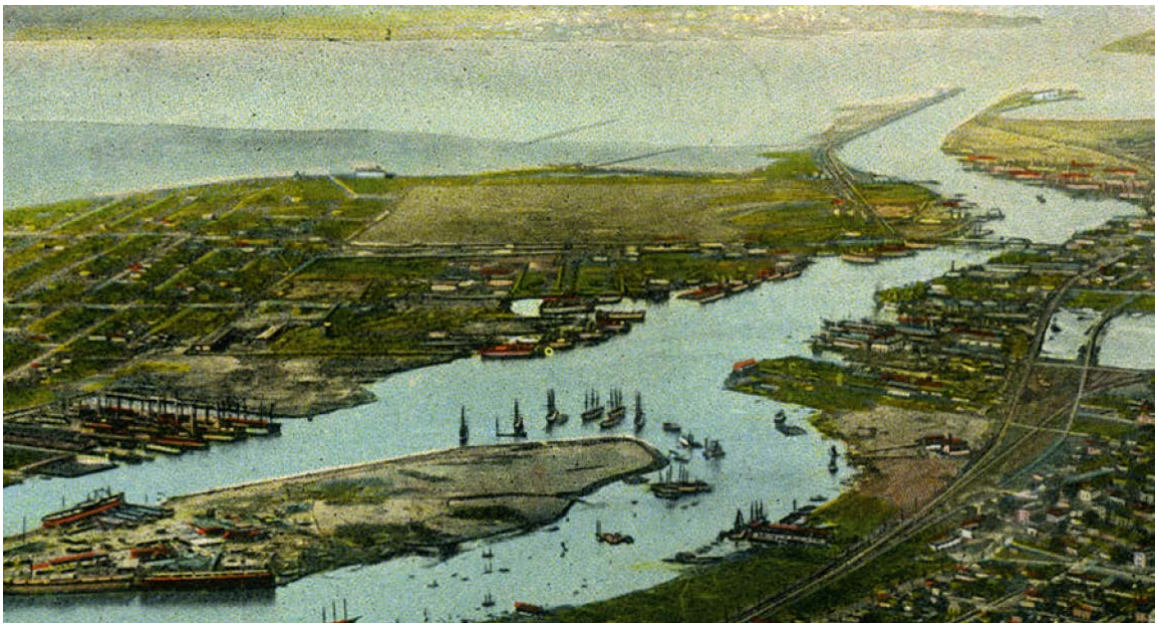

Figure G-7 – 1941 Aerial photograph showing former coal MGP and site locations
Photograph from http://www.alamedainfo.com/alameda_antique_maps.htm

Figure G-8 – 1897 Oil Refinery at Alameda Point – The six smaller tanks shown behind the smoke stack at the lower left corner are tar distillers (Sanborn, 1897)
from http://www.alamedanavalairmuseum.org/photos-nas.asp

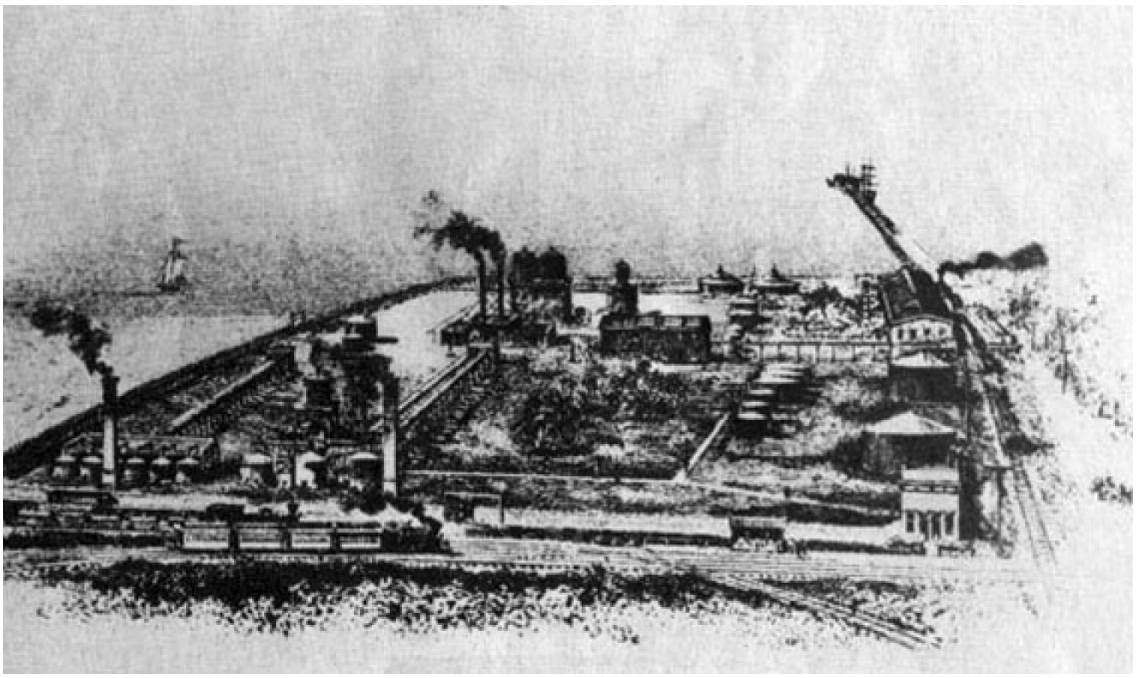

Figure G-9 – DNAPL distribution at former coal gas site in New York

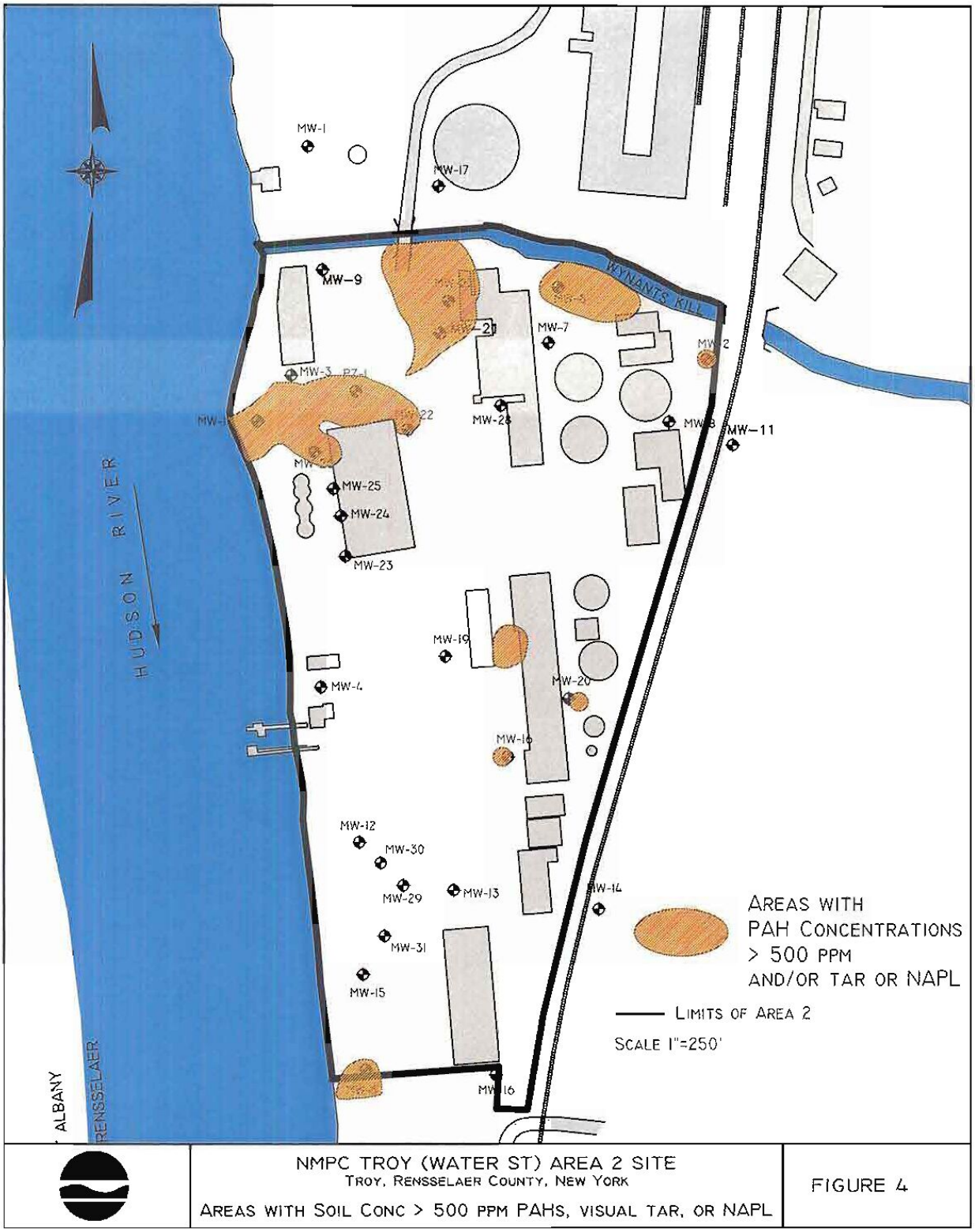

Figure G-10 – Benzene distribution at former coal gas site in New York

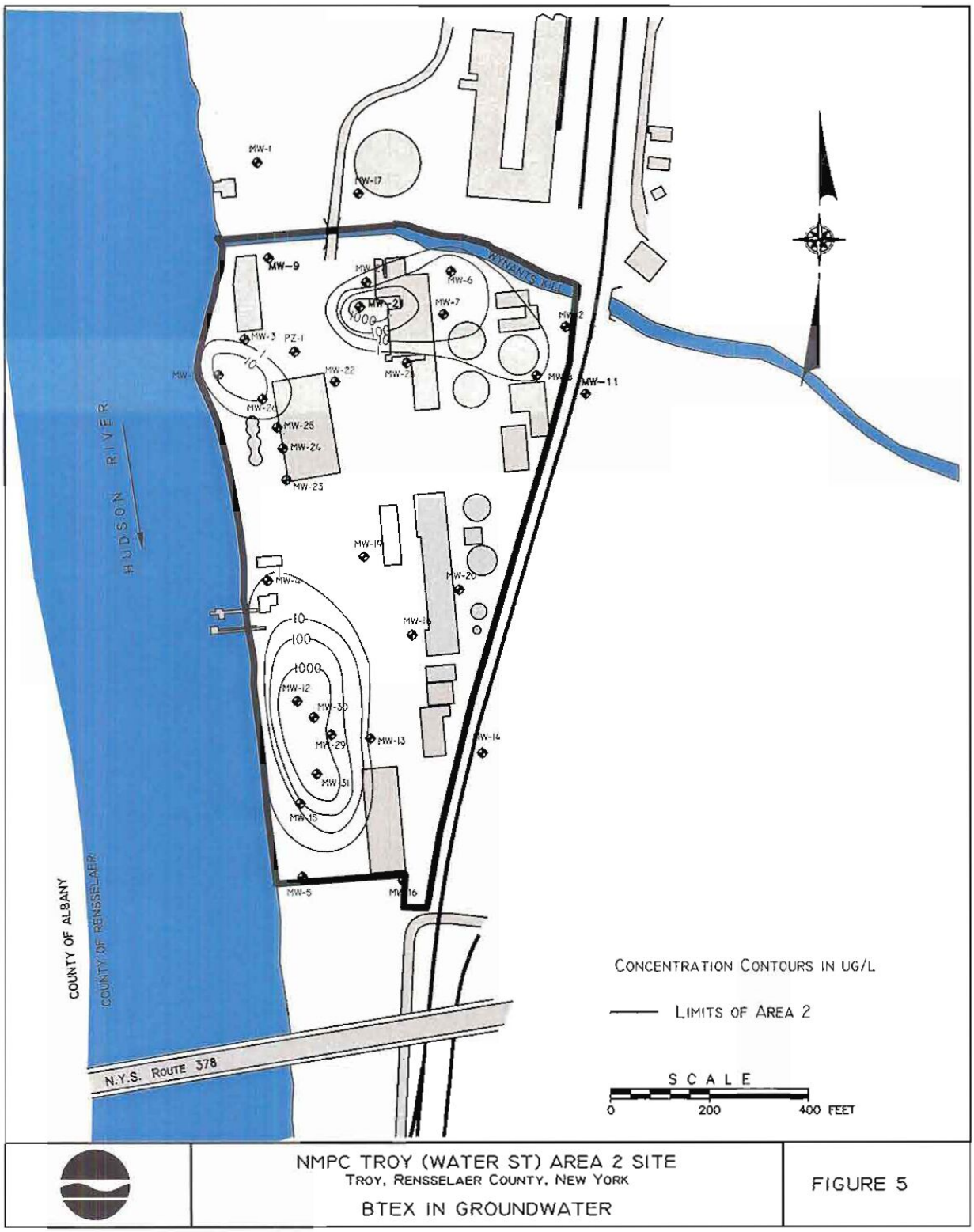

Figure G-11 – DNAPL distribution in surficial fill at former coal gas site in Washington State

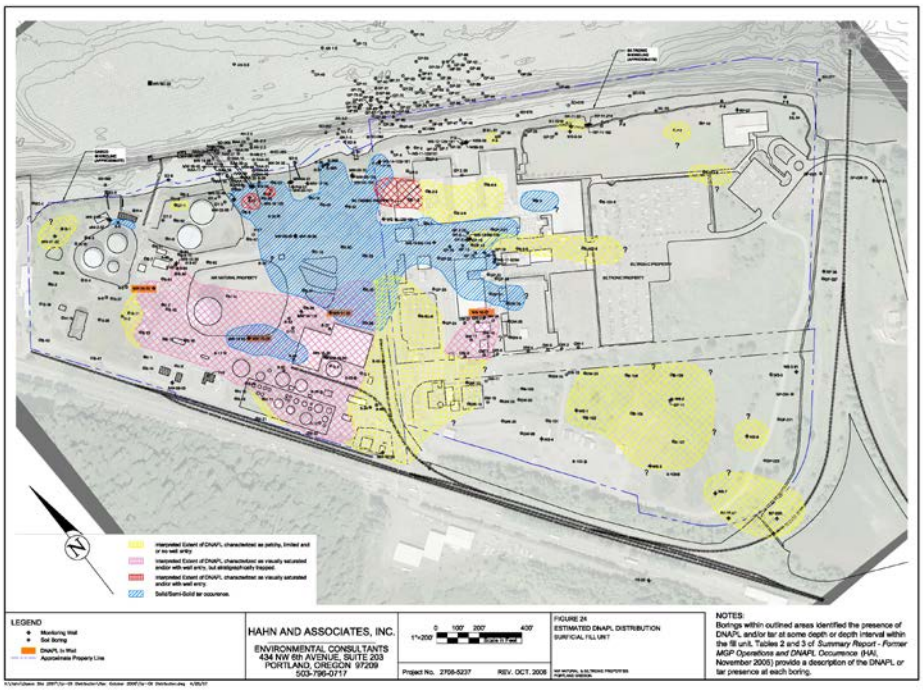

Figure G-12 – Benzene distribution in surficial fill at former coal gas site in Washington state – (Highest Conc. Under Former Naphthalene Plant and Coke Ovens)

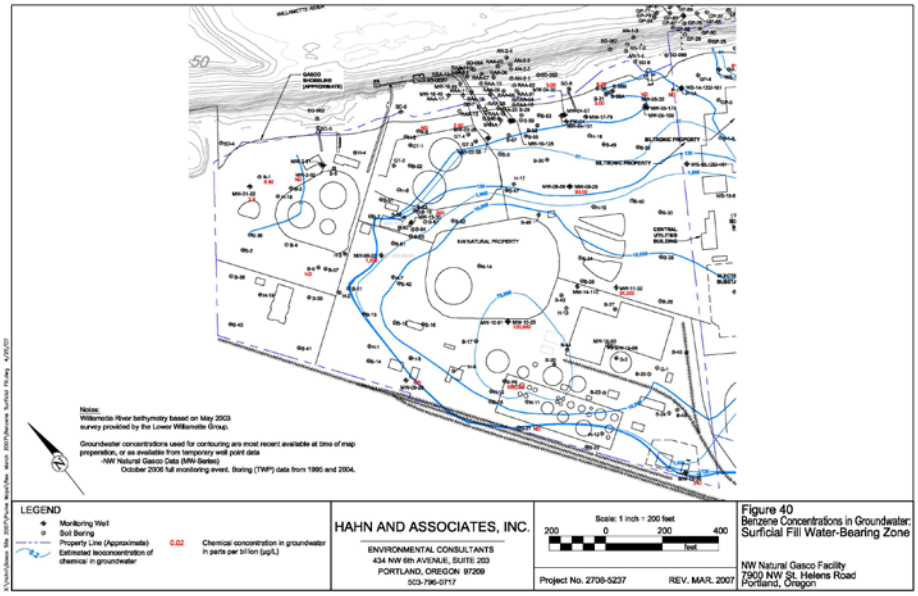

Figure G-13 – 1919 Aerial photograph showing gas holders and former coal MGP location
Photo from http://www.alamedainfo.com/Posey_Tube.htm

APPENDIX B
ADDITIONAL BACKGROUND INFORMATION ON THE SOIL GAS SAMPLING

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B-1. Additional Background Information on the Soil Gas Sampling

Soil gas samples were collected from 32 locations (see attached Figure 3-5 from the Operable Unit [OU-] 5 Remedial Investigation [RI] Report). These sampling points included locations where groundwater contamination had previously been confirmed and some locations where groundwater contamination had not been observed. Nearly all of these soil gas sampling locations were colocated with a HydroPunch® sampling location. Soil gas was sampled at two depths at each location: at approximately 2 feet below ground surface (bgs) and just above the capillary fringe (at approximately 8 feet bgs). The soil gas samples were collected in 6-liter Summa canisters and were analyzed for volatile organic compounds (VOCs) and naphthalene using EPA Method TO-14. In response to the conditions encountered in the field, the deeper soil gas samples were typically collected in the depth range of 6 to 7 feet, since the groundwater table was observed to be shallower than originally believed.

Results of the sampling showed that the near-surface benzene soil gas concentrations were low, with a maximum detected concentration of 20 micrograms per cubic meter ($\mu g/m^3$) at the depth of 2 feet, and 15 $\mu g/m^3$ at approximately 5 feet bgs. Naphthalene reported a maximum soil gas concentration of 54 $\mu g/m^3$ at 2 feet bgs and 180 $\mu g/m^3$ at approximately 5 feet bgs. The RI Report stated that these results indicated that little volatilization and release of benzene and naphthalene into the vadose zone soil was occurring. Table 4-10 and Figures 4-66 through 4-69 of the OU-5 RI Report present a more complete presentation of the soil gas sampling results.

A passive soil gas survey was conducted throughout the estimated plume center identified in the Groundwater RI/FS Report to refine plume center HydroPunch and soil boring locations. Eighty-nine Gore-Sorber modules were installed in May 2007, and 87 modules were removed in June a month later. Gore-Sorber modules were installed between 2.5 and 3 feet bgs, just above or within the clay layer that was encountered at most locations during soil sampling. The passive soil gas survey concluded that benzene and naphthalene concentrations were not detected in Gore-Sorber modules at the Kollman Circle Housing Area where high benzene and naphthalene concentrations had been reported in groundwater. This suggested that the vertical migration of soil vapor was apparently being limited. The continuous clay layer observed between approximately 3 and 8 feet bgs throughout the area appeared to be acting as an effective barrier to vapor migration.

In follow-up to this passive soil gas sampling, twenty-four soil gas probes were installed at the pilot test site and sampled in June of 2007. The probes were constructed using a 1.4-inch-long porous probe tip buried in 6 inches of filter sand. The probe tip was connected to 0.25-inch-diameter Teflon® tubing, which ran to the surface. The probe tips were all installed below the clay layer. Eleven probes were sampled for benzene and naphthalene. The eight Soil Vapor Extraction (SVE) wells also were sampled. Twelve other probes were used during the SVE radius of influence (ROI) testing and were not sampled for the baseline characterization. Probe

TA1-SG11 contained water and was not sampled. Baseline soil gas benzene concentrations ranged from below the detection limit of 0.88 $\mu g/m^3$ to 548 $\mu g/m^3$. Naphthalene concentrations ranged from below the detection limit of 0.16 $\mu g/m^3$ to an estimated concentration of 502 $\mu g/m^3$. Results indicate the presence of elevated benzene and naphthalene concentrations in vadose zone soil gas below the clay layer before the start of biosparging.

The passive soil gas survey and baseline soil gas sampling performed as part of the design of the biosparging system provided further evidence that soil gas concentrations were much lower above the clay layer than they were below it. The site characterization data show that this clay layer is over 2 feet thick throughout the area of interest. This layer is indicated to be acting as an effective barrier to upward vapor migration.

B-2. Additional Background Information on Indoor Air, Outdoor Air, and Crawl Space Air Sampling

The United States Coast Guard (USCG) collected indoor and outdoor air samples at the site to verify the air modeling results. Twenty-four hour Summa canister air samples were collected at the following locations:

The North Village Housing Area: 17 total samples were collected – 4 crawl space air samples, 4 outdoor ambient air samples, and 9 indoor air samples;

The Kollman Circle Housing Area (part of the North Village Housing area): 17 total samples were collected – 8 crawl space air samples, 1 outdoor ambient air sample, and 8 indoor air samples; and

The USCG Marina Village Housing Area: 19 total samples were collected – 6 outdoor ambient air samples and 13 indoor air samples (there are no crawl spaces).

The maximum detected indoor air measurements were compared to the EPA risk-based Ambient Air Preliminary Remediation Goal (PRG). The maximum measured benzene level exceeded its published PRG by as much as an order of magnitude (signifying a risk level on the order of 1×10^{-5}). Appendix A to the RI/FS Appendix B presents the risk assessment in more detail. Results of the sampling and comparisons to risk-based screening criteria indicated that:

- Volatile concentrations in crawl space air did not differ from indoor (or outdoor) air concentrations; and
- Indoor air volatile concentrations were consistent with the outdoor ambient air measurements.

Together, this evidence suggested that, although the housing at OU-5 may be built over a groundwater plume with benzene and naphthalene, the concentrations of these chemicals in indoor air were not elevated above ambient conditions for the San Francisco Bay Area. Thus, the indoor air inhalation risks are not likely to differ from those of other individuals residing in the San Francisco Bay Area.

Based on the linear relationship for volatiles migration from groundwater to indoor air in the modeling, the assessment recommended that additional soil gas and air sampling be considered if there is an increase of one to two orders of magnitude of the COC concentrations measured in groundwater. The report indicated that the rational for this recommendation is that ambient conditions could potentially be masking low levels of volatiles transport from groundwater to indoor air.

B.3 Additional Background Information on the Comparison of the Maximum Detected Soil Gas and Groundwater Concentrations to the Conservative Default USEPA Screening Levels Published in the Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils

An evaluation of the collected soil gas and groundwater data was performed using the questionnaire included in the Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (EPA 2002) to identify the primary COPCs and determine whether subsurface contamination poses any significant human health inhalation risks. A summary of the Tier 1 (primary screening) and Tier 2 (secondary screening) evaluation is presented in Appendix D of the RI/FS Report. Data from all previous investigations were compiled, and maximum concentrations for each detected compound in the soil gas and groundwater were compared to the Tier 2 generic screening values. The maximum detected concentrations of benzene, naphthalene, chloroform, and trichloroethylene in soil gas, and the maximum detected concentrations of benzene and naphthalene in groundwater were found to exceed the conservative USEPA generic screening levels corresponding to an incremental lifetime cancer risk (ILCR) of 1×10^{-6} risk or a hazard index of 1. However, the majority of the results of the comparisons showed that conditions were generally in the RMR.

B-4. Additional Background Information on the Clay Layer and Associated Stratigraphy

The soil stratigraphy in the study area where vapor intrusion is a potential concern was previously characterized by constructing a number of near-surface geological cross sections. These cross sections, labeled as AA' through HH', are reproduced as Technical Memorandum Figures 2 through 9. These figures are Figures 4-3, 4-4, 4-5, 4-13, 4-14, 4-15, 4-16, and 4-17 of the Remedial Design/RAWP (RD/RAWP), respectively. Technical Memorandum Figures 10 and 11 (Figures 4-2 and 4-12 of the RD/RAWP) show the locations of these cross sections. In general, the soil stratigraphy in the study area is defined by the presence of a clay layer with layers of sand, silt, silty sand, gravel and/or cobbles above or above and below the clay. Two distinct stratigraphies are evident with respect to the clay layer:

1. Clay Pattern 1 – The clay layer is completely within the vadose zone above the groundwater table and there is a layer of another soil type above and below the clay.

6. Clay Pattern 2 – The clay layer intersects the groundwater table and there is one or two layers of another soil type above the clay.

Table B-1 presents the soil type layers and their thicknesses at 10 locations exhibiting Clay Pattern 1 and at 11 locations exhibiting Clay Pattern 2. As noted in the footer, the soil layers are defined with Stratum A at the ground surface and Strata B and C (if applicable) beneath Stratum A in descending order as the groundwater table is approached. The following information summarizes the analysis of the near-surface geology associated with these two cases:

For the Areas with Clay Pattern 1:

The average depth to groundwater is 7.15 feet.

The minimum depth to groundwater is 5.0 feet.

The average thickness of the clay layer in the vadose zone is 2.17 feet.

The soil layer patterns in the soil columns (going from the ground surface down to the groundwater table):

- Sand-clay-sand (5 of 10)
- Silty sand-clay-sand (4 of 10)
- Silty sand-clay-silty sand (1 of 10)

For the Areas with Clay Pattern 2:

The average depth to groundwater is 7.91 feet.

The minimum depth to groundwater is 5.0 feet.

The average thickness of the clay layer above the groundwater table is 2.73 feet.

The soil layer patterns in the soil columns:

- Silty sand-sand-clay (4 of 11)
- Gravel-clay (4 of 11)
- Silty sand-silt-clay (1 of 11)
- Silt-clay (1 of 11)
- Silty gravel-clay (1 of 11)

B-5. Additional Background Information on Dissolved Groundwater Constituent Stratification

Prior to the start of the biosparging operation, HydroPunch sampling was performed at a number of locations throughout the study area to determine whether there was a concentration gradient across the shallow aquifer. Table B-2 shows the results for all groundwater Hydropunch sampling for benzene and naphthalene from July 2007 (pre-operations). Technical Memorandum Table 4 shows the multi-depth sampling results. The HydroPunch sample

locations are presented on Figure 14 (Figure 3-6 of the RD/RAWP). (Note multi-depth sample location PC2-6 was inadvertently omitted from the original Remedial Design/Remedial Action Work Plan Figure 3-6). Seven locations (PC2-1, PC2-3, PC2-4, PC2-6, PC3-4, PC3-13, and PC3-14) had groundwater sampling at multiple depths in the FWBZ (Technical Memorandum Table 4). All the results for the central and eastern portions of the plume (the PC2- and PC3-locations) showed significant stratification of benzene and naphthalene in the water column with the deeper samples being two or three orders of magnitude higher in concentration than the samples collected just below the groundwater table, which were at or below the method detection limit. Given the Marsh Crust source of contamination is at the bottom of the aquifer, this data indicates that contaminant stratification may be reestablished if/when the biosparging operation is terminated. The groundwater concentrations that actually drive or affect the vapor migration process are the groundwater concentrations at the top of the groundwater table, not the well-mixed dissolved groundwater concentrations or the higher groundwater concentrations that existed pre-operations deeper in the water bearing zone due to the proximity of the Marsh Crust source.

B-6. Additional Background Information on the "Low Strength Source" Paradigm for Screening Sites Relative to Potential Vapor Intrusion Concerns

Recent published results of extensive data analyses for sites with respect to natural attenuation of subsurface petroleum hydrocarbons and their potential to create vapor intrusion concerns has indicated that vapor intrusion is very unlikely to be a complete pathway given a certain set of conditions (Davis 2010; CSWRCB, 2010; API, 2009). An extensive Petroleum Vapor Database of paired groundwater and soil gas sampling results for over 100 locations (focusing primarily on benzene and total petroleum hydrocarbon (TPH) constituents like naphthalene) was analyzed to identify trends in the empirical attenuation of these constituents during upward migration under different conditions. A "low strength source" scenario was identified for which the vapor intrusion pathway for these constituents was empirically determined to not be complete. This case reflects a source that is dissolved constituents in groundwater with less than 1,000 micrograms per liter (µg/L) of benzene and less than10,000 µg/L of TPH that is overlain by 5 feet of clean soil in the vadose zone.

A detailed evaluation was made of data for sites with buildings with slab-on-grade construction and sites where sampling was performed very near and adjacent to the structures. The results showed that sand in the vadose zone created the best conditions for biodegradation and constituent attenuation, followed by silt and silty clay in the vadose zone. This is due, in part, to the combination of the ability of the sand to allow oxygen to penetrate deeper into the soil column and the sand providing a suitable matrix for microbes to grow on. Significant biodegradation rates for benzene in the soil column were seen from the data (leading to attenuation of these constituents by approximately two orders of magnitude). Pre-operational conditions at OU-5 match the conditions specified for a "low strength dissolved groundwater

source" at almost all locations, which would suggest that the vapor intrusion pathway for these constituents would not be complete for the majority of the site. Those locations that would not meet the "low strength dissolved groundwater source" definition based on the pre-operations characterization data are clustered in the area of the Shinsei Gardens Housing Development which was constructed with a vapor barrier and sub-slab depressurization foundation design. As such, the recently published research on vapor intrusion pathway completeness appears to be borne out by the characterizations and assessments performed for this site.

B-7. References

API. Simulating the Effect of Aerobic Biodegradation on Soil Vapor Intrusion into Buildings, Evaluation of Low Strength Sources Associated with Dissolved Gasoline Plumes. API Publication 4775. April.

CSWRCB (California State Water Resources Control). 2010. Board Draft for Public Comment Leaking Underground Fuel Tank Guidance Manual Version 2.0 – October 4.

Davis, R.V. 2010. Evaluating the Petroleum Vapor Intrusion Pathway – Studies of Natural Attenuation of Subsurface Petroleum Hydrocarbons & Recommended Screening Criteria. Robin V. Davis, Utah Department of Environmental Quality, Presentation at the 22nd Annual National Tanks Conference, Vapor Intrusion Workshop, Boston, MA. September 19.

