Red Hill Bulk Fuel Storage Facility
Final –Addendum Planning Documents
Pearl Harbor, Hawaii

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May 2006

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
Pearl Harbor, HI 96860-3134

NAVFAC
Naval Facilities Engineering Command
NAVFAC PACIFIC

Indefinite Delivery/ Indefinite Quantity Contract

Contract Number N62742-02-D-1802, CTO 007

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Prepared for:

Naval Facilities Engineering Command
NAVFAC PACIFIC

Department of the Navy
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258 Makalapa Drive, Suite #100
Pearl Harbor, HI 96860-3134

Prepared by:

TEC Inc.
1001 Bishop Street,
American Savings Bank Tower, Suite 1400
Honolulu, Hawaii 96813

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per Liter
mg/L	Milligrams per Liter
3-D	three-dimensional
ALs	Action Levels
AMEC	AMEC Earth and Environmental, Inc.
ARAR	applicable or relevant and appropriate requirement
ATL	Air Toxics Ltd.
AVGAS	aviation gasoline
bgs	below ground surface
BOWS	Honolulu Board Of Water Supply
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	constituents of potential concern
CSM	Conceptual Site Model
CTO	Contract Task Order
CWRM	Commission of Water Resources
DLNR	Department of Land and Natural Resources
DQO	data quality objectives
EAL	environmental action level
EPC	exposure point concentration
EPH	extractable-phase hydrocarbons
ERA	ecological risk assessment
ETIC	ETIC Engineering, Inc.
FISC	Fleet and Industrial Supply Center
FSP	Field Sampling Plan
GIS	Geographic Information Systems
GMS	Groundwater Modeling System
HAR	Hawaii Administrative Record
HDOH	State of Hawaii Department of Health
HERL	Hawaii Environmental Response Law
HHRA	human health risk assessment
HPWS	Hawaii Potable Water Systems
HSWA	Hazardous and Solid Waste Amendments
IWWP	installation–wide work plan
LNAPL	Light non-aqueous phase liquid
MADEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
mgd	million gallons per day
MOGAS	motor gasoline
msl	mean sea level

MTBE	methyl tert-butyl ether
NAVFAC	Naval Facilities Engineering Command
NPDW	National Primary Drinking Water
Ogden	Ogden Environmental and Energy Services
OWDF	Oily Waste Disposal Facility
OWS	Oil water separator
PACDIV	Pacific Division
PAH	Polynuclear aromatic hydrocarbons
PVC	polyvinyl choride
PWC	Public Works Center
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
QA	Quality assurance
QC	quality control
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RHS	Red Hill Shaft
RHSF	Red Hill Storage Facility
RI/FS	Remedial Investigation/Feasibility Study
SCP	State Contingency Plan
SCR	Site Characterization Report
SDWA	Safe Drinking Water Act
SI	Site Investigation
SOP	Standard operating procedure
SOW	Statement of Work
SSHSP	Site Specific Health and Safety Plan
SVMP	soil vapor monitoring points
SWAP	Source Water Assessment Program
TEC	TEC Inc.
TGM-SCP	TGM-SCP Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan
TGM-UST	Technical Guidance Manual for Underground Storage Tank Closure and Release Response
TPH-DRO	total petroleum hydrocarbons in the diesel range organics
TPH-GRO	total petroleum hydrocarbons in the gasoline range organics
TRC	Technical Review Committee
UH	University of Hawaii
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tanks
V2SDT	Variable Saturated Two Dimensional Flow and Transport
VOC	volatile organic compound

VPH	volatile-phase hydrocarbons
WP	Work Plan

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1.0 INTRODUCTION

The U.S. Navy Pacific Division, Naval Facilities Engineering Command (NAVFAC) Pacific, has requested that TEC Inc. (TEC) provide additional services for further evaluation of the impact of potential product release from the Fleet and Industrial Supply Center (FISC), Pearl Harbor bulk fuel storage facility located at Red Hill, Oahu, Hawaii (herein referred to as RHSF), (Figure 1-1 and Figure 1-2 [TEC, 2005]). This supplemental Work Plan has been prepared under Contract No. N62742-02-D-1802, Amendment 6, Revision 3 Dated 12 October 2005 for Contract Task Order (CTO) 007.

This document serves as a supplement to the *Red Hill Bulk Fuel Storage Facility Work Plan, Pearl Harbor, Hawaii*, (TEC, 2005), developed to support the ongoing Site Investigation (SI) and Risk Assessment activities at RHSF. These documents (supplemental and original Work Plan [WP], with the companion Field Sampling Plan [FSP] and Quality Assurance Project Plan [QAPP]), are the basis for conducting a SI and risk assessment activities for the Site.

The WP is divided into the following sections:

- Section 1 provides a site description, general project approach, objectives, statement of intended data usage and introduces the data team.
- Section 2 provides a summary of previous environmental investigations and describes the Phase I investigation activities.
- Section 3 presents the current Conceptual Site Model (CSM) including geology, hydrogeology and migration pathways.
- Section 4 describes the proposed activities.
- Section 5 presents the project schedule.
- Section 6 provides document references.

Various other supporting documents were provided in the original WP (TEC 2005) for ease of reference. They include a FSP (Appendix A), a QAPP (Appendix B), a summary of construction activities at the facility (Appendix C), a previously conducted Preliminary Risk Evaluation (Appendix D), regulatory correspondence (Appendix E), auxiliary maps, and logs and report excerpts (Appendix F), FISC specifications for Geographic Information Systems (GIS) data presented in Phase I Statement of Work (SOW), (Appendix G), and Pacific Division (PACDIV) standard operating procedures (SOPs) (Appendix H). A Site Specific Health and Safety Plan (SSHSP) is provided under separate cover outlines the procedures to protect all personnel present during field activities. These documents were updated for Phase II activities as required.

1.1 Location and Setting

The RHSF is located on the island of Oahu, Hawaii, approximately 2.5 miles northeast of Pearl Harbor (Figure 1-1 [TEC 2005]). The facility lies along the western edge of the Koolau Range and is situated on a topographic ridge that divides the Halawa Valley and the Moanalua Valley. The site is bordered to the south by the Salt Lake volcanic crater. The Site occupies approximately 144 acres of land. The majority of the surface topography of the Site lies at an elevation of approximately 200 to 500 feet above mean sea level (msl), however, much of the work conducted onsite is in underground tunnels, which are located between 100 to 120 feet above msl.

1.2 Site History

The facility was constructed by the U.S. Government in the early 1940s and incorporates 20 underground storage tanks (USTs), each with a capacity of approximately 12.5 million gallons (Figure 1-2). The tanks are constructed of steel and currently contain JP-5 and Diesel Fuel Marine. Previously, several of the tanks have also been used to store Navy Special Fuel Oil, Navy Distillate, aviation gasoline (AVGAS) and motor gasoline (MOGAS). The fueling system is a self-contained underground unit that was installed into native rock comprised primarily of basalt with some inter-bedded tuffs and breccias. Each tank measures approximately 245 feet in height and 100 feet in diameter. The upper domes of the tanks lie at depths varying between approximately 100 feet and 200 feet below the existing ground surface. The tanks are currently being inspected and refurbished by Dunkin and Bush, Inc.

It is unknown if the tanks are presently leaking; however, on the basis of the previous site investigation and associated analytical data, one or more unknown releases have occurred at the site. Additional site history is provided in Section 2.0 and a summary of the facility construction history is provided in Appendix C of Red Hill Bulk Fuel Storage Facility Work Plan, Pearl Harbor, Hawaii, (TEC, 2005).

1.3 Project Objectives and Scope of Work

Previous results of a SI (AMEC, 2002) indicated that petroleum hydrocarbons were reported in rock samples obtained beneath the USTs and that lead was detected in groundwater samples obtained from a monitoring well situated hydraulically down-gradient from the facility. The SI recommended the completion of a comprehensive risk assessment to quantify the risks associated with the observed compounds. In an effort to evaluate current and potential future risks from unauthorized releases to the subsurface, the State of Hawaii Department of Health (HDOH), Solid Waste Branch concurred in a letter dated October 10, 2003 (Appendix E, TEC, 2005) that the U.S. Navy would:

- Conduct a comprehensive Tier 3 risk assessment, and develop a comprehensive CSM incorporating fate and transport models to facilitate preparation of the risk assessment,
- Prepare a contingency plan to protect the Navy's groundwater supply at Red Hill, and

- Monitor groundwater in the underlying basal aquifer and at the Public Works Center (PWC) (PWC, now known as NAVFAC Hawaii), potable water source at Red Hill.

To accomplish these objectives, the Navy has developed a scope of work which is being completed in two phases. Phase I consists of a site characterization phase that is currently underway, as described in "*Red Hill Bulk Fuel Storage Facility Work Plan*, (TEC, 2005). The Phase II tasks include:

- Development of WP Addendum and include training documentation and onsite assistance to FISC for groundwater and air monitoring of the groundwater monitoring wells and soil vapor monitoring points (SVMPs).
- Conduct a closed-loop land survey of all pertinent local groundwater monitoring wells within the near vicinity of the site to fine tune local groundwater flow characteristics.
- Conduct a single round of RHSF groundwater monitoring from four wells and Navy Pumping Well 2254-01.
- Monitor groundwater levels and conduct pump tests to calibrate models and characterize groundwater flow.
- Install additional SVMPs in selected slant borings located beneath the facilities tanks to serve as an early warning system for future releases.
- Evaluate fate and transport of petroleum fuel–based compounds through the development of analytical and numerical modeling algorithms.
- Conduct a comprehensive risk assessment including Tier 1, 2 and 3 as necessary.
- Prepare a contingency plan to describe procedures to mitigate risk in the scenarios of concern.
- Develop a GIS-based groundwater and vapor database for the input of chemical results which will allow FISC to generate a visual and graphic description of historical results at each location.
- Prepare written technical reports to document all Phase I and Phase II activities.

1.4 Project Approach

The approach for the RHSF investigation is to obtain and evaluate information necessary to conduct a comprehensive risk assessment (up to Tier 3), and prepare a site contingency plan. This will be accomplished as practical and based on pilot tests, through the installation of additional SVMPs, completing a location and elevation survey of sample points, collection and analyses of groundwater, and soil vapor samples from the monitoring network, performing aquifer tests, construction of a GIS-based three-dimensional (3-D) Site Model, and contaminant fate and transport modeling. The resulting information will be used to conduct the risk assessment and prepare the Contingency Plan. Specific petroleum-related constituents of potential concern (COPCs) to be evaluated in subsurface rock, groundwater, and soil vapor samples have been selected on the basis of chemical data collected during the previous SI (Ogden, 1999) and the evaluation of fuels currently stored onsite. All COPCs are associated with petroleum fuels stored onsite. The proposed site investigation activities are further discussed in Section 4 of this WP and the proposed field activities are further detailed in the FSP (TEC, 2005).

1.5 Statement of Intended Data Usage (Data Quality Objectives)

The Navy is complying with release response requirements of the Hawaii Administrative Record (HAR) Title 11, Chapter 281, USTs for RHSF. These rules have provisions to aide in the determination of and response to a release from storage tanks. In order to meet the requirements of these rules, the Navy will prepare a CSM (including a fate and transport model), complete a risk assessment, prepare a contingency plan that protects the Pearl Harbor aquifer resource, as well as conduct groundwater monitoring of the underlying basal aquifer.

Data will be evaluated from the current SI Phase I and Phase II activities, previous and concurrent environmental investigations conducted at the site. These include: the investigation conducted by AMEC Earth and Environmental, Inc. (AMEC) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) CTO 229 (AMEC, 2002) and the ongoing long-term groundwater monitoring activities conducted at the site by the Dawson Group, Inc. under contract No. N62742-01D-1806 CTO 0013 (Dawson, 2005a, 2005b) (Appendix A). Data includes coring and groundwater quality data, groundwater level measurements, aquifer tests, and soil vapor quality data. Data will be collected from RHMW-01, -02, -03, -04, Red Hill Pumping Well 2254-01, and Oily Waste Disposal Facility [OWDF] -MW08 and OWDFMW09. These optimized sampling points are at locations that are upgradient and downgradient of the tanks, at the drinking water source, and at tanks that have evidence of a release.

Data will be collected to be within acceptable limits as defined in the FSP, the QAPP, SOPs, U.S. Environmental Protection Agency (USEPA) Methods, Massachusetts Department of Environmental Protection (MADEP) methods and other industry standards presented in this WP. The following paragraphs describe specific data quality objectives (DQOs) for the task associated with Phase II of this project (CTO 007).

- Wells will be surveyed for elevation to at least +/- 0.01 feet accuracy and precision for external wells and 0.05 feet for wells located within the tunnel.
- Chemical analyses for rock, soil and water will be analyzed according to the USEPA methods and quality assurance/quality control (QA/QC) procedures- total petroleum hydrocarbons in the diesel range organics (TPH-DRO) and gasoline range organics (TPH-GRO) (USEPA 8015), volatile organic compounds (VOCs) including methyl tert-butyl ether (MTBE) (USEPA 8260B), polynuclear aromatic hydrocarbons (PAHs) (USEPA 8270C SIM), Total Dissolved Lead (USEPA 6020), Tetra Ethyl Lead, Natural Attenuation Indicators (methane, nitrate, sulfate, ferrous iron, dissolve oxygen, carbon dioxide).
- Chemical analyses for soil vapor will be analyzed according to the USEPA methods and QA/QC procedures described in USEPA method TO-3 for benzene, toluene, xylenes, and ethylbenzene as well as naphthalene. The analyses will be completed at a certified air laboratory, Air Toxics Laboratory (ATL), of Folsom, California.
- Groundwater fate and transport models will be calibrated as appropriate.

- Risk assessment will be completed within guidance from Risk Assessment Guidance for Superfund, Volume 1 (Human Health Evaluation Manual) and Volume 2 (Environmental Evaluation Manual) (USEPA, 1989).
- Laboratory reporting limits for target compounds will be less than or equal to the preliminary screening action levels required for the risk assessment.

Additional data quality objectives may also be presented in the project task descriptions in Section 4 of this document.

1.5.1 Regulatory Requirements And Guidance

Based on the current knowledge of the site and the CSM (see Section 3), the State and Federal regulatory requirements that apply to RHSF include the following:

- Safe Drinking Water Act (SDWA) and National Primary Drinking Water Regulations (NPDW); The NPDW regulations at 40 Code of Federal Regulations (CFR) Part 141 carry out provisions of the SDWA. They establish maximum contaminant levels (MCLs) for various substances in potable water.
- Hawaii Rules Relating to Potable Water Systems - The HDOH Rules Relating to Hawaii Potable Water Systems (HPWS) (HAR Title 11, Chapter 20) set forth maximum contaminant levels (MCLs) of certain chemicals in public and private drinking water systems. These MCLs are analogous to the NPDW regulations.
- State of Hawaii Environmental Response Law (HERL) and State Contingency Plan (SCP) - The Hawaii Revised Statutes Title 19, Chapter 128D and SCP (HAR Title 11, Chapter 451) is intended to identify releases and other situations that may endanger public health or welfare, the environment, or natural resources; prescribe notification requirements; and establish methods to address such releases. The SCP is intended to address contaminants and releases not addressed by other State of Hawaii Laws and Rules. It establishes reportable quantities for hazardous substances, pollutants, and contaminants for release purposes. The HERL definition of a hazardous substance includes petroleum. Methods and criteria for investigations and response actions conducted under the SCP are described in the Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan (HDOH, 1997), hereafter referred to as the TGM-SCP. The TGM-SCP indicates that the following four criteria should be evaluated to determine whether further action is necessary for a site:

    - There has been no release of a hazardous substance, pollutant, or contaminant to the environment.
    - There is no threat of release of a hazardous substance, pollutant, or contaminant to the environment.
    - The site is adequately characterized, and
        - No hazardous substances remain on site, or
        - No significant threat to human health or the environment exists.
    - Response actions are complete, and adequate measures have been taken to protect human health and the environment.

- State of Hawaii UST Regulations - The Resource Conservation and Recovery Act (RCRA), established in 1979 and amended with the Hazardous and Solid Waste Amendments (HSWA) of 1984, established a comprehensive regulatory program for USTs. The State of Hawaii adopted its own UST statutes and regulations (Hawaii Revised Statutes, Title 19, Chapter 342L and HAR, Title 11, Chapter 281, Subchapters 1 through 10 to implement these laws in Hawaii. Owners and operators of USTs that contain regulated substances such as petroleum are required to take specific actions when investigating releases from their USTs. Regulations and requirements are explained in detail in the Technical Guidance Manual for Underground Storage Tank Closure and Release Response (HDOH, 2000), hereafter referred to as the TGM-UST.

Petroleum is specifically excluded from the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) definition of a hazardous substance (42 United States Code 9601(14)), therefore CERCLA will not be applicable unless there is a release of a hazardous substance that is not petroleum-related.