TABLES

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TABLE B-1

RANGE OF VADOSE ZONE SOIL COLUMN STRATIGRAPHIES

CLAY PATTERN 1

	AA1 Figure 2		AA2 Figure 2		AA3 Figure 2		BB1 Figure 3		BB2 Figure 3		CC1 Figure 4		CC2 Figure 4		GG1 Figure 8		GG2 Figure 8		GG3 Figure 8	
	Thickness (cm)	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**
Soil Stratum A	91.44	Sand	121.92	Sand	106.68	Sand	106.68	Silty Sand	106.68	Sand	91.44	Silty Sand	121.92	Sand	91.44	Silt	91.44	Silty Sand	91.44	Silty Sand
Soil Stratum B	45.72	Silt	45.72	Clay	91.44	Clay	45.72	Clay	45.72	Clay	60.96	Clay	60.96	Clay	30.48	Clay	91.44	Clay	121.92	Clay
Soil Stratum C	15.24	Sand	76.2	Sand	45.72	Sand	45.72	Sand	76.2	Sand	45.72	Silty Sand	30.48	Sand	60.96	Sand	60.96	Sand	60.96	Sand
Sum A+B+C (cm)	152.4		243.84		243.84		198.12		228.6		198.12		213.36		182.88		243.84		274.32	
Depth to GW (cm)	152.4		243.84		243.84		198.12		228.6		198.12		213.36		182.88		243.84		274.32	

CLAY PATTERN 2

	DD1 Figure 5		DD2 Figure 5		EE1 Figure 6		EE2 Figure 6		EE3 Figure 6		FF1 Figure 7		FF2 Figure 7		FF3 Figure 7		HH1 Figure 8		HH2 Figure 9		HH3 Figure 9	
	Thickness (cm)	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**	**Thickness (cm)**	**Soil Type**
Soil Stratum A	91.44	Silty Sand	106.68	Silty Sand	60.96	Silty Sand	121.92	Silty Sand	152.4	Silty Sand	152.4	Gravel	76.2	Silt	60.96	Silty Gravel	121.92	Clayey Gravel	152.4	Gravel	137.16	Gravel
Soil Stratum B	137.16	Sand	152.4	Sand	60.96	Silt	106.68	Sand	45.72	Sand	60.96	Clay	91.44	Clay	91.44	Clay	45.72	Clay	45.72	Clay	152.4	Clay
Soil Stratum C	91.44	Clay	30.48	Clay	106.68	Clay	106.68	Clay	91.44	Clay												
Sum A+B+C (cm)	320.04		289.56		228.6		335.28		289.56		213.36		167.64		152.4		167.64		198.12		289.56	
Depth to GW (cm)	320.04		289.56		228.6		335.28		289.56		213.36		167.64		152.4		167.64		198.12		289.56	

Notes:
Soil Stratum A is the soil layer at the surface of the ground.
Soil Stratum B is the soil layer between Stratum A and C (if there are 3 soil layers) or the soil layer directly above the groundwater table (if there are only 2 soil layers at that location).
Soil Stratum C is the soil layer directly above the groundwater table

Abbreviations and Acronyms:
cm – centimeter
GW – groundwater

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TABLE B-2
PRE-OPERATION HYDROPUNCH GROUNDWATER SAMPLING RESULTS FOR SAMPLES COLLECTED AT VARIOUS DEPTHS IN THE FWBZ

Location Code	Start Depth (ft)	End Depth (ft)	Collection Date	Benzene (µg/L)	Naphthalene (µg/L)
PC1-1	12	15	8/6/2007	170	2800
PC1-1	16	19	8/6/2007	0.46 J	6.8
PC1-2	11	14	8/1/2007	82	4300
PC1-3	12	15	7/31/2007	540	5,100 J
PC1-3A	12	15	8/21/2007	460	2000
PC1-3B	12	15	8/21/2007	73	4300
PC1-3C	12	15	8/21/2007	150	330
PC1-3D	12	15	8/24/2007	18	64
PC1-3E	12	15	8/29/2007	0.21 J	7.1
PC1-4	12	15	8/21/2007	1000	3900
PC1-4	15	18	8/21/2007	700	3300
PC1-4A	12	15	9/11/2007	200	2000
PC1-4A	15	18	9/11/2007	0.45 J	13
PC1-4B	12	15	9/11/2007	190	4300
PC1-4B	15	18	9/11/2007	39	490
PC2-1	6.5	9.5	7/31/2007	1.7	1.2 J
PC2-1	12	15	7/31/2007	170	1,500 J
PC2-1	14.5	17.5	7/26/2007	580	9600
PC2-2	15	18	7/26/2007	180	5700
PC2-2A	15	18	8/2/2007	870	9500
PC2-3	8	11	7/27/2007	0.50 U	0.64 J
PC2-3	11	14	7/27/2007	1800	6,100 J
PC2-4	12	15	8/31/2007	0.50 U	2.0 U
PC2-4	16	19	8/31/2007	160	1800
PC2-5	18	21	7/30/2007	2600	5500
PC2-5A	18	21	8/20/2007	78	420
PC2-6	11.5	14.5	8/1/2007	0.50 U	2.3
PC2-6	15	18	8/1/2007	490	4400
PC2-6A	4.5	17.5	8/29/2007	300	5300
PC2-7	14	17	7/30/2007	740	5800
PC2-7A	14	17	8/6/2007	420	3500
PC2-8	16.5	19.5	7/30/2007	680	4000
PC2-8 (Duplicate)	16.5	19.5	7/30/2007	680	5500
PC2-9	15	18	7/27/2007	710	4,100 J
PC2-10	13	16	8/6/2007	31	770
PC3-1	18	21	7/19/2007	4500	17000

TABLE B-2
PRE-OPERATION HYDROPUNCH GROUNDWATER SAMPLING RESULTS FOR SAMPLES COLLECTED AT VARIOUS DEPTHS IN THE FWBZ

Location Code	Start Depth (ft)	End Depth (ft)	Collection Date	Benzene (µg/L)	Naphthalene (µg/L)
PC3-1A	18	21	7/24/2007	1600	6200
PC3-2	18	21	7/19/2007	1300	5500
PC3-2A	18	21	7/24/2007	1200	3100
PC3-3	17	20	7/19/2007	1600	5300
PC3-3A	17	20	7/24/2007	1900	8400
PC3-3B	17	20	8/24/2007	10	1500
PC3-4	12.5	13.5	7/20/2007	0.50 U	0.68 J
PC3-4	14.5	17.5	7/20/2007	1300	5800
PC3-4A	14.5	17.5	7/25/2007	310	780
PC3-5	16.5	19.5	7/20/2007	400	12000
PC3-5A	17	20	7/25/2007	28	2100
PC3-5A (Duplicate)	17	20	7/25/2007	14	1600
PC3-6	17	19	7/23/2007	15	3600
PC3-6 (Duplicate)	17	19	7/23/2007	14	2200
PC3-7A	20	23	7/23/2007	360	5100
PC3-8	17	20	7/24/2007	230	2700
PC3-9	12	15	7/24/2007	5.1	12
PC3-10	14	17	7/25/2007	84	1600
PC3-11	12	15	7/25/2007	410	1300
PC3-12	13	16	8/2/2007	34	33
PC3-13	12	15	8/3/2007	8.1	660
PC3-13 (Duplicate)	12	15	8/3/2007	6.7	500
PC3-13	15	18	8/3/2007	730	7300
PC3-14	6	9	8/7/2007	0.50 U	2.0 U
PC3-14	12.5	15.5	8/7/2007	90	390

Notes:

Location Codes with an A, B, C, D, or E are stepout locations from the original sampling location.

Abbreviations and Acronyms:

µg/L – micrograms per liter
ft – foot
FWBZ – first water bearing zone
J – estimated value
U – not detected at the listed quantitation limit

FIGURES

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OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 3-5

SOIL GAS
SAMPLING LOCATIONS

APPENDIX C

ANALYSIS OF THE POTENTIAL RISKS ASSOCIATED WITH THE VAPOR INTRUSION PATHWAY

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APPENDIX C

ANALYSIS OF THE POTENTIAL RISKS ASSOCIATED WITH THE VAPOR INTRUSION PATHWAY

RI/FS Projections of Indoor Air Risk Based on the Soil Gas Sampling Results

The Groundwater RI/FS for Alameda Point Site 25 and Alameda Annex IR-02 (ERRG 2004) compiled and evaluated the soil gas data that had been collected for the site up to that time. This site is now referred to as Operable Unit 5/FISCA IR-02 Groundwater. This information was summarized in Table 4-3 of that Report. As part of that RI/FS, a human health risk assessment was performed to evaluate the potential risks to human health posed by chemicals detected in the groundwater. For the residential exposure scenario, the volatilization of groundwater contaminants into soil gas, that then migrate into indoor air, was estimated using the Johnson and Ettinger (J&E) model as modified by DTSC to include Cal/EPA toxicity criteria (ERRG 2004).

To test the validity of this assessment of the potential vapor intrusion risks from groundwater to indoor air, a second risk assessment (line of evidence) was performed using actual soil gas measurements at the source term in the modeling rather than the groundwater concentrations with some projected volatilization. The RI/FS Report noted that the measured benzene concentrations in the soil gas were lower than were predicted by the J&E modeling. In addition, the measured benzene soil gas concentrations were higher at Alameda Annex than they were at Alameda Point. As such, separate indoor air inhalation risk calculations were performed for the two areas in the RI. Table 6-2 from the RI/FS Report (ERRG 2004) (reproduced and included in this appendix following the text) presents the results of those vapor intrusion exposure pathway risk calculations for residents, school workers, and school students.

Under the Reasonable Maximum Exposure (RME) scenario, the noncarcinogenic Hazard Indices (HIs) ranged from 0.0076 to 0.0092 across both locations. These values were all well below the acceptable HI threshold of 1.0. The RME results for the incremental lifetime cancer (carcinogenic) risk (ILCR) ranged from 5×10^{-8} to 1×10^{-6}. All of these values are less than the ILCR target risk range of 10^{-6} to 10^{-4}. The Alameda Annex result for the resident was at the lower (most stringent) end of this range. These results indicated no unacceptable risks to the residents, school workers, or students due to vapor intrusion.

Additional Projections of Indoor Air Risk Based on the Soil Gas Sampling Results

Two evaluations were performed to assess the existing data using a more recent DTSC approach. First, the air sampling that has been performed in crawl spaces (Tetra Tech 2002) (i.e., in the North Housing and Kollmann Circle developments) was used to project indoor air concentrations using the conservative DTSC crawl space-to-indoor air attenuation factor of 1.0 (DTSC 2011). Applying this attenuation factor means that the crawl space air is assumed to be identical to the indoor air with no additional attenuation in contaminant concentrations as the air penetrates the building.

Four crawl spaces were sampled at the North Coast Guard Housing area, and eight were sampled at the Kollmann Circle development in the spring of 2002 (see Figure C-1, reproduced from Figure 6 of the Residential Risk Evaluation for U.S. Coast Guard Housing [Tetra Tech 2002]). Table C-1 shows the results of this sampling. Only benzene detections were reported (i.e., no naphthalene). Table C-1 also shows the results of applying the DTSC default crawl space attenuation factor to project an indoor air concentration for these structures. Table C-1 also shows results from concurrent sampling of indoor and outdoor air. Table C-1 then shows the conversion of the projected indoor air concentration to the time-weighted exposure concentration used by DTSC for inhalation risk assessments for carcinogens and noncarcinogens (DTSC 2011). Lastly, the DTSC toxicity criteria for benzene were applied to this exposure concentration to calculate the projected indoor air inhalation ILCRs and noncancer Hazard Quotients (HQs) for benzene (DTSC 2012b). Results in the last two columns of Table C-1 indicate that all 12 of the sampled residences with crawl spaces had projected HQs much less than 1.0, and all the sampled residences had projected ILCRs within the target risk range of 10^{-6} to 10^{-4}. The projected indoor air inhalation ILCRs were 10^{-6} for all except four residences, where the risk was 10^{-5}. These results serve as one line of evidence for verifying the RI/FS risk assessment findings.

A second evaluation was performed using a similar vapor migration and risk assessment approach with the broader set of soil gas measurements made across the site in June of 2001. Soil gas sampling was attempted at 32 locations spread throughout the site (see Figure C-2, reproduced from Figure 3-5 of the OU-5 RI Report [Neptune et al. 2002]). When possible, soil gas was collected from two depths: 2 feet and approximately 5 feet below ground surface (bgs). The samples were collected in 6-liter Summa® canisters and analyzed for volatile organic compounds and naphthalene by U.S. Environmental Protection Agency (EPA) Method TO-14A. Further details of the sampling procedure and approach used in the investigation are presented in Section 3.4.3.2 of the OU-5 RI Report (Neptune et al. 2002). Tables C-2B and C-2N present the results of that soil gas sampling for benzene and naphthalene, respectively. Tables C-2B and C-2N also show the results of applying the default DTSC attenuation factor for existing residential buildings (i.e., 0.002 [DTSC 2011]) to project benzene and naphthalene indoor air concentrations for each soil gas sampling location. The higher of the indoor air concentrations projected from the soil gas from 2 feet bgs and approximately 5 feet bgs was then conservatively taken as the projected indoor air concentration for that location. Tables C-2B and C-2N then show the conversion of the indoor air concentrations to the time-weighted exposure concentrations used by DTSC for inhalation risk assessments for carcinogens and noncarcinogens (as noted above). Lastly, the DTSC toxicity criteria for benzene and naphthalene were applied to calculate the projected indoor air inhalation ILCRs and noncancer HQs for both constituents (DTSC 2012a). The results are shown in the last two columns of Tables C-2B and C-2N.

With respect to benzene, Table C-2B shows that all the projected HQs were many orders of magnitude below the threshold of 1.0 and all the residences had projected ILCRs that were lower than the lowest endpoint of the target risk range of 10^{-6} to 10^{-4}. The RME results for the projected benzene ILCRs ranged from 4.8×10^{-8} to 4.8×10^{-7}. With respect to naphthalene, Table C-2N also shows that all the projected HQs were well below 1.0, and 28 of the 32 locations had projected

ILCRs that were lower than the lowest endpoint of the target risk range of 10^{-6} to 10^{-4}. The remaining four locations had projected ILCRs of 10^{-6}, the lowest endpoint of the target risk range. The RME results for the projected naphthalene ILCRs ranged from 5.6×10^{-8} to 5.0×10^{-6}. These results serve as another line of evidence for verifying the RI/FS risk assessment findings.

In summary, the findings of the RI/FS risk assessment of potential vapor intrusion are supported by current evaluations performed based on recent DTSC criteria using the collected crawl space and widespread soil gas data from multiple depths. As such, this additional analysis provides further support for the RI/FS conclusion that there are no unacceptable risks to the residents, school workers, or students at the site as the result of vapor intrusion.

RI/FS Projections of Indoor Air Risk Based on All Available Multi-Depth Groundwater Sampling Results

As noted above, the Groundwater RI/FS for Alameda Point Site 25 and Alameda Annex IR-02 (ERRG 2004) included a human health risk assessment that evaluated various potential pathways, including the volatilization of groundwater constituents into soil gas, which then could migrate into indoor air. The vapor intrusion evaluation was built on migration modeling using the J&E model as modified by DTSC to include Cal/EPA toxicity criteria (ERRG 2004). The default chemical properties provided in the J&E model were used when available. A default slab-on-grade residential structure was assumed. A depth to groundwater of 7.2 feet was modeled using soil properties taken from site-specific boring logs for the vadose zone. The RI/FS risk assessment (Final RI/FS Report, Section 6, page 6-1) included use of HydroPunch® data from samples collected at approximately 20 feet bgs (ERRG 2004). The Final RI/FS Report further documented (Section 6.4, page 6-6) that in both Tier 1 and Tier 2 analyses, exposure point concentration data included data from all depths at both Alameda Point and FISCA. Table 6-1 from that RI/FS (ERRG 2004), reproduced and included in this appendix following the text, presents the results of calculations for all noningestion pathways, as well as the hypothetical potable water usage, for various receptors, including residents, school workers, and students. Results for the resident, school worker, and student for the "Assuming No Domestic Potable Water Use" reflect the potential risks to these receptors from the vapor intrusion exposure pathway as projected using the groundwater contaminant concentrations as the source to the J&E modeling.

As can be seen for the nondomestic potable water use scenario, the projected HI (with contributions for all constituents in the groundwater) was calculated to be 0.29 for the resident, the school worker, and the student. Two different data kriging approaches (using different kriging radii) were used to obtain representative exposure point groundwater concentrations for this assessment. The projected HI of 0.29 was less than the threshold value of 1.0. For the nondomestic potable water use scenario, the RME results for the projected indoor air inhalation ILCRs from vapor intrusion from groundwater ranged from 2×10^{-6} for the student to 1×10^{-5} for the resident. Most of these results were due to benzene given the toxicity criteria used in the assessment. All of these ILCR estimates were within the target risk range of 10^{-6} to 10^{-4}. The Final RI/FS Report (ERRG 2004) concluded "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

Projections of Indoor Air Risk Based on the At/Near Water Table Groundwater Sampling Results

An independent evaluation was performed to verify the RI/FS results by applying a more current DTSC assessment approach to the available data. This evaluation was made by performing location-specific vapor intrusion modeling using the J&E model with all the DTSC toxicity and default input parameter adjustments for a slab-on-grade residential structure (DTSC 2012b). In addition, the modeling used only the groundwater concentrations measured across the site from the depth interval at or near the local water table. This selection of groundwater sampling results is supported by the fact that the groundwater concentrations at the water table dictate the volatilization of the dissolved constituents out of the liquid phase and into the soil gas (DTSC 2011).

Table C-3 lists the groundwater sampling results for benzene and naphthalene for this subset of the groundwater sampling locations where the sample was collected from as close to the water table as possible. Data from the summer of 2001 (Neptune et al. 2002) and 2007 (Tetra Tech 2010) are presented. Table C-3 lists the sampling location and the approximate sample depth, followed by the measured concentrations.

Thirty-seven locations had groundwater samples drawn from appropriate depth intervals to potentially capture groundwater at or near the water table. The locations of the 2001 samples are displayed on Figure C-3 (reproduced from Figure 3-4 of the Operable Unit 5 RI Report [Neptune et al. 2002]). The locations of the 2007 samples are displayed on Figure C-4 (reproduced from Figure 3-6 of the Remedial Design/Remedial Action Work Plan [Tetra Tech 2010]). Of these, 16 locations were nondetect for both benzene and naphthalene. An additional 14 locations were nondetect for benzene but reported a low concentration for naphthalene. Only 7 of the 37 locations had detected concentrations for both benzene and naphthalene. These cases were reviewed to identify those with a higher likelihood to result in potential vapor intrusion either because the reported groundwater concentrations were higher, the vadose zone at that location consisted of more permeable material, or the vadose zone was thinner. Based on this review, four locations were judged to warrant verification modeling: OS-HP2, OS-HP-10, PC2-1, and PC3-13. Table C-4 shows the measured groundwater concentrations at these four locations and the composition of the local vadose zone soil.

For purposes of comparison, the projected indoor air inhalation RME risks for each case were estimated using both the EPA Integrated Risk Information System (IRIS) toxicity criteria (EPA 2012) and the DTSC toxicity criteria (DTSC 2012a). Table C-5 shows the results of these calculations. For each of the four highlighted water table groundwater sampling locations (which represent the locations with conditions that potentially could result in vapor intrusion), Table C-5 lists the sampling date, the effective groundwater-to-indoor air attenuation factors for benzene and naphthalene, and the projected ILCRs and noncancer HQs for both constituents. Results are shown separately for the two sets of toxicity criteria.

As can be seen, DTSC considers naphthalene to be a carcinogen while IRIS does not. In addition, there are differences in the values of the remaining Unit Risk Factors and Reference Concentrations for these chemicals between the two sources. It should be noted that the most conservative value

from the range of Unit Risk Factors for benzene reported in IRIS was used in these projections. Once again, all the projected HQs for both chemicals were less than the HQ threshold value of 1.0. Specifically, all HQs for benzene were less than 0.010 using both DTSC and IRIS criteria, except for one location where the maximum HQ for benzene was 0.016. All HQs for naphthalene were less than 0.10 using both DTSC and IRIS criteria, except for one location where the maximum HQ for naphthalene was 0.81. Using IRIS toxicity criteria, the projected RME ILCRs for benzene were 10^{-7} except at one location, where the ILCR was 1.6×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for benzene ranged from 6.9×10^{-7} to 6.0×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for naphthalene ranged from 7.9×10^{-8} to a maximum of 3.6×10^{-5}.

All the projected RME ILCRs using both DTSC and IRIS criteria for both benzene and naphthalene were within or below the target risk range of 10^{-6} to 10^{-4}. Accordingly, even these individual locations with conditions that potentially would best promote vapor migration do not indicate an unacceptable indoor air inhalation risk. It should also be noted that the majority of the water table sampling results for these locations were non-detect for these constituents.

Summary

The RI/FS risk assessment evaluated multiple pathways, including vapor intrusion, using groundwater data from multiple depths down to 20 feet bgs and soil gas data (ERRG 2004). All HQs were less than 1 for all evaluations. Using soil gas data, the RI/FS vapor intrusion risk assessment estimated RME ILCRs ranging from 5×10^{-8} to 1×10^{-6} for residents and from 5×10^{-8} to 8×10^{-7} for school receptors. Using groundwater data from all depths, the RI/FS RME ILCR results were in the risk management range. The Final RI/FS Report (ERRG 2004) concluded "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

The findings of the RI/FS risk assessment of potential vapor intrusion are supported by subsequent evaluations performed using the current DTSC approach and the collected crawl space air and soil gas data from multiple depths over a widespread area. Using the more recent DTSC approach and the soil gas data, subsequent vapor intrusion evaluations presented in this appendix estimated the RME ILCR for benzene to range from 4.8×10^{-8} to 4.8×10^{-7} and for naphthalene to range from 5.6×10^{-8} to 5.0×10^{-6} across the site.

Additional evaluations presented in this appendix were performed using groundwater data collected near the water table, an approach that is recommended for use in vapor intrusion evaluations by current guidance. The groundwater at these depths shows much lower benzene and naphthalene concentrations than the data used in the RI/FS vapor intrusion risk assessment that were from depths considerably below the water table. Benzene and naphthalene were both detected at only 7 of 37 locations in the more recent water table data. Four of these locations were chosen for further vapor intrusion evaluation because they had the characteristics most likely to promote vapor migration and higher potential indoor air concentrations. Using IRIS toxicity criteria, the projected RME ILCRs for benzene at these locations were 10^{-7} except at one location, where the ILCR was 1.6×10^{-6}.

Using DTSC toxicity criteria, the projected RME ILCRs for benzene at these individual locations ranged from 6.9×10^{-7} to 6.0×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for naphthalene at these individual locations ranged from 7.9×10^{-8} to a maximum of 3.6×10^{-5}. All HQs were less than 1 for all evaluations based on groundwater. These results serve as another line of evidence for verifying the RI/FS risk assessment findings.

References

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——————. 2012a. OEHHA Toxicity Criteria Database. Department of Toxic Substances Control, California Environmental Protection Agency. http://www.dtsc.ca.gov/AssessingRisk /JE_Models.cfm.

——————. 2012b. Johnson and Ettinger Models. Department of Toxic Substances Control, California Environmental Protection Agency. http://oehha.ca.gov/tcdb/index.asp.

EPA (U.S. Environmental Protection Agency). 2012. Integrated Risk Information System (IRIS) Database. http://www.epa.gov/IRIS/.

ERRG (Engineering/Remediation Resources Group, Inc.). 2004. Final Groundwater Remedial Investigation/Feasibility Study (RI/FS) for Alameda Point Site 25 and Alameda Annex IR-02. Prepared for the U.S. Department of the Navy, Naval Facilities Engineering Command – Southwest Division. October.

Neptune and Company, Inc., IT Corporation, ENVIRON. 2002. Draft Final Operable Unit 5 Remedial Investigation Report for Alameda Point, Alameda, CA – Volumes I and II, Prepared for the U.S. Department of the Navy, Naval Facilities Engineering Command – Southwest Division. July.

TtEC (Tetra Tech EC, Inc.). 2002. Residential Risk Evaluation for U.S. Coast Guard Housing, Alameda, California, Prepared for the U.S. Coast Guard, Civil Engineering Unit Oakland. August.

——————. 2010. Final Remedial Design/Remedial Action Work Plan for Operable Unit 5/ IR-02 Groundwater, Alameda Point and FISCA, Alameda, California, Revision 2. Prepared for the Department of the Navy, Base Realignment and Closure, Program Management Office West. December.

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TABLES

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TABLE 6-2

SUMMARY OF TIER 2 HHRA RESULTS MODELED FROM SOIL GAS DATA ALAMEDA POINT SITE 25/ALAMEDA ANNEX IR-02 GROUNDWATER RI/FS

Exposure Scenario	Location	Noncarcinogenic Hazard Index		Carcinogenic Risk	
		Average Exposure	Reasonable Maximum Exposure	Average Exposure	Reasonable Maximum Exposure
Assuming No Domestic Potable Water Use					
Resident	Alameda Annex	0.0092	0.0092	1×10^{-6}	1×10^{-6}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}
School Worker	Alameda Annex	0.0087	0.0087	8×10^{-7}	8×10^{-7}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}
School Student	Alameda Annex	0.0084	0.0084	2×10^{-7}	2×10^{-7}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}

Source: Reproduced from ERRG 2004

Abbreviations and Acronyms:
HHRA – human health risk assessment
IR – Installation Restoration (Program)

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Table C-1
Projection of Indoor Air Inhalation Risk Due to Benzene from Crawl Space Air Sampled in February/April 2002

Housing Area	Address	Sample Type	Benzene Concentration [1] (mg/m^3)	Benzene Concentration ($\mu g/m^3$)	DTSC Existing Residential Structures with Crawl Spaces Attenuation Factor [2] (unitless)	Projected Benzene Indoor Air Concentration From Crawl Space Air ($\mu g/m^3$)	*Measured Benzene Indoor Air Concentration ($\mu g/m^3$)*	*Measured Benzene Outdoor Air Concentration ($\mu g/m^3$)*	Projected Benzene Indoor Air Exposure Concentration from Crawl Space Air [3] (Carcinogens) ($\mu g/m^3$)	Projected Benzene Indoor Air Exposure Concentration from Crawl Space Air [3] (Non-Carcinogens) ($\mu g/m^3$)	Projected Benzene Indoor Air from Crawl Space Cancer Risk [4] (unitless)	Projected Benzene Indoor Air from Crawl Space Hazard Quotient [4] (unitless)
North Housing	103 F Singleton	Crawl Space	1.10E-03	1.10E+00	1.0	1.1E+00	*2.6E+00*	*2.6E+00*	4.5E-01	1.1E+00	1.3E-05	1.76E-02
North Housing	2000 D Mayport	Crawl Space	2.70E-03	2.70E+00	1.0	2.7E+00	*3.9E+00*	*5.2E+00*	1.1E+00	2.6E+00	3.2E-05	4.32E-02
North Housing	2004 D Mayport	Crawl Space	2.40E-03	2.40E+00	1.0	2.4E+00	*2.9E+00*	*2.8E+00*	9.9E-01	2.3E+00	2.9E-05	3.84E-02
North Housing	2006 E Mayport	Crawl Space	1.80E-03	1.80E+00	1.0	1.8E+00	*4.6E+00*	*3.1E+00*	7.4E-01	1.7E+00	2.1E-05	2.88E-02
Kollmann Circle	2000 A Kollmann	Crawl Space	6.50E-04	6.50E-01	1.0	6.5E-01	*5.9E-01*	*Not Measured*	2.7E-01	6.2E-01	7.7E-06	1.04E-02
Kollmann Circle	2000 E Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*8.8E-01*	*Not Measured*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2002 C Kollmann	Crawl Space	4.60E-04	4.60E-01	1.0	4.6E-01	*6.5E-01*	*Not Measured*	1.9E-01	4.4E-01	5.5E-06	7.35E-03
Kollmann Circle	2004 C Kollmann	Crawl Space	4.60E-04	4.60E-01	1.0	4.6E-01	*5.2E-01*	*Not Measured*	1.9E-01	4.4E-01	5.5E-06	7.35E-03
Kollmann Circle	2006 B Kollmann	Crawl Space	6.50E-04	6.50E-01	1.0	6.5E-01	*5.2E-01*	*Not Measured*	2.7E-01	6.2E-01	7.7E-06	1.04E-02
Kollmann Circle	2006 E Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*5.5E-01*	*4.9E-01*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2008 D Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*5.9E-01*	*Not Measured*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2010 C Kollmann	Crawl Space	5.20E-04	5.20E-01	1.0	5.2E-01	*6.2E-01*	*Not Measured*	2.1E-01	5.0E-01	6.2E-06	8.31E-03
										Minimum	**5.5E-06**	**7.4E-03**
										Maximum	**3.2E-05**	**4.3E-02**

Sources:

[1] Residential Risk Evaluation for U.S. Coast Guard Housing, Alameda, CA, August 2002, Table 10

[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors, Existing Residential Structures: Crawl Space Air Samples

[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure Concentrations and Assumptions, Page C-3

[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations

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Table C-2B
Projection of Indoor Air Inhalation Risk Due to Benzene from Soil Gas Sampled in June 2001

Soil Gas Sampling Location [June 2001]	Benzene Concentration @ 2' bgs [1] (µg/m^3)	Benzene Concentration @ 5' bgs [1] (µg/m^3)	DTSC Existing Residential Building Attenuation Factor [2] (unitless)	Projected Benzene Indoor Air Concentration From SG @ 2' bgs (µg/m^3)	Projected Benzene Indoor Air Concentration From SG @ 5' bgs (µg/m^3)	Maximum Projected Benzene Indoor Air Concentration From SG (µg/m^3)	Maximum Projected Benzene Indoor Air Exposure Concentration [3] (Carcinogens) (µg/m^3)	Maximum Projected Benzene Indoor Air Exposure Concentration [3] (Non-Carcinogens) (µg/m^3)	Maximum Projected Benzene Indoor Air Cancer Risk [4] (unitless)	Maximum Projected Benzene Indoor Air Hazard Quotient [4] (unitless)
OU5-SG1	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG2	NS	3.1	0.002	NS	0.0062	0.0062	0.0025	0.0059	7.4E-08	9.91E-05
OU5-SG3	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG4	6.8	5.2	0.002	0.0136	0.0104	0.0136	0.0056	0.0130	1.6E-07	2.17E-04
OU5-SG5	3.0	NS	0.002	0.0060	NS	0.0060	0.0025	0.0058	7.2E-08	9.59E-05
OU5-SG6	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG7	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG8	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG9	4.4	NS	0.002	0.0088	NS	0.0088	0.0036	0.0084	1.0E-07	1.41E-04
OU5-SG10	NA	13	0.002	NA	0.0260	0.0260	0.0107	0.0249	3.1E-07	4.16E-04
OU5-SG11	<2	<2	0.002	0.0040	0.0040	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG12	7.2	<2	0.002	0.0144	0.0040	0.0144	0.0059	0.0138	1.7E-07	2.30E-04
OU5-SG13	6.6	NS	0.002	0.0132	NS	0.0132	0.0054	0.0127	1.6E-07	2.11E-04
OU5-SG14	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG15	3.1	NS	0.002	0.0062	NS	0.0062	0.0025	0.0059	7.4E-08	9.91E-05
OS-SG1	20	NS	0.002	0.0400	NS	0.0400	0.0164	0.0384	4.8E-07	6.39E-04
OS-SG2	<10	NS	0.002	0.0200	NS	0.0200	0.0082	0.0192	2.4E-07	3.20E-04
OS-SG3	5.1	<2	0.002	0.0102	0.0040	0.0102	0.0042	0.0098	1.2E-07	1.63E-04
OS-SG4	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG5	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG6	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG7	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG8	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG9	8.0	<2	0.002	0.0160	0.0040	0.0160	0.0066	0.0153	1.9E-07	2.56E-04
OS-SG10	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG11	4.4	3.9	0.002	0.0088	0.0078	0.0088	0.0036	0.0084	1.0E-07	1.41E-04
OS-SG12	3.9	14	0.002	0.0078	0.0280	0.0280	0.0115	0.0268	3.3E-07	4.47E-04
OS-SG13	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG14	4.9	15	0.002	0.0098	0.0300	0.0300	0.0123	0.0288	3.6E-07	4.79E-04
OS-SG15	4.3	NS	0.002	0.0086	NS	0.0086	0.0035	0.0082	1.0E-07	1.37E-04
OS-SG16	2.5	10	0.002	0.0050	0.0200	0.0200	0.0082	0.0192	2.4E-07	3.20E-04
OS-SG17	3.2	NS	0.002	0.0064	NS	0.0064	0.0026	0.0061	7.6E-08	1.02E-04
								Minimum	**4.8E-08**	**6.4E-05**
								Maximum	**4.8E-07**	**6.4E-04**