Where no specific regulatory standards exist for a chemical or situation, or where such standards are insufficiently protective, other guidance should be considered in determining the necessary level of cleanup to protect human health or the environment. Under the risk assessment process conducted in support of a UST site characterization, environmental action levels (EALs), rather than the 1995 action levels in HAR Title 11, Chapter 281, subchapter 78 can be used to screen for COPCs as described in Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater (HDOH, 2005b) while the 1995 action levels (ALs) in HAR Title 11, Chapter 281, subchapter 78 are being updated (estimated for completion in early 2006; HDOH 2005b).

According to HDOH (2005b):

> "The EALs are considered to be conservative. Under most circumstances, and within the limitations described, the presence of a chemical in soil, soil gas or groundwater at concentrations below the corresponding EAL can be assumed to not pose a significant, long-term (chronic) threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding EAL. Active remediation may or may not be required, however, depending on site-specific conditions and considerations."

and

> "The EALs are intended to serve as an update and supplement to the HDOH document Risk-Based Corrective Action and Decision Making at Sites With Contaminated Soil and Groundwater (June 1996). The change in terminology from "Risk-Based Action Levels" to "Environmental Action Levels" is intended to better convey the broad scope of the document and clarify that some action levels are not "risk-based" in a strict toxicological definition of this term. Use of the EALs is recommended not mandatory."

1.6 Investigative Team

The prime contractor and investigative team leader for the project is TEC. Primary support contractors include Valley Well Drilling, the University of Hawaii (UH) and Accutest, Inc. Table 1-1 presents a contact listing with a brief description of project responsibilities.

Table 1-1 Contact Listing-Red Hill Bulk Fuel Storage SI and RA, Phase II, Pearl Harbor, Hawaii

NAVFAC Pacific		
Project Contract Specialist	Ms. Jean Kuboyama	(808) 471-4666
Remedial Project Manager/Navy Technical Representative	Mr. Glenn Yoshinaga	(808) 472-1416
Fleet Industrial Supply Center		
Fuels Terminal Director	Lt.Com. Tom Gorman	(808) 473-7801
FISC Project Manager	Mr. Victor Peters	(808) 473-7890
RHSF Site Supervisor	Mr. Herb Kikuchi	(808) 437-7805 or 479-1063
Public Works Center		
Navy Hydrogeologist	Mr. Paul Eyre	(808) 473-0938
Halawa Firing Range		
Staff NCOIC	GySgt. Robert Flores robert.flores@navy.mil	(808) 471-4798, 471-2916, or 358-2407
Senior Instructor	Sgt. Steven Christopher steven.e.christopher@navy.mil	(808) 471-4798, 471-2916, or 358-2407
TEC Inc.		
Deputy Program Manager	Mr. Ryan Pingree	(808) 528-1445
Project Manager/ Hydrogeologist	Mr. Jeff Hart, R.G.	(808) 528-1445
Senior Risk Assessor	Mr. Glenn Metzler	(808) 528-1445
Regional Health and Safety Coordinator	Mr. Karl Bromwell	(808) 528-1445
Project Chemist	Mr. Peter Chapman	(808) 528-1445
Onsite Health and Safety Coordinator	Ms. April Chan	(808) 528-1445
Senior Geologist	Ms. Nicole Griffin	(808) 528-1445

Site Technician	Mr. Shawn Macmillan	(808) 528-1445
Subcontractors		
Air Toxics	Kyle Vagadori	(916) 985-1000
University of Hawaii Dept. Geology & Geophysics	Dr. Aly El-Kadi	(808) 956-6331
ETIC Engineering	Dr. Mehrdad Javaherian	(510) 208-1600
Valley Well Drilling, Supervisor	Mr. Mike Sober	(808) 682-1767
Accutest Analytical Services, Orlando Florida	Ms. Susan Bell	(407) 425-6700
Pacific Commercial Disposal Services	Dr. Jingbo Chang	(808) 545-4599

2.0 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

2.1 Investigation Prior To September 2004

This section provides a description of the pertinent environmental investigations conducted at RHSF since the facility was declassified (in the mid 1990's), up to September 2004. Details of these investigations can be found in *Red Hill Bulk Fuel Storage Facility Work Plan, Pearl Harbor, Hawaii* (TEC June, 2005). Details of the Investigations are provided in the referenced reports.

2.1.1 Wilbros Engineering Report

In 1998, Wilbros Engineers evaluated the conditions of the RHSF and estimated the impact to the basal aquifer if a major release were to occur. During the environmental impact evaluation, Wilbros Engineers used two hypothetical scenarios of petroleum releases from the large capacity USTs in conjunction with geologic/hydrogeologic data to estimate the potential environmental impact to the potable drinking water source of the basal aquifer. The first scenario involved a massive petroleum release with no improvements to the facility, and the second scenario included improvements to the facility designed to prevent large-scale impacts to the environment. (Wilbros Engineers, 1998).

Wilbros Engineers (1998) suggested that due to the potential for irreparable damage to the aquifer in the event of a massive release, preventive measures be taken to avoid a catastrophic disruption of potable water service to the Pearl Harbor community.

2.1.2 Ogden Oily Waste Disposal Facility RI/FS

Ogden Environmental and Energy Services (Ogden) completed several investigations at the Red Hill OWDF, which is located approximately 3,200 feet west of the RHSF tanks. The work for a Remedial Investigation/Feasibility Study (RI/FS) was conducted from August 1991 through June 1992, with the results presented in *Technical Review Committee (TRC) Findings Summary, Red Hill Oily Waste Disposal Pit, Naval Supply Center, Pearl Harbor, O'ahu, Hawai'i* (1992). Additional field activities occurred in January 1993, and are presented in the document entitled, *Red Hill Oily Waste Disposal Pit Site Stilling Basin Closure Plan, CTO 0109,* (1993). Additional risk assessment and removal action activities were performed in 1994 and 1995. Additional investigation activities were summarized in the report entitled, *Red Hill Oily Waste Disposal Facility Phase I RI Report, June 1996.*

2.1.3 Earth Tech Oily Waste Disposal Facility Investigations

EarthTech performed a Phase II RI at the OWDF in 1998 (EarthTech, 1999), with the objective to determine the nature and extent of impact to the soil and groundwater beneath the site. This report concluded that transport of contaminants to the basal aquifer from the OWDF was insignificant. OWDF-related contaminants were not detected in groundwater samples obtained from within the basal aquifer nor from water samples obtained from the Navy's PWC pumping station located in Adit #3. It recommended that no further action regarding the perched groundwater or the basal aquifer beneath the OWDF be taken.

2.1.4 Ogden/AMEC Red Hill Investigations

In March 1998, Ogden, subsequently known as AMEC, was contracted to identify potential petroleum product releases from the RHSF. The resulting site characterization was conducted in two phases: Phase I - Research Activities and Phase II - Investigation Activities.

A preliminary screening-level risk evaluation was conducted and indicated that seven constituents were detected in core samples at concentrations of potential concern: ethylbenzene, methylene chloride, 2-methylnaphthalene, naphthalene, phenanthrene, TPH (hydrocarbon range C10-C28), and an unknown hydrocarbon compound. Three constituents were detected in groundwater at concentrations of potential concern: bis(2-ethylhexyl)phthalate, lead, and TPH (C10-C28). Light non-aqueous phase liquid (LNAPL) was also detected within several monitoring wells at the site.

On the basis of the preliminary risk screening, the report recommended that a comprehensive risk assessment be completed to accurately assess current and potential future risk associated with the RHSF.

2.2 Investigations After September 2004

Starting in June 2005, field investigation activities began in order to obtain and evaluate information necessary to conduct a Tier 3 risk assessment and prepare a site contingency plan as well as to conduct groundwater monitoring. Activities are as described below:

Three additional wells were installed to upgrade the groundwater monitoring network at the RHSF. This included coring, sampling and installation of RHMW02 (in the lower access tunnel at Tank 5-6), RHMW03 (in the lower access tunnel at Tanks 13-14) and upgradient well RHMW04 (on the access road, near the firing range). Monitoring wells within the tunnel were completed with a Hageby skid-mounted drill rig, while the background well located upgradient and outside of the tunnel was completed with a Mobile B-90 rig with an air-percussion hammer . Select cores (from above the interpreted groundwater table interface), were analyzed for TPH-DRO, -GRO (by USEPA 8015), VOCs (USEPA 8260), MADEP volatile-phase hydrocarbons (VPH) and extractable-phase hydrocarbons (EPH), and total lead (USEPA 6020). The wells were completed to depths of approximately 125 feet below the tunnel floor inside the tunnel, and 300 feet below ground surface (bgs) outside of the tunnel. Wells were constructed with Schedule 40 polyvinyl chloride (PVC), with 0.20 slot, locking water tight well caps with steel covers and a traffic-rated flush-mount well box.

The wells were developed by surging with a surge block and removing approximately 3-5 well volumes of water. Wells RHMW02, RHMW03, and RHMW04 were purged, monitored for pH, conductivity and temperature and sampled during the week of September 19, 2005, while Navy pumping well 2254-01 was just sampled. The groundwater samples were properly containerized, preserved and sent to Accutest laboratories for analysis of TPH-DRO, -GRO (by USEPA 8015), VOCs (USEPA 8260), MADEP VPH and EPH, and total and dissolved lead (USEPA 6020) and methane (RSK 175). Samples for analysis of natural attenuation parameters (nitrate/nitrate, etc.) were sent to Oceanic Laboratories.

In addition, efforts are underway to conduct a pilot study to evaluate the use of a soil vapor monitoring system to assess releases of petroleum beneath each of the 20 USTs in the RHSF. The locations of the initial pilot test SVMPs were chosen at Tank 6, Tank 14 and Tank 1, because of signs of a possible past release.

The pilot test includes:

- Removing the existing PVC casing at each location.
- Installing three SVMPs at each boring, corresponding with the outer edge of the UST, the middle of the UST and the inner, tunnel side of the UST.
- Isolating each SVMP with bentonite seals.
- Collecting 1 round of soil vapor samples in summa canisters to be analyzed by ATL for benzene, toluene, ethylbenzene and xylenes as well as naphthalene and TPH by USEPA Method TO-3.

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3.0 CURRENT CONCEPTUAL SITE MODEL

This section presents updates to the CSM presented in Section 3 of the installation–wide work plan (IWWP) prepared by TEC in June of 2005.

3.1 Preliminary Conceptual Site Model

The CSM presented in the IWWP will continue to be the basis of the conceptual understanding at the site. Additional work conducted since June 2005 has provided additional information that should be included in the CSM. Three new wells have been added to the monitoring network, and several additional monitoring points (see Figure 3-1).

3.1.1 Perched Groundwater at RHMW04

During drilling activities at RHMW04, located approximately 800 feet north of the RHSF, TEC encountered perched water at approximately 90 feet below ground surface bgs. This perched water is expected to be hydraulically connected to the adjacent Halawa Stream located approximately 100 feet northwest. This groundwater is estimated to be approximately 230 feet above msl or about 100 feet above the bottom of the USTs. This is evidence of a perched water body of unknown extent that is associated with South Halawa Stream, adjacent to the site. This perched water was not observed when drilling RHMW02 adjacent to Tank No. 6 or at RHMW03 adjacent to Tank No. 14.

3.1.2 Drilling At RHMW02 and RHMW03

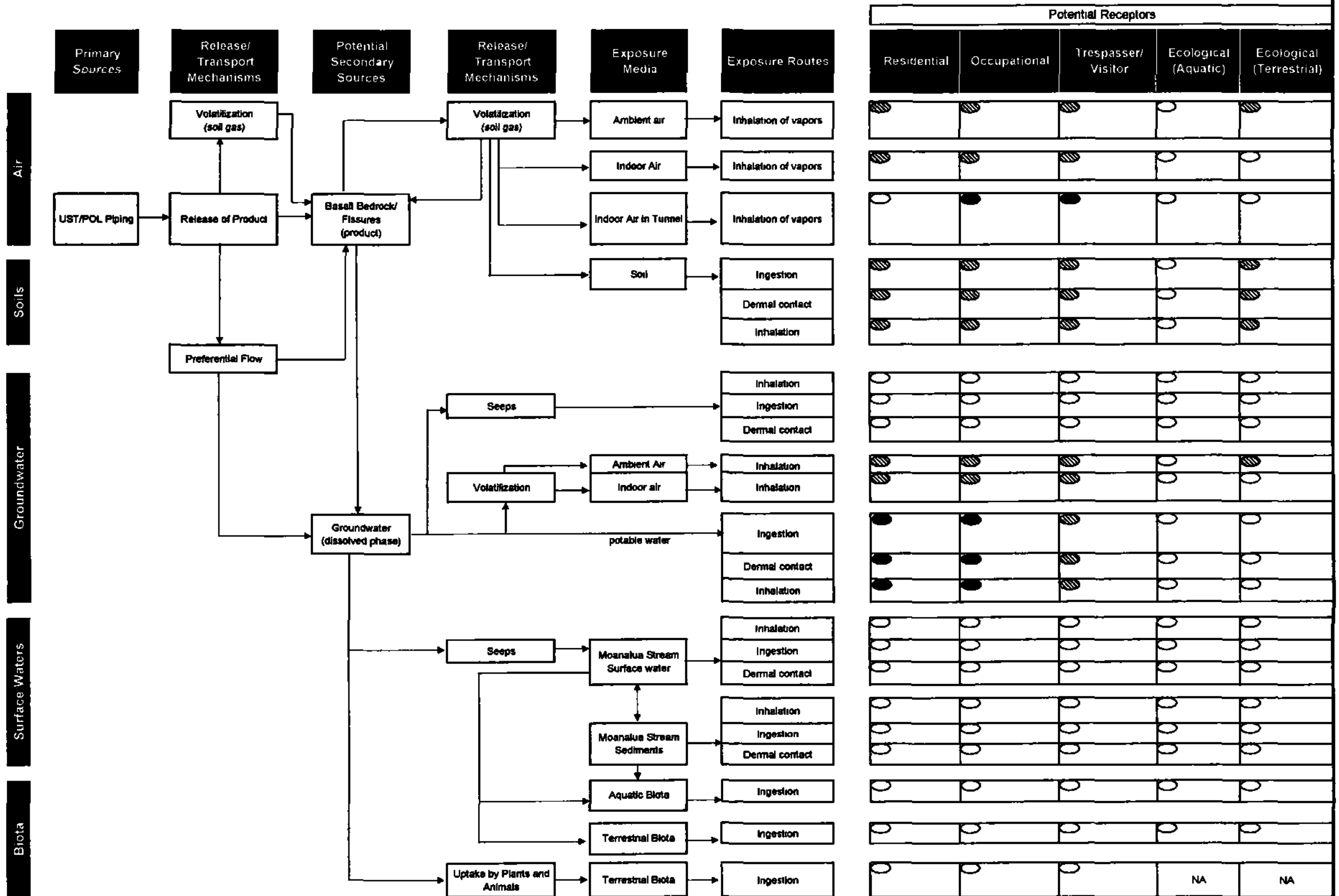
Core samples collected during drilling activities at RHMW02 and RHMW03, within the RHSF Lower Access Tunnel did not appear to be stained or impacted by petroleum compounds. These cores were collected from locations within the Lower Access Tunnel, approximately 50 feet away from the edge of the respective tanks, and indicated that petroleum compounds observed in core samples from angle borings under these tanks did not extend beneath the access tunnel at these locations.

3.1.3 Groundwater Sample Results

Groundwater samples were collected as part of the long term monitoring program for the RHSF in February, June, and September of 2005 by Dawson Group, Inc. of Honolulu Hawaii (Appendix A). Dawson sampled the Red Hill Navy Pump Station (2254-01) and the lower access tunnel well that was installed by AMEC in 2001, known in their report as V1D. This well has been renamed RHMW01 for the purposes of this Risk Assessment Project. TEC collected groundwater samples from 2254-01, RHMW01, RHMW02, RHMW03 and RHMW04, as part of the initial Risk Assessment data gathering task. Evidence of petroleum dissolved in groundwater was observed in RHMW01 and RHMW02 during these sampling events. Naphthalene (120 micrograms per Liter [μg/L]) and TCE (8.2 μg/L) were observed in the sample collected from RHMW02 on 20 September 2005, above their respective EALS of 6.2 μg/Land 5.0 μg/L.

In addition, methane was observed in groundwater samples from 2254-01, RHMW01, RHMW02, and RHMW03. Methane is an indicator compound for active anaerobic biodegradation of petroleum, and its presence can imply that microbial activity is anaerobically degrading petroleum dissolved in groundwater upgradient from each of these locations. Anaerobic degradation is expected to occur only after aerobic degradation has used up all the available dissolved oxygen in the groundwater. It can also indicate that biodegradation is an active process in the groundwater beneath the facilities.

Dawson analyzed groundwater samples for lead during their quarterly monitoring program. Samples collected in the first and second quarter were not filtered in the field prior to analysis for lead and results at RHMW01 (V1D) were elevated above the HDOH EAL of 0.0056 milligrams per Liter (mg/L). Samples were filtered in the third quarter and results were significantly below the EALs at all sampling locations.



LEGEND
Exposure Pathway Evaluated and Incomplete
Exposure Pathway Evaluated and Potentially Complete - Minor
Exposure Pathway Evaluated and Potentially Complete - Major
Minor Exposure Pathway = contaminants concentrations that would reach the exposure points are very small compared to the screening action levels and therefore deemed insignificant in impacting human health and the environment
Major Exposure Pathway = contaminants concentrations that would reach the exposure points have the potential to present an unacceptable risk to human health and the environment.
NA = Not Applicable

Figure 3-1
Preliminary Conceptual Site Model

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4.0 DESCRIPTION OF PROPOSED ACTIVITIES

4.1 Proposed Activities

The proposed activities for Phase II include the installation of dedicated sampling pumps, continued groundwater sampling, surveying of the wells, pump tests, fate and transport modeling and risk assessment. Information on those tasks is provided in the sections below. Additional detailed information regarding field tasks and analyses can also be found in the FSP and the QAPP (TEC, 2005) along with their respective updates.

4.2 Installation of Dedicated Pumps

Installation of dedicated sampling pumps will be completed in five wells at the RHSF. These wells include RHMW01 through -04 and 2254-01 (Figure 4-1). Each pump will be ordered with pre-fabricated tubing length to ensure the pump suction remains below the water table throughout the expected range of water elevations in these wells. The installation will consist of the following tasks:

- Unpacking the pump assemblies;
- Opening the monitoring wells
- Decontamination of pump assemblies;
- Installation of the pump assemblies in the wells; and
- Testing the pumps.

Well design specifications and the pump models to be installed in each well are listed in the Appendix B.

4.3 Groundwater Sampling

Groundwater samples will be collected from the two existing and three newly installed wells (RHMW01 through -04, and 2254-01). The monitoring program will collect data necessary to assess the groundwater quality within the basal aquifer underlying the RHSF Site. The groundwater samples will be analyzed for petroleum constituents (TEC, 2005).

Wells will be sampled using a dedicated pump system, requiring a source of compressed air. Inside of the RHSF tunnel, a compressed air supply line is usually available and will be used. A Geocontroller 2 control box for the dedicated pumps will be connected to the compressed air system with a filter and water trap in-line. The *Geotech Bladder Pumps Installation and Operations Manual* (Appendix B) gives details on setting up and operating the controller. Outside of the tunnel and if compressed air is unavailable inside the tunnel, a 200 standard cubic feet compressed gas cylinder containing clean dry nitrogen or carbon dioxide will be used or gas powered air compressor. The compressed gas pressure will be reduced to 125 pounds per square inch gauge, by use of a regulator with high and low pressure gauges attached to the cylinder. One cylinder should be sufficient to sample two wells. The Geocontroller 2 control box will be connected to the dedicated bladder pumps. Operation of the bladder pumps are described in:

- Geotech stainless steel bladder pumps with screen 1.66 inches x 36 inches (GEO1.66SS36) (Appendix B), and
- Geotech stainless steel bladder pump with screen, 0.85 inches x 24 inches (GEO850.SS24) (Appendix B).

Table 4-1 lists the wells to be sampled and the pump type in each well.

Prior to collecting a groundwater sample, the in situ groundwater in each monitoring well will be removed, or purged via a dedicated bladder pump fitted with dedicated Teflon lined polyethylene tubing. All wells will be sampled directly from the dedicated bladder pumps systems. Immediately following purging, each monitoring well will be sampled. The field sampling report form to be used is provided in Appendix H of the original WP (TEC, 2005). Information regarding analyses is presented in Table 4-2 of the original WP (TEC, 2005).

Dissolved lead samples will be filtered in the field using 0.4 micron sized filters. Purge water will be placed directly into the drain system that leads to the FISC oil/water separator (OWS) and associated disposal tanks. Sample containers will be labeled with the date, sample identification number, type of analysis, and sampler's name. The containers will then be placed on ice in sample coolers and transported under chain-of-custody procedures to the certified laboratory for analysis. Groundwater samples will be labeled and documented in accordance with SOPs presented in Appendix H of the original WP (TEC, 2005). Figure 4-2 shows the location of regional wells in proximity to the site.

Table 4-1 Summary of Groundwater Sampling Requirements

Well	**RHMW01**	**RHMW02**	**RHMW03**	**RHMW04**	**2254-01**
Sampling Method	Dedicated pump	Dedicated pump	Dedicated pump	Dedicated pump	Dedicated pump
Pump Model	GEO850.SS 24	GEO1.66SS36			
Location	Lower Tunnel, Near Tank 1	Lower Tunnel, Near Tank 6	Lower Tunnel, Near Tank 14	Access Rd. by Firing Range	RHS

4.4 Installation of Soil Vapor Monitoring Points

SVMPs will be installed in angled borings beneath tanks to aide in the assessment of vapors. Three SVMPs will be installed inside each of the chosen angled borings in the outer third, middle third, and inner third of the vadose zone below the bottom of certain USTs. Typical construction details for installation are depicted on Figure 4-3. Angled soil borings that may be chosen include those at Tanks 2, 12, 13, 16, 17, 19, and 20.

The existing casing has a small diameter (1.5 to 2 inches in diameter) and construction of the SVMPs will require close attention to the sizes of the required equipment (i.e., tremie pipe, etc.). The casing should also be evaluated for contamination that may have entered through the screen and pooled at the bottom. In general, the screens are 15 feet long and located at the outer third of the borings. To construct the SVMPs, the screen will be cut, the casing removed and each third increment of the boring (100 feet, 66 feet, 33 feet) will be isolate with a bentonite seal, while copper tubing SVMPs are installed in each. A bentonite seal and steel cap will also be placed at grade, with the steel identifier tags on each of the SVMPs.

Installation specifications are listed in the FSP (TEC, 2005) and its respective updates.

4.5 Soil Vapor Sampling

SVMPs will be purged and sampled for VOCs using Method TO-3, which is described in the QAPP (TEC, 2005). Purging will be accomplished using a 1-gallon per minute electric air pump or comparable equipment. It is estimated that three MP volumes should be removed from each MP prior to sampling. A typical MP will consist of approximately 25 feet of 3.5-inch open hole to purge at 0.5 gallon per foot. Therefore, approximately 36 gallons are to be removed per MP prior to sampling.

Sampling will consist of field readings, and samples collected for laboratory analysis. Field readings will include oxygen, carbon dioxide, and TPH by volume, which shall be collected using a calibrated multi-gas meter and data will be entered on field forms and in the dedicated logbook for the project.

Laboratory samples will be analyzed at ATL, Folsom, California. ATL will provide 6-liter summa canisters for 10 samples, including nine MP sampling locations and a duplicate. Following purging, the summa canister dedicated to the MP will be labeled and logged with appropriate QC information. The canisters will be checked to ensure that they are at a vacuum of greater than 25 inches of mercury. The summa canister inlet will then be connected directly to the MP outlet barb via tygon tubing and the outlet barb will be opened. The summa canister valve will then be opened slowly, and the soil vapor will be drawn into the canister, replacing the vacuum. When the canister vacuum has returned to ambient pressure, the canister valve will be closed, the check valve on the MP will be closed, and the dedicated tygon tubing will be removed from the summa canister inlet. QC information, such as final pressure will be recorded on the sample label and the logbook and field forms and the summa canister will be capped. Canisters will be shipped to ATL under chain of custody procedures via direct air courier.

4.6 Fate and Transport Assessment

4.6.1 Vadose Zone

Methods for estimating the migration of LNAPL and/or soil vapor migration in unsaturated, fractured basalts that are anisotropic, heterogeneous, and localized in scale are highly dependant upon the resolution of the geologic data within the migration volume. In the proposed study, the local stratigraphy for the migration volume will be developed from a limited number of boreholes (three within the lower access tunnel that were cored).

Effort in this area will be focused on estimating travel time for LNAPL to reach the basal aquifer, retention capacity of the unsaturated basalt in an effort to estimate:

- The size of release required for LNAPL to reach the basal aquifer;
- The amount of the release that would reach the basal aquifer as LNAPL, based on the release volume;
- The travel time for the release to reach the basal aquifer, based on the release volume; and
- The effect of dissolved petroleum in infiltrating groundwater on the basal aquifer quality.

Due to the limited vertical cores in the RHSF, detailed models based on known geology will not be produced, but efforts will be utilized in evaluating a small number of simplified models to provide qualitative answers to these questions. In addition, TEC does not propose any methods for calibrating the unsaturated zone models used for this investigation during this phase of the study. For these reasons, the unsaturated zone models should be considered qualitative, and will be used to estimate general migration characteristics.

TEC proposes to evaluate the vadose zone migration using one or more of the following models.

- SESOIL, an EPA supported model utilized by the HDOH in their Risk Based Corrective Action (RBCA) and EALs program for vadose zone contaminant fate and transport.
- V2SDT (Variable Saturated 2D flow and Transport), a finite difference 2 dimensional model for determining the fate of landfill chemicals and surface releases in the unsaturated zone.
- UTCHEM, a 3 dimensional finite difference model, which will allow four-phase simulation (water, petroleum, micro-emulsion, gas) in vertical and horizontal wells.

4.6.2 Saturated Zone

4.6.2.1 Pumping Tests

The purpose of the aquifer pumping test will be to estimate the hydraulic parameters of the Pearl Harbor Aquifer in the vicinity of the RHSF. The parameter estimation will be done using inverse modeling. The inverse modeling process involves adjusting the hydraulic parameters in a numerical model to get the simulated drawdowns to match the measured aquifer drawdowns. This calibrated model will in turn be used to simulate the transport of a hypothetical contaminant release from the RHSF.

In its simplest sense, an aquifer test consists of pumping at one well and measuring the decrease in the water table elevation in that well and possibly other wells. For this test the primary pumping well will be 2254-01. In addition, following consultation with the Honolulu

Board Of Water Supply (BOWS), the Halawa shaft (2354-01) will also be used as a pumping well in coordination with 2254-01 to better define the effectiveness of the Halawa Valley fill separating the Moanalua and Waimalu aquifer sectors. It is proposed that approximately seven monitoring points should be evaluated during the tests, including RHMW01 through RHMW04, installed as part of the long-term monitoring program at the RHSF, two wells located adjacent to Adit 3 in the Former OWDF (OWDFMW1 and OWDFMW2), and the Halawa Deep Monitoring Well (2253-03). In addition, the project will consider collecting data at monitoring well 2254-02, located approximately 300 feet from 2254-01 and a monitoring well observed adjacent to Tripler Army Medical Center. These wells will be monitored for changes in water elevation via pressure transducer data loggers or manually (Figure 4-1). In addition, efforts will be made to collect chloride concentrations in at least one nearby deep basal monitoring well. The Halawa Deep Monitoring Well (2253-03) is currently being monitored for chloride content by the State of Hawaii Commission on Water Resource Management (CWRM), of the Department of Land and Natural Resources (DLNR).

Several factors make an accurate aquifer test assessment at this site difficult. The factors include:

- The unconfined nature of the aquifer;
- The geometry of the primary pumping center (infiltration galleries with a pump rather than a fully penetrating well);
- The large vertical extent of the aquifer;
- The dual nature of the aquifer (i.e. freshwater floating on saltwater);
- Valley fill and caprock boundaries at the margins of the aquifer; and
- Heterogeneity of the aquifer.

Due to these complexities, the primary method used for aquifer analysis will be a numerical model. However, analytical methods will be used to ensure the reasonableness of the numerical model results, to derive some information about the distance to low or no-flow boundaries, and to determine the relative imperviousness of the boundaries. Figure 4-2 shows the locations and types of regional wells in the vicinity of the project site.

4.6.2.1.1 Pre-Test Modeling

A series of preliminary simulations will be run using the localized Source Water Assessment Program (SWAP) model to provide insight into the aquifer test design. Specifically the simulations shall look at the following factors:

- The pumping rates and durations necessary to adequately assess the hydraulic parameters of the aquifer;
- The expected drawdowns in monitoring wells based on pumping rates agreed upon by TEC, UH, and PWC; and
- Interaction between the RHSF pumping center and the BOWS Halawa Shaft.

The pre-test modeling is described in Groundwater Flow and Aquifer Test Model (Section 4.6.2.2.2).

4.6.2.1.2 Aquifer Test Design Considerations

The following excerpt summarized points that should be considered when conducting an aquifer test (Williams and Soroos, 1973).

"The controlling factors in most pumping tests seem to be economic, i.e., budgets are limited, insufficient personnel and equipment are available, time cannot be spared, etc. However, if the effort is made to conduct a pumping, then for a relatively small additional investment of effort, a maximum of information can be obtained. In particular, recovery data can be acquired after every drawdown test which will give an independent determination of transmissivity and, in general, provide a check on the drawdown data. Also, advantage should be taken of any additional observation wells as each one will provide an independent estimate of the aquifer properties. If observation wells on three different rays from the pumped well are used, the estimates of the anisotropic properties of the aquifer can be made. Finally, before the test is conducted care should be taken to determine "background" fluctuations in the piezometric head which may result from barometric pressure changes, irrigation in the vicinity of the test site, tidal generated oscillations, etc. Drawdown data may be corrected for these effects if desired."

The following points summarize the conclusions concerning pumping tests analyses and Hawaiian aquifers:

- Analyses by at least several methods will be required to study thoroughly a set of pump test data.
- In general, the Theis or Jacob method should always be included in a study since either will provide a set of reference values for the aquifer properties. These values will tend to be conservative if partial penetration is a factor. If a moderate amount of leakage or boundaries are considered, the values should be reasonably good estimates of the aquifer properties if the calculations are based on the earlier-time data.
- Early-time match points are preferred to late-time match points provided the early-time data is reliable.
- For tests on the basal aquifer, either Hantush-Theis method for non-equilibrium data of the Anger method applied to step drawdown data may be used. If leakage or boundaries are also a factor, then the former method with early-time data is recommended.
- In designing a pumping test, at least two or three observation wells will be used if they are available to monitor recovery in the wells after pumping has stopped. The recovery data, if equilibrium is sufficiently approximated at shutdown, may be analyzed as drawdown data.
- A good working description of the geology and hydrogeology of the region will be developed. This description should include standardized driller's logs and site-specific data.

Based on the previously stated considerations, the UH will review relevant aquifer test data and in consultation with TEC, PWC, BOWS, and the CWRM of the DLNR, provide technical specifications for performing the aquifer tests. Listed below are factors that should be considered when developing the technical specifications.

4.6.2.1.3 Pumping Well Geometry

The well at 2254-01 is the Red Hill Shaft (RHS). It is a series of infiltration tunnels or galleries to minimize drawdown and upconing of seawater. Since the RHS is not a vertical well, it violates the normal assumptions of the analytical methods for estimating aquifer parameters. Although using analytical methods may result in inaccurate parameter estimation, these methods may be instructive to assess such things as the impact of boundaries and aquifer thickness on simulated well drawdowns.

4.6.2.1.4 Aquifer Thickness

The fresh-water basal aquifer is generally assumed to have a thickness equal to the distance between the water table and the mid-point of the transition zone. This distance is approximately equal to 40 times the elevation of the water table elevation above sea level (Fetter, 1994), (i.e., if the water table is 10 feet above sea level, the distance to the transition zone is 10 feet times 40, or 400 feet). This assumption works well when looking at the aquifer as a source of potable water. However, the boundary is dynamic since there is no "hard" boundary between the fresh and salt water, and when considering flow to a well the effect of the salt water body beneath the fresh water can not be dismissed.

The United States Geological Survey (USGS) commonly uses an aquifer thickness in density dependent groundwater models of 2,000 meters (6,560 feet), which includes both the freshwater lens and a portion of the saltwater aquifer (USGS 2002). Therefore an effective bottom boundary must be defined during the aquifer test analysis. The effective bottom boundary is that aquifer thickness beyond which any increases in aquifer thickness will have no significant effect on the drawdown of the water table. Sensitivity to aquifer thickness will be analyzed using a numerical model.

4.6.2.1.5 Drawdown

Pumping rates must be adjusted so that the drawdown at the well does not uncover the pump suction, but is sufficient to be detected at the selected monitoring points. The expected drawdowns can be estimated using the preliminary aquifer test model, simple analytical models, and a review of previous aquifer tests. Groundwater elevations were collected at the Red Hill OWDF monitoring wells via data loggers in August of 1998 and correlated to water levels collected at 2254-01. This data will be useful in developing the initial calibration scenario, and is presented as Figures 3-2 and 3-3 of the original work plan (TEC 2005).

4.6.2.1.6 Pumping Duration & Rates

Pumping rates and duration will be determined by consultation between NAVFAC, PWC, TEC, UH, CWRM, and BOWS. The following personnel shall represent their respective organizations during these consultations:

- NAVFAC – Glenn Yoshinaga,

- PWC – Paul Eyre,
- TEC – Jeff Hart and Robert Whittier,
- UH – Dr. Aly El-Kadi and Kolja Rotzoll,
- CWRM – Kevin Gooding, and
- BOWS – Chester Lao.

There are several factors to be considered when specifying the pumping rates and durations. These include:

- Time for drawdown to reach monitored wells;
- Time the pump could be run without overburdening the water distribution system (i.e. overflowing the storage reservoirs);
- Time pumps can be run at each pumping rate without excessive drawdown.
- Time the RHS and Halawa Shaft(s) can remain off without water demand depleting the water storage, or remain on without oversupplying the system(s);
- Pumping rate vs. drawdown.