Sources:

[1] Operable Unit 5 Remedial Investigation Report, Alameda Point, Alameda, CA Draft Final, July 12, 2002: Appendix D remedial Investigation Data Tables, Table D-3

[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors, Existing Residential Structures

[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure Concentrations and Assumptions, Page C-3

[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations

NS No sample attempted or no recovery

NA Constituent not analyzed

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Table C-2N
Projection of Indoor Air Inhalation Risk Due to Naphthalene from Soil Gas Sampled in June 2001

Soil Gas Sampling Location [June 2001]	Naphthalene Concentration @ 2' bgs [1] ($\mu g/m^3$)	Naphthalene Concentration @ 5' bgs [1] ($\mu g/m^3$)	DTSC Existing Residential Building Attenuation Factor [2] (unitless)	Projected Naphthalene Indoor Air Concentration From SG @ 2' bgs ($\mu g/m^3$)	Projected Naphthalene Indoor Air Concentration From SG @ 5' bgs ($\mu g/m^3$)	Maximum Projected Naphthalene Indoor Air Concentration From SG ($\mu g/m^3$)	Maximum Projected Naphthalene Indoor Air Exposure Concentration [3] (Carcinogens) ($\mu g/m^3$)	Maximum Projected Naphthalene Indoor Air Exposure Concentration [3] (Non-Carcinogens) ($\mu g/m^3$)	Maximum Projected Naphthalene Indoor Air Cancer Risk [4] (unitless)	Maximum Projected Naphthalene Indoor Air Hazard Quotient [4] (unitless)
OU5-SG1	21	NS	0.002	0.0420	NS	0.0420	0.0173	0.0403	5.9E-07	4.47E-03
OU5-SG2	NS	17	0.002	NS	0.0340	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG3	22	NS	0.002	0.0440	NS	0.0440	0.0181	0.0422	6.1E-07	4.69E-03
OU5-SG4	54	42	0.002	0.1080	0.0840	0.1080	0.0444	0.1036	1.5E-06	1.15E-02
OU5-SG5	9.1	NS	0.002	0.0182	NS	0.0182	0.0075	0.0175	2.5E-07	1.94E-03
OU5-SG6	14	NS	0.002	0.0280	NS	0.0280	0.0115	0.0268	3.9E-07	2.98E-03
OU5-SG7	18	NS	0.002	0.0360	NS	0.0360	0.0148	0.0345	5.0E-07	3.84E-03
OU5-SG8	9.3	NS	0.002	0.0186	NS	0.0186	0.0076	0.0178	2.6E-07	1.98E-03
OU5-SG9	2.1	NS	0.002	0.0042	NS	0.0042	0.0017	0.0040	5.9E-08	4.47E-04
OU5-SG10	NA	4.3	0.002	NA	0.0086	0.0086	0.0035	0.0082	1.2E-07	9.16E-04
OU5-SG11	24	31	0.002	0.0480	0.0620	0.0620	0.0255	0.0595	8.7E-07	6.61E-03
OU5-SG12	17	14	0.002	0.0340	0.0280	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG13	17	NS	0.002	0.0340	NS	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG14	12	NS	0.002	0.0240	NS	0.0240	0.0099	0.0230	3.4E-07	2.56E-03
OU5-SG15	8.2	NS	0.002	0.0164	NS	0.0164	0.0067	0.0157	2.3E-07	1.75E-03
OS-SG1	11	NS	0.002	0.0220	NS	0.0220	0.0090	0.0211	3.1E-07	2.34E-03
OS-SG2	<10	NS	0.002	0.0200	NS	0.0200	0.0082	0.0192	2.8E-07	2.13E-03
OS-SG3	7.4	13	0.002	0.0148	0.0260	0.0260	0.0107	0.0249	3.6E-07	2.77E-03
OS-SG4	12	NS	0.002	0.0240	NS	0.0240	0.0099	0.0230	3.4E-07	2.56E-03
OS-SG5	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	5.6E-08	4.26E-04
OS-SG6	18	NS	0.002	0.0360	NS	0.0360	0.0148	0.0345	5.0E-07	3.84E-03
OS-SG7	3.6	NS	0.002	0.0072	NS	0.0072	0.0030	0.0069	1.0E-07	7.67E-04
OS-SG8	4.7	NS	0.002	0.0094	NS	0.0094	0.0039	0.0090	1.3E-07	1.00E-03
OS-SG9	17	28	0.002	0.0340	0.0560	0.0560	0.0230	0.0537	7.8E-07	5.97E-03
OS-SG10	14	NS	0.002	0.0280	NS	0.0280	0.0115	0.0268	3.9E-07	2.98E-03
OS-SG11	13	17	0.002	0.0260	0.0340	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OS-SG12	19	38	0.002	0.0380	0.0760	0.0760	0.0312	0.0729	1.1E-06	8.10E-03
OS-SG13	44	NS	0.002	0.0880	NS	0.0880	0.0362	0.0844	1.2E-06	9.38E-03
OS-SG14	13	15	0.002	0.0260	0.0300	0.0300	0.0123	0.0288	4.2E-07	3.20E-03
OS-SG15	19	NS	0.002	0.0380	NS	0.0380	0.0156	0.0364	5.3E-07	4.05E-03
OS-SG16	19	180	0.002	0.0380	0.3600	0.3600	0.1479	0.3452	5.0E-06	3.84E-02
OS-SG17	9.0	NS	0.002	0.0180	NS	0.0180	0.0074	0.0173	2.5E-07	1.92E-03
								Minimum	**5.6E-08**	**4.3E-04**
								Maximum	**5.0E-06**	**3.8E-02**

Sources:

[1] Operable Unit 5 Remedial Investigation Report, Alameda Point, Alameda, CA Draft Final, July 12, 2002: Appendix D remedial Investigation Data Tables, Table D-3
[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors,
[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure
[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations
NS No sample attempted or no recovery
NA Constituent not analyzed

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TABLE 6-1

SUMMARY OF TIER 2 HHRA RESULTS
ALAMEDA POINT SITE 25/ALAMEDA ANNEX IR-02 GROUNDWATER RI/FS

Exposure Scenario	Noncarcinogenic Hazard Index		Carcinogenic Risk	
	Average Exposure	Reasonable Maximum Exposure	Average Exposure	Reasonable Maximum Exposure
Assuming No Domestic Potable Water Use (500-foot radius Kriging)				
Car Wash Worker	0.38	0.99	2×10^{-6}	2×10^{-5}
Landscape Worker	0.66	0.98	3×10^{-6}	3×10^{-5}
Resident	0.29	0.29	1×10^{-5}	1×10^{-5}
School Worker	0.29	0.29	7×10^{-6}	7×10^{-6}
School Student	0.29	0.29	2×10^{-6}	2×10^{-6}
Assuming Domestic Potable Water Use (500-foot radius Kriging)				
Resident	88	145	5×10^{-3}	2×10^{-2}

Source: Reproduced from ERRG 2004

Abbreviations and Acronyms:
HHRA – human health risk assessment
IR – Installation Restoration (Program)

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Table C-3
Summary of Benzene and Naphthalene Groundwater Concentrations from Samples Collected At/Near the Surface of the Water Table at Hydropunch Locations

Hydropunch Sample Location	Sample Depth Interval (feet)	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Sampling Date	Comment	Next Shallowest Sample Depth Interval (feet)
OU5-HP-1	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-2	8-12	2.2	34	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-3	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-4	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-5	12-16	3.8	26	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OU5-HP-6	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-7	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-8	8-12	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-9	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-10	8-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-11	8-12	<1	5	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-12	8-12	<1	14	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-13	8-12	<2	2.3	June - 2001	Sample collected at/nearest the water table	12 - 15
OU5-HP-14	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-15	7-11	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-16	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-17	6-10	<1	2.2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-18	8-12	<2	0.79	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-19	8-12	<2	4.7	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-20	6-10	0.4	27	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-21	8-12	<1	21	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-22	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP1		No Reported Data		June - 2001		
OS-HP2	8-12	41	270	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP3	12-16	<2	0.6	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP4	12-16	12	839	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP5	12-16	7.1	89	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP6	6-10	<1	2.6	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP7	10-14	375	3180	June - 2001	Shallowest sample - Not representative of conditions at the water table	14 - 18
OS-HP8	6-10	<1	4.4	June - 2001	Sample collected at/nearest the water table	11 - 15
OS-HP9	8-12	<1	30	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP10	6-10	4.2	49	June - 2001	Sample collected at/nearest the water table	9 - 13
OS-HP11	8-12	0.49	0.89	June - 2001	Sample collected at/nearest the water table	12 - 16

Hydropunch Sample Location	Sample Depth Interval (feet)	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Sampling Date	Comment	Next Shallowest Sample Depth Interval (feet)
OS-HP12	5.5-9.5	<2	13	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP13	16-20	850	19000	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP14	12-16	742	3710	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 19
OS-HP15		No Reported Data		June - 2001		
OS-HP16		No Reported Data		June - 2001		
OS-HP17	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP18	17.5-20	27	2400	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP19		No Reported Data		June - 2001		
OS-HP20	16-20	17	210	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP21	12-16	0.6	0.7	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP22	16-20	8.8	370	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP23		No Reported Data		June - 2001		
OS-HP24		No Reported Data		June - 2001		
OS-HP25	12-16	<2	6.6	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP26	12-16	<2	<2	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP27	12-16	<2	1.3	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP28	8-12	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP29	12-16	<2	<2	June - 2001	Shallowest sample - Not representative of conditions at the water table	17 - 21
OS-HP30	12-16	1.2	390	June - 2001	Shallowest sample - Not representative of conditions at the water table	17 - 21
OS-HP31	12-16	113	235	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP32		No Reported Data		June - 2001		
OS-HP33		No Reported Data		June - 2001		
OS-HP34		No Reported Data		June - 2001		
OS-HP35	16-20	230	3400	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP36	8-12	<1	9.2	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP37	6-10	<1	4.9	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP38		No Reported Data		June - 2001		
OS-HP39	12-16	90	1200	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
PC2-1	6.5-9.5	1.7	1.2	July/August 2007	Sample collected at/nearest the water table	12 - 15
PC2-3	8-11	<0.5	0.64	July/August 2007	Sample collected at/nearest the water table	11 - 14
PC2-4	8-11	No Sample Could Be Obtained		July/August 2007		
PC2-4	12-15	<0.5	<2	July/August 2007	Sample collected at/nearest the water table	16 - 19
PC3-13	7.5-10.5	No Sample Could Be Obtained		July/August 2007		
PC3-13	12-15	8.1	660	July/August 2007	Sample collected nearest the water table	15 - 18
PC3-14	6-9	<0.5	<2	July/August 2007	Sample collected at/nearest the water table	12.5 - 15.5

TABLE C-4

GROUNDWATER CONCENTRATIONS AND LOCAL VADOSE ZONE SOIL COMPOSITION

Water Table Groundwater Sampling Location	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Vadose Zone Stratigraphy (Starting at the surface)	Depth to Groundwater (feet bgs)
OS-HP-2	41	270	Sand - Clay	6.0
OS-HP-10	4.2	49	Sand - Clay - Sand	7.0
PC2-1	1.7	1.2	Sand - Silt - Sand	6.9
PC3-13	8.1	660	Sand - Clay - Sand	8.1

Abbreviations and Acronyms:
µg/L – micrograms per liter
bgs – below ground surface

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Table C-5
Projection of Indoor Air Inhalation Risk Due to Benzene and Naphthalene from Near Water Table Groundwater at Four Worst Case Locations Using USEPA, IRIS, and Cal/EPA DTSC Toxicity Criteria

	Month/Year of Near Water Table Groundwater Sampling	Groundwater to Indoor Air Modeling Results				Incremental Cancer Risk from Vapor Intrusion to Indoor Air		Incremental Non-Cancer Hazard Quotient from Vapor Intrusion to Indoor Air	
		Benzene		Napthalene		Benzene	Naphthalene	Benzene	Naphthalene
		Attenuation Factor	Projected Maximum Indoor Air Concentration	Attenuation Factor	Projected Maximum Indoor Air Concentration				
		(unitless)	($\mu g/m^3$)	(unitless)	($\mu g/m^3$)	(unitless)	(unitless)	(unitless)	(unitless)
OS-HP2	June - 2001								
IRIS Toxicity Criteria		6.51E-06	0.058	2.61E-05	0.13	2.0E-07	NA	0.0019	0.0410
DTSC Toxicity Criteria		6.51E-06	0.058	2.61E-05	0.13	6.9E-07	1.8E-06	0.0009	0.0140
OS-HP-10	June - 2001								
IRIS Toxicity Criteria		2.72E-04	0.25	1.99E-04	0.18	7.9E-07	NA	0.0079	0.0570
DTSC Toxicity Criteria		2.72E-04	0.25	1.99E-04	0.18	3.0E-06	2.5E-06	0.0040	0.0190
PC2-1	July/August - 2007								
IRIS Toxicity Criteria		3.42E-04	0.13	2.56E-04	0.0057	4.0E-07	NA	0.0040	0.0018
DTSC Toxicity Criteria		3.42E-04	0.13	2.56E-04	0.0057	1.5E-06	7.9E-08	0.0020	0.0006
PC3-13	July/August - 2007								
IRIS Toxicity Criteria		2.86E-04	0.50	2.10E-04	2.6	1.6E-06	NA	0.0160	0.8100
DTSC Toxicity Criteria		2.86E-04	0.50	2.10E-04	2.6	6.0E-06	3.6E-05	0.0080	0.2700

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FIGURES

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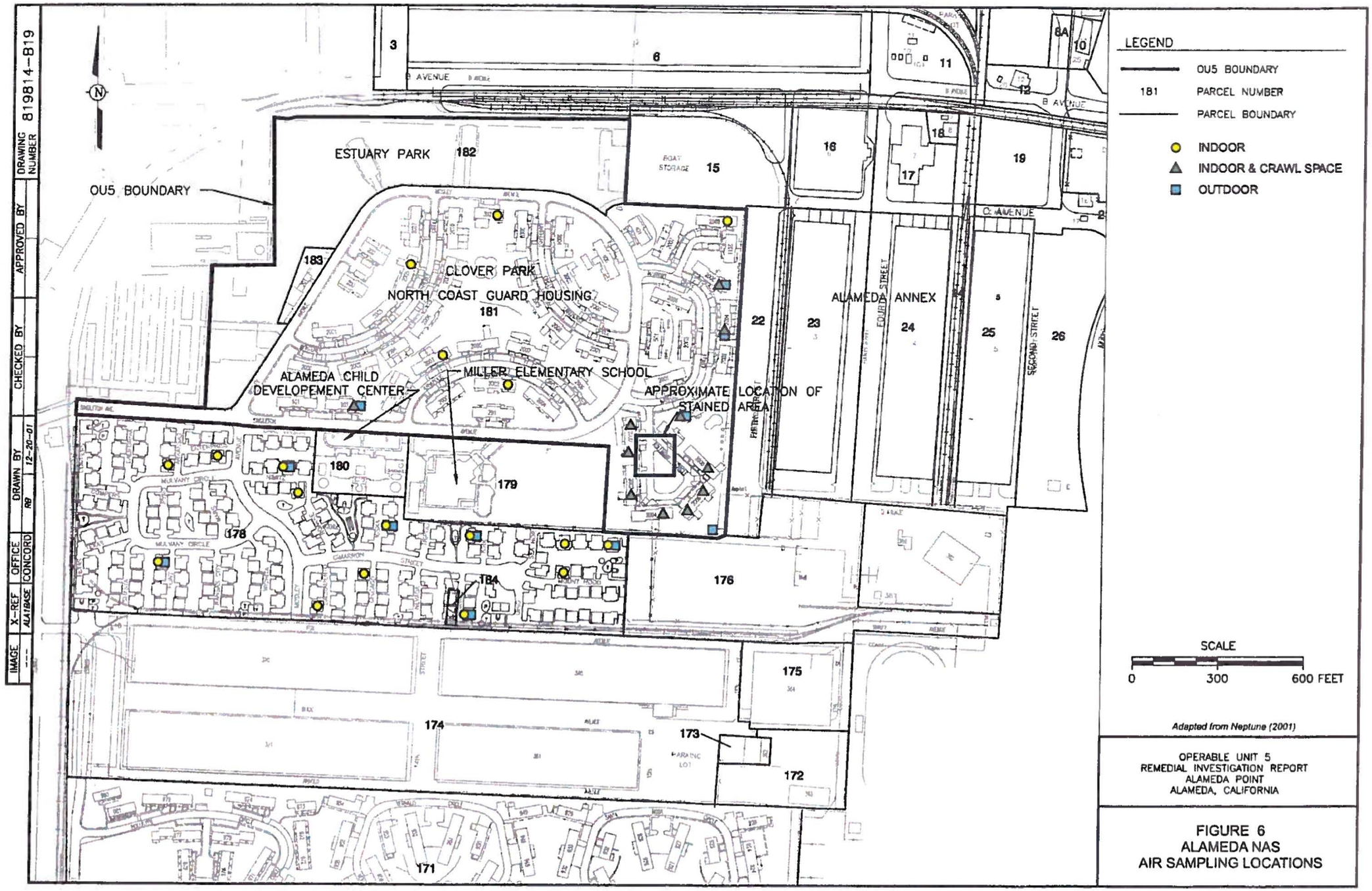
LEGEND
OU5 BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
INDOOR
INDOOR & CRAWL SPACE
OUTDOOR
SCALE
0 300 600 FEET
Adapted from Neptune (2001)
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 6
ALAMEDA NAS
AIR SAMPLING LOCATIONS
ESTUARY PARK 182
OU5 BOUNDARY
CLOVER PARK
NORTH COAST GUARD HOUSING
181
ALAMEDA CHILD DEVELOPEMENT CENTER
MILLER ELEMENTARY SCHOOL
APPROXIMATE LOCATION OF STAINED AREA
ALAMEDA ANNEX
EDWARD STREET
SECOND STREET
B AVENUE
C AVENUE
BOAT STORAGE
3
6
6A
10
11
12
15
16
17
18
19
22
23
24
25
26
171
172
173
174
175
176
178
179
180
183
184
DRAWING NUMBER 819814-B19
APPROVED BY
CHECKED BY
DRAWN BY RB 12-20-01
OFFICE CONCORD
X-REF ALATBASE
IMAGE

FIGURE C-1

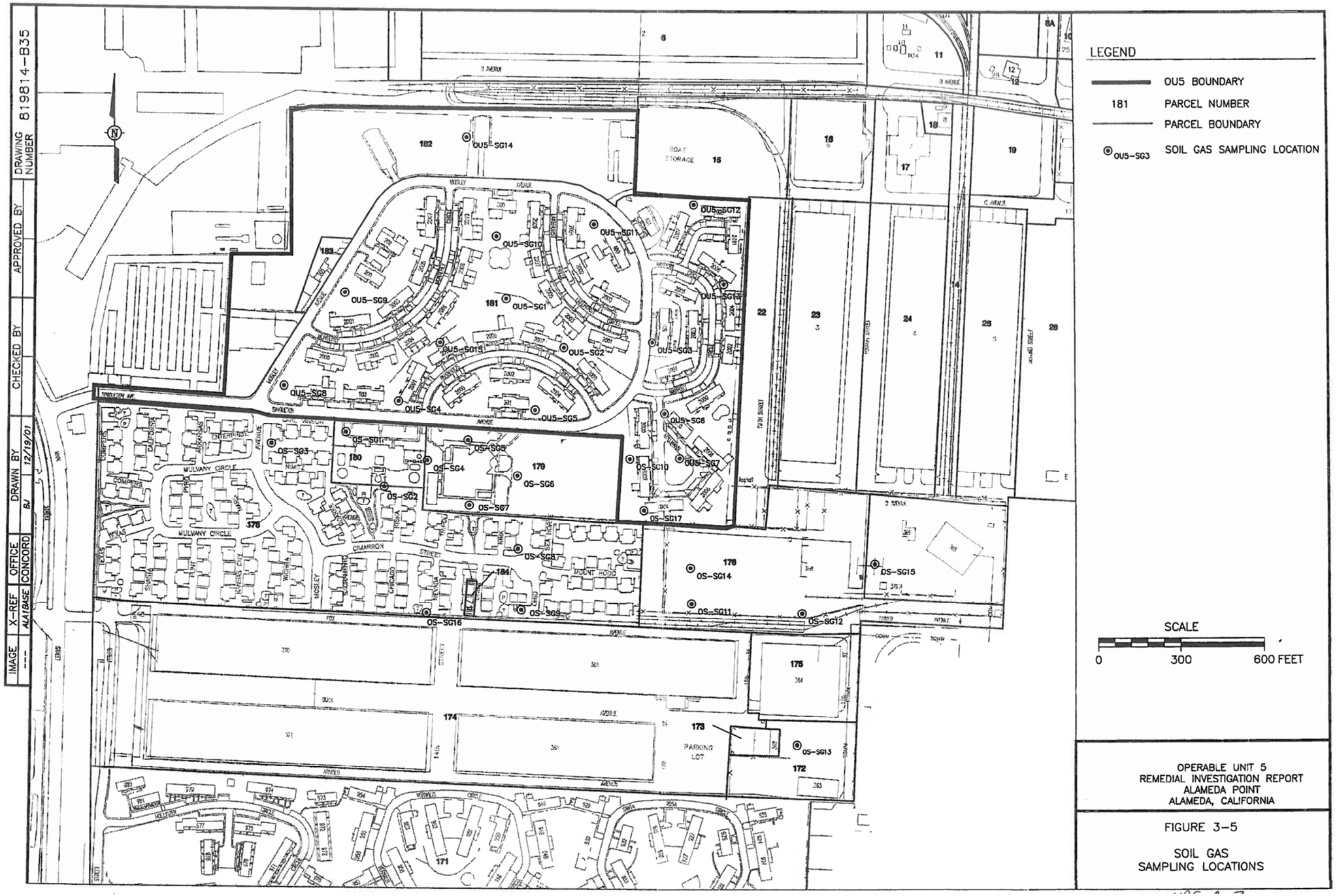
LEGEND
OU5 BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
OU5-SG3 SOIL GAS SAMPLING LOCATION
SCALE
0 300 600 FEET
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 3-5
SOIL GAS
SAMPLING LOCATIONS
DRAWING NUMBER 819814-B35
APPROVED BY
CHECKED BY
DRAWN BY BJ 12/19/01
OFFICE CONCORD
X-REF ALATBASE
IMAGE ---
182
183
181
180
179
178
177
176
175
174
173
172
171
184
OU5-SG14
OU5-SG12
OU5-SG11
OU5-SG10
OU5-SG9
OU5-SG1
OU5-SG13
OU5-SG15
OU5-SG2
OU5-SG3
OU5-SG8
OU5-SG4
OU5-SG5
OU5-SG6
OU5-SG7
OS-SG1
OS-SG8
OS-SG3
OS-SG4
OS-SG6
OS-SG2
OS-SG7
OS-SG10
OS-SG17
OS-SG14
OS-SG15
OS-SG11
OS-SG12
OS-SG16
OS-SG9
OS-SG13
BOAT STORAGE
PARKING LOT
MULVANY CIRCLE
CIMARRON STREET
MOUNT HOOD
SHOREMOORE AVENUE
KINGSTON AVE
B AVENUE
C AVENUE
FORM STREET
SQUARE STREET

FIGURE C-2

LEGEND
OU5-BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
OS-HP24 DIRECT PUSH (HYDROPUNCH) GROUNDWATER SAMPLING LOCATIONS
S-35 MONITORING WELL LOCATION
OS-HP24 DIRECT PUSH (HYDROPUNCH) GROUNDWATER SAMPLING LOCATIONS SAMPLED FOR NATURAL ATTENUATION PARAMETER
SCALE
0 300 600 FEET
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 3-4
GROUNDWATER SAMPLING LOCATIONS
DRAWING NUMBER 819814-B36
APPROVED BY
CHECKED BY
DRAWN BY BJ 12/19/01
OFFICE CONCORD
X-REF ALA1BASE
IMAGE

FIGURE C-3

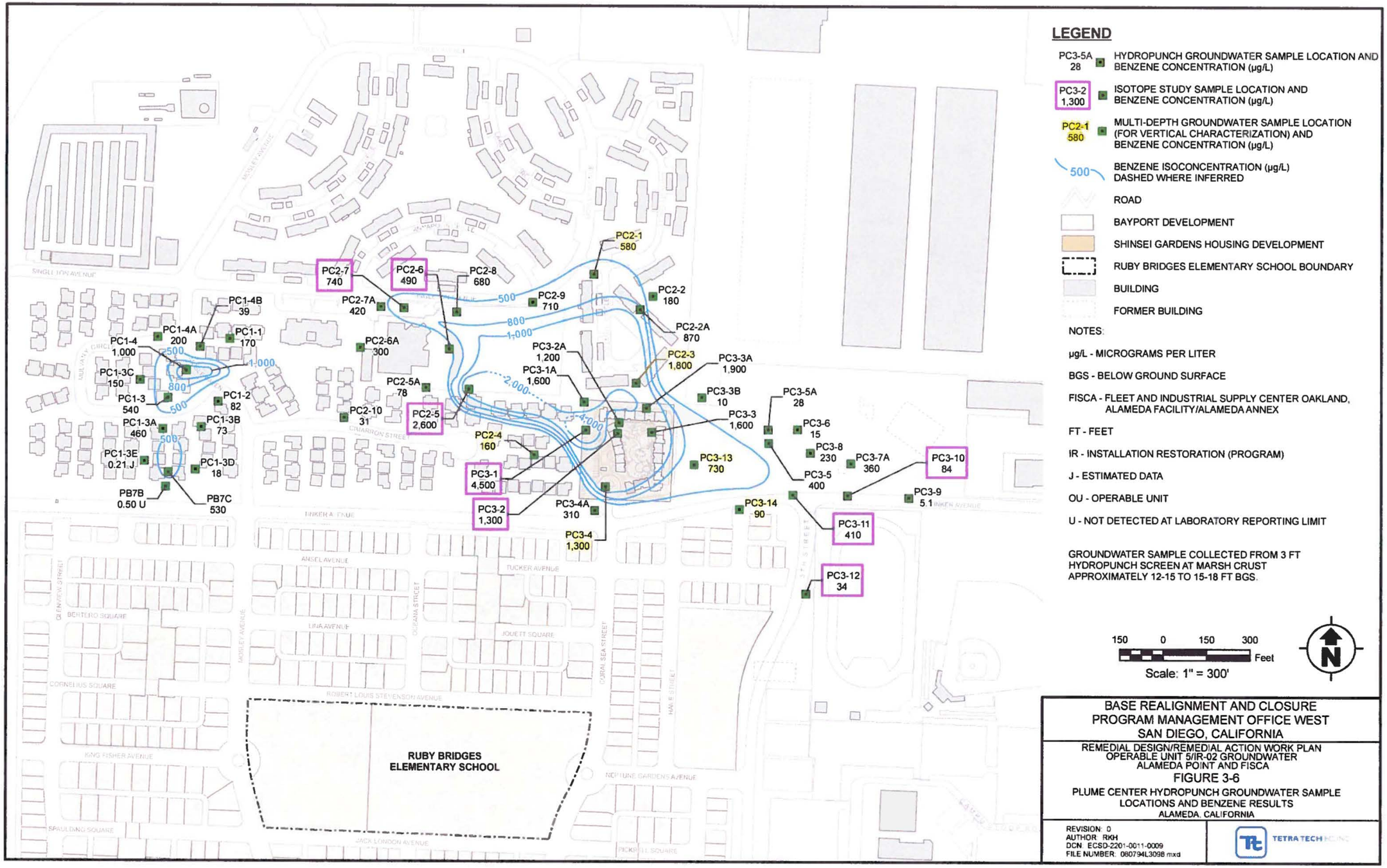
LEGEND
PC3-5A 28 HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC3-2 1,300 ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC2-1 580 MULTI-DEPTH GROUNDWATER SAMPLE LOCATION (FOR VERTICAL CHARACTERIZATION) AND BENZENE CONCENTRATION (µg/L)
500 BENZENE ISOCONCENTRATION (µg/L) DASHED WHERE INFERRED
ROAD
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
µg/L - MICROGRAMS PER LITER
BGS - BELOW GROUND SURFACE
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
FT - FEET
IR - INSTALLATION RESTORATION (PROGRAM)
J - ESTIMATED DATA
OU - OPERABLE UNIT
U - NOT DETECTED AT LABORATORY REPORTING LIMIT
GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.
150 0 150 300 Feet
Scale: 1" = 300'
N
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-6
PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLE LOCATIONS AND BENZENE RESULTS
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3098.mxd
TETRA TECH INC
PC2-7 740
PC2-6 490
PC2-8 680
PC2-1 580
PC2-7A 420
PC2-9 710
PC2-2 180
PC2-2A 870
PC2-3 1,800
PC1-4B 39
PC1-4A 200
PC1-1 170
PC1-4 1,000
PC1-3C 150
PC1-3 540
PC1-2 82
PC1-3A 460
PC1-3B 73
PC1-3E 0.21 J
PC1-3D 18
PB7B 0.50 U
PB7C 530
PC2-6A 300
PC2-5A 78
PC2-10 31
PC2-5 2,600
PC2-4 160
PC3-2A 1,200
PC3-1A 1,600
PC3-3A 1,900
PC3-3B 10
PC3-3 1,600
PC3-5A 28
PC3-6 15
PC3-8 230
PC3-7A 360
PC3-5 400
PC3-13 730
PC3-10 84
PC3-9 5.1
PC3-1 4,500
PC3-2 1,300
PC3-4A 310
PC3-4 1,300
PC3-14 90
PC3-11 410
PC3-12 34
500
800
1,000
2,000
4,000
SINGLETON AVENUE
MOSLEY AVENUE
CIMARRON STREET
TINKER AVENUE
ANSEL AVENUE
TUCKER AVENUE
GLENVIEW STREET
BERTERO SQUARE
MOSLEY AVENUE
LINA AVENUE
QUIANA STREET
JOUETT SQUARE
CORAL SEA STREET
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
HALE STREET
KING FISHER AVENUE
RUBY BRIDGES ELEMENTARY SCHOOL
NEPTUNE GARDENS AVENUE
SPAULDING SQUARE
JACK LONDON AVENUE
PICKRELL SQUARE

FIGURE C-4

APPENDIX D

RESPONSES TO AGENCY COMMENTS ON THE DRAFT TECHNICAL MEMORANDUM

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RESPONSE TO COMMENTS
DRAFT TECHNICAL MEMORANDUM
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION
ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER
AND FISCA SITE IR-02 GROUNDWATER
ALAMEDA, CALIFORNIA

Comments from Michelle Dalrymple, PG 6339
Engineering Geologist, Geological Services Unit
Office of Geology
Brownfields and Environmental Restoration Program

Comments Dated: September 10, 2012

GENERAL COMMENT	RESPONSE
Comment 1. The purpose of the TM is to provide technical support for moving toward a ROD amendment, but that purpose is not transparent in the document. Please further explain the purpose of performing a "focused" evaluation of groundwater quality and why the five questions needed to establish an effective path forward are being asked at this point in time. Without providing this context, the purpose and scope of the TM seems arbitrary.	**Response 1.** The Technical Memorandum (Tech Memo) was revised to provide more detail and clarify its purpose, as well as to further explain and clarify how the purpose was achieved. Section 1.1 was revised to state: **"The purpose of this Technical Memorandum is to provide technical support for moving toward a ROD amendment. Accordingly, this Technical Memorandum reviews the conceptual site model (CSM) in light of the additional data collected since the issuance of the ROD. Specifically, this Technical Memorandum summarizes the technical evaluations and conclusions presented in previous documents (such as the risk assessment results and conclusions presented in the Final Remedial Investigation/Feasibility Study [RI/FS] Report and the post-ROD predesign groundwater and soil stratigraphy investigation results presented in the Final Remedial Design/Remedial Action Work Plan [RD/RAWP]). This Technical Memorandum presents an evaluation of the full body of site characterization data and land-use information to assess the potential for vapor intrusion at the site."**
Comment 2. If groundwater becomes reclassified as recommended in the TM, the main pathway of concern for human health risk is soil vapor intrusion into indoor air. Therefore, recent soil vapor data should be collected at appropriate locations and depths based on the revised	**Response 2.** The key aspect of the CSM regarding the vertical stratification of the COCs remains unchanged from the ROD. The ROD states "benzene concentrations have been found to increase with depth to the top of the Marsh Crust, with the highest concentrations detected in HydroPunch samples

conceptual site model (CSM). These data are needed to verify the CSM and ensure that plume displacement due to remedial activities, long-screened monitoring wells, thin or absent clay layers, and other factors have not resulted in increased soil vapor concentrations that would potentially pose a vapor intrusion risk. Please revise the TM to include recommendations for verification soil gas sampling (passive and/or active) in support of the ROD amendment.	collected from approximately 16 to 20 feet bgs." The Tech Memo has been revised to clarify that this ROD CSM is still valid. The refinements to the CSM are related to the post-ROD pre-design investigation and additional total dissolved solids data, which affect the viability of non-vapor intrusion pathways but do not call into question the RI/FS risk assessment for vapor intrusion. Since it is estimated that the source of contamination has been in place for approximately 100 years, much soil gas data have been collected and were evaluated in the RI/FS, and re-equilibration of the water body chemistry and the conditions within the water column will follow turning the treatment system off, post-treatment contaminant concentrations and risk should not have increased. Therefore, rather than recommending additional data collection, the Navy has performed a verification evaluation of the potential for vapor intrusion using the data collected to date in light of current methodologies and toxicity criteria. This additional evaluation provides another line of evidence regarding the strength of the RI/FS risk assessment results that may assist in drawing conclusions about the significance of the vapor intrusion pathway and the appropriate protective, risk-based path forward at this site. Details of this evaluation can be found in Attachment A to these comment responses. This reevaluation indicated that sufficient, high-quality characterization data from before the start of treatment operations in multiple media (i.e., soil gas, crawl space air, indoor air, water table groundwater) exist with which to draw solid conclusions about the vapor intrusion pathway at the site. This evaluation was added as an appendix to the Tech Memo, with key components included in the main text.