Ideally, both the RHS and the Halawa Shaft(s) will be utilized as pumping points for the aquifer test, which will require a high level of cooperation with the Pearl Harbor PWC and the BOWS. During the first test the RHS will be pumped at approximately 6 million gallons per day (mgd) and 16 mgd for durations agreed upon by consultation. The Halawa Shaft will remain shut down during the RHS pumping test. During the second pumping test the opposite will occur. The Halawa Shaft will be pumped at rates and durations agreed upon during consultation and the RHS will remain off. This will help assess the effectiveness of the Halawa Valley Fill as a protective barrier to prevent RHSF contamination from being captured by the Halawa Shaft.

It is important to note that all water pumped during the aquifer tests must be utilized by the water distribution systems or stored in the reservoirs. Depletion of the reservoirs prior to pumping will allow the water to be pumped for a longer duration and/or a higher pumping rate.

4.6.2.1.7 Aquifer Boundaries

As the cone of depression around a pumping center expands outward it may encounter flow boundaries. The boundaries then affect the nature of the drawdown. No-flow or low-flow boundaries increase the rate of drawdown, while constant head boundaries such as streams decrease the rate of drawdown. Knowledge of these boundaries is critical when interpreting the aquifer test results. Boundaries to consider during this aquifer test are:

- The Halawa Valley Fill (a low-flow boundary);
- The Moanalua Valley Fill (a low-flow boundary);
- The Pearl Harbor Caprock (a low-flow boundary); and
- Depth at which rock is compressed to the point it no long efficiently transmits water (the bottom boundary).

4.6.2.1.8 Aquifer Test Analysis

The aquifer test will be analyzed by the UH. The primary method will be inverse modeling using a Pearl Harbor Aquifer model developed from the SWAP model of Oahu. These models are described in Groundwater Flow and Aquifer Test Model. The hydraulic parameters of the numerical model will be adjusted to get the best match between spatial and temporal variations in aquifer drawdowns induced by the pumping test.

If the geometric requirements of the available analytical models are valid, or if it is determined that reasonable assumptions regarding invalid requirements can be made to account for their influence, pump test results will also be assessed using one or more of the analytical models as a check of the validity of the numerical model and to better understand the effect of the physical aquifer boundaries. The Theis and Jacob methods will be considered as possible analytical models for this assessment

4.6.2.2 Aquifer Modeling and Analysis

The Navy will conduct groundwater modeling of the underlying basal aquifer and the potable water sources potentially down gradient from the RHSF. The modeling will be done in several phases:

- The first phase will simulate the response of the freshwater/saltwater transition zone in the Moanaula and Aquifer Systems to various pumping and recharge scenarios. This modeling will be done using a model of the Honolulu Aquifer developed by ETIC Engineering, Inc. (ETIC) for BOWS.
- The second phase will include a comprehensive review of the State of SWAP groundwater model of Oahu, identifying any modifications that need to be made to the regional model. Once the modifications are made to the Oahu model, it will be localized to the RHSF area. This localized model will be used to evaluate the aquifer pump test. The Groundwater Modeling System (GMS) will be used for this phase and specifically, USGS modeling code MODFLOW 2000 will be the numerical modeling code used to simulate the groundwater flow.

4.6.2.2.1 Finite Element Model for Saltwater Aquifer Test and Modeling – Groundwater Modeling

The FEFLOW model developed for the BOWS shall be used to assess the response of the freshwater/seawater interface to changes in pumping stress at the RHS. This phase of the groundwater modeling will:

- Use the current calibrated FEFLOW model developed for and reviewed by the BOWS;
- Run two scenarios to steady state, using this model, (i.e., use an average pumping rate of 6 mgd and average recharge conditions developed in the BOWS mode for the first scenario, and use a maximum pumping of 16 mgd and average recharge conditions developed in the BOWS model for the second scenario).

A data set from each scenario will be used in the fate and transport modeling and includes:

- A report describing the model, referencing the BOWS report when appropriate.
- A graphical description of how the transition zone changes from the introduction of pumping until steady state has been achieved in both scenarios.
- A data set importable into GMS of the mid-point of the transition zone (this can be a dense scatter point file in ASCII format having x, y, and z information); and
- Salinity profiles which include the initial time step, the midpoint between start up and steady state, and steady state.

4.6.2.2.2 Groundwater Flow and Aquifer Test Model

This phase of the modeling will done using GMS, and the MODFLOW and MODPATH numerical modeling codes included in GMS. It will consist of preliminary aquifer test simulations, review and revision of the Oahu SWAP model, localization of the Oahu SWAP model, and aquifer test modeling.

4.6.2.2.3 Red Hill Aquifer Model

A numerical model of the regional hydrogeology at the RHSF will be created to support the development of a comprehensive fate and transport model to provide supporting data for risk assessment. This model will be a localization of the SWAP model of Oahu, with the following tasks being done.

The SWAP Oahu model was developed using the GMS, and specifically, the MODFLOW and MODPATH numerical modeling codes included in GMS. This model delineated the two and ten year capture zones for all public drinking water wells on Oahu. This model will be localized to assess the hydraulic characteristics of the aquifer in the vicinity of the RHSF and provide a groundwater platform for the fate and transport modeling phase of this study.

In this phase of the study, the regional Oahu SWAP model shall be reviewed by the UH, TEC, and NAVFAC to determine what modifications are needed to allow development of an accurate groundwater model of the RHSF area. This will include a review of:

- the water budget used in the model,
- the model calibration,
- the horizontal and vertical resolution of the model,
- the value of the hydraulic parameters used in the model, and
- the model boundaries.

Once the agreed upon changes have been made to the Oahu SWAP model, a localized model well be developed that focuses in on the RHSF area. This localization will include:

- Mutually agreed upon, changes will be made to Oahu SWAP model to improve the resolution and detail in the Pearl Harbor;
- Localizing the model boundaries to cover the portions of the Pearl Harbor and Honolulu Aquifers;

- Calibration of the localized model to water level data recorded at wells RHMW03, RHMW02, RHMW01, RHMW04, and RHOWFMW8 at the RHSF; and the Moanalua Observation Well (2153-09), Halawa Observation Well (2153-09), Upper Waimalu Observation Well (2455-01), Halawa Deep Monitoring Well (2253-03), New Town Deep Well (2456-04), the Navy's Aiea small boat harbor well (2256-10), an adjacent well that has historic chloride concentrations (2256-11 or 12), and 2255-32 (the Navy's Halawa shaft, about a mile down gradient from the BOWS Halawa shaft outside of the RHSF.
- Adjusting the bottom boundary of the model to elevation of the mid-point of the transition between freshwater and saltwater as estimated in the FEFLOW models.

4.6.2.2.4 Aquifer Test Preliminary Simulations

A preliminary localized GMS model based on the Oahu SWAP model will be run to provide insight into the test design. The following factors will be reviewed:

- The pumping rates and durations necessary to adequately assess the hydraulic parameters of the aquifer;
- The expected drawdowns in monitoring wells based on pumping rates agreed upon by TEC, UH, and PWC; and
- Interaction between the RHS pumping center and the BOWS Halawa Shaft.

4.6.2.2.5 Aquifer Test Analysis Modeling

This model will analyze the results of the aquifer test and to provide the groundwater flow regime for the fate and transport model. The model will be a transient groundwater flow model based on the data collected during the aquifer test. It will be calibrated to get the best agreement between the absolute values of water table elevation, temporal response to pumping stresses, and to get reasonable water budget values at the model boundaries. Once calibrated, the model will provide the best estimates available of aquifer hydraulic conductivity, storativity, and specific yield. The final model will then be used for the contaminant fate and transport assessment.

4.6.2.2.6 Finite Difference Model for Contaminant Fate and Transport

The localized model developed and calibrated previously will be used to simulate the transport and predict the fate of potential contamination from the RHSF. The contaminant transport modeling will be done using the numerical modeling code RT3D. This code directly simulates the reduction in benzene, toluene, ethylbenzene and xylenes contamination concentration due biological action utilizing the primary electron acceptors that include dissolved oxygen, nitrate, sulfate, and ferrous iron. The model shall be used to assess contaminant transport in response to a variety of pumping scenarios. Specifically, the model will include the following conditions and scenarios:

- A constant and conservative source beneath one or more pairs of tanks will be assumed. The specific geometry of the source shall be agreed upon during discussions between TEC and NAVFAC.
- The initial simulations will not initially consider the effects of chemical decay or transformation, but will consider the effect of dispersion. This will simulate the "worst case" scenario for contaminant transport.
- The following wells are considered as receptors points, the RHS (2254-01), the Halawa Shaft (2354-01), the Moanalua Wells (2153-10 through 2153-12, modeled as a single pumping source).
- A first scenario will be simulated with contaminant transport using the average pumpage for the years from 1995 through 2004 for the modeled area and recharge computed in the same manner as was done for the revised Oahu SWAP model.
- A scenario will be simulated with contaminant transport if the RHS is pumped at 16 mgd while the remaining wells are pumped at the 1995 through 2004 average pumping rate.
- A scenario will be simulated with drought conditions, and the RHS out of service. The recharge used in the first scenario shall be reduced to values consistent with rainfall during 1998 (the driest year recorded at the Honolulu International Airport since 1994). The total pumpage for each aquifer sector shall be proportionally increased from the base pumpage so that the total pumpage will be equal to the sustainable yield for those aquifer sectors as set by the CWRM. This is a worst case scenario to assess whether any drinking water well other than the RHS could be impacted by contamination from the RHSF.
- For each simulation scenario described above except the transition recovery simulation, the model will be used to calculate the concentration of chemicals of concern at RHMW03, RHMW02, and RHMW01 that will result in Tier 1 action level exceedances at the receptor points.
- A second set of simulations will be done that estimate the reduction in contaminant concentration due to natural attenuation. This model will incorporate natural attenuation data collected in the field into the RT3D model. The model will predict the reduction in contamination described in the previous scenarios due to biologic action.

4.6.2.3 Natural Attenuation Analytical Assessment

In addition to evaluating the contaminant degradation through the numerical model, an analytical assessment of the assimilative capacity of the Pearl Harbor Basal Aquifer will be conducted, based on *The Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater (AFCEE, 1995).* This analysis will be conducted using site-specific groundwater concentrations of the major biodegradation parameters (dissolved oxygen, nitrate, sulfate, ferrous iron, and methane). The assessment will compare the concentrations of these parameters in up-gradient well (RHMW04) to wells within the RHSF (RHMW01, RHMW02, and RHMW03), and to the down gradient Navy Pumping well at 2254-01.

The difference in the biodegradation parameter concentrations in these locations will be assumed to be the result of the biodegradation of the fuel in the groundwater beneath the site. Using the stoichiometric relationships for aerobic and anaerobic degradation of petroleum, estimates will be made for the degradation of petroleum for each of the major biodegradation parameters. The analysis will include an estimate of the volume of water that flows though the upper portion of the aquifer that can be expected to be degraded by the fuel storage activities and will estimate the volume of petroleum degraded over time, based on the changes in the aquifer geochemistry. These results will be used to ensure the numerical fate and transport model is producing similar results.

4.7 Comprehensive Risk Assessment

4.7.1 Previous Screening Risk Assessments

An initial screening level risk assessment was performed for the RHSF as part of the Phase II SI Report (AMEC, 2002). This assessment was used as a qualitative tool to identify the constituents that were present in environmental media at concentrations of potential concern. The results of the screening level assessment indicated that seven constituents were detected in core samples below the tanks at concentrations of potential concern: ethylbenzene, methylene chloride, 2-methylnaphthalene, naphthalene, phenanthrene, TPH (C10-C28), and unknown hydrocarbon. Three constituents were detected in groundwater from one monitoring well beneath the tanks at concentrations of potential concern: bis(2-ethylhexyl)phthalate, lead, and TPH (C10-C28). The investigation also indicated the presence of petroleum in the form of LNAPL in several slant borings screened approximately 85 to 100 feet above the basal aquifer at the site.

A screening level ecological risk assessment (ERA) was previously conducted for the Red Hill Oily Water Disposal Facility (Ogden, 1996). The facility is located approximately 0.6 miles northwest of the RHSF and the screening level ERA performed for the OWDF is considered representative of the site.

The screening level ERA indicated that the OWDF is located in a partially vegetated industrial area surrounded by developed land. The majority of land comprising the OWDF is either developed or is non-native habitat utilized by common urban species. The biological survey performed of the Red Hill Naval Reservation indicated that the habitat consists of scrub vegetation, disturbed habitat and developed land. All habitats found onsite were of poor quality, were dominated by non-native species, and contained no species with federal or state status. Poor habitat quality is primarily due to habitat alteration and degradation by development.

4.7.2 Comprehensive Human Health Risk Assessment Methods

The human health risk assessment (HHRA) will follow the methodology of the U.S. Navy (NFESC, 2001), which uses the basic concepts of the USEPA risk assessment methodology (USEPA, 1989). The risk assessment Tier system of HDOH (2005a) with Tiers 1, 2, and 3 will be used since that system will be used for screening.

This Work Plan will address the following procedures:

- A conceptual site exposure model identifying exposure scenarios, exposure assumptions, and algorithms used to quantify exposure;
- Tier 2 (equivalent to a Navy Tier 1B) screening to select COPCs;
- Tier 3 (equivalent to a Navy Tier 2) development of site-specific ALs; and
- Uncertainty.

4.7.2.1 Conceptual Site Exposure Model

A preliminary risk evaluation was included in the Phase I Work Plan (TEC, 2005). This evaluation included a site-specific exposure assessment and development of a CSM.

The objective of the exposure assessment was to evaluate potential human and environmental exposure to site-related constituents of potential concern. The exposure assessment identified the pathways by which human and environmental receptors are potentially exposed. The process included:

- Characterization of the exposure setting;
- Identification of potentially exposed populations; and
- Identification of potential exposure pathways.

The exposure setting was discussed and displayed in figures in detail in the preliminary risk evaluation.

4.7.2.2 Potentially Exposed Populations

Current and future use and zoning was discussed in the Phase I Work Plan (TEC, 2005). Based on this analysis, the current and future use of the RHSF site is military-industrial. The existing residential areas to the south will remain and the existing industrial-commercial and parkland areas to the north will also remain.

Current groundwater use was discussed in the Phase I Work Plan (TEC, 2005). There are three nearby potable water supply wells within the study area (Figure 4-1): BOWS Halawa Shaft Well No. 2354-01, RHS No. 2254-01, and BOWS Moanalua Supply Well No. 2153-10. It is assumed that groundwater will continue to be used for potable water in the future. Details of groundwater consumption patterns for these wells will be evaluated in the comprehensive risk assessment.

4.7.2.3 Identification of Potential Exposure Pathways

The exposure assessment evaluates all potential exposure pathways and identifies those that are complete and those that are incomplete or that are minor pathways. There are four elements used to establish a complete exposure pathway:

- a source and a mechanism of release to the environment;
- an environmental transport medium;

- a point of potential contact between a receptor and the environmental medium (referred to as the exposure point); and
- an exposure route or uptake mechanism.

The exposure pathway analysis is performed by means of the development of the CSM. The CSM identifies the relationship among sources, release mechanisms, impacted media, exposure routes, exposure points, and receptors potentially affected by constituents present at or released from the site. Figure 3-1 depicts the Preliminary CSM for the RHSF. Cross sections shown in Figure 3-2 and Figure 3-3 of the original work plan (TEC 2005) visually illustrate aspects of the CSM.

Pathways identified in the preliminary risk evaluation and CSM as significant include the following:

- Risks to residential and occupational receptors using potable water wells that result from RHSF UST releases.
- Risks to industrial workers in the underground tunnels resulting from UST releases and vapor intrusion into the tunnels.

The Comprehensive Risk Assessment will evaluate these pathways in detail. Other pathways identified as minor pathways in the CSM will be evaluated to determine if all the assumptions used in the preliminary risk evaluation are still valid after the completion of all studies being conducted in Phases I and II. These pathways will not be evaluated quantitatively unless these previous assumptions are found to be incorrect.

4.7.2.4 Screening to Select COPCs

The screening step will be equivalent to a HDOH Tier 2 risk screening (HDOH, 2005a) since the basic steps for a Tier 1 screening have already been completed in the preliminary risk evaluation and risk screening evaluations.

The Tier 2 Risk-Based Screening process consists of the following steps:

- Evaluate DQOs;
- Compare site concentrations to background and eliminate chemicals that are not elevated above background;
- Identify appropriate screening levels;
- Identify appropriate site chemical concentrations for each medium;
- Perform risk-based screening by comparing chemical concentrations screening levels for each medium; and
- Evaluate the results of the screening to determine if the site can exit the cleanup process or warrants further study.

The appropriate screening levels to be used for step 6, based on the CSM, are taken from the HDOH screening tables (HDOH, 2005a) and are as follows (tables of these EALs are provided in Appendix C):

- Groundwater – Table C-1A, Groundwater Action Levels for Evaluation of Potential Indoor-air Impacts; Table D-2, Summary of Drinking Water Action Levels for Human Toxicity; and Table G-1, Groundwater Gross Contamination Ceiling Levels.
- Soil Vapor – Table C-2, Shallow Soil Gas Action Levels of Revaluation of Potential Indoor-air Impacts.
- Soil – Table C-1B, Soil Action Levels of Evaluation of Potential Indoor-air Impacts.

Chemicals that are detected at a low frequency (e.g., less than 5% frequency of detection and at low concentrations) for a medium will be eliminated from further consideration in the risk assessment process based on USEPA risk assessment guidance (USEPA, 1989).

The three ways to exit the human health risk assessment process from the risk-based screening step are as follows:

- The existence of incomplete Exposure Pathways
- Background – If there are no chemical concentrations present on site that are greater than background concentrations then the site may exit the HHRA process. This only applies to chemicals that are detected in background samples.
- The existence of potentially complete pathways that require further risk-based screening.

4.7.2.5 Tier 3 Development of Action Levels

Tier 3 (Tier 2 Navy) HHRA risk assessment methods will be used to calculate ALs. The approach is to select an exposure point concentration (EPC) that is acceptable based on risk considerations and then use fate and transport models to determine what the monitoring point concentration would be that would result in that EPC. For risks to the basal aquifer and potable water production wells, the acceptable EPC for a compound will be an MCL if one exists, or, if none exists, one will be developed. If one receptor will clearly have the lowest acceptable EPC, then acceptable EPCs for other receptor groups may not be calculated.

To develop the acceptable EPC, applicable or relevant and appropriate requirements (ARARs), toxicity, and taste/odor will be considered. If an MCL exists for a compound, this will be the acceptable EPC, otherwise both toxicity and taste/odor will be considered. For toxicity a hazard index of 1.0 will be used for non-carcinogenic COPCs, and for carcinogenic COPCs a series of EPCs will be established using risk levels of 10-4, 10-5, and 10-6. For taste/odor concerns, if the concentration in Table G-1 of the Hawaii EAL document (HDOH, 2005a) is less than the EPC calculated for toxicity using a hazard index of 1.0 for non-carcinogens or the 10-4 risk level for carcinogens, then this concentration will also be an EPC. The predictive fate and transport models will then use the EPC(s) to determine the ALs.

4.7.2.6 Risk Characterization Components

The risk characterization section of the report will identify and highlight noteworthy risk conclusions. These would include:

- An analysis of current risks based on the comparison of existing measured concentrations of COPCs with ALs for each location and receptor type;
- The COPCs, exposure pathways, and media responsible for the majority of the risks;
- Discussion of any chemicals for which toxicity information was not available; and
- Any unique characteristics of the exposed populations that may be useful to decision makers.

4.7.2.7 Uncertainty

The uncertainty discussion will be qualitative. The relative direction and magnitude of the uncertainty associated with the key assumptions/parameters used to calculate the risks will be identified. It will highlight the key uncertainties and provide some measure of the impact on the site risk estimates.

4.7.2.8 Reporting

The risk assessment will be a section within the Site Characterization Report (SCR). The SCR will include the elements recommended in Appendix 5-H of the TGM-UST, unless superseded by EAL screening guidance (HDOH, 2005b)

4.8 Site Characterization and Risk Assessment Report

The SCR will follow applicable guidelines in the TGM-UST, and will also include the risk assessment. Because this investigation does not directly fall under one of the categories in the TGM, it will include applicable elements from several reporting categories. These include Appendix 5-C (Format For Initial Release Response Report) and Appendix 5-F (Format For Corrective Action Plan) (TGM, 2005). Results of the Risk Assessment will also be included in the SCR. The basic outline of the report will be as follows:

- Executive Summary

- Introduction/Purpose

- Site and Location Characteristics
  - Facility description
  - Physical setting
  - Groundwater and Surface Water
  - Ecological setting

- Surrounding Populations Land Use

- Previous Investigations and Conditions
  - Facility Condition and History of Releases
  - Description of previous study results

- Site Characterization Investigation Activities
- Site Characterization Results
- Conceptual Site Model and Contaminant Fate and Transport
  - Conceptual Site Model
  - Physical and Chemical Characteristics of the Contaminants
  - Groundwater Modeling Summary
  - Soil Vapor Transport Evaluation
- Applicable Regulations and Guidance
- Risk Assessment
  - Methods
  - Data Evaluation
  - Exposure Assessment and Conceptual Model
  - Tier 2 Screening
  - Development of Tier 3 Action Levels
  - Uncertainty
- Conclusions/Recommendations

The site characterization and risk assessment report will include data from both phases of the investigation.

4.9 Prepare A Monitoring And Contingency Plan

The contingency plan will describe methods to monitor and respond to releases from the USTs to protect the drinking water resource of the basal aquifer, to protect RHSF worker health, and to address any other unacceptable risks that are determined during the RHSF facility investigation. The plan will describe procedures for monitoring groundwater and soil vapor to provide an early warning system for the potential unacceptable degradation of the groundwater resource and nearby potable water wells, and the potential unacceptable degradation of air quality in the lower access tunnel, or in ground surface buildings in the vicinity of the facility.

4.9.1 Elements of the Plan

The Monitoring and Contingency Plan will have the following major elements:

- Introduction - Purpose and what will be covered
- Description of the facility - Storage tank physical features, types of fuels stored and quantities
- Communication and Responsibilities
- Description of the Existing Monitoring System
- Status and Trends – results of monitoring to date
- Long-Term monitoring program - GIS database; Action Levels and Response Actions

- Training

4.9.2 Long-Term Monitoring Program

Based on the results obtained during the Facility Investigation, a long-term monitoring program will be recommended. The plan will describe the locations to be sampled, the analytes, and the frequency of testing. A set of action levels will be developed for analytes that will be used to compare against all future monitoring results. Fate and transport modeling and risk assessment will be inputs to these decisions.

Because future leaks and migration will also be monitored, the contingency plan will contain a list of future compounds of potential concern and the calculated site specific health based action level for each monitoring point (basal water wells and vapor monitoring points located within the lower access tunnel). These will be analytes not currently detected or not resulting in current risk, but that could reasonably be determined to result in future risk. These will be in addition to those substances currently posing a risk. These "future-risk" analytes will be selected based on a combination of what substances are present in the fuels stored on site, and their toxicity, mobility, and persistence; a maximum of seven compounds or hydrocarbon groups will be included.

4.9.3 Action Levels and Response Actions

The procedure used to set risk-based action levels will be described. The approach is to select an EPC that is acceptable based on risk considerations and then use fate and transport models to determine what the monitoring point concentration would be that would result in that EPC. Risk assessment procedures that will be used are described in Section 4.7. A description of the fate and transport models to be used and the basic methodology are described in Section 4.7.

The scenarios for which action levels and responses will be developed include:

- Detection of petroleum-related substances in a monitoring well on RHSF
- Detection of petroleum-related substances in a potable water production well down-gradient of RHSF
- Detection of petroleum-related substance in a vapor monitoring point beneath the USTs

For each contingency, a decision tree will be developed to visually guide the user through the decision and response process. Response procedures will address the degree of eminent risk associated with concentrations that are 1/10 times the action level, and 10 times the action level.

Response actions will describe the action measures in response to each of the scenarios listed above. This discussion will include personnel, equipment, which would be needed to implement each response. HDOH notification procedures will be included. It will also include a timeline.

4.9.4 Training

Training for RHSF personnel will be described in this section. It will describe who should receive training, how often, and what will be covered in the training. Two training areas will be covered including the procedures for monitoring well and vapor monitoring point sampling as well as knowledge and implementation of the contingency plan.

For the contaminated media sampling, the training will include a set of instructions that will allow RHSF personnel to conduct future groundwater and soil vapor monitoring including permits, as required by the HDOH for active underground storage release sites overlying important groundwater resources. It also includes onsite training for individuals that will be required to collect these samples. The contingency plan training will cover the elements of this contingency plan.

4.10 Sample and Data Management Training Plan

TEC will develop a system that is compatible with FISC's GIS-based interface and will assist FISC in developing a graphical output for the data that will allow the data to be queried and displayed in a series of charts and tables according to their needs. This system will include a database structure that will allow all the data to be stored in a central electronic repository that can be accessed via the graphical user interface.

TEC will develop a permanent GIS data repository of Red Hill environmental data including past environmental investigations and future monitoring. This data will be installed in GeoMedia Professional on the FISC workstation using FISC's Oracle database. Using Microsoft .NET technology, TEC will create a stand-alone application that will convert environmental monitoring data into FISC's Oracle database. TEC will develop dynamic query sets of the environmental data and organize the information in appropriate map views to depict environmental conditions in the Red Hill area. The dynamic queries will be designed to capture and map future monitoring data as it is collected and uploaded to the FISC database.

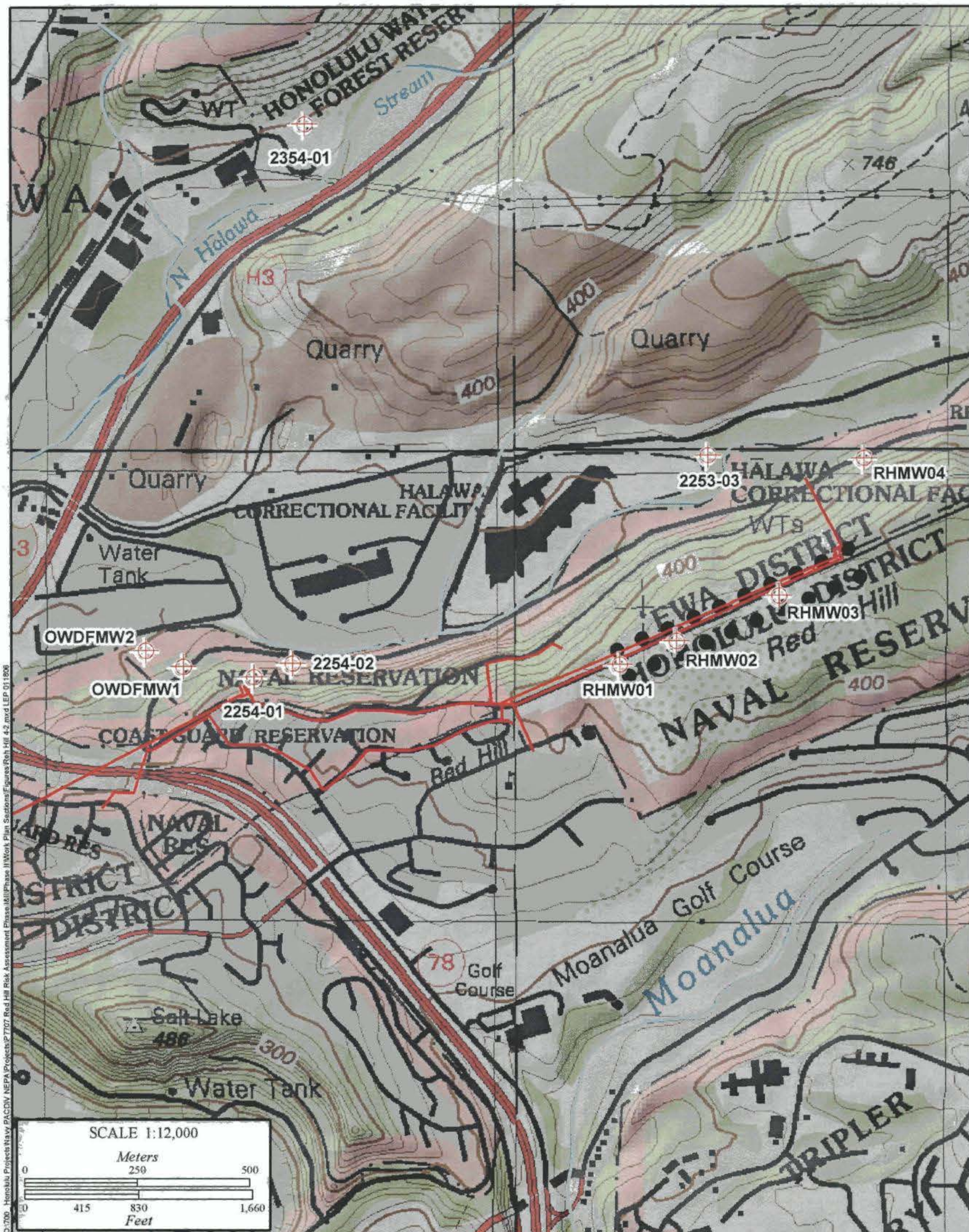

Figure 4-1
Project Well Location Map
Red Hill / NAVFAC

TEC inc

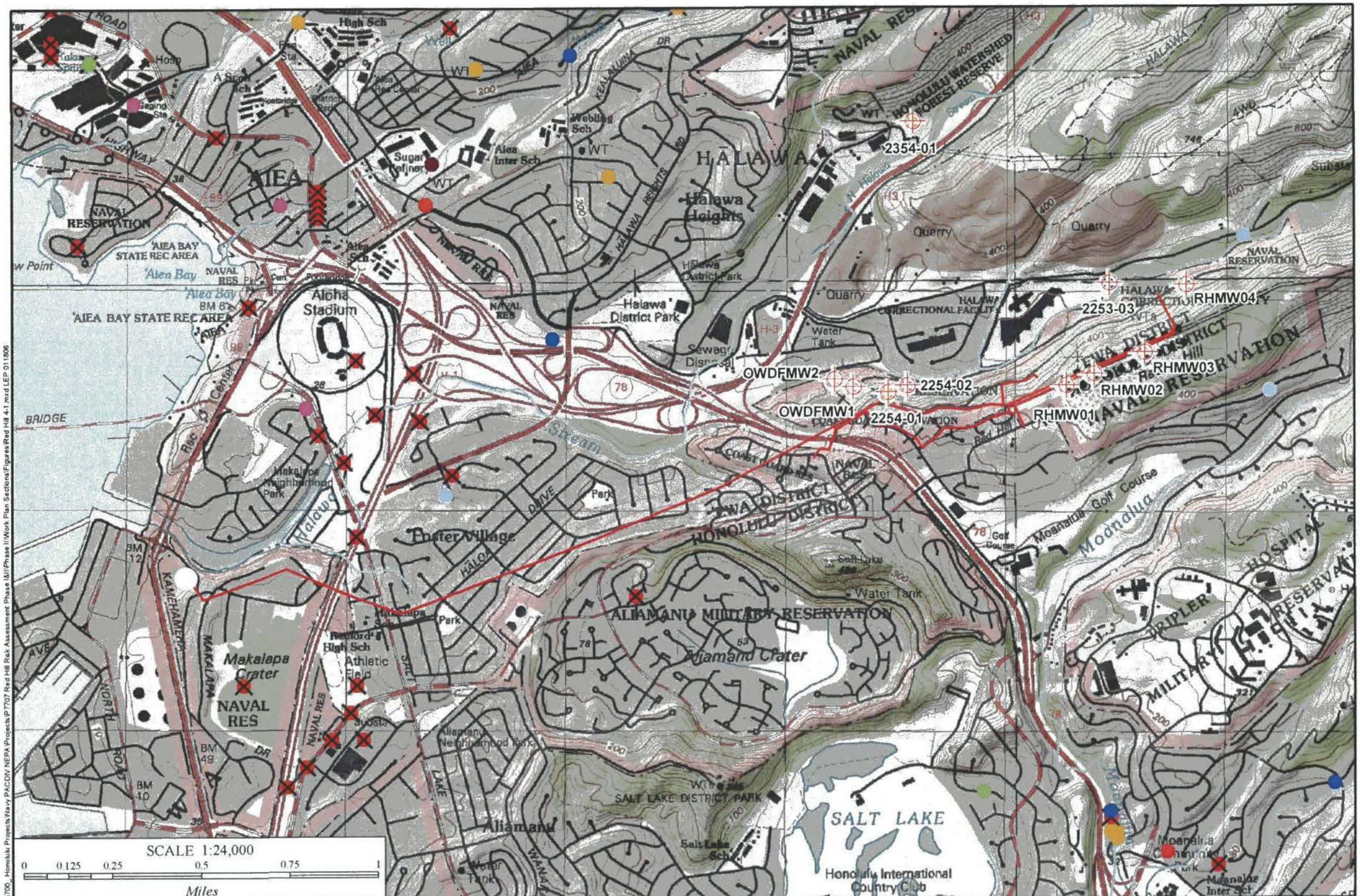

Figure 4-2
Area Well Location Map
Red Hill / NAVFAC

DLNR Wells: domestic, industrial, irrigation, military, monitoring, municipal, observation, other, sealed, unused