RESPONSE TO COMMENTS DRAFT TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER AND FISCA SITE IR-02 GROUNDWATER ALAMEDA, CALIFORNIA	
SPECIFIC COMMENT	**RESPONSE**
Comment 1. Section 1.3 – Summary. At this point in the document (i.e., Introduction), supporting data has not been provided for the significant recommendation to discontinue operation of the biosparge system. Please remove this section from the TM and defer this recommendation to *Section 6.0 – Findings and Recommendations.*	**Response 1.** In accordance with this comment, Section 1.3 was re-written to summarize other aspects of the prior and current evaluations and delete the recommendation to discontinue operation of the biosparge system.
Comment 2. Section 2.3 – Geology a. Please remove the first sentence and reference to "TtEMI 2000." This outdated information is not needed in light of the revised CSM based on the pre-design sampling data. b. It is unlikely that the Merritt Sand Formation would be present beneath the Bay Sediment Unit (BSU) where the BSU is 100 feet in thickness. Please revise this information.	**Response 2.** a. The first sentence was deleted. b. Mention of the Merritt Sand has been removed from the Tech Memo. The Merritt Sand was not encountered or investigated as part of post-ROD activities.
Comment 3. Section 2.4 – Hydrogeology a. The hydrogeology sections should not include a description of the dissolved-phase contamination. Please remove the first sentence from this section. b. Please include a groundwater contour map and reference the cross-sections that illustrate the updated hydrogeologic CSM. c. Please define the FWBZ and discuss the occurrence of the second water bearing zone (SWBZ) beneath the site.	**Response 3.** a. The first sentence was removed. Section 2.4 now reads as follows: **"The uppermost permeable unit at Alameda Point is referred to as the FWBZ. The FWBZ beneath OU-5 occurs in the artificial fill. The saturated thickness of the FWBZ is approximately 8 feet in the eastern portion of OU-5 and 2 feet in the western portion of OU-5. FWBZ groundwater depth ranges from 5 to 9 feet bgs (TtEC 2010). The groundwater has a lateral flow direction that is variable, but is generally north to northwest toward Oakland's Inner Harbor as shown on Figure 12 (Figure 3-1 of the RD/RAWP). Groundwater contour maps generated during basewide sampling events indicate a high level of local variability.**

	This local variation likely results primarily from the permeability variability of the shallow aquifer fill material (ERRG 2004). **The BSU forms an aquitard between the FWBZ and second water-bearing zone (SWBZ), the deeper, confined aquifer beneath the site (PRC and Versar 1996). BSU thicknesses of 25 to 100 feet were reported beneath the site (PRC and Versar 1996).”** b. A groundwater contour map has been added. In addition, the following was added to the last paragraph of Section 2.6 where the CSM is first introduced. “**The CSM is not reflective of any particular location. It is a general representation of the conditions encounted along cross-section E-E’ on Figure 6**.” c. See the revised Section 2.4 in Response 3a, which includes a description of the FWBZ. The SWBZ was not investigated as part of post-ROD activities. The SWBZ is described in the RI/FS.
Comment 4. Section 3.0 – Groundwater Quality. The TM should include a map with monitoring well locations and associated chemical data. A map showing Hydropunch™ sampling locations and chemical data for benzene is included (Figure 12), but this map is not called out in the text. It is recommended that additional figures be included to illustrate plume conditions for benzene and naphthalene at both Hydropunch™ and monitoring well locations. A similar map with total dissolved solids concentrations would be useful for recommendations in favor of groundwater reclassification.	**Response 4.** Figures showing HydroPunch locations with benzene and naphthalene concentrations were added to the Tech Memo. A figure showing plume boundary monitoring well locations with benzene and naphthalene concentrations was also added to the Tech Memo. TDS data are described in the text and on Tables 2 and 3. References to figures showing the HydroPunch (Figure 14)and well locations (Figure 16) are now included in Sections 3.1 and 3.2.

RESPONSE TO COMMENTS
DRAFT TECHNICAL MEMORANDUM
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION
ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER
AND FISCA SITE IR-02 GROUNDWATER
ALAMEDA, CALIFORNIA

Comment 5. Section 6.0 – Findings and Recommendations	**Response 5.**
a. The TM concludes that the FWBZ at the site should be considered Class III groundwater instead of Class II groundwater. It further concludes that the FWBZ is not suitable for non-potable uses such as wash water, irrigation, or landscaping. If the Navy chooses to pursue reclassification of the groundwater, it is recommended that the Navy provide a formal request to the San Francisco Bay Regional Water Quality Control Board. b. GSU defers to the DTSC project manager and/or Human and Ecological Risk Office for conclusions regarding benzene and naphthalene toxicity and the validity of prior risk evaluations. c. GSU cannot concur with the proposal to shut down the biosparge system before the above two comments have been addressed.	a. Reclassification of the FWBZ under the 1995 Basin Plan is not recommended in the Technical Memorandum for this remedial action under CERCLA regulations. Reclassification is not considered necessary for implementation of this remedial action and a possible associated ROD amendment. The ROD remains protective and continues to meet substantive ARARs. To constitute an ARAR, a requirement must be substantive. As such, only the substantive provisions of the Basin Plan definitions and requirements can be identified as ARARs. Administrative requirements and provisions of generally relevant federal and state statutes and regulations that are determined to be procedural or nonenvironmental, are not considered to be ARARs. Please also refer to ROD Section 13.2.1.1 discussion of classes and the determination that MCLs are not ARARs at this site. In addition, the 2000 Beneficial Use evaluation (TTEMI 2000) stated that the Class II groundwater in the central region (i.e., the area including OU-5 and FISCA) should not be considered a potential drinking water source for CERCLA cleanup decisions. As reiterated in the ROD, "because of saltwater intrusion and naturally high total dissolved solids, it is unlikely that the shallow groundwater beneath the OU-5/IR-2 area would be used as a source of drinking water." b. Comment noted. c. Comment noted.

RESPONSE TO COMMENTS DRAFT TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER AND FISCA SITE IR-02 GROUNDWATER ALAMEDA, CALIFORNIA	
Comment 6. Section 7.0 – References. At least two references are missing: Davis 2010 and CSWRCB 2010. Please check the references section for completeness.	**Response 6.** The Davis 2010 reference was corrected and the CSWRCB reference was added.
Comment 7. Appendix B. It is recommended that the information in Appendix B be incorporated into the main body of the TM. Isolating this information and back- referencing figures and tables in the main body of the report is needlessly cumbersome. For example, Figures 12 and 13 are presented in the main body of the report but are not referenced until Appendix B.	**Response 7.** A summary related to vapor intrusion was added to the main text. A verification evaluation of the potential for vapor intrusion was performed using the data collected to date in combination with current methodologies and toxicity criteria. The details of this evaluation can be found in Attachment A to these comment responses. The results of this evaluation and other key supporting information were incorporated into the report. All figures in the main text are now referenced in the main text. With the addition in the Tech Memo main text of this additional risk evaluation, it is considered appropriate to leave the details of the historic information in Appendix B.

RESPONSE TO COMMENTS
DRAFT TECHNICAL MEMORANDUM
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION
ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER
AND FISCA SITE IR-02 GROUNDWATER
ALAMEDA, CALIFORNIA

Comments from Chris Lichens
Remedial Project Manager
Federal Facilities and Site Cleanup Branch
U. S. Environmental Protection Agency, Region IX

Comments Dated: September 14, 2012

GENERAL COMMENT	RESPONSE
Comment 1. Although the text in Section 2.6 states "the RD/RAWP [Remedial Design/Remedial Action Work Plan] determined the source of benzene and naphthalene in the groundwater of the FWBZ [first water bearing zone] is the Marsh Crust," further justification is required to support this statement. Questions originally raised in the Draft RD/RAWP, as follows, should be addressed in the Tech Memo: - why benzene and naphthalene plumes are not present in other areas where the Marsh Crust is present, - whether surface releases in the OU-5/Installation Restoration (IR)-02 area could have mobilized benzene and naphthalene, - why significant concentrations of ethylbenzene, toluene, and xylenes are not present in groundwater samples, - why polynuclear aromatic hydrocarbons, phenols, and creosol are not present in Marsh Crust and groundwater samples, since manufactured gas plant (MGP) releases contain these compounds, - whether surface and subsurface samples can be considered representative to evaluate surface releases, given the extensive grading that occurred during development and redevelopment of stained areas (i.e., soils would have been mixed, potentially diluting contaminants and allowing aerobic degradation)	**Response 1.** In accordance with this comment, further justification was added to Section 2.6, but additional details are provided in other previously issued reports and in Appendix A of the Tech Memo. This RD/RAWP determination is consistent with the vertical stratification of COCs documented in the ROD and other site data. The statement is supported by multiple lines of evidence from extensive investigations, the results of which have been presented in the Final RD/RAWP, the IRACR, and are included again in Appendix A. A brief summary with reference to the previous report and location within that report for the technical details follows. Question 1 – The statement that the source of benzene and naphthalene in groundwater is the Marsh Crust is only being made for OU5/IR-02 where the historical, physical, chemical, and isotopic soil and groundwater data substantiate this statement. Appendix A of the Tech Memo (RD/RAWP Appendix G) explains why varying concentrations would be expected given the erosional/depositional processes of an estuarine marsh combined with the potential variability of wastes discharged associated with the nearby MGPs. Question 2 – It does not follow that a surface or near surface release of benzene and naphthalene would: • leave no physical or chemical evidence in the vadose zone soil above the near surface clay;

	• leave no chemical or physical evidence of a smear zone along the surface of the near surface clay (above the water table); • penetrate the near surface clay and leave no physical or chemical evidence in the near surface clay; and • leave no chemical or physical evidence of a smear zone at the water table (below the near surface clay). Theoretically, there may be some situation where this could have occurred, but all lines of evidence indicate the Marsh Crust as the source of contamination in this area. Questions 3 and 4 – Chapter 4 of the RI/FS identified the groundwater potential contaminants of concern (PCOCs) as BTEX, PAHs, SVOC, VOCs, and TPH. Based on the results of the risk assessment and as agreed upon with the BCT, only benzene and naphthalene were subsequently retained as the chemicals of concern (COCs) in the ROD. Therefore, benzene and naphthalene were the only contaminants analyzed during all post-ROD sampling activities. Question 5 – Grading and removing of surface soil to below the water table would be required to eliminate evidence of surface or near surface releases (see answer to question 2). Furthermore, even if all evidence of a surface or near surface release were removed, the resulting vertical distribution profile would be that of higher concentrations at the surface of the water table (closer to the source) and lower concentrations at depth. Instead the opposite is observed; non-detect to near non-detect concentrations at the top of the water table, increasing concentrations at depth, and the highest groundwater contamination at the Marsh Crust (the source of site groundwater contamination based on isotopic analyses of soil and groundwater and other site data). Therefore, the previous multi-depth soil and groundwater

	sampling, much of which was conducted post-ROD, is considered representative and sufficient to evaluate whether there were historical surface releases. Documentation is provided in previous CERCLA reports including the RI/FS that presents higher concentrations at depth, the RD/RAWP that includes results of the pre-design investigation, and the IRACR that summarizes data collected to date.
Comment 2. The quantities of benzene and naphthalene destroyed through biosparging, as documented in Section 2.8 of the Tech Memo, seem to be much higher than would be expected from the Marsh Crust alone; "back of the envelope" calculations regarding the latter are attached for the Navy's consideration. This apparent discrepancy should be discussed in the Tech Memo, with supporting data and calculations.	**Response 2.** The calculations for the quantity in the Draft Tech Memo were reviewed. An error in the previous calculations for initial mass and mass removed was discovered and corrected. Estimates of initial mass are based on site-specific data. These data included samples of the Marsh Crust and groundwater within the treatment areas conducted prior to treatment. Based on the revised calculations, an initial mass of approximately 44 kg of benzene and 4,211 kg of naphthalene existed at the site. Approximately 4.33 kg (9.55 pounds) of benzene and 39.04 kg (86.07 pounds) of naphthalene have been removed. Section 2.8 was revised. The calculations were included in the Final Tech Memo.
SPECIFIC COMMENT	**RESPONSE**
Comment 1. Section 1.3, Summary, Page 3, partial paragraph at top of page: The text states that there have been no updates to the EPA Integrated Risk Information System toxicity values for either benzene or naphthalene; however, as of 2005, the State of California considers naphthalene to be a carcinogen (http://www.dtsc.ca.gov/AsessingRisk/upload/Naphthalene Handout.pdf). Please revise this section to include the State of California change for naphthalene.	**Response 1.** The statement in the Tech Memo is correct with respect to IRIS. The Tech Memo has been revised to reflect other sources of toxicity values (e.g., CalEPA/DTSC). See Attachment A to these RTCs, which was provided in response to DTSC's comments and previous BCT meeting discussion.

Comment 2. Section 3.3.1, Ammonia, Page 10: This section should discuss the source(s) of ammonia, as other sections do for other contaminants.	**Response 2.** This section was revised based on a comment from another reviewer. Dr. Peter Russell provided a comment related to ammonia and recommended removing ammonia discussion from the Tech Memo. The Navy concurs with Dr. Russell, who recommended "removing discussion of ammonia from this document, because the levels observed in OU-5 groundwater are not toxicologically interesting with respect to humans. (Typically, 4,000 mg of ammonia per day are produced endogenously in the human intestine.)" The discussion of ammonia was removed from the Tech Memo without any impact to the conclusions in the Tech Memo.
Comment 3. Section 5.2, RAOs Consistent with Revised CSM, Page 18: Although the First Water Bearing Zone (FWBZ) is a Class II Aquifer and not likely to be used as a source of potable water, the FWBZ is classified as a potential source of drinking water in the Basin Plan. The BCT chose to consider the groundwater ingestion pathway in the Human Health Risk Assessment (HHRA), and that decision is documented in the ROD. Since HHRAs are often based on hypothetical scenarios, more justification is necessary to revise or eliminate RAOs that reflect BCT-approved scenarios. The ROD also states that the Regional Water Quality Control Board (RWQCB) required the Navy to evaluate non-potable uses for water at the Fleet and Industrial Supply Center Oakland, Alameda Facility/Alameda Annex (FISCA). The Navy determined that there were agricultural and industrial uses for groundwater, but that those uses were unlikely due to elevated total dissolved solids (TDS). Therefore, the discussion in the text is not sufficient to change the RAOs established in the ROD. Please delete this discussion or provide a detailed justification	**Response 3.** The Tech Memo was revised to provide clarification since it was not the intent of the Tech Memo to "revise or eliminate the RAOs". The Tech Memo did not specify revision to the ROD RAOs. The Tech Memo text was revised to include the RAOs as stated in the ROD. Section 5.2 now reads as follows: **The ROD states:** **"RAOs for OU-5/IR-02 were developed to guide the development and evaluation of remedial alternatives for the groundwater plume. The DON proposes to reduce contaminant concentrations as a risk management decision, which was made in coordination with the regulatory agencies (DON 2006). The RAOs for groundwater are to protect human health by preventing exposure of potential residents and occupational workers to benzene and naphthalene present within groundwater at OU-5/IR-02."** Section 5.2 also was revised to state: "**The ROD RAO of ensuring "to protect human health by preventing exposure of potential residents and occupational workers to benzene and**

for proposing that the RAOs be modified.	**naphthalene present within groundwater at OU-5/IR-02" is still intact given the evaluation of the post-ROD data herein.**" It may be noted that the RI/FS risks for the agricultural and industrial uses of groundwater cited in this comment are in the risk management range; the RI/FS risk assessment conservatively included HydroPunch data from depth (up to 20 feet bgs). The Tech Memo provides further assessment of the likely viability of these hypothetical pathways.
Comment 4. Section 4.3, Evaluation of Groundwater Classification for the FWBZ: This section states that groundwater was not found to be feasible for crop or landscape irrigation due to TDS concentrations, but non-potable water is often used for landscape irrigation. For example, "grey water" can be used for irrigating landscaping, so the text should not conclude that high TDS concentrations alone are sufficient to dismiss this type of non-potable use. Please revise the text to acknowledge that non-potable water can be used for landscape irrigation or provide a more-detailed and site-specific justification for the conclusion that groundwater is not feasible for this non-potable use.	**Response 4.** Section 4.3 states that the average FWBZ TDS concentration is 16,075 mg/L. This concentration significantly exceeds acceptable levels for either crop/landscape irrigation or livestock watering (i.e., below 5,000 mg/L). Therefore, the site-specific data collected post-ROD support that agricultural supply should not be considered a viable potential beneficial use of the FWBZ groundwater. This groundwater would not meet conventional definitions of "gray water." The following additional information was added to the Tech Memo to specifically address landscape irrigation: "**Acceptable TDS concentrations for turf grass irrigation range from 200 to 500 mg/L. TDS concentrations higher than 2,000 mg/L can damage turf grasses (Penn State 2012)**. As the average TDS concentration in the groundwater (16,075 mg/L) significantly exceeds acceptable levels for crop irrigation or livestock watering (i.e., below 5,000 mg/L**) or landscape watering (i.e., below 2,000 mg/L)**, agricultural supply is not a potential beneficial use of the FWBZ groundwater."
Comment 5. Section 5.2.1.2, Evidence Regarding the Completeness and Significance of the Vapor Intrusion Exposure Pathway, Page 20: The text states that a significant and consistent body of evidence	**Response 5.** Based on this comment and DTSC's comments, the Tech Memo was revised to present further detail, including the additional evaluation of the potential vapor intrusion pathway added as Appendix C, and

supports the conclusion that VOCs from the dissolved plume of benzene and naphthalene are not migrating upwards; however it is not clear from the text what evidence is available to support this conclusion. It also appears that sub-slab soil gas data have not been collected. Note that near-slab soil gas samples may have been collected at a depth that would be too shallow to be useful for evaluating vapor intrusion (VI); see Conceptual Model Scenarios for the Vapor Intrusion Pathway, EPA 530-R-10-003, February 2012 (VIP CMS) and note that only low concentrations are likely to be present at shallow depths adjacent to buildings. Please revise the text to include site specific evidence to support the conclusion in the text and clarify whether sub-slab gas samples have been collected. Please also discuss the depths and proximity of soil gas samples to residential buildings and compare those depths and proximity to the scenarios in the VIP CMS.	clarification of the lines of evidence to support this statement (only partially cited in your comment). The following was added to Section 5.2.1.2: **More specifically, these lines of evidence (presented in more detail below) include: (1) direct measurements of soil gas crawl space air, indoor air and outdoor ambient air that in combination indicated that there is not a significant contribution to indoor air COC levels from a subsurface source; (2) numerous borings with associated analytical sampling at different depths that have demonstrated that there are extensive, layered clay deposits at the site that are blocking the upward migration of volatile COCs in the soil gas; (3) soil characterization in the vadose zone that showed that the conditions that are conducive to biodegradation of COCs like benzene and naphthalene are likely to be present across much of the site; (4) analytical results for multi-depth groundwater sampling performed in the absence of hydraulic pumping and mixing showed a natural vertical stratification of COC concentrations with the highest concentrations at depth at the Marsh Crust; (5) site-specific vapor intrusion modeling performed in accordance with recent studies and vapor intrusion guidance projected indoor air concentrations not indicative of significant vapor migration; (6) RI/FS risk assessment results showed RME ILCRs of 1×10^{-6} to 5×10^{-8} for residents based on use of soil gas data; and (7) the results of additional vapor intrusion evaluations using current DTSC criteria that were recently performed and added as Appendix C of this Technical Memorandum. The additional evaluations were performed using the soil gas measurements from across the site, and the RME results for the projected benzene indoor air inhalation ILCRs ranged from 4.8×10^{-8} to 4.8×10^{-7}. The RME results from the additional evaluations had projected naphthalene indoor air inhalation ILCRs ranging from 5.6×10^{-8} to 5.0×10^{-6}."**

	The Tech Memo addressed a number of different topics and lines of evidence relative to potential vapor intrusion. The Tech Memo briefly described the scope of each VI investigation and restated its conclusions, just as they were presented in the original report. It is beyond the scope of the Tech Memo to present all details or re-justify all of the study parameters and weight of evidence considerations that went into each previous study's conclusions. It is understood that most of these VI investigations may not have been documented strictly according to the current DTSC guidance, or present the rational for the findings using the lines of evidence as defined in the current DTSC guidance. These details (e.g., CMSs, sampling particulars, and quantitative results) may be found in the original reports that present the investigations and their findings. This Tech Memo summarized the multiple previous studies that have been performed over time to show the consistent multiple findings of no significant VI risk. Ample crawl space, soil gas, and water table groundwater samples have been collected, even though no sub-slab samples were collected. These data were re-evaluated with current conservative vapor migration and risk assessment methods (see Attachment A to these comment responses). The placement and quality of the samples that generated these data were sufficient to support informed site management decision-making. The weight of evidence supports that vapor intrusion, while a potentially complete exposure pathway, is not adversely affecting potential site users at risk levels in excess of regulatory thresholds for acceptability.
Comment 6. Section 5.2.1.2.1, Evidence Based on Direct Soil Gas, Groundwater, and Air Sampling, Page 20: The text states that soil gas measurements have been taken multiple times across the study area; however the range of concentrations for naphthalene and benzene	**Response 6.** The design details (e.g., CMSs, soil column stratigraphy, sampling design rationale, sampling and analytical particulars, and quantitative results) can be found in the original reports cited in the Tech Memo that present the investigations and their findings. This Tech Memo

detected in soil gas are not provided. Also, since the responses to comments on the RD/RAWP state that EPA and the Navy believe that the Gore-Sorber results should not be considered reliable; these data should be excluded from consideration. Also, the text does not consider whether indoor air samples were collected from a range of buildings, including buildings directly over groundwater hot spots and buildings that are more distant, nor is there a discussion of how soil gas and indoor air sampling results correlate with groundwater concentrations. Please discuss the range of naphthalene and benzene detections in soil gas, excluding the Gore-Sorber results. Finally, please discuss the correlation between indoor air samples and groundwater contaminant concentrations in the vicinity of the buildings where indoor air samples were collected.	summarized the multiple previous studies that have been performed over time to show the consistent multiple findings of no significant VI risk. The findings of these earlier reports were independently checked through a verification analysis (see Attachment A to these comment responses). The Gore-Sorber results were only used in the Tech Memo to provide a qualitative indication of volatile contaminant presence/absence and potential migration relative to the clay layer and not as a quantitative measure of the amount of volatile present. The Gore-Sorber results were not used in any assessments of risk. Indoor air samples were previously collected at a number of residences at the North Village Housing Area, the Kollman Circle Housing Area, and the USCG Marina Village Housing Area. The report for this sampling effort (cited in the Tech Memo; see Appendix B) indicates that representative residences and structures in these developments were selected for sampling. The Tech Memo summarizes the results of previous reports for the site, and it is not appropriate or possible to attempt to re-assess former report statements and/or conclusions. The Residential Risk Evaluation for U.S. Coast Guard Housing, as referenced in the Tech Memo (see Appendix B), discusses the comparison and possible correlation of the collected indoor air sampling results and the co-located groundwater sampling results. Chemical concentrations in indoor air also were compared to concentrations in crawl space air in this Report. The comparisons in this report indicated that only the concentration of benzene differed in crawl space air from indoor air. However, the concentrations in the crawl spaces were lower than in indoor air. The concentrations of all of the other VOCs measured in crawl spaces were consistent with indoor air. Other site studies have identified some degree of correlation between groundwater concentrations (at all depths in the water bearing unit) and indoor air.

RESPONSE TO COMMENTS DRAFT TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER AND FISCA SITE IR-02 GROUNDWATER ALAMEDA, CALIFORNIA	
Comment 7. Section 5.2.1.2.2, Evidence Based on Vapor Intrusion Modeling and Risk Assessment, B-1: The text states that soil gas to indoor air modeling was performed as part of the Baseline Human Health Risk Assessment (BHHRA), which used projected indoor air concentrations to evaluate carcinogenic and non-carcinogenic risks; however, the text does not provide detailed descriptions or the projected indoor air concentration values used. Also, a detailed discussion of the associated carcinogenic and non-carcinogenic risks was not included. Please revise the text to address these issues.	**Response 7.** The description of the soil gas to indoor air modeling performed for the BHHRA can be found in Section 2.3.1.1 and Tables A-6 and A-8 of Appendix E of the RI/FS. The projected indoor air concentrations and associated cancer and non-cancer risk projections are identified in this original Report. Providing detailed re-presentations and discussions of these investigations and modeling efforts was not the purpose of the Tech Memo. Similar modeling was performed as part of a verification analysis to determine if the BHHRA findings were still valid. The results of these evaluations are presented in Attachment A to these comment responses. The verification evaluation indicated similar estimates of risk and that the original findings remain valid.
Comment 8. Section 5.2.1.2.3, Evidence Associated with Better Defined Site Characteristics that Affect Vapor Migration, C-4, Page 24: This section discusses vapor intrusion of petroleum hydrocarbons (including benzene) in theory, but a site-specific analysis should be provided.	**Response 8.** Items C-1 and C-3 in this section are site-specific. The other two items (C-2 and C-4) provide the results of multiple studies that provide context and allow the implications of the site-specific data to be better understood. These general findings relate to characteristics of the contaminants and their general behavior in the environment that have been found to be generally applicable to sites like this one. The discussion of the "low strength dissolved groundwater source" was presented because its defining conditions are met by the site-specific conditions measured at this site.
Comment 9. Section 5.2.1.2.3, Evidence Associated with Better Defined Site Characteristics that Affect Vapor Migration, Page 25: The text states that the recently derived "low strength source" paradigm indicates that the modeling and measurement evidence is anticipated at the site; however, the text does not explain the low strength paradigm in detail or relate it to the site. Please provide a detailed and site-specific discussion of the low strength source paradigm.	**Response 9.** Section 5.2.1.2.3 lays out the site conditions that the recent Draft LUFT Manual defines as a "low strength source" that could be assumed to pose no unacceptable risk from vapor intrusion according to the "Vapor Intrusion Risk Screening Tool". These are: 1. 5 feet or more of clean soil between the bottom of the building and the shallowest impacted groundwater ("Clean" soil has TPH concentrations < 100 mg/kg, PID readings < 10 ppm, or oxygen

	present at concentrations >4%) 2. Dissolved-phase benzene groundwater concentrations below 1,000 µg/L 3. Dissolved phase TPH concentrations (including naphthalene) below 10,000 µg/L
Comment 10. Section 5.2.1.2.4, Findings Relative to the Vapor Intrusion Exposure Pathway, Bullet Point 1, Page 25: EPA and State VI guidance typically require sub-slab soil gas sampling and indoor air sampling to support conclusions about VI, but sub-slab soil gas data are not discussed. Also, Department of Toxic Substances Control (DTSC) VI guidance indicates that an attenuation factor should be applied to sub-slab soil gas data, rather than Johnson and Ettinger modeling. A link to EPA's vapor intrusion web page is attached referenced here for your convenience. Please revise this section to incorporate current VI guidance and site-specific data. http://www.epa.gov/oswer/vaporintrusion/	**Response 10.** Crawl space, soil gas, and water table groundwater samples have been collected. Housing located over the portion of the plume with the highest previously detected groundwater contamination concentrations (the Kollman Circle Area) is crawl space construction. Accordingly, air samples were collected from the crawl spaces of these structures (along with the associated indoor air and outdoor air) for this development as the initial focus of investigations. The crawl space data is believed to provide a clear line of evidence about the magnitude of potential vapor intrusion that is not confounded by possible internal sources of the contaminants of concern. These data were re-evaluated with current conservative vapor migration and risk assessment methods (including the DTSC default attenuation factors in Appendix B of their guidance) (see Attachment A to these comment responses). This evaluation of site-specific data indicates that the overall placement, quantity, and quality of the samples that generated these data were sufficient to support informed site management decision-making.
Comment 11. Section 5.2.1.2.4, Findings Relative to the Vapor Intrusion Exposure Pathway, Bullet Point 2, Page 26: This section states that the shallow groundwater does not have "extraordinarily high" concentrations of dissolved benzene and naphthalene but the text does not include the range of concentrations for benzene and naphthalene in shallow ground water. Also, the term "not extraordinarily high" is	**Response 11.** This confusing language was removed from the Tech Memo. Groundwater concentrations were judged relative to their potential impact on risks. In addition, chemical concentrations in indoor air were compared to concentrations in crawl space air in the Residential Risk Assessment for U.S. Coast Guard Housing. The report comparisons indicated that only the concentration of benzene differed in crawl space air from indoor air. However, the concentrations in the crawl spaces were lower than in indoor

vague. Please revise the text to include a more site- specific justification. It also appears that the Tech Memo does not consider that ambient air could have been impacted by soil vapor. A detailed and site-specific analysis is needed to support the conclusion that indoor air concentrations are not significant because "benzene and naphthalene were not present in the indoor air at concentration that were demonstrably higher than in the collocated ambient air." Also, it is unclear if detailed surveys were done to evaluate potential sources of ambient contamination. For example, in unoccupied housing areas without vehicles, ambient sources of benzene and naphthalene are unlikely. Please provide a detailed and site-specific analysis of indoor air and ambient sample concentrations.	air. The concentrations of all of the other VOCs measured in crawl spaces were consistent with indoor air. This finding does not support the presence of a significant subsurface source of benzene vapors. Except in the cases of significant spills or releases of concentrated product to the near subsurface, emissions from subsurface sources rarely have a significant and detectable impact on the ambient air. In this case, large dilution due to the prevailing wind and air flow work to keep concentrations low. In addition, the water table groundwater measurements indicate that there is limited volatilization of contaminants like benzene and naphthalene from the groundwater and even less migration through the nearly ubiquitous clay layer. This would mean that there would be even less emissions of these constituents at the ground surface. The measured ambient air concentrations are completely consistent with the local and regional air quality associated with this area.
Comment 12. Section 5.2.1.2.4, Findings Relative to the Vapor Intrusion Exposure Pathway, Bullet Point 2, Page 27: The text states that pre-operational condition at OU-5 match the conditions for a "low strength dissolved groundwater source"; however, a detailed explanation in the text defining low strength dissolved groundwater source was not provided. Please revise the text to address this issue.	**Response 12.** The elements of a "low strength dissolved groundwater source" are enumerated under bullet C-4 in Section 5.2.1.2.3. A cross-reference to this section was added.
Comment 13. Section 5.2.1.2.4, Findings Relative to the Vapor Intrusion Exposure Pathway, Bullet Point 3, Page 27: This section states that "the vapor intrusion pathway is not complete and does not contribute significantly to potential indoor air inhalation risk," but a more detailed justification should be provided for this statement.	**Response 13.** A more detailed justification of the insignificance of this pathway, in the form of a verification evaluation, is presented as Attachment A to these comment responses.

Comment 14. Section 6.0, Findings and Recommendations, Last bullet point, Page 29: The text states that the biosparging operation should be shut down, but it is premature to conclude that additional contaminant mass removal is not necessary. Questions and comments in this letter regarding the conceptual site model (e.g., sources) and risk pathways (e.g., VI) must be resolved before discontinuing the biosparging system can be considered.	**Response 14.** Comment noted. The Tech Memo explains that: • No direct exposure pathways relative to site groundwater (i.e., ingestion/drinking, incidental ingestion, dermal absorption, or inhalation of volatiles released during use) were identified to be complete. • The indirect vapor intrusion/indoor air inhalation exposure pathway is potentially complete at this site. Prior risk assessments and the verification evaluation presented in Attachment A to these comment responses both indicate that the projected indoor air inhalation risks from potential vapor intrusion are within or below the regulatory threshold levels used for site management decision-making. • Previous assessments and the verification evaluation indicated that the vapor intrusion pathway would not become potentially significant unless the dissolved groundwater concentrations of benzene and naphthalene were to increase to levels one to two orders of magnitude higher than they were at the pre-operations levels. Therefore, if there was no significant risk via the vapor intrusion pathway before system operation, continued system operation for additional contaminant mass removal is not necessary to maintain protectiveness. The most protective action to guide against vapor intrusion would be to turn off the biosparging system. This would allow the subsurface environment to re-equilibrate (re-stratify with non-detect contaminant concentrations at the top of the groundwater table) and eliminate the artificial pressure gradients and potential for forced vapor movement associated with biosparging.

Comment 15. Table 3, Quarterly Groundwater Monitoring Well Sampling Results: Table 3 only includes 2007 and 2008 data and does not include data from 2009 to 2011 data (i.e., data collected after biosparging began). Please revise the table to include all the groundwater sampling data.	**Response 15.** Section 3.0 specifies the 2007 and 2008 pre-design investigation and that the groundwater quality data generated by this sampling is described below. The next sentence in this section of the Tech Memo cites Tables 2 and 3 presenting these pre-remediation data for HydroPunch and monitoring wells, respectively. Therefore, adding additional remediation data to Table 3 is not appropriate. The title of Table 3 was revised to add 2007 and 2008, for clarity. In accordance with the comment, the previously submitted remediation data were added in an attachment to the Tech Memo.
Comment 16. Appendix A, Target Remediation Zone – Background Information, Pages A.1 and A.2; Appendix G, Section 5.0, Fate and Transport Characteristics of the Source Material; and Appendix G, Section 6.0, Accretion/Depositional and or Erosion Processes Affecting Contaminant Source Distributions: The description of MGP residual releases and the text in Appendix G do not take into account the fact that coal tar is a dense nonaqueous phase liquid (DNAPL), which is not likely to be transported across San Antonio Creek from the Oakland MGP to the OU-5/IR-02 area (approximately one mile). Also, "dissolved-phase coal tar residuals" would have been diluted by the waters in San Antonio Creek and the marshlands (i.e., water is required for transport, so at low tide transport is not likely to have occurred given the one mile distance to the site across the San Antonio Creek incised channel). The conceptual site model should discuss these issues and explain how 0.5 to 1 inch of Marsh Crust could have been created from diluted dissolved-phase coal tar residuals.	**Response 16.** For completeness, the Tech Memo Appendix A presents portions of previously issued reports. Therefore, no revisions were made to this appendix, but a response to your comment follows. Regarding the CSM, the ROD states "benzene concentrations have been found to increase with depth to the top of the Marsh Crust, with the highest concentrations detected in HydroPunch samples collected from approximately 16 to 20 feet bgs." An objective of the pre-design investigation was to verify the CSM's vertical stratification of COCs cited in the ROD, including the location and nature of the contaminant source. The background information presented in Appendix A is from the Final RD/RAWP, and cites that MGP waste streams included not only dissolved phased coal tar but light oil (benzol). Naphthalene and BTEX are the main constituents of light oil. Appendix G Section 5.0 Fate and Transport Characteristics of the Source Material explains: "Naphthalene and BTEX are more water soluble and mobile in the environment, whereas coal tar has low water solubility and strongly adsorbs to organic matter (i.e., marsh peat) and fine grained sediments (i.e., as found in estuaries). However, if elevated concentrations of BTEX/naphthalene and

	coal tar are together, the BTEX/naphthalene acts as a cosolvent and increases the solubility of coal tar in water, facilitating its transport. Microglobules of coal tar (tar-water emulsions) are also a main component in process wastewater from coal tar plants (Hatheway, 2006) and can be transported to the environment via this medium. Additionally, if mixed together, the BTEX/naphthalene will dissolve into the coal tar and stay associated with it, particularly in water-logged sediment (both are hydrophobic and lypophillic). Once in an estuarine environment such as San Antonio Creek and adjacent tidelands/marshes on Alameda, dissolved-phase coal tar residuals, primarily BTEX and/or naphthalene, and suspended microglobules of coal tar will migrate with the tidal currents and become adsorbed to the tidal marsh organic matter/sediment. This will typically be restricted to a thin layer (i.e., a fraction of an inch to a few inches) due to the highly adsorptive nature of the marshes/tidal flats organic peat and/or fine-grained sediments." The CSM relative to the source is supported by all historical, physical, chemical, and isotopic soil and groundwater data for this site.
Response 17. Appendix A, Target Remediation Zone – Background Information, Pages A.2: The text states "benzol may be discharged at different rates or different times than the coal tar," but benzol was considered a saleable byproduct of the MGP process. As such, it is unlikely that it would have been released. However, ammoniacal liquors may have been considered wastes. The text does not indicate whether Marsh Crust samples were analyzed for ammonia. Please provide a detailed justification, including references, to support the quoted statement. Also, please discuss whether ammonia was analyzed or detected in the Marsh Crust samples.	**Response 17.** For completeness, the Tech Memo Appendix A presents portions of previously issued reports. Therefore, no revisions were made to this appendix, but a response to your comment follows. During the 1880s at oil refineries, gasoline was considered a waste product and was often boiled off into the air. It wasn't until the mid- to late-1890s that benzene and gasoline production began. (*Historical Summary and Evaluation of Historical Chemical Sources, NAS Alameda*, IT 1997). The Oakland MGP site began operation in 1866. Therefore, for approximately 30 years, benzol would have been a waste product with little or no commercial value. From Hatheway, A.W. 2006. Geo-environmental classification of residuals and wastes of gas manufacturing. *Engineering Geology* 64:317-338.

	"Motor spirit (a.k.a. Benzol) was the forerunner of our gasoline and benzine was a distilled derivitive of the benzol. Today, these two light nonaqueous-phase liquids (LNAPLs) are commonly found as groundwater contaminants, though more often not as free phase." It is stated in Appendix G that "coal was used from 1866 to 1904 exclusively, until more modern, cost-efficient MGPs that used oil (petroleum) came on-line in Oakland in 1902 (Howard Terminal)." "Until the demand was created by early motorcars in the early 1900s for benzol as a fuel (aka "motor spirits") and/or as an octane-boosting additive to gasoline, or for naphthalene as a solvent, BTEX and naphthalene were primarily unwanted by-product wastes to be disposed of. The principal purpose of the MGP was to generate large quantities of gas, not benzol." Consistent with the Final Pre-design Work Plan, analysis of the Marsh Crust for ammonia was not a characterization objective and was not included in post-ROD sample analysis. However, it also should be noted that the ammonia levels in the groundwater are low. Dr. Russell, in his comment on the Tech Memo, stated that he recommended "removing discussion of ammonia from this document, because the levels observed in OU-5 groundwater are not toxicologically interesting with respect to humans. (Typically, 4,000 mg of ammonia per day are produced endogenously in the human intestine.)" The Navy concurs with Dr. Russell, and ammonia was removed from discussion in the Tech Memo.

RESPONSE TO COMMENTS DRAFT TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER AND FISCA SITE IR-02 GROUNDWATER ALAMEDA, CALIFORNIA	
Comment 18. Appendix A, Page A.3. Last bullet: The last bullet states that soil sampling was conducted to investigate "dark colored areas," but surface and near surface sampling results may not be representative, given the extensive grading that occurred during development and redevelopment of stained areas (i.e., soils would have been mixed during grading, potentially diluting contaminants and allowing aerobic degradation). Please revise the text to discuss this issue.	**Response 18.** Nine piezometers installed for the biosparge/SVE pilot testing were located in the dark colored area. These borings were continuously cored and logged from ground surface to the Marsh Crust. The only evidence of contamination was at the Marsh Crust. A figure showing the location of these wells is included in Appendix A. Boring logs for these wells were included in Appendix C of the RD/RAWP.
Comment 19. Appendix F: There are no references to support the statements in this section. Please revise this section to include references.	**Response 19.** References are only required for the stable isotope values typical for coal and MGP residuals, petrogenic crude oil, and crude oil derived products, all of which were provided in the footnote of Table F-1 included in the Appendix. All other statements made in this section are based on the GC/FID, stable isotope and/or concentration data that are presented.
Comment 20. Appendix F, Page F.4, Second Paragraph: This section indicates that all the plots in Appendix B do not indicate clustering, but the plot titled "Naphthalene Isotopes for δ^{13} C Soil only" depicts clustering. Please resolve this discrepancy.	**Response 20.** There is no discrepancy. Clustering is only relevant for the 2-dimensional (e.g., δ^{13}C vs. δ ^{2}H) compound specific isotope analysis (CSIA) conducted for this project. The plot titled "Naphthalene Isotopes for δ^{13}C Soil only" is a 1-dimensional CSIA plot that depicts all δ^{13}C Soil grouped together as denoted by the values falling within the upper and lower horizontal lines on the plot.

Comment 21. Appendix G, Section 4, Page G.3, Second Paragraph: This section concludes that specific types of improper disposal from the MGP plant did occur, but there is no direct evidence or references to support this statement. Please provide references to support the discussion in this section.	**Response 21.** For completeness, the Tech Memo Appendix A presents portions of previously issued reports, including Appendix G. Therefore, no revisions were made to this appendix, but a response to your comment follows. It is well established that aromatic hydrocarbon (e.g., benzene) and PAH (e.g., naphthalene) releases to the environment were a common occurrence at MGP sites throughout the country. The direct evidence of disposal is found in the Marsh Crust where coal carbonization-based benzene and naphthalene were reported at concentrations up to 150,000 µg/kg and 11,000,000 µg/kg, respectively.
Comment 22. Appendix G, Section 6, Page G.4: This section should include a detailed analysis of physical transport processes, including elevations of the marsh, the bottom of San Antonio Creek, and both nearby MGP plants to support the discussion in the text. The text should also include a discussion of dilution/attenuation of dissolved phase constituents in brackish water over a one-mile distance to demonstrate that dissolved phase transport would result in contamination in the OU 5/IR-02 area.	**Response 22.** For completeness, the Tech Memo Appendix A presents portions of previously issued reports, including Appendix G. Therefore, no revisions were made to this appendix, but a response to your comment follows. Proof that MGP waste could migrate to the OU-5/IR-02 area from MGP sites is found in the Marsh Crust, a thin layer of coal carbonization-based sediments found at the base of the artificial fill.
MINOR COMMENT	**RESPONSE**
Comment 1. Table 4, Vertical Groundwater Contamination Distributions at the Hydropunch Sampling Locations: The footnote for the table does not explain the colors used to highlight cells.	**Response 1.** The colors were used as an aid to separate the result. There is no meaning to the two different colors. The table was revised to eliminate one of the colors.
Comment 2. Figure 12, Plume Center Hydropunch Groundwater Sample Locations and Benzene Results: The figure should include a groundwater flow direction.	**Response 2.** A groundwater contour map was added to the Tech Memo.

RESPONSE TO COMMENTS DRAFT TECHNICAL MEMORANDUM OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER AND FISCA SITE IR-02 GROUNDWATER ALAMEDA, CALIFORNIA	
Comment 3. Figure 13, Soil Gas locations: There is no footnote provided in the figure that gives information on the colored locations on the map. Please define the colors used in this figure, and if the figure has been modified from another document, please include the source of this figure.	**Response 3.** Figure 13 was removed from the text and is included in Appendix B where it is identified as Figure 3-5 from the OU-5 Remedial Investigation (RI) Report. The yellow dots are soil gas sample locations. A yellow dot was added to the legend.
Comment 4. Figure 14, Conceptual Site Model: The footnote for the figure does not define the black colored zone in the figure.	**Response 4.** All colors on Figure 14 (now Figure 13) are identified in the legend. There is no black colored zone on this figure.
Comment 5. Appendix F, Attachment B, Stable Isotope Plots: It appears that some of the stable isotope plot titles are not on the same page as the associated plot. For example, the first page has 3 titles and it appears that the title at the bottom of the page belongs with the top plot on the next page. This appears to continue until the sixth page, which has a single title (associated with the bottom plot). The seventh page also has three titles, while the eighth page has none.	**Response 5.** The titles were adjusted as suggested.
Comment 6. Appendix F, Attachments A and B: There are no page numbers or figure numbers provided, making it difficult to reference specific plot or chromatograms. Please include page numbers and/or figure numbers for Attachments A and B.	**Response 6.** Page numbers were added to Attachments A and B of Appendix F.

RESPONSE TO COMMENTS
DRAFT TECHNICAL MEMORANDUM
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER DATA EVALUATION
ALAMEDA POINT OU-5 (SITES 25, 30, AND 31) GROUNDWATER
AND FISCA SITE IR-02 GROUNDWATER
ALAMEDA, CALIFORNIA

Comments from Peter Russell, PhD, PE
Russell Resources, Inc.
440 Nova Albion Way, Suite 1
San Rafael, CA 94903

Comments Dated: September 15, 2012

SPECIFIC COMMENTS	RESPONSE
Comment 1. Sections 3.3.1 and 3.7 both state that the MCL for ammonia is 30 mg/L. This is incorrect: neither California nor the US has an MCL for ammonia. Consider removing discussion of ammonia from this document, because the levels observed in OU-5 groundwater are not toxicologically interesting with respect to humans. (Typically, 4,000 mg of ammonia per day are produced endogenously in the human intestine.) Correcting this misstatement would not undercut the tech memo's conclusions. On the other hand, this misstatement would be embarrassing if it were to appear in the final document.	**Response 1.** The Navy concurs with this comment, and the discussion of ammonia was removed from the Tech Memo.

ATTACHMENT A

ANALYSIS OF THE POTENTIAL RISKS ASSOCIATED WITH THE VAPOR INTRUSION PATHWAY

RI/FS Projections of Indoor Air Risk Based on the Soil Gas Sampling Results

The Groundwater RI/FS for Alameda Point Site 25 and Alameda Annex IR-02 (ERRG 2004) compiled and evaluated the soil gas data that had been collected for the site up to that time. This site is now referred to as Operable Unit 5/FISCA IR-02 Groundwater. This information was summarized in Table 4-3 of that Report. As part of that RI/FS, a human health risk assessment was performed to evaluate the potential risks to human health posed by chemicals detected in the groundwater. For the residential exposure scenario, the volatilization of groundwater contaminants into soil gas, that then migrate into indoor air, was estimated using the Johnson and Ettinger (J&E) model as modified by DTSC to include Cal/EPA toxicity criteria (ERRG 2004).

To test the validity of this assessment of the potential vapor intrusion risks from groundwater to indoor air, a second risk assessment (line of evidence) was performed using actual soil gas measurements at the source term in the modeling rather than the groundwater concentrations with some projected volatilization. The RI/FS Report noted that the measured benzene concentrations in the soil gas were lower than were predicted by the J&E modeling. In addition, the measured benzene soil gas concentrations were higher at Alameda Annex than they were at Alameda Point. As such, separate indoor air inhalation risk calculations were performed for the two areas in the RI. Table 6-2 from the RI/FS Report (ERRG 2004) (reproduced and included in Appendix C following the text) presents the results of those vapor intrusion exposure pathway risk calculations for residents, school workers, and school students.

Under the Reasonable Maximum Exposure (RME) scenario, the noncarcinogenic Hazard Indices (HIs) ranged from 0.0076 to 0.0092 across both locations. These values were all well below the acceptable HI threshold of 1.0. The RME results for the incremental lifetime cancer (carcinogenic) risk (ILCR) ranged from 5×10^{-8} to 1×10^{-6}. All of these values are less than the ILCR target risk range of 10^{-6} to 10^{-4}. The Alameda Annex result for the resident was at the lower (most stringent) end of this range. These results indicated no unacceptable risks to the residents, school workers, or students due to vapor intrusion.

Additional Projections of Indoor Air Risk Based on the Soil Gas Sampling Results

Two evaluations were performed to assess the existing data using a more recent DTSC approach. First, the air sampling that has been performed in crawl spaces (Tetra Tech 2002) (i.e., in the North Housing and Kollmann Circle developments) was used to project indoor air concentrations using the conservative DTSC crawl space-to-indoor air attenuation factor of 1.0 (DTSC 2011). Applying this attenuation factor means that the crawl space air is assumed to be identical to the indoor air with no additional attenuation in contaminant concentrations as the air penetrates the building.

Four crawl spaces were sampled at the North Coast Guard Housing area, and eight were sampled at the Kollmann Circle development in the spring of 2002 (see Figure A-1, reproduced from Figure 6 of the Residential Risk Evaluation for U.S. Coast Guard Housing [Tetra Tech 2002]). Table A-1 shows the results of this sampling. Only benzene detections were reported (i.e., no naphthalene). Table A-1 also shows the results of applying the DTSC default crawl space attenuation factor to project an indoor air concentration for these structures. Table A-1 also shows results from concurrent sampling of indoor and outdoor air. Table A-1 then shows the conversion of the projected indoor air concentration to the time-weighted exposure concentration used by DTSC for inhalation risk assessments for carcinogens and noncarcinogens (DTSC 2011). Lastly, the DTSC toxicity criteria for benzene were applied to this exposure concentration to calculate the projected indoor air inhalation ILCRs and noncancer Hazard Quotients (HQs) for benzene (DTSC 2012b). Results in the last two columns of Table A-1 indicate that all 12 of the sampled residences with crawl spaces had projected HQs much less than 1.0, and all the sampled residences had projected ILCRs within the target risk range of 10^{-6} to 10^{-4}. The projected indoor air inhalation ILCRs were 10^{-6} for all except four residences, where the risk was 10^{-5}. These results serve as one line of evidence for verifying the RI/FS risk assessment findings.

A second evaluation was performed using a similar vapor migration and risk assessment approach with the broader set of soil gas measurements made across the site in June of 2001. Soil gas sampling was attempted at 32 locations spread throughout the site (see Figure A-2, reproduced from Figure 3-5 of the OU-5 RI Report [Neptune et al. 2002]). When possible, soil gas was collected from two depths: 2 feet and approximately 5 feet below ground surface (bgs). The samples were collected in 6-liter Summa® canisters and analyzed for volatile organic compounds and naphthalene by U.S. Environmental Protection Agency (EPA) Method TO-14A. Further details of the sampling procedure and approach used in the investigation are presented in Section 3.4.3.2 of the OU-5 RI Report (Neptune et al. 2002). Tables A-2B and A-2N present the results of that soil gas sampling for benzene and naphthalene, respectively. Tables A-2B and A-2N also show the results of applying the default DTSC attenuation factor for existing residential buildings (i.e., 0.002 [DTSC 2011]) to project benzene and naphthalene indoor air concentrations for each soil gas sampling location. The higher of the indoor air concentrations projected from the soil gas from 2 feet bgs and approximately 5 feet bgs was then conservatively taken as the projected indoor air concentration for that location. Tables A-2B and A-2N then show the conversion of the indoor air concentrations to the time-weighted exposure concentrations used by DTSC for inhalation risk assessments for carcinogens and noncarcinogens (as noted above). Lastly, the DTSC toxicity criteria for benzene and naphthalene were applied to calculate the projected indoor air inhalation ILCRs and noncancer HQs for both constituents (DTSC 2012a). The results are shown in the last two columns of Tables A-2B and A-2N.

With respect to benzene, Table A-2B shows that all the projected HQs were many orders of magnitude below the threshold of 1.0 and all the residences had projected ILCRs that were lower than the lowest endpoint of the target risk range of 10^{-6} to 10^{-4}. The RME results for the projected benzene ILCRs ranged from 4.8×10^{-8} to 4.8×10^{-7}. With respect to naphthalene, Table A-2N also shows that all the projected HQs were well below 1.0, and 28 of the 32 locations had projected

ILCRs that were lower than the lowest endpoint of the target risk range of 10^{-6} to 10^{-4}. The remaining four locations had projected ILCRs of 10^{-6}, the lowest endpoint of the target risk range. The RME results for the projected naphthalene ILCRs ranged from 5.6×10^{-8} to 5.0×10^{-6}. These results serve as another line of evidence for verifying the RI/FS risk assessment findings.

In summary, the findings of the RI/FS risk assessment of potential vapor intrusion are supported by current evaluations performed based on recent DTSC criteria using the collected crawl space and widespread soil gas data from multiple depths. As such, this additional analysis provides further support for the RI/FS conclusion that there are no unacceptable risks to the residents, school workers, or students at the site as the result of vapor intrusion.

RI/FS Projections of Indoor Air Risk Based on All Available Multi-Depth Groundwater Sampling Results

As noted above, the Groundwater RI/FS for Alameda Point Site 25 and Alameda Annex IR-02 (ERRG 2004) included a human health risk assessment that evaluated various potential pathways, including the volatilization of groundwater constituents into soil gas, which then could migrate into indoor air. The vapor intrusion evaluation was built on migration modeling using the J&E model as modified by DTSC to include Cal/EPA toxicity criteria (ERRG 2004). The default chemical properties provided in the J&E model were used when available. A default slab-on-grade residential structure was assumed. A depth to groundwater of 7.2 feet was modeled using soil properties taken from site-specific boring logs for the vadose zone. The RI/FS risk assessment (Final RI/FS Report, Section 6, page 6-1) included use of HydroPunch® data from samples collected at approximately 20 feet bgs (ERRG 2004). The Final RI/FS Report further documented (Section 6.4, page 6-6) that in both Tier 1 and Tier 2 analyses, exposure point concentration data included data from all depths at both Alameda Point and FISCA. Table 6-1 from that RI/FS (ERRG 2004), reproduced and included in this appendix following the text, presents the results of calculations for all noningestion pathways, as well as the hypothetical potable water usage, for various receptors, including residents, school workers, and students. Results for the resident, school worker, and student for the "Assuming No Domestic Potable Water Use" reflect the potential risks to these receptors from the vapor intrusion exposure pathway as projected using the groundwater contaminant concentrations as the source to the J&E modeling.

As can be seen for the nondomestic potable water use scenario, the projected HI (with contributions for all constituents in the groundwater) was calculated to be 0.29 for the resident, the school worker, and the student. Two different data kriging approaches (using different kriging radii) were used to obtain representative exposure point groundwater concentrations for this assessment. The projected HI of 0.29 was less than the threshold value of 1.0. For the nondomestic potable water use scenario, the RME results for the projected indoor air inhalation ILCRs from vapor intrusion from groundwater ranged from 2×10^{-6} for the student to 1×10^{-5} for the resident. Most of these results were due to benzene given the toxicity criteria used in the assessment. All of these ILCR estimates were within the target risk range of 10^{-6} to 10^{-4}. The Final RI/FS Report (ERRG 2004) concluded "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

Projections of Indoor Air Risk Based on the At/Near Water Table Groundwater Sampling Results

An independent evaluation was performed to verify the RI/FS results by applying a more current DTSC assessment approach to the available data. This evaluation was made by performing location-specific vapor intrusion modeling using the J&E model with all the DTSC toxicity and default input parameter adjustments for a slab-on-grade residential structure (DTSC 2012b). In addition, the modeling used only the groundwater concentrations measured across the site from the depth interval at or near the local water table. This selection of groundwater sampling results is supported by the fact that the groundwater concentrations at the water table dictate the volatilization of the dissolved constituents out of the liquid phase and into the soil gas (DTSC 2011).

Table A-3 lists the groundwater sampling results for benzene and naphthalene for this subset of the groundwater sampling locations where the sample was collected from as close to the water table as possible. Data from the summer of 2001 (Neptune et al. 2002) and 2007 (Tetra Tech 2010) are presented. Table A-3 lists the sampling location and the approximate sample depth, followed by the measured concentrations.

Thirty-seven locations had groundwater samples drawn from appropriate depth intervals to potentially capture groundwater at or near the water table. The locations of the 2001 samples are displayed on Figure A-3 (reproduced from Figure 3-4 of the Operable Unit 5 RI Report [Neptune et al. 2002]). The locations of the 2007 samples are displayed on Figure A-4 (reproduced from Figure 3-6 of the Remedial Design/Remedial Action Work Plan [Tetra Tech 2010]). Of these, 16 locations were nondetect for both benzene and naphthalene. An additional 14 locations were nondetect for benzene but reported a low concentration for naphthalene. Only 7 of the 37 locations had detected concentrations for both benzene and naphthalene. These cases were reviewed to identify those with a higher likelihood to result in potential vapor intrusion either because the reported groundwater concentrations were higher, the vadose zone at that location consisted of more permeable material, or the vadose zone was thinner. Based on this review, four locations were judged to warrant verification modeling: OS-HP2, OS-HP-10, PC2-1, and PC3-13. Table A-4 shows the measured groundwater concentrations at these four locations and the composition of the local vadose zone soil.

For purposes of comparison, the projected indoor air inhalation RME risks for each case were estimated using both the EPA Integrated Risk Information System (IRIS) toxicity criteria (EPA 2012) and the DTSC toxicity criteria (DTSC 2012a). Table A-5 shows the results of these calculations. For each of the four highlighted water table groundwater sampling locations (which represent the locations with conditions that potentially could result in vapor intrusion), Table A-5 lists the sampling date, the effective groundwater-to-indoor air attenuation factors for benzene and naphthalene, and the projected ILCRs and noncancer HQs for both constituents. Results are shown separately for the two sets of toxicity criteria.

As can be seen, DTSC considers naphthalene to be a carcinogen while IRIS does not. In addition, there are differences in the values of the remaining Unit Risk Factors and Reference Concentrations for these chemicals between the two sources. It should be noted that the most conservative value

from the range of Unit Risk Factors for benzene reported in IRIS was used in these projections. Once again, all the projected HQs for both chemicals were less than the HQ threshold value of 1.0. Specifically, all HQs for benzene were less than 0.010 using both DTSC and IRIS criteria, except for one location where the maximum HQ for benzene was 0.016. All HQs for naphthalene were less than 0.10 using both DTSC and IRIS criteria, except for one location where the maximum HQ for naphthalene was 0.81. Using IRIS toxicity criteria, the projected RME ILCRs for benzene were 10^{-7} except at one location, where the ILCR was 1.6×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for benzene ranged from 6.9×10^{-7} to 6.0×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for naphthalene ranged from 7.9×10^{-8} to a maximum of 3.6×10^{-5}.

All the projected RME ILCRs using both DTSC and IRIS criteria for both benzene and naphthalene were within or below the target risk range of 10^{-6} to 10^{-4}. Accordingly, even these individual locations with conditions that potentially would best promote vapor migration do not indicate an unacceptable indoor air inhalation risk. It should also be noted that the majority of the water table sampling results for these locations were non-detect for these constituents.

Summary

The RI/FS risk assessment evaluated multiple pathways, including vapor intrusion, using groundwater data from multiple depths down to 20 feet bgs and soil gas data (ERRG 2004). All HQs were less than 1 for all evaluations. Using soil gas data, the RI/FS vapor intrusion risk assessment estimated RME ILCRs ranging from 5×10^{-8} to 1×10^{-6} for residents and from 5×10^{-8} to 8×10^{-7} for school receptors. Using groundwater data from all depths, the RI/FS RME ILCR results were in the risk management range. The Final RI/FS Report (ERRG 2004) concluded "Additionally, potential inhalation of VOCs in indoor air by residential and school receptors does not pose an unacceptable risk."

The findings of the RI/FS risk assessment of potential vapor intrusion are supported by subsequent evaluations performed using the current DTSC approach and the collected crawl space air and soil gas data from multiple depths over a widespread area. Using the more recent DTSC approach and the soil gas data, subsequent vapor intrusion evaluations presented in this appendix estimated the RME ILCR for benzene to range from 4.8×10^{-8} to 4.8×10^{-7} and for naphthalene to range from 5.6×10^{-8} to 5.0×10^{-6} across the site.

Additional evaluations presented in this appendix were performed using groundwater data collected near the water table, an approach that is recommended for use in vapor intrusion evaluations by current guidance. The groundwater at these depths shows much lower benzene and naphthalene concentrations than the data used in the RI/FS vapor intrusion risk assessment that were from depths considerably below the water table. Benzene and naphthalene were both detected at only 7 of 37 locations in the more recent water table data. Four of these locations were chosen for further vapor intrusion evaluation because they had the characteristics most likely to promote vapor migration and higher potential indoor air concentrations. Using IRIS toxicity criteria, the projected RME ILCRs for benzene at these locations were 10^{-7} except at one location, where the ILCR was 1.6×10^{-6}.