project wells, stream, waterlines

N

TEC inc

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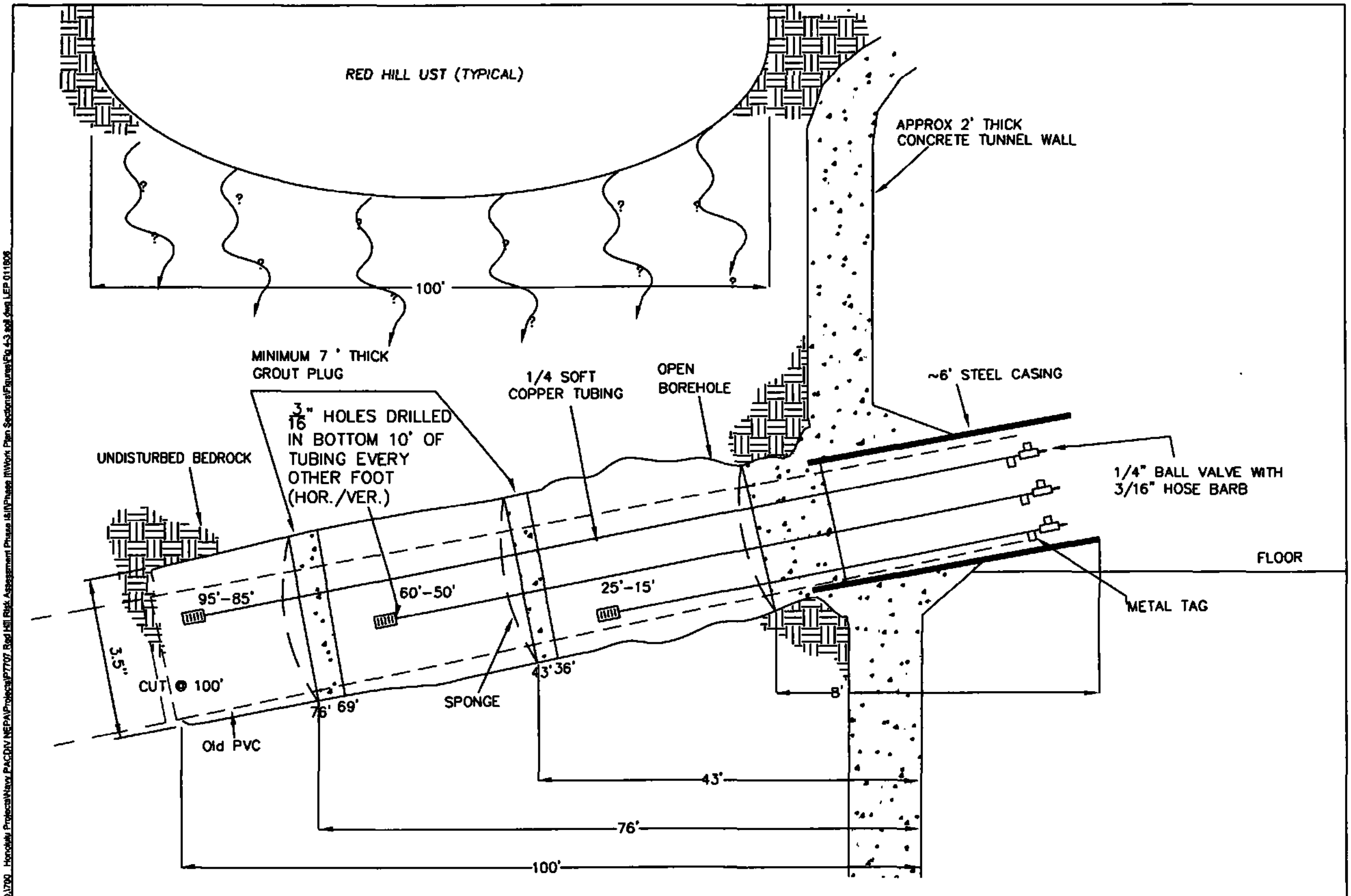

Figure 4-3
Soil Vapor Monitoring Point Construction Details
Red Hill BFSF

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5.0 PROJECT SCHEDULE

The project schedule is presented in Figure 5-1.

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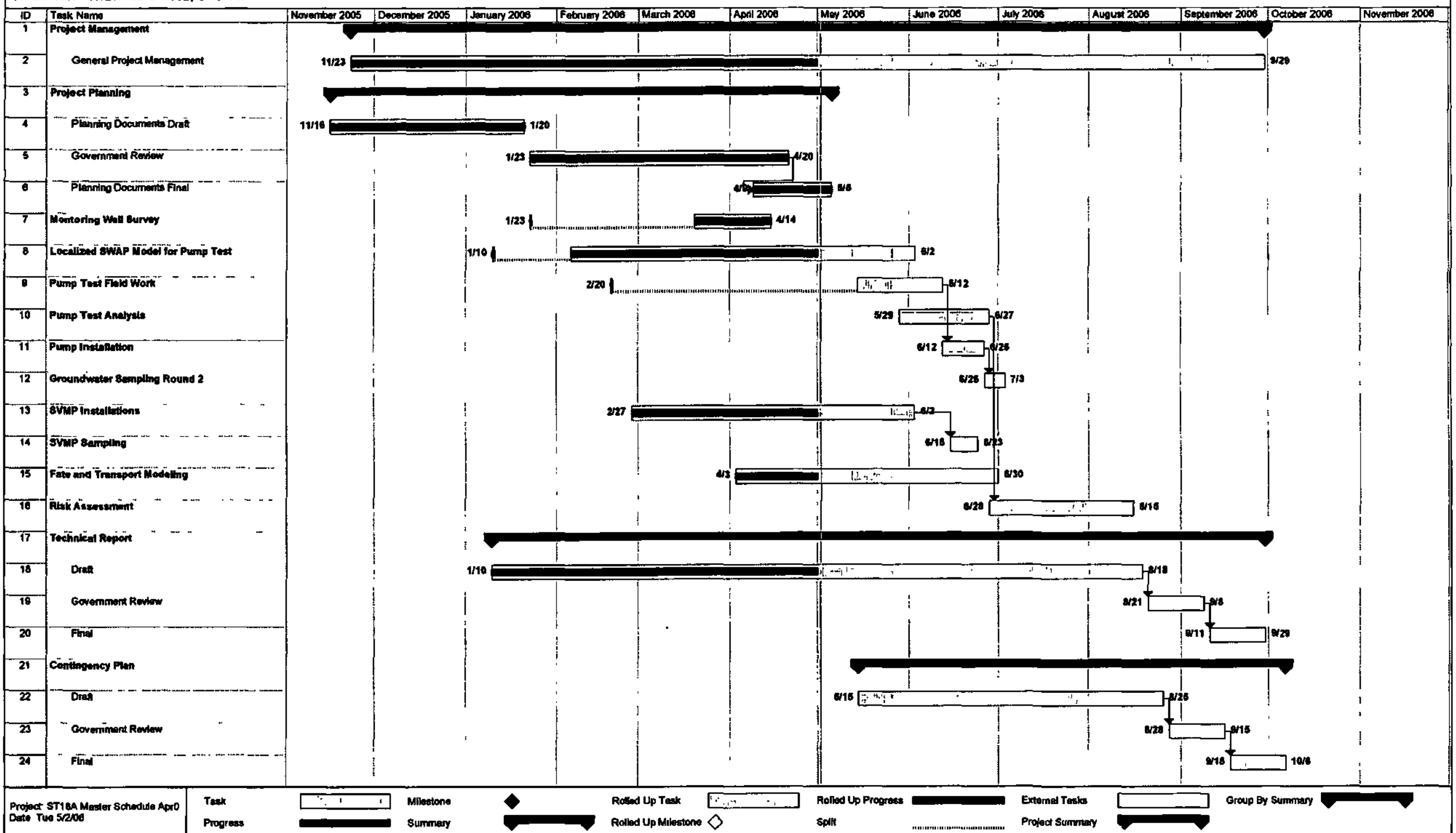
Figure 5-1. Project Schedule
Red Hill Site Characterization and Risk Assessment, Phase 2
Contract No N6274-02-D-1802, CTO 007



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6.0 REFERENCES

Code of Federal Regulations Title 40, Part 141.

Hawaii Administrative Record (HAR) Title 11. Chapters 20, 281, 451.

Hawaii Revised Statutes Title 19, Chapters 128D and 342L.

AMEC (AMEC Earth and Environmental Inc.). 2002a. Red Hill Bulk Fuel Storage Facility Investigation Report. Prepared for NFEC. August.

Dawson. 2005a. Groundwater Sampling, Red Hill Fuel Storage Facility, Hawaii, First Quarter 2005. Dawson Group. April 2005.

Dawson. 2005b. Groundwater Sampling, Red Hill Fuel Storage Facility, Hawaii, Second Quarter 2005. Dawson Group. August 2005.

Earth Tech. 1999. Draft Report Phase II Remedial Investigation, Red Hill Oily Waste Disposal Facility, January 1999.

Fetter. 1994. Applied Hydrogeology. Fetter, C.W. Prentice Hall. 1994

Hawaii Administrative Rules, Chapter 11-281, Underground Storage Tanks

HDOH. 1995b. State Contingency Plan. Hawaii Administrative Rules, Chapter 11-451. August 1995.

HDOH. 1996. Risk Based Corrective Action and Decision Making at Sites with Contaminated Soil and Groundwater, Honolulu, Hawaii. State of Hawaii, Department of Health, Environmental Management Division. Revised June 1996.

HDOH. 1997. Draft Edition: Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan. Hazard Evaluation & Emergency Response. October 1997.

HDOH. 2000. Technical Guidance Manual for Underground Storage Tank Closure and Release Responses. Environmental Management Division Solid and Hazardous Waste Branch, Underground Storage Tank Section. March 2000.

HDOH. 2003. Interim Draft: Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater. Environmental Management Division. December 2003.

HDOH. 2005. Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater. Interim Final. May.

HDOH. 2005b. Use of May 2005 Environmental Action Levels ("EALs") at Leaking Underground Storage Tank sites. Memo from Steven Chang, Chief, Solid & Hazardous Waste Branch To Interested Parties. July 15.

Massachusetts Department of Environmental Protection (MADEP). 1995. Guidance for Disposal Site Risk Characterization: Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards, July 1995.

NFEC (Naval Facilities Engineering Command). 2001. U.S. Navy Human Health Risk Assessment Guidance. Prepared for NFEC and Navy Environmental Health Center. Prepared by PTC Pioneer Technologies Corporation.

Ogden, 1992. Technical Review Committee (TRC) Findings Summary, Red Hill Oily Waste Disposal Pit, Naval Supply Center, Pearl Harbor, O'ahu, Hawai'i.

Ogden, 1993. Red Hill Oily Waste Disposal Pit Site Stilling Basin Closure Plan, CTO 0109, 1993.

Ogden, 1996. Red Hill Oily Waste Disposal Facility, Phase I RI Report, June 1996.

Ogden, 1999. Initial Phase II Site Characterization Report, Fleet Industrial Supply Center, Bulk Storage Facility at Red Hill (Draft). March, 1999.

TEC Inc., 2005. Red Hill Bulk Fuel Storage Facility Final Health & Safety Plan. June 2005.

USEPA. 1989. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual, (RAGS), Interim Final. EPA/540/1-89/002. December.

USGS, 2002. Numerical Simulation of Ground-water Withdrawals in the Southern Lihue Basin, Kauai, Hawaii. Scot Izuka, Scot and Oki, Delwyn S.. USGS Water Resources investigations Report 01-4200. Prepared in cooperation with the County of Kauai Department of Water.

Wilbros Engineers, Inc., 1998. Regional Study of Military Bulk POL Distribution Systems and Storage Facilities, Hawaii, Red Hill Complex, Fire Life Safety and Environmental Risk Assessment/Analysis, Amendment 3, Volume 1 of 11, prepared for Department of the Navy, Naval Facilities Engineering Command, Pacific Division, Pearl Harbor, Hawaii. August, 1998.

Williams and Soroos. 1973. Evaluation of Methods of Pumping Test Analyses For Application to Hawaiian Aquifers. Williams John A. and Soroos, Ronald L. University of Hawaii at Manoa, Water Resources Research Center. July 1973.

Appendix A
Dawson LTM Data

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

				Pumps Offline	Pumps Offline		Relative Percent Difference (RPD)	Pumps Offline	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
			SAMPLE IDENTIFICATION	RH-B-001	RH-B-004	RH-B-005		RH-B-007			
			SAMPLE TYPE	Primary	Primary	Duplicate		Primary			
			DATE COLLECTED	02/16/2005	06/28/2005	06/28/2005		09/08/2005			
	ANALYSIS	EPA METHOD	MRL								
Metals	Total Lead	6020	*0 000050*	0 00033	0 000952	0 000549	*54%*	0 00005 ④	0 0056	0 015 ①②	mg/L
Hydrocarbons	TPH as Diesel	8015M	*0 052*	ND	0 043 J	0 067 Z	*44%*	0 045 J	NE	0 100 ①	mg/L
	TPH as Residual Range	8015M	*0 100*	ND	NA	NA	NA	0 059 J	NE	0 100 ①	mg/L
	TPH as Gasoline	8015M	*0 050*	ND	<0 050	<0 050	NA	<0 050	NE	0 100 ①	mg/L
EDB	1,2-Dibromoethane (EDB)	504 1	*0 0000095*	ND	<0 0000095	<0 0000097	NA	<0 0000095	NE	0 00012 ②	mg/L
VOCs	Benzene	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	1 70 ③	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	0 02 ③	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	0 001	<0 00050	<0 00050	NA	<0 00050	2 1 ③	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	0 14 ③	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	10 0 ③	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	10 0 ③	0 020 ①	mg/L
	1,2-Dichloroethane (1,2-DCA)	8260B	*0 00050*	ND	<0 00050	<0 00050	NA	<0 00050	0 005 ②	0 00012 ①	mg/L
PAHs	Naphthalene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	0 000085	0 24	0 0062 ①	mg/L
	2-Methylnaphthalene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 010 ①	mg/L
	Acenaphthylene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 240 ①	mg/L
	Acenaphthene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	0 32	0 020 ①	mg/L
	Dibenzofuran	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	NE	mg/L
	Fluorene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 240 ①	mg/L
	Phenanthrene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 0077 ①	mg/L
	Anthracene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	NE	mg/L
	Fluoranthene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	0 01	0 040 ①	mg/L
	Pyrene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 002 ①	mg/L
	Benz(a)anthracene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 000027 ①	mg/L
	Chrysene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 00035 ①	mg/L

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

			Pumps Offline	Pumps Offline		Relative Percent Difference (RPD)	Pumps Offline			
		SAMPLE IDENTIFICATION	RH-B-001	RH-B-004	RH-B-005		RH-B-007			
		SAMPLE TYPE	Pnmary	Pnmary	Duplicate		Pnmary			
		DATE COLLECTED	02/16/2005	08/28/2005	08/28/2005		09/08/2005			
ANALYSIS	EPA METHOD	MRL						HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
Benzo(b)fluoranthene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 000092 ①	mg/L
Benzo(k)fluoranthene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 00040 ①	mg/L
Benzo(a)pyrene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	0 0002	0 000014 ①	mg/L
Indeno(1,2,3-cd)pyrene	8270C SIM	*0 000020*	ND	<0 000020	<0 000020	NA	<0 000020	NE	0 000092 ①	mg/L
Dibenz(a,h)anthracene	8270C SIM	*0 000020*	ND	<0 000020	<0 000026 I	NA	<0 000020	NE	0 0000092 ①	mg/L
Benzo(g,h,i)perylene	8270C SIM	*0 000024*	ND	<0 000024 I	<0 000020	NA	<0 000020	NE	0 0001 ①	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
RH	Red Hill Fuel Station Facility
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	method reporting limit
<	less than
J	the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL
Z	the chromatographic fingerpnnt does not resemble a petroleum product
I	the MRL/MDL has been elevated due to a chromatographic interference
RPD	relative percent difference between pnmary and duplicate sample results RPD = Absolute value (pnmary - duplicate) / average (pnmary duplicate)
B	Stilling Basin
Bold	value is greater than regulatory action level
NE	none established
VOCs	volatile organic carbons
ND	not detected at or above laboratory MRL

Notes

① State of Hawaii Department of Health, 2005 Screening for Environmental Concerns At Sites with Contaminated Soil and Groundwater Volume 1, May 2005

② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards

③ State of Hawaii Department of Health, 2000 Hawaii Underground Storage Tank (UST) Technical Guidance Manual March 2000