Using DTSC toxicity criteria, the projected RME ILCRs for benzene at these individual locations ranged from 6.9×10^{-7} to 6.0×10^{-6}. Using DTSC toxicity criteria, the projected RME ILCRs for naphthalene at these individual locations ranged from 7.9×10^{-8} to a maximum of 3.6×10^{-5}. All HQs were less than 1 for all evaluations based on groundwater. These results serve as another line of evidence for verifying the RI/FS risk assessment findings.

References

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——————. 2012a. OEHHA Toxicity Criteria Database. Department of Toxic Substances Control, California Environmental Protection Agency. http://www.dtsc.ca.gov/AssessingRisk /JE_Models.cfm.

——————. 2012b. Johnson and Ettinger Models. Department of Toxic Substances Control, California Environmental Protection Agency. http://oehha.ca.gov/tcdb/index.asp.

EPA (U.S. Environmental Protection Agency). 2012. Integrated Risk Information System (IRIS) Database. http://www.epa.gov/IRIS/.

ERRG (Engineering/Remediation Resources Group, Inc.). 2004. Final Groundwater Remedial Investigation/Feasibility Study (RI/FS) for Alameda Point Site 25 and Alameda Annex IR-02. Prepared for the U.S. Department of the Navy, Naval Facilities Engineering Command – Southwest Division. October.

Neptune and Company, Inc., IT Corporation, ENVIRON. 2002. Draft Final Operable Unit 5 Remedial Investigation Report for Alameda Point, Alameda, CA – Volumes I and II, Prepared for the U.S. Department of the Navy, Naval Facilities Engineering Command – Southwest Division. July.

TtEC (Tetra Tech EC, Inc.). 2002. Residential Risk Evaluation for U.S. Coast Guard Housing, Alameda, California, Prepared for the U.S. Coast Guard, Civil Engineering Unit Oakland. August.

——————. 2010. Final Remedial Design/Remedial Action Work Plan for Operable Unit 5/ IR-02 Groundwater, Alameda Point and FISCA, Alameda, California, Revision 2. Prepared for the Department of the Navy, Base Realignment and Closure, Program Management Office West. December.

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TABLES

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TABLE 6-2

SUMMARY OF TIER 2 HHRA RESULTS MODELED FROM SOIL GAS DATA ALAMEDA POINT SITE 25/ALAMEDA ANNEX IR-02 GROUNDWATER RI/FS

Exposure Scenario	Location	Noncarcinogenic Hazard Index		Carcinogenic Risk	
		Average Exposure	Reasonable Maximum Exposure	Average Exposure	Reasonable Maximum Exposure
Assuming No Domestic Potable Water Use					
Resident	Alameda Annex	0.0092	0.0092	1×10^{-6}	1×10^{-6}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}
School Worker	Alameda Annex	0.0087	0.0087	8×10^{-7}	8×10^{-7}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}
School Student	Alameda Annex	0.0084	0.0084	2×10^{-7}	2×10^{-7}
	Alameda Point	0.0076	0.0076	5×10^{-8}	5×10^{-8}

Source: Reproduced from ERRG 2004

Abbreviations and Acronyms:
HHRA – human health risk assessment
IR – Installation Restoration (Program)

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Table A-1
Projection of Indoor Air Inhalation Risk Due to Benzene from Crawl Space Air Sampled in February/April 2002

Housing Area	Address	Sample Type	Benzene Concentration [1] (mg/m^3)	Benzene Concentration ($\mu g/m^3$)	DTSC Existing Residential Structures with Crawl Spaces Attenuation Factor [2] (unitless)	Projected Benzene Indoor Air Concentration From Crawl Space Air ($\mu g/m^3$)	*Measured Benzene Indoor Air Concentration ($\mu g/m^3$)*	*Measured Benzene Outdoor Air Concentration ($\mu g/m^3$)*	Projected Benzene Indoor Air Exposure Concentration from Crawl Space Air [3] (Carcinogens) ($\mu g/m^3$)	Projected Benzene Indoor Air Exposure Concentration from Crawl Space Air [3] (Non-Carcinogens) ($\mu g/m^3$)	Projected Benzene Indoor Air from Crawl Space Cancer Risk [4] (unitless)	Projected Benzene Indoor Air from Crawl Space Hazard Quotient [4] (unitless)
North Housing	103 F Singleton	Crawl Space	1.10E-03	1.10E+00	1.0	1.1E+00	*2.6E+00*	*2.6E+00*	4.5E-01	1.1E+00	1.3E-05	1.76E-02
North Housing	2000 D Mayport	Crawl Space	2.70E-03	2.70E+00	1.0	2.7E+00	*3.9E+00*	*5.2E+00*	1.1E+00	2.6E+00	3.2E-05	4.32E-02
North Housing	2004 D Mayport	Crawl Space	2.40E-03	2.40E+00	1.0	2.4E+00	*2.9E+00*	*2.8E+00*	9.9E-01	2.3E+00	2.9E-05	3.84E-02
North Housing	2006 E Mayport	Crawl Space	1.80E-03	1.80E+00	1.0	1.8E+00	*4.6E+00*	*3.1E+00*	7.4E-01	1.7E+00	2.1E-05	2.88E-02
Kollmann Circle	2000 A Kollmann	Crawl Space	6.50E-04	6.50E-01	1.0	6.5E-01	*5.9E-01*	*Not Measured*	2.7E-01	6.2E-01	7.7E-06	1.04E-02
Kollmann Circle	2000 E Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*8.8E-01*	*Not Measured*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2002 C Kollmann	Crawl Space	4.60E-04	4.60E-01	1.0	4.6E-01	*6.5E-01*	*Not Measured*	1.9E-01	4.4E-01	5.5E-06	7.35E-03
Kollmann Circle	2004 C Kollmann	Crawl Space	4.60E-04	4.60E-01	1.0	4.6E-01	*5.2E-01*	*Not Measured*	1.9E-01	4.4E-01	5.5E-06	7.35E-03
Kollmann Circle	2006 B Kollmann	Crawl Space	6.50E-04	6.50E-01	1.0	6.5E-01	*5.2E-01*	*Not Measured*	2.7E-01	6.2E-01	7.7E-06	1.04E-02
Kollmann Circle	2006 E Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*5.5E-01*	*4.9E-01*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2008 D Kollmann	Crawl Space	4.90E-04	4.90E-01	1.0	4.9E-01	*5.9E-01*	*Not Measured*	2.0E-01	4.7E-01	5.8E-06	7.83E-03
Kollmann Circle	2010 C Kollmann	Crawl Space	5.20E-04	5.20E-01	1.0	5.2E-01	*6.2E-01*	*Not Measured*	2.1E-01	5.0E-01	6.2E-06	8.31E-03
										Minimum	**5.5E-06**	**7.4E-03**
										Maximum	**3.2E-05**	**4.3E-02**

Sources:

[1] Residential Risk Evaluation for U.S. Coast Guard Housing, Alameda, CA, August 2002, Table 10

[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors, Existing Residential Structures: Crawl Space Air Samples

[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure Concentrations and Assumptions, Page C-3

[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations

Table A-2B
Projection of Indoor Air Inhalation Risk Due to Benzene from Soil Gas Sampled in June 2001

Soil Gas Sampling Location [June 2001]	Benzene Concentration @ 2' bgs [1] ($\mu g/m^3$)	Benzene Concentration @ 5' bgs [1] ($\mu g/m^3$)	DTSC Existing Residential Building Attenuation Factor [2] (unitless)	Projected Benzene Indoor Air Concentration From SG @ 2' bgs ($\mu g/m^3$)	Projected Benzene Indoor Air Concentration From SG @ 5' bgs ($\mu g/m^3$)	Maximum Projected Benzene Indoor Air Concentration From SG ($\mu g/m^3$)	Maximum Projected Benzene Indoor Air Exposure Concentration [3] (Carcinogens) ($\mu g/m^3$)	Maximum Projected Benzene Indoor Air Exposure Concentration [3] (Non-Carcinogens) ($\mu g/m^3$)	Maximum Projected Benzene Indoor Air Cancer Risk [4] (unitless)	Maximum Projected Benzene Indoor Air Hazard Quotient [4] (unitless)
OU5-SG1	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG2	NS	3.1	0.002	NS	0.0062	0.0062	0.0025	0.0059	7.4E-08	9.91E-05
OU5-SG3	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG4	6.8	5.2	0.002	0.0136	0.0104	0.0136	0.0056	0.0130	1.6E-07	2.17E-04
OU5-SG5	3.0	NS	0.002	0.0060	NS	0.0060	0.0025	0.0058	7.2E-08	9.59E-05
OU5-SG6	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG7	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG8	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG9	4.4	NS	0.002	0.0088	NS	0.0088	0.0036	0.0084	1.0E-07	1.41E-04
OU5-SG10	NA	13	0.002	NA	0.0260	0.0260	0.0107	0.0249	3.1E-07	4.16E-04
OU5-SG11	<2	<2	0.002	0.0040	0.0040	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG12	7.2	<2	0.002	0.0144	0.0040	0.0144	0.0059	0.0138	1.7E-07	2.30E-04
OU5-SG13	6.6	NS	0.002	0.0132	NS	0.0132	0.0054	0.0127	1.6E-07	2.11E-04
OU5-SG14	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OU5-SG15	3.1	NS	0.002	0.0062	NS	0.0062	0.0025	0.0059	7.4E-08	9.91E-05
OS-SG1	20	NS	0.002	0.0400	NS	0.0400	0.0164	0.0384	4.8E-07	6.39E-04
OS-SG2	<10	NS	0.002	0.0200	NS	0.0200	0.0082	0.0192	2.4E-07	3.20E-04
OS-SG3	5.1	<2	0.002	0.0102	0.0040	0.0102	0.0042	0.0098	1.2E-07	1.63E-04
OS-SG4	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG5	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG6	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG7	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG8	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG9	8.0	<2	0.002	0.0160	0.0040	0.0160	0.0066	0.0153	1.9E-07	2.56E-04
OS-SG10	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG11	4.4	3.9	0.002	0.0088	0.0078	0.0088	0.0036	0.0084	1.0E-07	1.41E-04
OS-SG12	3.9	14	0.002	0.0078	0.0280	0.0280	0.0115	0.0268	3.3E-07	4.47E-04
OS-SG13	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	4.8E-08	6.39E-05
OS-SG14	4.9	15	0.002	0.0098	0.0300	0.0300	0.0123	0.0288	3.6E-07	4.79E-04
OS-SG15	4.3	NS	0.002	0.0086	NS	0.0086	0.0035	0.0082	1.0E-07	1.37E-04
OS-SG16	2.5	10	0.002	0.0050	0.0200	0.0200	0.0082	0.0192	2.4E-07	3.20E-04
OS-SG17	3.2	NS	0.002	0.0064	NS	0.0064	0.0026	0.0061	7.6E-08	1.02E-04
								Minimum	**4.8E-08**	**6.4E-05**
								Maximum	**4.8E-07**	**6.4E-04**

Sources:

[1] Operable Unit 5 Remedial Investigation Report, Alameda Point, Alameda, CA Draft Final, July 12, 2002: Appendix D remedial Investigation Data Tables, Table D-3

[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors, Existing Residential Structures

[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure Concentrations and Assumptions, Page C-3

[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations

NS No sample attempted or no recovery

NA Constituent not analyzed

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Table A-2N
Projection of Indoor Air Inhalation Risk Due to Naphthalene from Soil Gas Sampled in June 2001

Soil Gas Sampling Location [June 2001]	Naphthalene Concentration @ 2' bgs [1] (µg/m^3)	Naphthalene Concentration @ 5' bgs [1] (µg/m^3)	DTSC Existing Residential Building Attenuation Factor [2] (unitless)	Projected Naphthalene Indoor Air Concentration From SG @ 2' bgs (µg/m^3)	Projected Naphthalene Indoor Air Concentration From SG @ 5' bgs (µg/m^3)	Maximum Projected Naphthalene Indoor Air Concentration From SG (µg/m^3)	Maximum Projected Naphthalene Indoor Air Exposure Concentration [3] (Carcinogens) (µg/m^3)	Maximum Projected Naphthalene Indoor Air Exposure Concentration [3] (Non-Carcinogens) (µg/m^3)	Maximum Projected Naphthalene Indoor Air Cancer Risk [4] (unitless)	Maximum Projected Naphthalene Indoor Air Hazard Quotient [4] (unitless)
OU5-SG1	21	NS	0.002	0.0420	NS	0.0420	0.0173	0.0403	5.9E-07	4.47E-03
OU5-SG2	NS	17	0.002	NS	0.0340	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG3	22	NS	0.002	0.0440	NS	0.0440	0.0181	0.0422	6.1E-07	4.69E-03
OU5-SG4	54	42	0.002	0.1080	0.0840	0.1080	0.0444	0.1036	1.5E-06	1.15E-02
OU5-SG5	9.1	NS	0.002	0.0182	NS	0.0182	0.0075	0.0175	2.5E-07	1.94E-03
OU5-SG6	14	NS	0.002	0.0280	NS	0.0280	0.0115	0.0268	3.9E-07	2.98E-03
OU5-SG7	18	NS	0.002	0.0360	NS	0.0360	0.0148	0.0345	5.0E-07	3.84E-03
OU5-SG8	9.3	NS	0.002	0.0186	NS	0.0186	0.0076	0.0178	2.6E-07	1.98E-03
OU5-SG9	2.1	NS	0.002	0.0042	NS	0.0042	0.0017	0.0040	5.9E-08	4.47E-04
OU5-SG10	NA	4.3	0.002	NA	0.0086	0.0086	0.0035	0.0082	1.2E-07	9.16E-04
OU5-SG11	24	31	0.002	0.0480	0.0620	0.0620	0.0255	0.0595	8.7E-07	6.61E-03
OU5-SG12	17	14	0.002	0.0340	0.0280	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG13	17	NS	0.002	0.0340	NS	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OU5-SG14	12	NS	0.002	0.0240	NS	0.0240	0.0099	0.0230	3.4E-07	2.56E-03
OU5-SG15	8.2	NS	0.002	0.0164	NS	0.0164	0.0067	0.0157	2.3E-07	1.75E-03
OS-SG1	11	NS	0.002	0.0220	NS	0.0220	0.0090	0.0211	3.1E-07	2.34E-03
OS-SG2	<10	NS	0.002	0.0200	NS	0.0200	0.0082	0.0192	2.8E-07	2.13E-03
OS-SG3	7.4	13	0.002	0.0148	0.0260	0.0260	0.0107	0.0249	3.6E-07	2.77E-03
OS-SG4	12	NS	0.002	0.0240	NS	0.0240	0.0099	0.0230	3.4E-07	2.56E-03
OS-SG5	<2	NS	0.002	0.0040	NS	0.0040	0.0016	0.0038	5.6E-08	4.26E-04
OS-SG6	18	NS	0.002	0.0360	NS	0.0360	0.0148	0.0345	5.0E-07	3.84E-03
OS-SG7	3.6	NS	0.002	0.0072	NS	0.0072	0.0030	0.0069	1.0E-07	7.67E-04
OS-SG8	4.7	NS	0.002	0.0094	NS	0.0094	0.0039	0.0090	1.3E-07	1.00E-03
OS-SG9	17	28	0.002	0.0340	0.0560	0.0560	0.0230	0.0537	7.8E-07	5.97E-03
OS-SG10	14	NS	0.002	0.0280	NS	0.0280	0.0115	0.0268	3.9E-07	2.98E-03
OS-SG11	13	17	0.002	0.0260	0.0340	0.0340	0.0140	0.0326	4.8E-07	3.62E-03
OS-SG12	19	38	0.002	0.0380	0.0760	0.0760	0.0312	0.0729	1.1E-06	8.10E-03
OS-SG13	44	NS	0.002	0.0880	NS	0.0880	0.0362	0.0844	1.2E-06	9.38E-03
OS-SG14	13	15	0.002	0.0260	0.0300	0.0300	0.0123	0.0288	4.2E-07	3.20E-03
OS-SG15	19	NS	0.002	0.0380	NS	0.0380	0.0156	0.0364	5.3E-07	4.05E-03
OS-SG16	19	180	0.002	0.0380	0.3600	0.3600	0.1479	0.3452	5.0E-06	3.84E-02
OS-SG17	9.0	NS	0.002	0.0180	NS	0.0180	0.0074	0.0173	2.5E-07	1.92E-03
								Minimum	**5.6E-08**	**4.3E-04**
								Maximum	**5.0E-06**	**3.8E-02**

Sources:

[1] Operable Unit 5 Remedial Investigation Report, Alameda Point, Alameda, CA Draft Final, July 12, 2002: Appendix D remedial Investigation Data Tables, Table D-3
[2] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix B - Preliminary Screening Attenuation Factors,
[3] Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Final, DTSC/CalEPA, October 2011 : Appendix C - Human Risk Assessment, Exposure
[4] DTSC Toxicity Criteria: Inhalation Unit Risks and Chronic reference Concentrations
NS No sample attempted or no recovery
NA Constituent not analyzed

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TABLE 6-1

SUMMARY OF TIER 2 HHRA RESULTS
ALAMEDA POINT SITE 25/ALAMEDA ANNEX IR-02 GROUNDWATER RI/FS

Exposure Scenario	Noncarcinogenic Hazard Index		Carcinogenic Risk	
	Average Exposure	Reasonable Maximum Exposure	Average Exposure	Reasonable Maximum Exposure
Assuming No Domestic Potable Water Use (500-foot radius Kriging)				
Car Wash Worker	0.38	0.99	2×10^{-6}	2×10^{-5}
Landscape Worker	0.66	0.98	3×10^{-6}	3×10^{-5}
Resident	0.29	0.29	1×10^{-5}	1×10^{-5}
School Worker	0.29	0.29	7×10^{-6}	7×10^{-6}
School Student	0.29	0.29	2×10^{-6}	2×10^{-6}
Assuming Domestic Potable Water Use (500-foot radius Kriging)				
Resident	88	145	5×10^{-3}	2×10^{-2}

Source: Reproduced from ERRG 2004

Abbreviations and Acronyms:
HHRA – human health risk assessment
IR – Installation Restoration (Program)

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Table A-3
Summary of Benzene and Naphthalene Groundwater Concentrations from Samples Collected At/Near the Surface of the Water Table at Hydropunch Locations

Hydropunch Sample Location	Sample Depth Interval (feet)	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Sampling Date	Comment	Next Shallowest Sample Depth Interval (feet)
OU5-HP-1	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-2	8-12	2.2	34	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-3	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-4	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-5	12-16	3.8	26	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OU5-HP-6	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-7	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-8	8-12	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-9	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-10	8-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-11	8-12	<1	5	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-12	8-12	<1	14	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-13	8-12	<2	2.3	June - 2001	Sample collected at/nearest the water table	12 - 15
OU5-HP-14	6-10	<2	<2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-15	7-11	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-16	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-17	6-10	<1	2.2	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-18	8-12	<2	0.79	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-19	8-12	<2	4.7	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-20	6-10	0.4	27	June - 2001	Sample collected at/nearest the water table	10 - 14
OU5-HP-21	8-12	<1	21	June - 2001	Sample collected at/nearest the water table	12 - 16
OU5-HP-22	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP1		No Reported Data		June - 2001		
OS-HP2	8-12	41	270	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP3	12-16	<2	0.6	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP4	12-16	12	839	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP5	12-16	7.1	89	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP6	6-10	<1	2.6	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP7	10-14	375	3180	June - 2001	Shallowest sample - Not representative of conditions at the water table	14 - 18
OS-HP8	6-10	<1	4.4	June - 2001	Sample collected at/nearest the water table	11 - 15
OS-HP9	8-12	<1	30	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP10	6-10	4.2	49	June - 2001	Sample collected at/nearest the water table	9 - 13

Hydropunch Sample Location	Sample Depth Interval (feet)	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Sampling Date	Comment	Next Shallowest Sample Depth Interval (feet)
OS-HP11	8-12	0.49	0.89	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP12	5.5-9.5	<2	13	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP13	16-20	850	19000	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP14	12-16	742	3710	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 19
OS-HP15		No Reported Data		June - 2001		
OS-HP16		No Reported Data		June - 2001		
OS-HP17	8-12	<1	<1	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP18	17.5-20	27	2400	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP19		No Reported Data		June - 2001		
OS-HP20	16-20	17	210	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP21	12-16	0.6	0.7	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP22	16-20	8.8	370	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP23		No Reported Data		June - 2001		
OS-HP24		No Reported Data		June - 2001		
OS-HP25	12-16	<2	6.6	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP26	12-16	<2	<2	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP27	12-16	<2	1.3	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP28	8-12	<2	<2	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP29	12-16	<2	<2	June - 2001	Shallowest sample - Not representative of conditions at the water table	17 - 21
OS-HP30	12-16	1.2	390	June - 2001	Shallowest sample - Not representative of conditions at the water table	17 - 21
OS-HP31	12-16	113	235	June - 2001	Shallowest sample - Not representative of conditions at the water table	16 - 20
OS-HP32		No Reported Data		June - 2001		
OS-HP33		No Reported Data		June - 2001		
OS-HP34		No Reported Data		June - 2001		
OS-HP35	16-20	230	3400	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
OS-HP36	8-12	<1	9.2	June - 2001	Sample collected at/nearest the water table	12 - 16
OS-HP37	6-10	<1	4.9	June - 2001	Sample collected at/nearest the water table	10 - 14
OS-HP38		No Reported Data		June - 2001		
OS-HP39	12-16	90	1200	June - 2001	Shallowest sample - Not representative of conditions at the water table	None
PC2-1	6.5-9.5	1.7	1.2	July/August 2007	Sample collected at/nearest the water table	12 - 15
PC2-3	8-11	<0.5	0.64	July/August 2007	Sample collected at/nearest the water table	11 - 14
PC2-4	8-11	No Sample Could Be Obtained		July/August 2007		
PC2-4	12-15	<0.5	<2	July/August 2007	Sample collected at/nearest the water table	16 - 19
PC3-13	7.5-10.5	No Sample Could Be Obtained		July/August 2007		
PC3-13	12-15	8.1	660	July/August 2007	Sample collected nearest the water table	15 - 18
PC3-14	6-9	<0.5	<2	July/August 2007	Sample collected at/nearest the water table	12.5 - 15.5

TABLE A-4

GROUNDWATER CONCENTRATIONS AND LOCAL VADOSE ZONE SOIL COMPOSITION

Water Table Groundwater Sampling Location	Benzene Concentration (µg/L)	Naphthalene Concentration (µg/L)	Vadose Zone Stratigraphy (Starting at the surface)	Depth to Groundwater (feet bgs)
OS-HP-2	41	270	Sand - Clay	6.0
OS-HP-10	4.2	49	Sand - Clay - Sand	7.0
PC2-1	1.7	1.2	Sand - Silt - Sand	6.9
PC3-13	8.1	660	Sand - Clay - Sand	8.1

Abbreviations and Acronyms:
µg/L – micrograms per liter
bgs – below ground surface

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Table A-5
Projection of Indoor Air Inhalation Risk Due to Benzene and Naphthalene from Near Water Table Groundwater at Four Worst Case Locations Using USEPA, IRIS, and Cal/EPA DTSC Toxicity Criteria

	Month/Year of Near Water Table Groundwater Sampling	Groundwater to Indoor Air Modeling Results				Incremental Cancer Risk from Vapor Intrusion to Indoor Air		Incremental Non-Cancer Hazard Quotient from Vapor Intrusion to Indoor Air	
		Benzene		Napthalene		Benzene	Naphthalene	Benzene	Naphthalene
		Attenuation Factor	Projected Maximum Indoor Air Concentration	Attenuation Factor	Projected Maximum Indoor Air Concentration				
		(unitless)	(µg/m^3)	(unitless)	(µg/m^3)	(unitless)	(unitless)	(unitless)	(unitless)
OS-HP2	June - 2001								
IRIS Toxicity Criteria		6.51E-06	0.058	2.61E-05	0.13	2.0E-07	NA	0.0019	0.0410
DTSC Toxicity Criteria		6.51E-06	0.058	2.61E-05	0.13	6.9E-07	1.8E-06	0.0009	0.0140
OS-HP-10	June - 2001								
IRIS Toxicity Criteria		2.72E-04	0.25	1.99E-04	0.18	7.9E-07	NA	0.0079	0.0570
DTSC Toxicity Criteria		2.72E-04	0.25	1.99E-04	0.18	3.0E-06	2.5E-06	0.0040	0.0190
PC2-1	July/August - 2007								
IRIS Toxicity Criteria		3.42E-04	0.13	2.56E-04	0.0057	4.0E-07	NA	0.0040	0.0018
DTSC Toxicity Criteria		3.42E-04	0.13	2.56E-04	0.0057	1.5E-06	7.9E-08	0.0020	0.0006
PC3-13	July/August - 2007								
IRIS Toxicity Criteria		2.86E-04	0.50	2.10E-04	2.6	1.6E-06	NA	0.0160	0.8100
DTSC Toxicity Criteria		2.86E-04	0.50	2.10E-04	2.6	6.0E-06	3.6E-05	0.0080	0.2700

FIGURES

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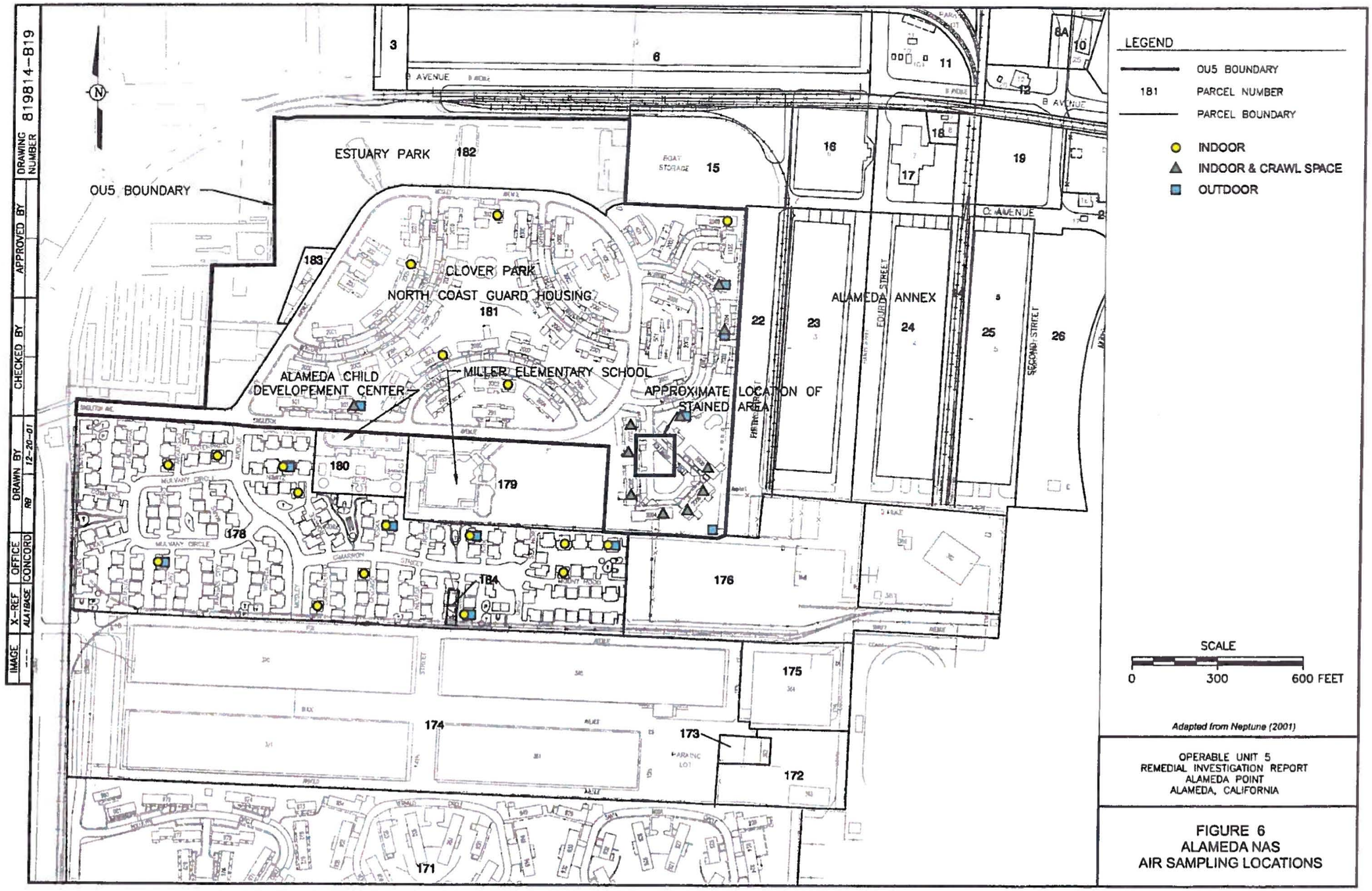
LEGEND
OU5 BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
INDOOR
INDOOR & CRAWL SPACE
OUTDOOR
SCALE
0 300 600 FEET
Adapted from Neptune (2001)
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 6
ALAMEDA NAS
AIR SAMPLING LOCATIONS
ESTUARY PARK 182
OU5 BOUNDARY
CLOVER PARK
NORTH COAST GUARD HOUSING
181
ALAMEDA CHILD DEVELOPEMENT CENTER
MILLER ELEMENTARY SCHOOL
APPROXIMATE LOCATION OF STAINED AREA
ALAMEDA ANNEX
EDWARD STREET
SECOND STREET
B AVENUE
C AVENUE
BOAT STORAGE
3
6
6A
10
11
12
15
16
17
18
19
22
23
24
25
26
171
172
173
174
175
176
178
179
180
183
184
DRAWING NUMBER 819814-B19
APPROVED BY
CHECKED BY
DRAWN BY RB 12-20-01
OFFICE CONCORD
X-REF ALATBASE
IMAGE

FIGURE A-1

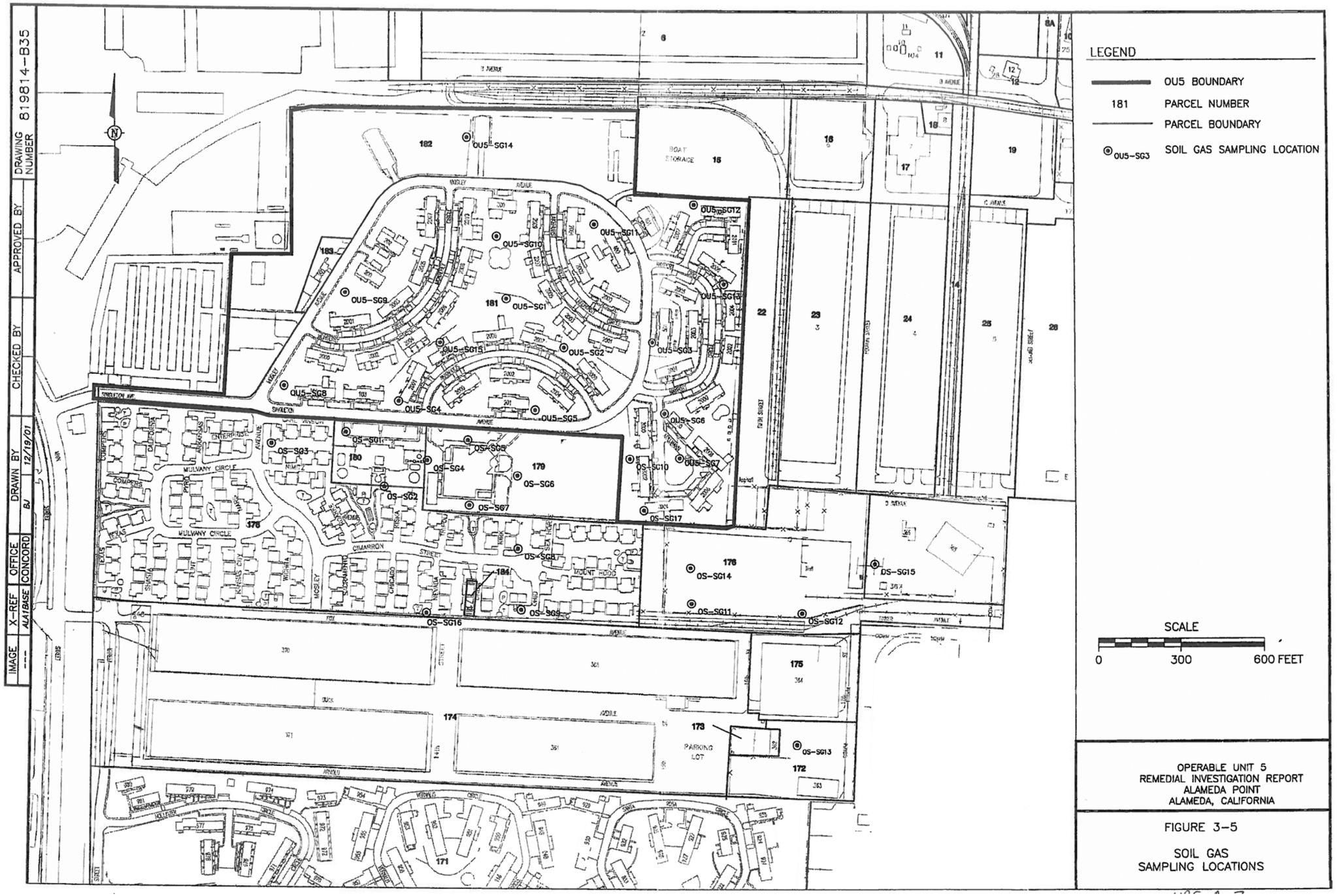
LEGEND
OU5 BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
OU5-SG3 SOIL GAS SAMPLING LOCATION
SCALE
0 300 600 FEET
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 3-5
SOIL GAS
SAMPLING LOCATIONS
DRAWING NUMBER 819814-B35
APPROVED BY
CHECKED BY
DRAWN BY BJ 12/19/01
OFFICE CONCORD
X-REF ALATBASE
IMAGE ---
182
183
181
180
179
178
176
175
174
173
172
171
184
OU5-SG14
OU5-SG12
OU5-SG11
OU5-SG10
OU5-SG9
OU5-SG1
OU5-SG13
OU5-SG15
OU5-SG2
OU5-SG3
OU5-SG8
OU5-SG4
OU5-SG5
OU5-SG6
OU5-SG7
OS-SG1
OS-SG8
OS-SG3
OS-SG4
OS-SG6
OS-SG2
OS-SG7
OS-SG10
OS-SG17
OS-SG14
OS-SG15
OS-SG11
OS-SG12
OS-SG16
OS-SG9
OS-SG13
PARKING LOT
BOAT STORAGE
MULVANY CIRCLE
CIMARRON STREET
MOUNT HOOD
MOSLEY
SKELTON AVE
MOORE AVENUE
FORM STREET
SOUTH STREET

FIGURE A-2

LEGEND
OU5-BOUNDARY
181 PARCEL NUMBER
PARCEL BOUNDARY
OS-HP24 DIRECT PUSH (HYDROPUNCH) GROUNDWATER SAMPLING LOCATIONS
S-35 MONITORING WELL LOCATION
OS-HP24 DIRECT PUSH (HYDROPUNCH) GROUNDWATER SAMPLING LOCATIONS SAMPLED FOR NATURAL ATTENUATION PARAMETER
SCALE
0 300 600 FEET
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA
FIGURE 3-4
GROUNDWATER SAMPLING LOCATIONS
DRAWING NUMBER 819814-B36
APPROVED BY
CHECKED BY
DRAWN BY BJ 12/19/01
OFFICE CONCORD
X-REF ALA1BASE
IMAGE

FIGURE A-3

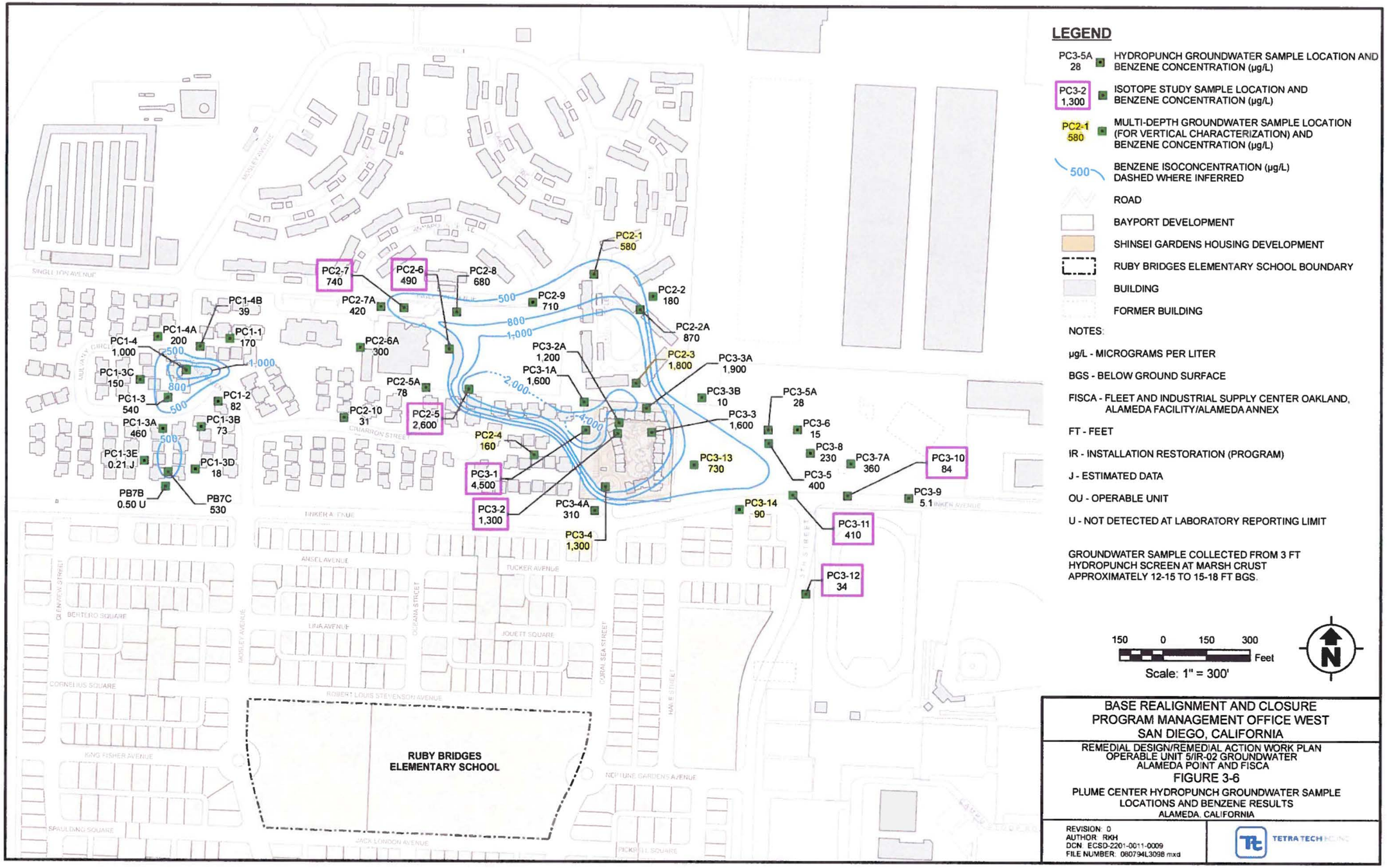
LEGEND
PC3-5A 28 HYDROPUNCH GROUNDWATER SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC3-2 1,300 ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/L)
PC2-1 580 MULTI-DEPTH GROUNDWATER SAMPLE LOCATION (FOR VERTICAL CHARACTERIZATION) AND BENZENE CONCENTRATION (µg/L)
500 BENZENE ISOCONCENTRATION (µg/L) DASHED WHERE INFERRED
ROAD
BAYPORT DEVELOPMENT
SHINSEI GARDENS HOUSING DEVELOPMENT
RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY
BUILDING
FORMER BUILDING
NOTES:
µg/L - MICROGRAMS PER LITER
BGS - BELOW GROUND SURFACE
FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX
FT - FEET
IR - INSTALLATION RESTORATION (PROGRAM)
J - ESTIMATED DATA
OU - OPERABLE UNIT
U - NOT DETECTED AT LABORATORY REPORTING LIMIT
GROUNDWATER SAMPLE COLLECTED FROM 3 FT HYDROPUNCH SCREEN AT MARSH CRUST APPROXIMATELY 12-15 TO 15-18 FT BGS.
150 0 150 300 Feet
Scale: 1" = 300'
N
PC2-7 740
PC2-6 490
PC2-8 680
PC2-1 580
PC2-7A 420
PC2-9 710
PC2-2 180
PC2-2A 870
PC1-4B 39
PC1-4A 200
PC1-1 170
PC1-4 1,000
PC2-6A 300
PC3-2A 1,200
PC3-1A 1,600
PC2-3 1,800
PC3-3A 1,900
PC1-3C 150
PC2-5A 78
PC3-3B 10
PC3-5A 28
PC1-3 540
PC1-2 82
PC2-10 31
PC2-5 2,600
PC3-3 1,600
PC3-6 15
PC1-3A 460
PC1-3B 73
PC2-4 160
PC3-8 230
PC3-7A 360
PC3-10 84
PC1-3E 0.21 J
PC1-3D 18
PC3-13 730
PC3-5 400
PC3-1 4,500
PC3-9 5.1
PB7B 0.50 U
PB7C 530
PC3-2 1,300
PC3-4A 310
PC3-14 90
PC3-11 410
PC3-4 1,300
PC3-12 34
500
800
1,000
2,000
4,000
TINKER AVENUE
ANSEL AVENUE
TUCKER AVENUE
BERTERO SQUARE
LINA AVENUE
JOUETT SQUARE
CORNELIUS SQUARE
ROBERT LOUIS STEVENSON AVENUE
KING FISHER AVENUE
SPAULDING SQUARE
JACK LONDON AVENUE
NEPTUNE GARDENS AVENUE
RUBY BRIDGES ELEMENTARY SCHOOL
BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA
FIGURE 3-6
PLUME CENTER HYDROPUNCH GROUNDWATER SAMPLE LOCATIONS AND BENZENE RESULTS
ALAMEDA, CALIFORNIA
REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3098.mxd
TETRA TECH INC

FIGURE A-4

ATTACHMENT 1

BENZENE AND NAPHTHALENE INITIAL MASS AND POUNDS REMOVED CALCULATIONS

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Benzene and Naphthalene Initial Mass and Pounds Removed Calculations

The total mass of benzene and naphthalene in the treatment areas was estimated using soil and groundwater sampling results. Masses of both contaminants were estimated within the Eastern Biosparge Treatment Area (EBTA) and Western Biosparge Treatment Area (WBTA) where biosparging is in progress. Calculations for mass of contaminants in the two treatment areas are shown in Table 1.

Sampling of the Marsh Crust conducted in 2007 during predesign fieldwork from locations within the treatment areas (PC 1-3 and PC 1-4 for the WBTA; and PC 2-3, PC 2-5, PC 3-1, PC 3-2, and PC 3-4 for the EBTA [see RD/RAWP Figures 3-4 and 3-5 attached]) was used to estimate the mass of contaminants within the Marsh Crust. Baseline sampling of the biosparge monitoring wells conducted in 2009 (BZMW-7 and M25-01 for the WBTA and BZMW-1 through -6 for the EBTA) was used to estimate the mass of contaminants in the groundwater prior to treatment (see Figure 1). To estimate contaminant mass within each treatment area, concentrations of each contaminant were averaged over the treatment area using the mean of sampling results obtained from the above sampling locations.

Volumes within each treatment area were calculated for both the aquifer within each treatment area and for the Marsh Crust located beneath each treatment area. Total contaminant mass was calculated by adding the contaminant mass in the aquifer, derived from baseline sampling data, to the contaminant mass in the Marsh Crust soil, derived from soil sampling data.

Changes in mass of benzene and naphthalene were calculated based on the July 2009 to July 2012 biosparge system monitoring events. Concentrations of each contaminant were averaged over each treatment area using mean sampling results. Change in contaminant mass from each monitoring event to the subsequent event was calculated from the mean concentrations. The cumulative mass flux results from the 2009 to 2012 monitoring events were used to calculate total mass removed.

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TABLES

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TABLE 1

CONTAMINANT INITIAL MASS CALCULATIONS

WBTA	
Aquifer Properties	
Area (ft^2)	30,492
Aquifer Thickness (ft)	2
Volume (ft^3)	60,984
Soil Porosity (%)	30%
Gallons of Water	136,858
Liters of Water	518,062
Mean Initial Concentration Benzene (µg/l)	510
Initial Benzene Mass (kg)	0.26
Mean Initial Concentration Naphthalene (µg/l)	3700
Initial Naphthalene Mass (kg)	1.92
Marsh Crust Properties	
Thickness (in)	0.75
Marsh Crust Dry Bulk Density (g/cm^3)	1.85
Volume of Marsh Crust in WBTA (ft^3)	1,906
Mean Initial Concentration Benzene (µg/kg)	31,000
Initial Benzene Mass (kg)	3.1
Mean Initial Concentration Naphthalene (µg/kg)	6,150,000
Initial Naphthalene Mass (kg)	614
Estimated initial mass	
Benzene (kg)	3.4
Napthalene (kg)	616
EBTA	
Aquifer	
Area (ft^2)	235,224
Aquifer Thickness (ft)	6.5
Volume (ft^3)	1,528,956
Soil Porosity (%)	30%
Gallons of Water	3,431,216
Liters of Water	12,988,564
Mean Initial Concentration Benzene (µg/l)	201
Initial Benzene Mass (kg)	2.61
Mean Initial Concentration Naphthalene (µg/l)	2,572
Initial Naphthalene Mass (kg)	33.5

TABLE 1

CONTAMINANT INITIAL MASS CALCULATIONS

EBTA (continued)	
Marsh Crust	
Thickness (in)	0.75
Marsh Crust Dry Bulk Density (g/cm^3)	1.85
Volume of Marsh Crust in EBTA (ft^3)	14,702
Mean Initial Concentration Benzene (µg/kg)	49,480
Initial Benzene Mass (kg)	38.1
Mean Initial Concentration Naphthalene (µg/kg)	4,624,000
Initial Naphthalene Mass (kg)	3,561
Estimated initial mass	
Benzene (kg)	40.7
Naphthalene (kg)	3,595
Estimated Combined Treatment Area Mass	
Benzene (kg)	**44**
Naphthalene (kg)	**4,211**

Calculations:

Mass in Groundwater = Aquifer Volume × Porosity × Mean Contaminant Concentration

Initial Mass in Groundwater = Liters of Water × Mean Initial Contaminant Concentration / 1,000,000,000

Mass in Soil = Marsh Crust Volume × Dry Bulk Density × Mean Contaminant Concentration

Initial Mass in Soil = Volume of Marsh Crust × (12 × 2.54)^3 × Dry Bulk Density / 1,000 × Mean Initial Contaminant Concentration / 1,000,000,000

Estimated Initial Mass = Initial Mass in Groundwater + Initial Mass in Soil

FIGURES

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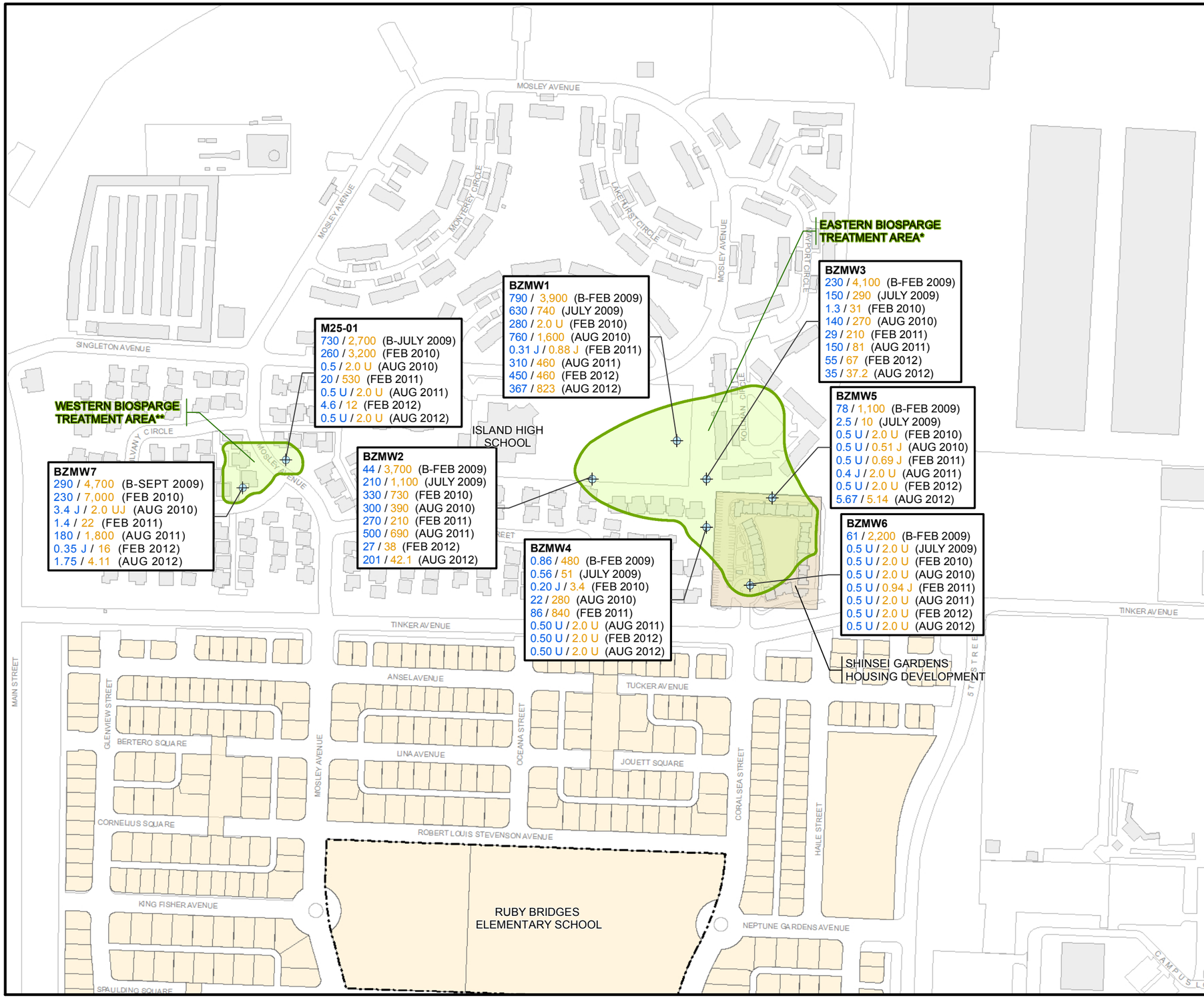


LEGEND

- GROUNDWATER MONITORING WELL
- ROAD
- BIOSPARGE TREATMENT AREA
- BAYPORT DEVELOPMENT
- BUILDING

SAMPLE RESULTS

POINT ID	BZMW1
PRE-REMEDIATION BASELINE DATA (SAMPLE DATE)	790 / 3,900 (B-FEB 2009)
SEMI-ANNUAL DATA (SAMPLE DATE)	630 / 740 (JULY 2009)
SEMI-ANNUAL DATA (SAMPLE DATE)	280 / 2.0 U (FEB 2010)
SEMI-ANNUAL DATA (SAMPLE DATE)	76 / 1,600 (AUG 2010)
SEMI-ANNUAL DATA (SAMPLE DATE)	0.31 J / 0.88 J (FEB 2011)
SEMI-ANNUAL DATA (SAMPLE DATE)	310 / 460 (AUG 2011)
SEMI-ANNUAL DATA (SAMPLE DATE)	450 / 460 (FEB 2012)
SEMI-ANNUAL DATA (SAMPLE DATE)	367 / 823 (AUG 2012)

BENZENE RESULTS

NAPHTHALENE RESULTS

NOTES:

µg/L - MICROGRAMS PER LITER

B - BASELINE (PRE-REMEDIATION) DATA

BENZENE RESULTS IN µg/L

J - ESTIMATED VALUE

NAPHTHALENE RESULTS IN µg/L

U - NOT DETECTED ABOVE SCREENING LIMIT

* NON-SHINSEI GARDENS PORTION OF TREATMENT SYSTEM START-UP IN MARCH 2009
SHINSEI GARDENS PORTION OF TREATMENT SYSTEM START-UP MAY 2009.

** SYSTEM START-UP OCTOBER 2009

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

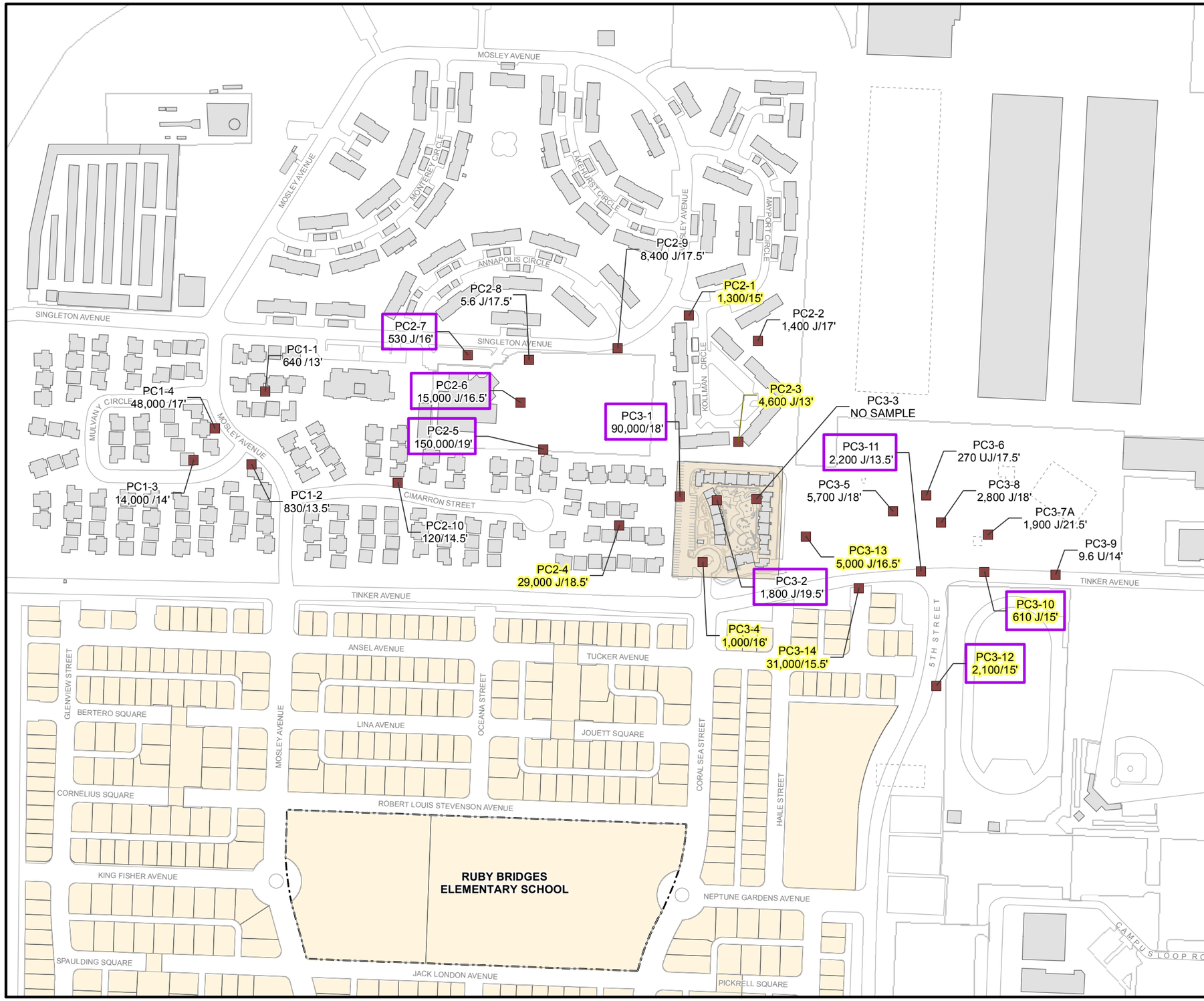
BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 1

BASELINE AND SEMI-ANNUAL BENZENE
AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: A
AUTHOR: MS
DCN: ECSD-3211-0007-0015
FILE NUMBER: 120301A7584.mxd

TETRA TECH EC, INC.



LEGEND

PC1-2 830 /13.5' — SOIL SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH BASED ON HIGHEST CONCENTRATION INDICATED BY FIELD SCREENING)

PC2-6 15,000 J/16.5' — ISOTOPE STUDY SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH IS MARSH CRUST)

PC2-1 1,300/15' — MULTI-DEPTH SOIL SAMPLE LOCATION AND BENZENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (RESULTS LISTED ARE HIGHEST OF SAMPLES ANALYSED FROM 3 DEPTHS AT EACH LOCATION)

ROAD

BAYPORT DEVELOPMENT

SHINSEI GARDENS HOUSING DEVELOPMENT

RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY

BUILDING

FORMER BUILDING

NOTES:

µg/kg - MICROGRAMS PER KILOGRAM

BGS - BELOW GROUND SURFACE

FT - FEET

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

150 0 150 300 Feet

Scale: 1" = 300'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

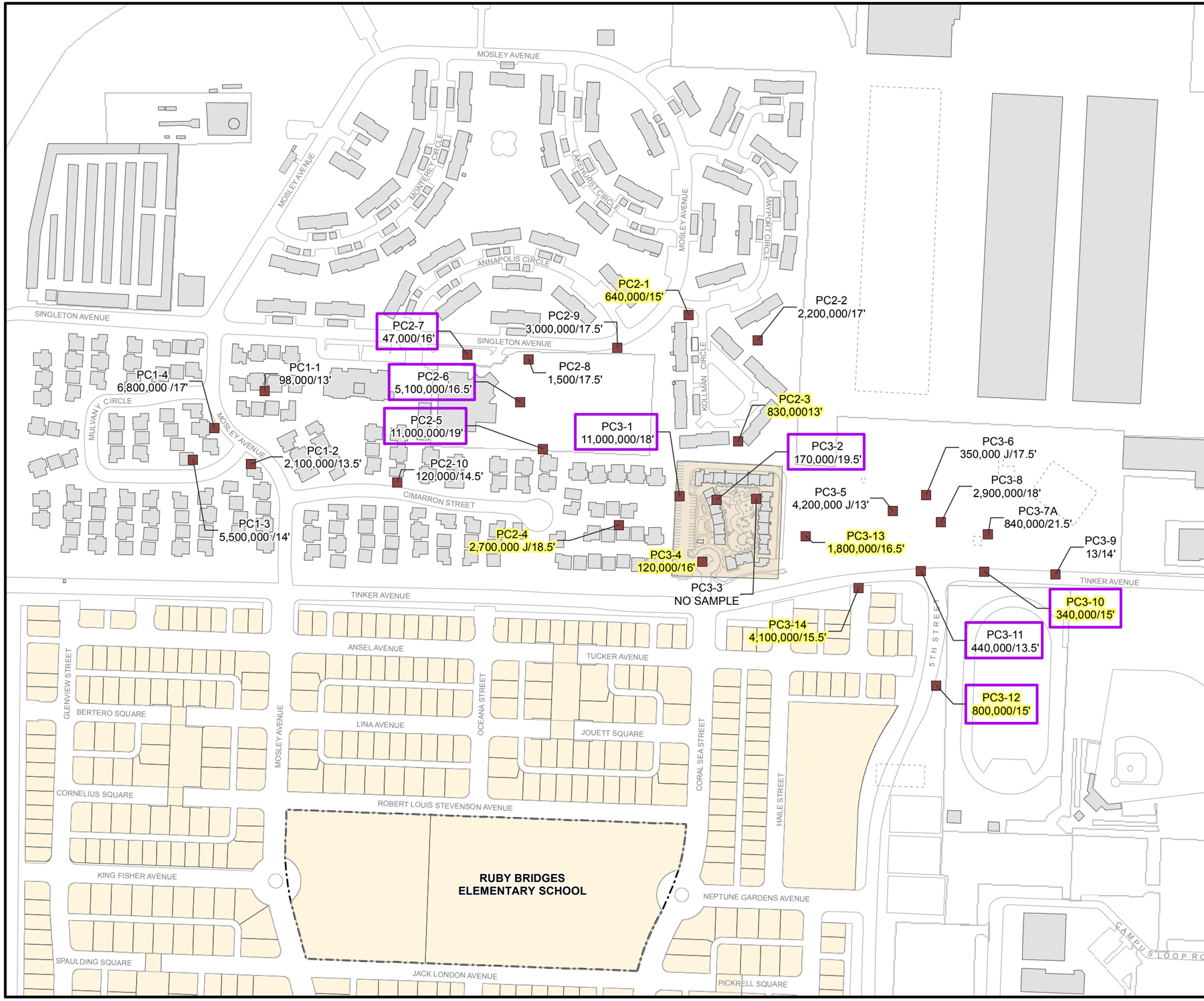
REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 3-4

PLUME CENTER SOIL SAMPLE
LOCATIONS AND BENZENE RESULTS
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
FILE NUMBER: 080794L3096.mxd

TETRA TECH EC, INC.



LEGEND

PC2-8 1,500/17.5' — SOIL SAMPLE LOCATION AND NAPHTHALENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH BASED ON HIGHEST CONCENTRATION INDICATED BY FIELD SCREENING)

PC2-7 47,000/16' — ISOTOPE STUDY SAMPLE LOCATION AND NAPHTHALENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (SAMPLE DEPTH IS MARSH CRUST)

PC2-1 640,000/15' — MULTI-DEPTH SOIL SAMPLE LOCATION AND NAPHTHALENE CONCENTRATION (µg/kg)/DEPTH (FT BGS) (RESULTS LISTED ARE HIGHEST OF SAMPLES ANALYSED FROM 3 DEPTHS AT EACH LOCATION)

ROAD

BAYPORT DEVELOPMENT

SHINSEI GARDENS HOUSING DEVELOPMENT

RUBY BRIDGES ELEMENTARY SCHOOL BOUNDARY

BUILDING

FORMER BUILDING

NOTES:

µg/kg - MICROGRAMS PER KILOGRAM

BGS - BELOW GROUND SURFACE

FT - FEET

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

IR - INSTALLATION RESTORATION (PROGRAM)

OU - OPERABLE UNIT

J - ESTIMATED DATA

150 0 150 300 Feet

Scale: 1" = 300'

N

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

REMEDIAL DESIGN/REMEDIAL ACTION WORK PLAN
OPERABLE UNIT 5/IR-02 GROUNDWATER
ALAMEDA POINT AND FISCA

FIGURE 3-5

PLUME CENTER SOIL SAMPLE
LOCATIONS AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVISION: 0
AUTHOR: RKH
DCN: ECSD-2201-0011-0009
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TETRA TECH EC, INC.