④ Lead samples were filtered in the field

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

				Pumps Online		Relative Percent Difference (RPD)	Pumps Online			
			SAMPLE IDENTIFICATION	RH-B-002	RH-B-003		RH-B-006			
			SAMPLE TYPE	Pnmary	Duplicate		Pnmary			
			DATE COLLECTED	02/16/2005	02/16/2005		06/28/2005	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	
	ANALYSIS	EPA METHOD	MRL							UNITS
Metals	Total Lead	6020	*0 000050*	0 00006	0 00005	*18%*	0 000129	0 0056	0 015 ①②	mg/L
Hydrocarbons	TPH as Diesel	8015M	*0 052*	ND [0 053]	ND	NA	0 058 Z	NE	0 100 ①	mg/L
	TPH as Residual Range	8015M	*0 100*	ND [0 11]	ND	NA	NA	NE	0 100 ①	mg/L
	TPH as Gasolıne	8015M	*0 050*	ND	ND	NA	<0 050	NE	0 100 ①	mg/L
EDB	1,2-Dibromoethane (EDB)	504 1	*0 0000095*	ND [0 0000081]	ND [0 0000082]	NA	<0 0000095	NE	0 00012 ②	mg/L
VOCs	Benzene	8260B	*0 00050*	ND	ND	NA	<0 00050	1 70 ③	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	ND	ND	NA	<0 00050	0 02 ③	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	0 0012	0 00081	*39%*	<0 00050	2 1 ③	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	ND	ND	NA	<0 00050	0 14 ③	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	ND	ND	NA	<0 00050	10 0 ③	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	ND	ND	NA	<0 00050	10 0 ③	0 020 ①	mg/L
	1,2-Dichloroethane (1,2-DCA)	8260B	*0 00050*	ND	ND	NA	<0 00050	0 005 ②	0 00012 ①	mg/L
PAHs	Naphthalene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	0 24	0 0062 ①	mg/L
	2-Methylnaphthalene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 010 ①	mg/L
	Acenaphthylene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 240 ①	mg/L
	Acenaphthene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	0 32	0 020 ①	mg/L
	Dibenzofuran	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	NE	mg/L
	Fluorene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 240 ①	mg/L
	Phenanthrene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 0077 ①	mg/L
	Anthracene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	NE	mg/L
	Fluoranthene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	0 01	0 040 ①	mg/L
	Pyrene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 002 ①	mg/L
	Benz(a)anthracene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 000027 ①	mg/L
	Chrysene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 00035 ①	mg/L

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

ANALYSIS	EPA METHOD	MRL	Pumps Online		Relative Percent Difference (RPD)	Pumps Online	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
		SAMPLE IDENTIFICATION	RH-B-002	RH-B-003		RH-B-008			
		SAMPLE TYPE	Primary	Duplicate		Primary			
		DATE COLLECTED	02/16/2005	02/16/2005		06/28/2005			
Benzo(b)fluoranthene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 000092 ①	mg/L
Benzo(k)fluoranthene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 00040 ①	mg/L
Benzo(a)pyrene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	0 0002	0 000014 ①	mg/L
Indeno(1,2,3-cd)pyrene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 000092 ①	mg/L
Dibenz(a,h)anthracene	8270C SIM	*0 000020*	ND	ND	NA	<0 000021	NE	0 0000092 ①	mg/L
Benzo(g,h,i)perylene	8270C SIM	*0 000024*	ND	ND	NA	<0 000021	NE	0 0001 ①	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
RH	Red Hill Fuel Station Facility
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	method reporting limit
<	less than
J	the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL
Z	the chromatographic fingerprint does not resemble a petroleum product
i	the MRL/MDL has been elevated due to a chromatographic interference
RPD	relative percent difference between primary and duplicate sample results *RPD = Absolute value (primary - duplicate) / average (primary duplicate)*
B	Stilling Basin
Bold	value is greater than regulatory action level
NE	none established
VOCs	volatile organic carbons
ND	not detected at or above laboratory MRL

Notes

① State of Hawaii Department of Health, 2005 Screening for Environmental Concerns At Sites with Contaminated Soil and Groundwater Volume 1, May 2005

② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards

③ State of Hawaii Department of Health, 2000 Hawaii Underground Storage Tank (UST) Technical Guidance Manual March 2000

④ Lead samples were filtered in the field

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

				Pumps Online		Relative Percent Difference (RPD)			
			SAMPLE IDENTIFICATION	RH-B-008	RH-B-009				
			SAMPLE TYPE	Pnmary	Duplicate				
			DATE COLLECTED	09/08/2005	09/08/2005		HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	
	ANALYSIS	EPA METHOD	MRL						UNITS
Metals	Total Lead	6020	*0 000050*	0 00003 ④	0 00027 ④	*160%*	0 0056	0 015 ①②	mg/L
Hydrocarbons	TPH as Diesel	8015M	*0 052*	<0 050	<0 050	NA	NE	0 100 ①	mg/L
	TPH as Residual Range	8015M	*0 100*	<0 100	<0 100	NA	NE	0 100 ①	mg/L
	TPH as Gasoline	8015M	*0 050*	<0 050	<0 050	NA	NE	0 100 ①	mg/L
EDB	1,2-Dibromoethane (EDB)	504 1	*0 0000095*	<0 0000095	<0 0000095	NA	NE	0 00012 ②	mg/L
VOCs	Benzene	8260B	*0 00050*	<0 00050	<0 00050	NA	1 70 ③	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	<0 00050	<0 00050	NA	0 02 ③	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	<0 00050	<0 00050	NA	2 1 ③	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	<0 00050	<0 00050	NA	0 14 ③	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	1,2-Dichloroethane (1,2-DCA)	8260B	*0 00050*	<0 00050	<0 00050	NA	0 005 ②	0 00012 ①	mg/L
PAHs	Naphthalene	8270C SIM	*0 000020*	<0 000020	0 000045	NA	0 24	0 0062 ①	mg/L
	2-Methylnaphthalene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 010 ①	mg/L
	Acenaphthylene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 240 ①	mg/L
	Acenaphthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	0 32	0 020 ①	mg/L
	Dibenzofuran	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	NE	mg/L
	Fluorene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 240 ①	mg/L
	Phenanthrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 0077 ①	mg/L
	Anthracene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	NE	mg/L
	Fluoranthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	0 01	0 040 ①	mg/L
	Pyrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 002 ①	mg/L
	Benz(a)anthracene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 000027 ①	mg/L
	Chrysene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 00035 ①	mg/L

TABLE 1
Summary of Groundwater Sample Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

		SAMPLE IDENTIFICATION	Pumps Online RH-B-008	RH-B-008	Relative Percent Difference (RPD)	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
		SAMPLE TYPE	Primary	Duplicate				
		DATE COLLECTED	09/08/2005	09/08/2005				
ANALYSIS	EPA METHOD	MRL						
Benzo(b)fluoranthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 000092 ①	mg/L
Benzo(k)fluoranthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 00040 ①	mg/L
Benzo(a)pyrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	0 0002	0 000014 ①	mg/L
Indeno(1,2,3-cd)pyrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 000092 ①	mg/L
Dibenz(a,h)anthracene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 0000092 ①	mg/L
Benzo(g,h,i)perylene	8270C SIM	*0 000024*	<0 000020	<0 000020	NA	NE	0 0001 ①	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
RH	*Red Hill Fuel Station Facility*
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	method reporting limit
<	less than
J	the result is an estimated concentration that is less than the MRL but greater than or equal to the MDL
Z	the chromatographic fingerprint does not resemble a petroleum product
i	the MRL/MDL has been elevated due to a chromatographic interference
RPD	relative percent difference between primary and duplicate sample results RPD = Absolute value (primary - duplicate) / average (primary duplicate)

Notes

① State of Hawaii Department of Health, 2005 Screening for Environmental Concerns At Sites with Contaminated Soil and Groundwater Volume 1, May 2005
② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards
③ State of Hawaii Department of Health, 2000 Hawaii Underground Storage Tank (UST) Technical Guidance Manual March 2000
④ Lead samples were filtered in the field

TABLE 2
Summary of Groundwater Sample Results
MW-V1D
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

				MW-1VD		Relative Percent Difference (RPD)	MW-1VD		Relative Percent Difference (RPD)			
			SAMPLE IDENTIFICATION	RH-W-001 ③	RH-W-002		RH-W-003	RH-W-004				
			SAMPLE TYPE	Primary	Duplicate		Primary	Duplicate				
			DATE COLLECTED	02/17/2005	02/17/2005		06/28/2005	06/28/2005		HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
ANALYSIS		EPA METHOD	MRL									
Metals	Total Lead	6020	*0 000050*	**0.0102**	**0.0119**	*15%*	**0.006700**	**0.006980**	*4%*	0 0056	0 015 ①②	mg/L
Hydrocarbons	TPH as Diesel	8015M	*0 052*	1 4 [Y]	1 5	*7%*	1 300 Z	1 100 Z	*17%*	NE	0 100 ①	mg/L
	TPH as Residual Range	8015M	*0 100*	0 77 [O]	0 89	*14%*	ND	NA	NA	NE	0 100 ①	mg/L
	TPH as Gasoline	8015M	*0 05*	ND	ND	NA	<0 050	<0 050	NA	NE	0 100 ①	mg/L
EDB	1,2-Dibromoethane (EDB)	504 1	*0 0000095*	ND	ND [0 0000082]	NA	<0 0000095	<0 0000095	NA	NE	0 00012 ②	mg/L
BTEX	Benzene	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	1 70 ③	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	0 02 ③	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	2 1 ③	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	0 14 ③	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	1,2-Dichloroethane (1,2-DCA)	8260B	*0 00050*	ND	ND	NA	<0 00050	<0 00050	NA	0 005 ②	0 00012 ①	mg/L
PAHs	Naphthalene	8270C SIM	*0 000020*	0 00025	0 00021	*17%*	0 000073	0 000055	*28%*	0 24	0 0062 ①	mg/L
	2-Methylnaphthalene	8270C SIM	*0 000020*	0 00014	0 000057	*84%*	0 000054	0 000051	*6%*	NE	0 010 ①	mg/L
	Acenaphthylene	8270C SIM	*0 000020*	ND	ND	NA	<0 000020	<0 000020	NA	NE	0 240 ①	mg/L
	Acenaphthene	8270C SIM	*0 000020*	0 000052	0 000054	*4%*	0 000061	0 000061	*0%*	0 32	0 020 ①	mg/L
	Dibenzofuran	8270C SIM	*0 000020*	0 00013	0 00011	*17%*	0 00012	0 00012	*0%*	NE	NE	mg/L
	Fluorene	8270C SIM	*0 000020*	0 000053	0 000043	*21%*	0 000041	0 000039	*5%*	NE	0 240 ①	mg/L
	Phenanthrene	8270C SIM	*0 000020*	0 00012	0 000082	*38%*	0 00014	0 00010	*33%*	NE	0 0077 ①	mg/L
	Anthracene	8270C SIM	*0 000020*	ND	ND	NA	<0 000020	<0 000020	NA	NE	NE	mg/L
	Fluoranthene	8270C SIM	*0 000020*	0 000035	0 000021	*50%*	0 000093	0 000064	*37%*	0 01	0 040 ①	mg/L
	Pyrene	8270C SIM	*0 000020*	0 000056	0 000029	*64%*	0 00011	0 000072	*42%*	NE	0 002 ①	mg/L
	Benz(a)anthracene	8270C SIM	*0 000020*	ND	ND	NA	0 000047	0 000033	*35%*	NE	0 000027 ①	mg/L
	Chrysene	8270C SIM	*0 000020*	0 00002	ND	NA	0 000062	0 000044	*34%*	NE	0 00035 ①	mg/L

TABLE 2
Summary of Groundwater Sample Results
MW-V1D
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

		SAMPLE IDENTIFICATION	MW-1VD RH-W-001 ③	MW-1VD RH-W-002	Relative Percent Difference (RPD)	MW-1VD RH-W-003	MW-1VD RH-W-004	Relative Percent Difference (RPD)	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
		SAMPLE TYPE	Primary	Duplicate		Primary	Duplicate				
		DATE COLLECTED	02/17/2005	02/17/2005		06/28/2005	06/28/2005				
ANALYSIS	EPA METHOD	MRL									
Benzo(b)fluoranthene	8270C SIM	*0 000020*	0 000025	ND	NA	0 00004	0 000028	*35%*	NE	0 000092 ①	mg/L
Benzo(k)fluoranthene	8270C SIM	*0 000020*	ND	ND	NA	0 000051	0 000035	*37%*	NE	0 00040 ①	mg/L
Benzo(a)pyrene	8270C SIM	*0 000020*	0 000022	ND	NA	0 000045	0 000031	*37%*	0 0002	0 000014 ①	mg/L
Indeno(1,2,3-cd)pyrene	8270C SIM	*0 000020*	ND	ND	NA	0 000037	0 000024	*43%*	NE	0 000092 ①	mg/L
Dibenz(a,h)anthracene	8270C SIM	*0 000020*	ND	ND	NA	<0 000020	<0 000020	NA	NE	0 0000092 ①	mg/L
Benzo(g,h,i)perylene	8270C SIM	*0 000020*	ND	ND	NA	0 000034	0 000022	*43%*	NE	0 0001 ①	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
RH	Red Hill Fuel Station Facility
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	*method reporting limit*
B	Stilling Basin at PWC Potable Water Facility
<	less than
Z	the chromatographic fingerprint does not resemble a petroleum product
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correc carbon range, but the elution pattern does not match the calibration standard
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard
RPD	relative percent difference between primary and duplicate sample results RPD = Absolute value (primary - duplicate) / average (primary duplicate)
Bold	value is greater than regulatory action level
NE	none established
VOCs	volatile organic carbons
ND	not detected at or above the laboratory MRL

Notes

① State of Hawaii Department of Health, 2005 Screening for Environmental Concerns At Sites with Contaminated Soil and Groundwater Volume 1, May 2005
② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards
③ State of Hawaii Department of Health, 2000 Hawaii Underground Storage Tank (UST) Technical Guidance Manual March 2000
④ Lead samples were filtered in the field

TABLE 2
Summary of Groundwater Sample Results
MW-V1D
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

				MW-1VD		Relative Percent Difference (RPD)	HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
			SAMPLE IDENTIFICATION	RH-W-005	RH-W-006				
			SAMPLE TYPE	Primary	Duplicate				
			DATE COLLECTED	09/08/2005	09/08/2005				
ANALYSIS		EPA METHOD	MRL						
Metals	Total Lead	6020	*0 000050*	0 00021 ④	0 000050 ④	***123%***	0 0056	0 015 ①②	mg/L
Hydrocarbons	TPH as Diesel	8015M	*0 052*	0 950 Y	1 100 Y	***15%***	NE	0 100 ①	mg/L
	TPH as Residual Range	8015M	*0 100*	0 540 O	0 720 O	***25%***	NE	0 100 ①	mg/L
	TPH as Gasoline	8015M	*0 05*	<0 050	<0 050	NA	NE	0 100 ①	mg/L
EDB	1,2-Dibromoethane (EDB)	504 1	*0 0000095*	<0 0000096	<0 0000094	NA	NE	0 00012 ②	mg/L
BTEX	Benzene	8260B	*0 00050*	<0 00050	<0 00050	NA	1 70 ③	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	<0 00050	<0 00050	NA	0 02 ③	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	0 00015 J	0 00015 J	***0%***	2 1 ③	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	<0 00050	<0 00050	NA	0 14 ③	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	<0 00050	<0 00050	NA	10 0 ③	0 020 ①	mg/L
	1,2-Dichloroethane (1,2-DCA)	8260B	*0 00050*	<0 00050	<0 00050	NA	0 005 ②	0 00012 ①	mg/L
PAHs	Naphthalene	8270C SIM	*0.000020*	0 00083	0 00078	***6%***	0 24	0 0062 ①	mg/L
	2-Methylnaphthalene	8270C SIM	*0 000020*	0 000038	0 000038	***0%***	NE	0 010 ①	mg/L
	Acenaphthylene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 240 ①	mg/L
	Acenaphthene	8270C SIM	*0 000020*	0 000054	0 000056	***4%***	0 32	0 020 ①	mg/L
	Dibenzofuran	8270C SIM	*0 000020*	0 00013	0 00013	***0%***	NE	NE	mg/L
	Fluorene	8270C SIM	*0 000020*	0 000064	0 000064	***0%***	NE	0 240 ①	mg/L
	Phenanthrene	8270C SIM	*0 000020*	0 00011	0 00012	***9%***	NE	0 0077 ①	mg/L
	Anthracene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	NE	mg/L
	Fluoranthene	8270C SIM	*0 000020*	0 000025	0 000049	***65%***	0 01	0 040 ①	mg/L
	Pyrene	8270C SIM	*0 000020*	0 000030	0 000058	***64%***	NE	0 002 ①	mg/L
	Benz(a)anthracene	8270C SIM	*0 000020*	<0 000020	0 000025	NA	NE	0 000027 ①	mg/L
	Chrysene	8270C SIM	*0 000020*	0 000022	0 000036	***48%***	NE	0 00035 ①	mg/L

TABLE 2
Summary of Groundwater Sample Results
MW-V1D
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

			MW-1VD		Relative Percent Difference (RPD)			
		SAMPLE IDENTIFICATION	RH-W-005	RH-W-006				
		SAMPLE TYPE	Primary	Duplicate				
		DATE COLLECTED	09/08/2005	09/08/2005				
ANALYSIS	EPA METHOD	MRL				HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
Benzo(b)fluoranthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 000092 ①	mg/L
Benzo(k)fluoranthene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 00040 ①	mg/L
Benzo(a)pyrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	0 0002	0 000014 ①	mg/L
Indeno(1,2,3-cd)pyrene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 000092 ①	mg/L
Dibenz(a,h)anthracene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 0000092 ①	mg/L
Benzo(g,h,i)perylene	8270C SIM	*0 000020*	<0 000020	<0 000020	NA	NE	0 0001 ①	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
RH	Red Hill Fuel Station Facility
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	method reporting limit
B	Stilling Basin at PWC Potable Water Facility
<	less than
Z	the chromatographic fingerprint does not resemble a petroleum product
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correc carbon range, but the elution pattern does not match the calibration standard
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard
RPD	relative percent difference between primary and duplicate sample results RPD = Absolute value (primary - duplicate) / average (primary duplicate