ATTACHMENT 2

BIOSPARGE AREA AND PLUME BOUNDARY MONITORING WELL RESULTS

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BIOSPARGE AREA MONITORING WELL SEMIANNUAL RESULTS
BASELINE THROUGH AUGUST 2012

Table 1
Biosparge Zone Monitoring Well Results

	Method	EPA 8260B	EPA 8260B	EPA 300.0	EPA 300.0	EPA 300.0	EPA 350.2	EPA 351.3	EPA 9060	NA
	Analyte	BENZENE	NAPHTHALENE	NITRATE	ORTHO-PHOSPHATE	SULFATE	AMMONIA	TKN	TOC	DISSOLVED OXYGEN[a]
	Unit	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L
Location	**Collection Date**									
BZMW1	2/12/2009	790	3,900	244	1,000 U	115,000	16.0	20.4	25.5	0.3
BZMW1	7/22/2009	630	740	803	518 J	427,000	13.6	16.5	33.2	0.1
BZMW1	2/17/2010	280	2.0 U	107	500U	1,150,000	12.2	16.9	35.6	0.1
BZMW1	8/18/2010	760	1,600	67.2 J	500U	2,290,000	7.66	10.6	24.2	0.2
BZMW1	2/16/2011	0.26 J	0.88 J	67.2 J	2,500 U	2,340,000	5.31	7.80	17.5	1.3
BZMW1	8/17/2011	310	460	1,220	2,500 U	1,870,000	3.95	7.01	15.6	3.8
BZMW1	2/29/2012	450	460	990	500 U	2,170,000	1.29	5.48	18.9	2.7
BZMW1	8/29/2012	367	823	40 U	2,150	1,990,000	8.08	7.45	15.6	0.8
BZMW2	2/12/2009	44	3,700	165	2,090	563,000	6.70	6.68	17.8	0.3
BZMW2	7/23/2009	210	1,000	200 U	1,000 U	1,170,000	13.7	15.3	23.1	0.1
BZMW2	2/17/2010	330	730	604	500 U	383,000	17.6	22.2	30.7	1.9
BZMW2	8/18/2010	300	390	350	500U	493,000	7.66	11.0	20.9	0.2
BZMW2	2/16/2011	270	210	500 U	2,460 J	968,000	21.8	22.1	40.3	0.3
BZMW2	8/17/2011	500	690	500 U	2,500 U	758,000	15.1	19.8	16.1	4.2
BZMW2	2/29/2012	27	38	203	426 J	1,140,000	13.3	13.4	20.6	5.8
BZMW2	8/29/2012	201	42.1	40 U	4,230	906,000	13.5	14.0	19.3	1.0
BZMW3	2/12/2009	230	4,100	167	500 U	4,410	5.07	5.56	7.65	0.2
BZMW3	7/22/2009	150	290	258	1,000 U	4,830,000	4.06	5.74	10.1	0.1
BZMW3	2/16/2010	1.3	31	16,200	500 U	776,000	0.217	0.899	6.85	0.3
BZMW3	8/17/2010	140	270	100 U	500 UJ	1,420,000	0.923 J	1.62	5.36	0.3
BZMW3	2/15/2011	29	210	94.5 J	500 U	3,250,000	2.66	2.76	5.03	0.4
BZMW3	8/16/2011	150	81	100 U	500 U	1,170,000	0.407	0.819	5.21	4.1
BZMW3	2/29/2012	55	67	144	500 U	1,600,000	0.479	1.05	4.57	4.1
BZMW3	8/29/2012	35	37.2	20 J	10,000 U	1,010,000	0.604	0.994	8.13	0.9
BZMW4	2/12/2009	0.69 J	430 J	155	10,700	426,000	4.61	6.12	12.0	0.4
BZMW4	7/23/2009	0.56	51	117	500 U	2,810,000	6.59	7.88	12.4	0.3
BZMW4	2/17/2010	0.20 J	3.4	417	847	1,100,000	0.368	1.50	8.13	9.0
BZMW4	8/18/2010	22	280	1,150	1,000U	4,720,000	4.50	6.15	6.98	4.0
BZMW4	2/15/2011	86	840	500 U	2,500 U	6,040,000	26.5	29.8	13.9	0.7
BZMW4	8/17/2011	0.50 U	2.0 U	1,430	394 J	1,290,000	0.169	0.883	7.55	–
BZMW4	2/29/2012	0.50 U	2.0 U	1,380	457 J	895,000	0.0957 J	0.457	5.56	8.0
BZMW4	8/30/2012	0.50 U	2.0 U	2,710	716	1,630,000	0.026 U	0.545 J	9.23	7.1

Table 1
Biosparge Zone Monitoring Well Results

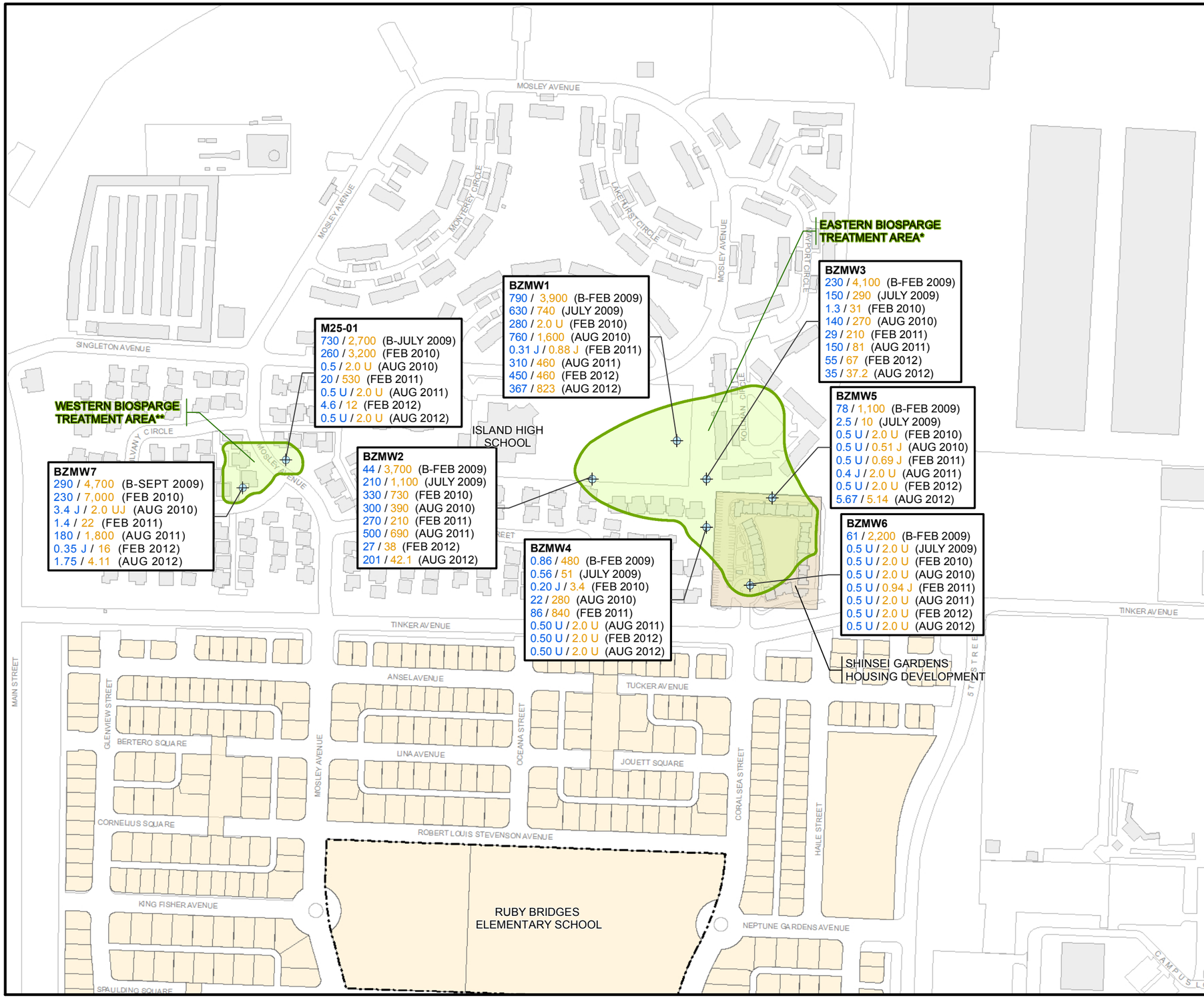
	Method	EPA 8260B	EPA 8260B	EPA 300.0	EPA 300.0	EPA 300.0	EPA 350.2	EPA 351.3	EPA 9060	NA
	Analyte	BENZENE	NAPHTHALENE	NITRATE	ORTHO-PHOSPHATE	SULFATE	AMMONIA	TKN	TOC	DISSOLVED OXYGEN[a]
	Unit	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L
Location	**Collection Date**									
BZMW5	2/12/2009	78	1,100	149	260 J	173,000	2.41	2.58	8.19	0.3
BZMW5	7/23/2009	2.5	10	11,200	500 U	389,000	0.727	0.742	4.74	3.8
BZMW5	2/16/2010	0.50 U	2.0 U	18,600	500 U	1,090,000	0.158	0.665	5.66	8.0
BZMW5	8/17/2010	0.50 U	0.51 J	2,110	500 UJ	1,130,000	0.100 UJ	0.474	4.14	7.1
BZMW5	2/15/2011	0.50 U	0.69 J	6,480	500 U	775,000	0.100 U	0.373	3.12	7.1
BZMW5	8/16/2011	0.40 J	2.0 U	6,200	500 U	998,000	0.100 U	1.08	3.66	9.6
BZMW5	2/29/2012	0.50 U	2.0 U	10,400	500 U	1,070,000	0.284	0.42	4.15	8.0
BZMW5	8/29/2012	5.67	5.14	6.63 J	10,000 U	1,120,000	0.206	0.734	12.8	1.8
BZMW6	2/12/2009	61	2,200	185 J	13,000	361,000	9.52	10.9	17.9	0.2
BZMW6	7/23/2009	0.50 U	2.0 U	22,200	297 J	1,060,000	0.410	1.14	17.3	5.6
BZMW6	2/16/2010	0.50 U	2.0 U	19,100	500 U	2,210,000	0.174	0.643	12.8	8.2
BZMW6	8/17/2010	0.50 U	2.0 U	2,430	500 UJ	1,740,000	0.103 J	0.672	11.3	8.3
BZMW6	2/16/2011	0.50 U	0.94 J	9,680	319 J	1,790,000	0.100 U	0.662	9.28	7.6
BZMW6	8/16/2011	0.50 U	2.0 U	5,440	500 U	2,010,000	0.100 U	0.633	8.75	9.8
BZMW6	2/29/2012	0.50 U	2.0 U	10,100	500 U	1,850,000	0.399	0.677	7.34	8.2
BZMW6	8/29/2012	0.50 U	2.0 U	3,290	10,000 U	2,680,000	0.05 U	0.607	9.11	7.9
BZMW7	9/17/2009	290	4,700	248	2,880	490,000	36	41.5	54.7	0.3
BZMW7	2/16/2010	230	7,000	200 U	1,480	636,000	26.6	32.6	44.9	0.2
BZMW7	8/17/2010	3.4 J	2.0 UJ	200 U	1,000 UJ	142,000	0.408 J	7.78	63	0.5
BZMW7	2/16/2011	1.4	22	500 U	2,500 U	154,000	22.3	23.1	33.2	0.1
BZMW7	8/16/2011	180	1,800	500 U	1,460 J	1,920 J	31.9	32.1	35.3	5.2
BZMW7	2/29/2012	0.35 J	16	1590	2,500 U	287,000	15.5	21.3	43.1	6.1
BZMW7	8/30/2012	1.75	4.11	1,000 U	4,000 U	103,000	0.547	9.77	58.6	3.0
M25-01	7/23/2009	730	2,700	448	2,880	642 J	37.0	38.7	53.7	0.4
M25-01	2/17/2010	260	3,200	225	830 J	1,070,000	38.4	43.5	96.1	0.1
M25-01	8/18/2010	0.50 UJ	2.0 UJ	30,500	1,680 J	1,200,000	1.74	3.44	49.1	5.1
M25-01	2/15/2011	20	530	4,500	2,500 U	2,950,000	27.5	29.0	35.8	1.9
M25-01	8/17/2011	0.50 U	2.0 U	34,100	2,500 U	1,620,000	1.64	5.42	34.6	8.4
M25-01	2/29/2012	4.6	12	21,900	2,500 U	1,520,000	0.806	3.87	47.4	7.5
M25-01	8/30/2012	0.5 U	2.0 U	2,350	4,000 U	3,960,000	0.142	10.0	82.5	4.5

Notes:

[a] Dissolved oxygen measured using field instruments during pre-sampling well purging.

Abbreviations and Acronyms:

µg/L – micrograms per liter
EPA – U.S. Environmental Protection Agency
J – estimated value
mg/L – milligrams per liter
NA – not applicable
TKN – total Kjeldahl nitrogen
U – analyte not detected above project reporting limit
TOC – total organic carbon



LEGEND

- GROUNDWATER MONITORING WELL
- ROAD
- BIOSPARGE TREATMENT AREA
- BAYPORT DEVELOPMENT
- BUILDING

SAMPLE RESULTS

POINT ID	BZMW1
PRE-REMEDIATION BASELINE DATA (SAMPLE DATE)	790 / 3,900 (B-FEB 2009)
SEMI-ANNUAL DATA (SAMPLE DATE)	630 / 740 (JULY 2009)
SEMI-ANNUAL DATA (SAMPLE DATE)	280 / 2.0 U (FEB 2010)
SEMI-ANNUAL DATA (SAMPLE DATE)	76 / 1,600 (AUG 2010)
SEMI-ANNUAL DATA (SAMPLE DATE)	0.31 J / 0.88 J (FEB 2011)
SEMI-ANNUAL DATA (SAMPLE DATE)	310 / 460 (AUG 2011)
SEMI-ANNUAL DATA (SAMPLE DATE)	450 / 460 (FEB 2012)
SEMI-ANNUAL DATA (SAMPLE DATE)	367 / 823 (AUG 2012)

BENZENE RESULTS

NAPHTHALENE RESULTS

NOTES:

µg/L - MICROGRAMS PER LITER

B - BASELINE (PRE-REMEDIATION) DATA

BENZENE RESULTS IN µg/L

J - ESTIMATED VALUE

NAPHTHALENE RESULTS IN µg/L

U - NOT DETECTED ABOVE SCREENING LIMIT

* NON-SHINSEI GARDENS PORTION OF TREATMENT SYSTEM START-UP IN MARCH 2009
SHINSEI GARDENS PORTION OF TREATMENT SYSTEM START-UP MAY 2009.

** SYSTEM START-UP OCTOBER 2009

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 1

BASELINE AND SEMI-ANNUAL BENZENE
AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: A
AUTHOR: MS
DCN: ECSD-3211-0007-0015
FILE NUMBER: 120301A7584.mxd

TETRA TECH EC, INC.

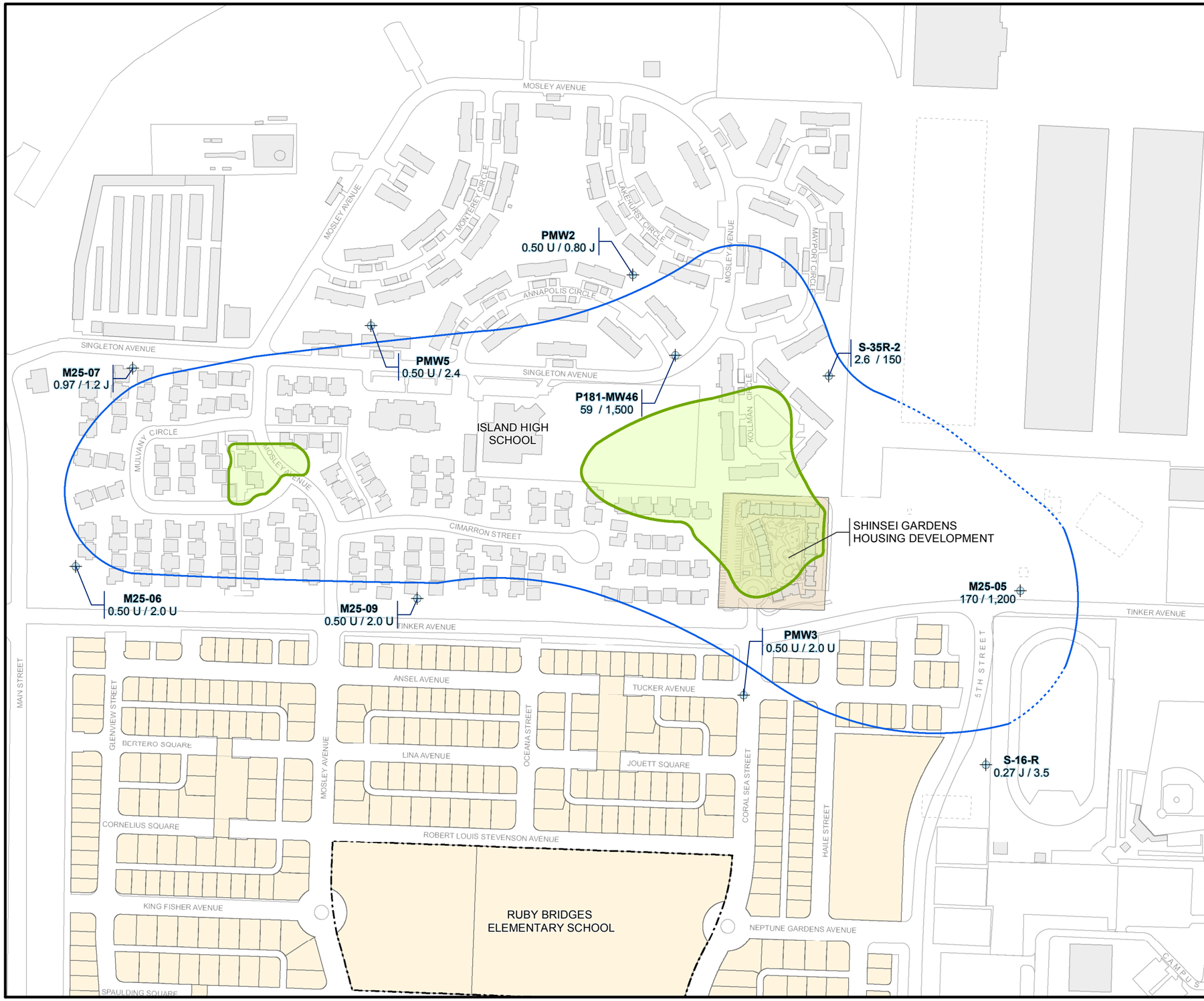
2009 ANNUAL PERIMETER MONITORING WELL RESULTS

TABLE 1

PERIMETER GOUNDWATER MONITORING WELL RESULTS

Well Name	Sample Date	EPA Method 8260B Benzene (µg/L)	EPA Method 8260B Naphthalene (µg/L)	Dissolved Oxygen (mg/L)	EPA Method 300 Nitrate (µg/L)	EPA Method 300 Orthophosphate (µg/L)	EPA Method 300 Sulfate (µg/L)	EPA Method 350.2 Ammonia as Nitrogen (mg/L)	EPA Method 351.3 Total Kjeldahl Nitrogen (mg/L)	EPA Method 9060 Total Organic Carbon (mg/L)
M25-05	7/22/2009	170	1,200	0.12	1,280	12,500	8,560	39.0	38.4	43.1
M25-06	7/21/2009	0.50 U	2.0 U	0.1	1,760	18,500	23,200	80.9	72.8	43.2
M25-07	7/22/2009	0.97	1.2 J	0.31	1,000	2,500 U	2,500 U	1.48	1.50	17.5
M25-09	7/22/2009	0.50 U	2.0 U	0.53	366	1,000 U	2,450	4.74	10.9	35.1
P181-MW46	7/21/2009	59	1,500	0.21	598	2,500 U	454 J	18.1	12.2	20.3
PMW2	7/21/2009	0.50 U	0.80 J	0.21	137	500 U	139,000	4.10	3.98	6.83
PMW3	7/22/2009	0.50 U	2.0 U	0.27	76.4 J	1,830	359,000	0.485	1.59	7.85
PMW5	7/21/2009	0.50 U	2.4	0.11	96.3 J	682	1,250	1.94	2.06	6.16
S-16-R	7/22/2009	0.27 J	3.5	0.54	1,660	16,000	30,100	35.7	37.4	42.1
S-35R-2	7/21/2009	2.6	150	0.17	99.3 J	2,140	132,000	3.46	3.50	8.15

Abbreviations and Acronyms:
µg/L – micrograms per liter
J – estimated value
mg/L – milligrams per liter
NA – not analyzed
U – analyte is not detected at the listed reporting limit



LEGEND

M25-05 170 / 1,200 — MONITORING WELL BENZENE/NAPHTHALENE RESULT (µg/L) 10 FT WELL SCREEN (APPROXIMATELY 10-20 FT BGS)

1 — 1 µg/L BENZENE CONCENTRATION DASHED WHERE INFERRED

ROAD

BIOSPARGE ZONE BOUNDARY

BAYPORT DEVELOPMENT

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

2009-2010 ANNUAL REPORT FOR BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 4-1

JULY 2009 GROUNDWATER MONITORING WELL
BENZENE/NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: A
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FILE NUMBER: 100115L5783.mxd

TETRA TECH EC, INC.

2010 ANNUAL PERIMETER MONITORING WELL RESULTS

Table 1
Perimeter Groundwater Monitoring Well Results

	Method	EPA 300.0	EPA 300.0	EPA 300.0	EPA 350.2	EPA 351.3	EPA 8260B	EPA 8260B	EPA 9060
	Analyte	NITRATE	ORTHO-PHOSPHATE	SULFATE	AMMONIA	TKN	BENZENE	NAPHTHALENE	TOC
	Unit	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L	mg/L
Location	Collection Date								
S-35R-2	8/17/2010	100 U	1,430 J	226,000	2.77 J	2.93	1.5	66	6.19
P181-MW46	8/17/2010	175	510 J	521	13.9 J	15.8	74	2,000	18.6
PMW2	8/17/2010	55.3 J	500 UJ	465,000	3.74 J	4.99	0.50 U	0.98 J	7.15
PMW5	8/17/2010	67.2 J	858 J	4,030	1.20 J	1.77	0.50 U	2.0 U	7.49
M25-06	8/17/2010	818	12,400 J	1,070	52.9 J	57.7	1.0 J	3.3 J	51.9
PMW3	8/18/2010	193	500 U	395,000	0.100 U	0.604	0.50 U	2.0 U	5.59
M25-07	8/17/2010	498 J	500 UJ	464 J	21.4 J	24.6	0.83 J	1.2 J	17
S-16-R	8/18/2010	634	14,500	129,000	56.5	68.5	0.50 UJ	2.6 J	36.5
M25-05	8/18/2010	252 J	10,900	38,700	23	27.5	170	300	23.3
M25-09	8/18/2010	500 U	2,500 U	1,410 J	7.76	9.47	0.50 U	2.0 U	30.9

Abbreviations and Acronyms:

µg/L – micrograms per liter
EPA – U.S. Environmental Protection Agency
J – estimated value
mg/L – milligrams per liter
TKN – total Kjeldahl nitrogen
TOC – total organic carbon
U – analyte not detected above project reporting limit

LEGEND

M25-05 170 / 1,200 — MONITORING WELL BENZENE/NAPHTHALENE RESULT (µg/L) 10 FT WELL SCREEN (APPROXIMATELY 10-20 FT BGS)

1 — 1 µg/L BENZENE CONCENTRATION/ ESTIMATED PLUME BOUNDARY (DASHED WHERE INFERRED)

ROAD

BIOSPARGE TREATMENT AREA

BAYPORT DEVELOPMENT

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

SVE - SOIL VAPOR EXTRACTION

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 1

AUGUST 2010 PERIMETER GROUNDWATER
MONITORING WELL BENZENE AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: D
AUTHOR: GFG
DCN: ECSD-2201-0011-0017
FILE NUMBER: 007A6361.mxd

TETRA TECH EC, INC.

2011 ANNUAL PERIMETER MONITORING WELL RESULTS

Table 1
Perimeter Groundwater Monitoring Well Results

	Method	EPA 300.0	EPA 300.0	EPA 300.0	EPA 350.2	EPA 351.3	EPA 8260B	EPA 8260B	EPA 9060
	Analyte	NITRATE	ORTHO-PHOSPHATE	SULFATE	AMMONIA	TKN	BENZENE	NAPHTHALENE	TOC
	Unit	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L	mg/L
Location	Collection Date								
S-35R-2	8/15/2011	100 U	978	302,000	3.78	3.75	1.0	18	5.94
P181-MW46	8/15/2011	500 U	3020	4,920	17.1	17.9	65	1,400	14.7
PMW2	8/15/2011	100 U	500 U	555,000	4.02	4.71	0.50 U	2.6	4.92
PMW5	8/15/2011	56.1 J	500 U	2,620	1.62	1.78	0.50 U	2.1	7.72
M25-06	8/15/2011	500 U	16,200	21,600	70.2	74.6	0.50 U	0.77J	37.1
PMW3	8/16/2011	100 U	677	374,000	0.407	0.709	0.50 U	2.0 U	5.81
M25-07	8/15/2011	500 U	2,500 U	2,500 U	25.3	33.9	0.91	1.7J	13.2
S-16-R	8/16/2011	261 J	16,400	333,000	57.5	66.6	0.50 U	2.0 U	26.4
M25-05	8/16/2011	500 U	12,300	7,420	37.3	35.1	190	120	20.7
M25-09	8/15/2011	500 U	2,500 U	2,500 U	8.16	18.3	0.50 U	2.0 U	20.6

Abbreviations and Acronyms:

µg/L – micrograms per liter
EPA – U.S. Environmental Protection Agency
J – estimated value
mg/L – milligrams per liter
TKN – total Kjeldahl nitrogen
TOC – total organic carbon
U – analyte not detected above project reporting limit

LEGEND

M25-05 / 170 / 1,200 — MONITORING WELL BENZENE/NAPHTHALENE RESULT (µg/L) 10 FT WELL SCREEN (APPROXIMATELY 10-20 FT BGS)

1 — 1 µg/L BENZENE CONCENTRATION/ ESTIMATED PLUME BOUNDARY (DASHED WHERE INFERRED)

ROAD

BIOSPARGE TREATMENT AREA

BAYPORT DEVELOPMENT

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

SVE - SOIL VAPOR EXTRACTION

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 1

AUGUST 2011 PERIMETER GROUNDWATER
MONITORING WELL BENZENE AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: D
AUTHOR: GFG
DCN: ECSD-2201-0011-0017
FILE NUMBER: 007A7263.mxd

TETRA TECH EC, INC.

2012 ANNUAL PERIMETER MONITORING WELL RESULTS

Table 2
Perimeter Groundwater Monitoring Well Results

	Method	EPA 300.0	EPA 300.0	EPA 300.0	EPA 350.2	EPA 351.3	EPA 8260B	EPA 8260B	EPA 9060	NA
	Analyte	NITRATE	ORTHO-PHOSPHATE	SULFATE	AMMONIA	TKN	BENZENE	NAPHTHALENE	TOC	DISSOLVED OXYGEN[a]
	Unit	µg/L	µg/L	µg/L	mg/L	mg/L	µg/L	µg/L	mg/L	mg/L
Location	**Collection Date**									
S-35R-2	8/30/2012	250 U	1,070	264,000	4.03	4.59	0.5 U	2.0 U	6.01	0.82
P181-MW46	8/29/2012	400 U	8,560	9,520	17.3	16.1	2.68	34.2	25.7	0.49
PMW2	8/29/2012	20 U	128 J	274,000	4.3	4.67	0.5 U	2.85 U	8.02	0.54
PMW5	8/29/2012	20 U	500 U	3,200	1.54	2.08	0.5 U	2.0 U	10.4	0.14
M25-06	8/30/2012	1,000 U	4,000 U	4,220 J	51.4	49.3	0.271 J	2.89	70.5	1.5
PMW3	8/29/2012	20 U	418 J	289,000	0.293	0.671	0.5 U	2.0 U	8.67	0.63
M25-07	8/30/2012	1,000 U	4,000 U	20,000 U	28.8	27.5	1.67	2.64	23.9	1.08
S-16-R	8/29/2012	200 U	48,100	287,000	72.4	61.7	0.5 U	2.0 U	52.4	0.28
M25-05	8/28/2011	100 U	38,200	2,800	41.3	40.4	166	194	43.6	0.18
M25-09	8/29/2012	20 U	179	136 J	12.1	12.4	0.175 J	6.92	32.5	0.32

Notes:

[a] Dissolved oxygen measured using field instruments during pre-sampling well purging.

Abbreviations and Acronyms:

µg/L – micrograms per liter
EPA – U.S. Environmental Protection Agency
J – estimated value
mg/L – milligrams per liter
TKN – total Kjeldahl nitrogen
TOC – total organic carbon
U – analyte not detected above project reporting limit

LEGEND

M25-05 166 / 194 — MONITORING WELL BENZENE/NAPHTHALENE RESULT (µg/L) 10 FT WELL SCREEN (APPROXIMATELY 10-20 FT BGS)

1 — 1 µg/L BENZENE CONCENTRATION/ ESTIMATED PLUME BOUNDARY (DASHED WHERE INFERRED)

ROAD

BIOSPARGE TREATMENT AREA

BAYPORT DEVELOPMENT

BUILDING

FORMER BUILDING

NOTES:

µg/L - MICROGRAMS PER LITER

BGS - BELOW GROUND SURFACE

FISCA - FLEET AND INDUSTRIAL SUPPLY CENTER OAKLAND, ALAMEDA FACILITY/ALAMEDA ANNEX

FT - FEET

IR - INSTALLATION RESTORATION (PROGRAM)

J - ESTIMATED DATA

SVE - SOIL VAPOR EXTRACTION

U - NOT DETECTED AT LABORATORY REPORTING LIMIT

N

150 0 150 300 Feet

BASE REALIGNMENT AND CLOSURE
PROGRAM MANAGEMENT OFFICE WEST
SAN DIEGO, CALIFORNIA

BIOSPARGE/SVE SYSTEMS
OPERABLE UNIT 5/FISCA IR-02 GROUNDWATER

FIGURE 2

AUGUST 2012 PERIMETER GROUNDWATER
MONITORING WELL BENZENE AND NAPHTHALENE RESULTS
ALAMEDA, CALIFORNIA

REVIEW: D
AUTHOR: GFG
DCN: ECSD-2201-0011-0017
FILE NUMBER: 120301A7684.mxd

TETRA TECH EC, INC.