Notes

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② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards
③ State of Hawaii Department of Health, 2000 Hawaii Underground Storage Tank (UST) Technical Guidance Manual March 2000
④ Lead samples were filtered in the field

TABLE 3
Summary of Trip Blank Results
Stilling Basin
Red Hill Fuel Storage Facility
Red Hill, Oahu, Hawaii

			SAMPLE IDENTIFICATION	Trip Blank *	Trip Blank *	Trip Blank			
			SAMPLE TYPE	Trip Blank	Trip Blank	Trip Blank			
			DATE COLLECTED	02/17/2005	06/28/2005	09/08/2005			
	ANALYSIS	EPA METHOD	MRL				HDOH Tier 1 Groundwater Action Levels	Environmental Action Levels	UNITS
Hydrocarbons	TPH as Gasoline	8015M	*0 05*	NA	<0 050	NA	NE	0 100 ①	mg/L
BTEX	Benzene	8260B	*0 00050*	ND	<0 00050	<0 00050	1 70 ①	0 0050 ①	mg/L
	Methyl tert-Butyl Ether	8260B	*0 00050*	ND	<0 00050	<0 00050	0 02 ①	0 0050 ①	mg/L
	Toluene	8260B	*0 00050*	0 0014	0 00054	<0 00050	2 1 ①	0 040 ①	mg/L
	Ethylbenzene	8260B	*0 00050*	ND	<0 00050	<0 00050	0 14 ①	0 030 ①	mg/L
	m,p-Xylenes	8260B	*0 00050*	ND	<0 00050	<0 00050	10 0 ①	0 020 ①	mg/L
	o-Xylene	8260B	*0 00050*	ND	<0 00050	<0 00050	10 0 ①	0 020 ①	mg/L
	1,2-Dichloroethane (DCA)	8260B	*0 00050*	ND	<0 00050	<0 00050	0 005 ②	0 005 ②	mg/L

Acronyms and Abbreviations

EPA	United States Environmental Protection Agency
PAHs	polynuclear aromatic hydrocarbons
mg/L	milligrams per liter
MRL	method reporting limit
<	less than
Bold	value is greater than regulatory action level
NE	none established
VOCs	volatile organic compounds
ND	not detected at or above the laboratory MRL

Notes

① State of Hawaii Department of Health, 2005 Screening for Environmental Concerns At Sites with Contaminated Soil and Groundwater Volume 1, May 2005

② State of Hawaii, Department of Health, 2002 Hawaii Administrative Rules Chapter 11, Title 20 Potable Water Drinking Water Standards

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Appendix B
Pump Manuals

Geotech Environmental Equipment, Inc
8035 East 40th Avenue Denver, Colorado 80207
(303) 320-4764 • **(800) 833-7958** • FAX (303) 322-7242
email: sales@geotechenv.com website: www.geotechenv.com

geotech

Geotech Bladder Pumps

Installation and Operation Manual

Rev. 3 2/24/04 Part # 21150035

geotech

Geotech Bladder Pumps

Installation and Operation Manual

Rev 3 2/24/04 Part # 21150035

TABLE OF CONTENTS

DOCUMENTATION CONVENTIONS

This manual uses the following conventions to present information:

WARNING

An exclamation point icon indicates a **WARNING** of a situation or condition that could lead to personal injury or death. You should not proceed until you read and thoroughly understand the **WARNING** message.

CAUTION

A raised hand icon indicates **CAUTION** information that relates to a situation or condition that could lead to equipment malfunction or damage. You should not proceed until you read and thoroughly understand the **CAUTION** message.

NOTE

A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

Chapter 1: System Description

Function and Theory

Geotech's pneumatic Bladder Pumps operate with a unique action, ideal for both, gentle low-flow sampling and high flow rate purging. Timed on/off cycles of compressed air alternately squeeze the flexible bladder to displace water out of the pump to the surface and exhaust allowing the pump to refill. Fluid enters the pump through the fluid inlet check valve at the bottom of the pump body, via hydrostatic pressure (automatically by submergence). The bladder then fills with fluid. Compressed air enters the space between the bladder and the interior of the pump wall housing. The intake check valve closes and the discharge check valve opens. The compressed air squeezes the bladder, pushing the fluid to the surface. The discharge check valve prevents back flow from the discharge tubing. Driven by the GEOCONTROLLER 2, this cycle automatically repeats.

Compressed air does not contact the sample! The bladder prevents contact between the pump drive air and the sample.

System Components

The GEOTECH Bladder Pump consists of three parts. The Bladder Cartridge Assembly, the Pump Housing, and the Intake Screen.

Bladder Cartridge Assembly

Geotech's bladder cartridge assembly is factory assembled and tested, and is designed to be field replaceable (see figure 1).

The cartridge assembly components consist of an upper and lower head constructed of virgin grade PTFE, (for bladder pump models GEO1.66PVC36 and GEO1.66PVC18 the upper and lower heads are constructed of NSF-grade PVC, extruded with no markings or lubricants). The internal flow tubes are constructed of electro polished 316 stainless steel, or NSF-grade PVC. The bladder material is constructed of inert virgin grade polymer resins, (proprietary resin grade PTFE – G303).

The bladder tube is assembled using a 316 stainless steel clamp, providing a true zero leak seal.

Housing

The bladder pump housing is constructed of electro polished 316 Stainless Steel. The housing components consist of threaded top and bottom caps, and the housing tube. For bladder pump models GEO1.66PVC36 and GEO1.66PVC18 the housing is constructed of NSF-grade PVC. Viton O-rings provide the high pressure seals between the end caps and the housing tube.

Intake screen

The intake filter screen is constructed of 316 Stainless Steel and is easily removable for field maintenance. For models Geo 1.66 PVC36 and Geo 1.66 PVC18, the intake screen is constructed of NSF-Grade PVC. The intake filter screen is intended to protect and extend the life of the bladder material (see warranty).

Figure 1 – SS Bladder Pump Assembly

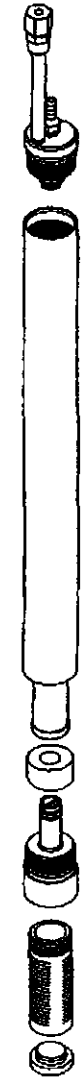


Figure 2 – PVC Bladder Pump Assembly

Chapter 2: System Installation

Bladder Pump

Geotech's Bladder Pumps are engineered for easy installation and use. Dedicated Bladder Pumps are shipped from GEOTECH with the tubing attached. Well identifications (supplied by customer) are located on tags connected to the tubing, and on the tubing bags.

Upon reaching the well head, connect the air line tubing to air line connection at the top of the Bladder Pump (see figure 3). The air line is smaller than the sample line. Next attach the sample line to the sample line connection at the top of pump (see figure 3).

The optional Bladder Pump Hanger is attached to the Quick Link on the safety cable and to the Pump Hanger. Carefully lower the Bladder Pump into the well using the reverse coil method to avoid kinking, until the well cap seats.

Reverse Coil Method (see figure 4)

When lowering the pump into the well it is important to reverse the natural bend of the coiled tubing so that the tubing will straighten out as it is lowered. As the pump and tubing are lowered down into the well, the direction of the bend should be reversed from the direction in which it is coiled up. If the tubing is allowed to uncoil naturally and the natural bend not interrupted, the tubing will continue its coil into the well. Using the reverse coil method will avoid hang-ups or difficulty in lowering the pump into the well, especially when the well is not completely vertical, or has come out of alignment for any reason.

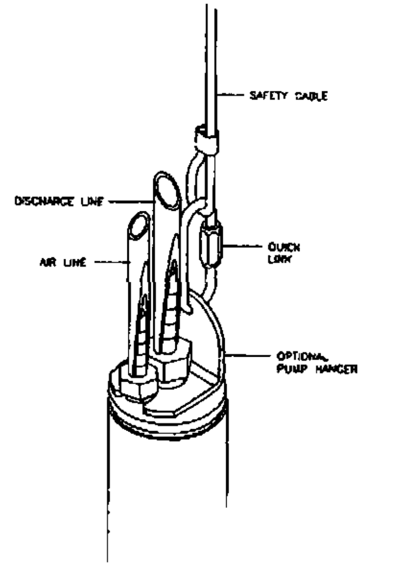


Figure 3

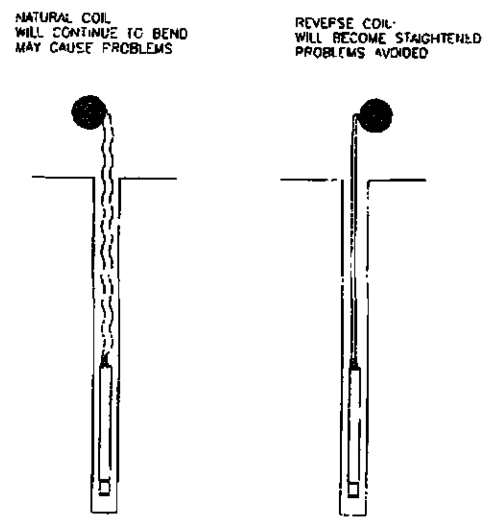


Figure 4 – Reverse Coil Method

Chapter 3: System Operation

Bladder Pump Operation

Fluid enters the pump through the fluid inlet check valve at the bottom of the pump body, and the bladder fills with fluid. Compressed air enters the space between the bladder and the interior of the pump wall housing, the inlet check valve closes and the discharge check valve opens. The compressed air squeezes the bladder pushing the fluid to the surface. The discharge check valve prevents backflow from the discharge tubing.

Selecting an Air Source

The following explanation is based on the Model GEO1.66SS36 with a .170 ID air supply tubing. To determine the required capacity of the air source used, calculate the air consumption as follows. With 100 ft. of air line tubing in or out of the well, the air consumption is 125 cubic inches per cycle, with 6 cycles per minute (average).

Example: For 100 ft. of tubing you will need 125 cu. in. x 6 per min. which equals 750 cu. in. / min. or 45,000 cu. in. / hr. For each additional 100 ft. add 59 cu. in. If you plan to use an air compressor we advise that you use one with a reserve tank to insure proper air supply to the pump. If you plan to use a Nitrogen Tank, see figure 9 for Nitrogen Tank Volume vs. Bladder Pump consumption.

Determining PSI

Determine the air pressure needed to operate the Bladder Pump based on the length of the air supply line to the pump (well depth). Use the simplified formula of (1/2 PSI per foot) + 10 PSI for friction.

Example: For a pump 100 ft. away from the air source, uses 100 ft. divided by 2 then add 10. This equals 60 PSI (100' / 2 + 10 = 60 PSI).

The additional 10 PSI is to account for the pump itself and friction loss along the air line tubing. When the length of the air line to the Bladder Pump is 50 ft. or less, the additional 10 PSI need not be added.
To determine minimum operating pressures for the specific Bladder Pump model you are using, consult pumps specifications. Typically the minimum operating pressure will be 5 PSI above static head.

Example: Bladder Pump depth is 50 ft 50 / 2 = 25 + 5 = 30 PSI.

The formulas stated above are not absolute, and are meant to provide baseline information.

Flowrates

Flow rates are based on Geotech's models GEO1.66ss36 Stainless Steel Bladder Pump, and GEO1.66PVC36 PVC Bladder Pumps PERFORMANCE CURVE (see figures 5, 6, 7, & 8).

For determining the number of cycles it will take to receive sample fluid at the well head, see figure 9 CYCLES vs. DEPTH.

If using a nitrogen tank as an air source, see figure 10 NITROGEN TANK VOLUME vs BLADDER PUMP CONSUMPTION.

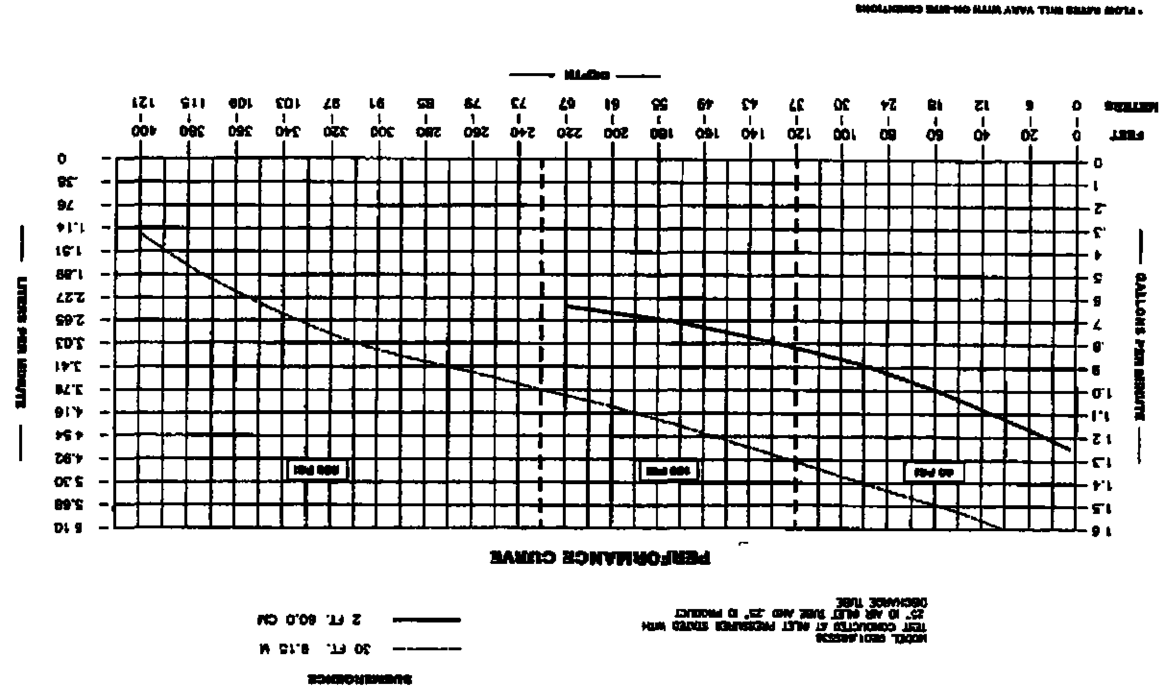


Figure 6 – Performance Curve

11

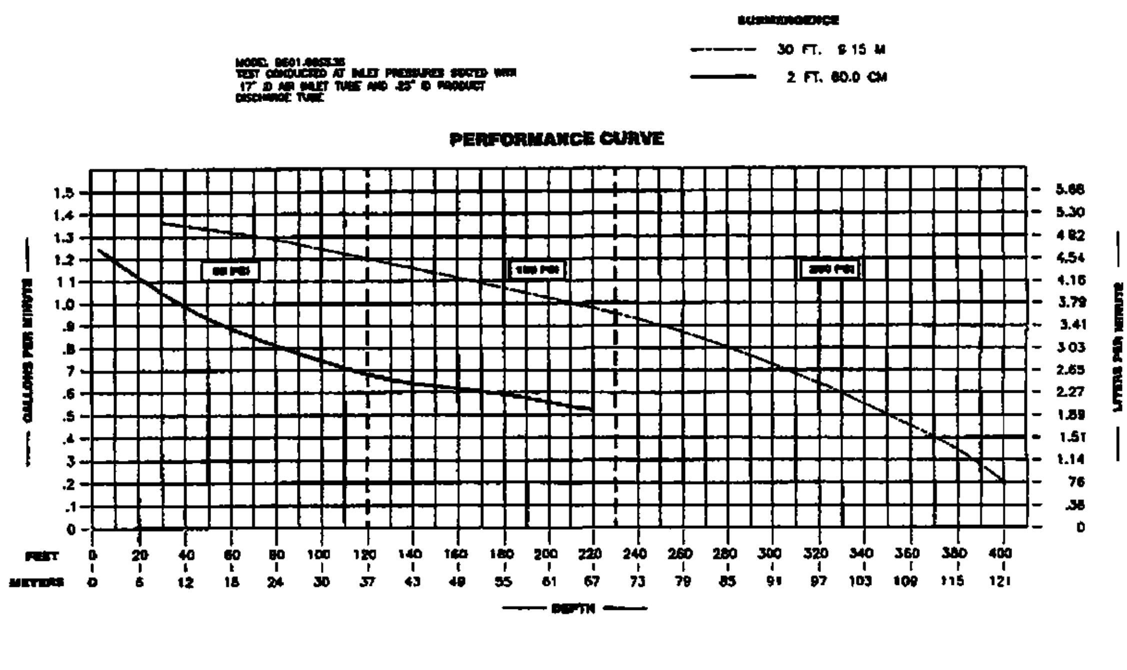


Figure 5 – Performance Curve

10

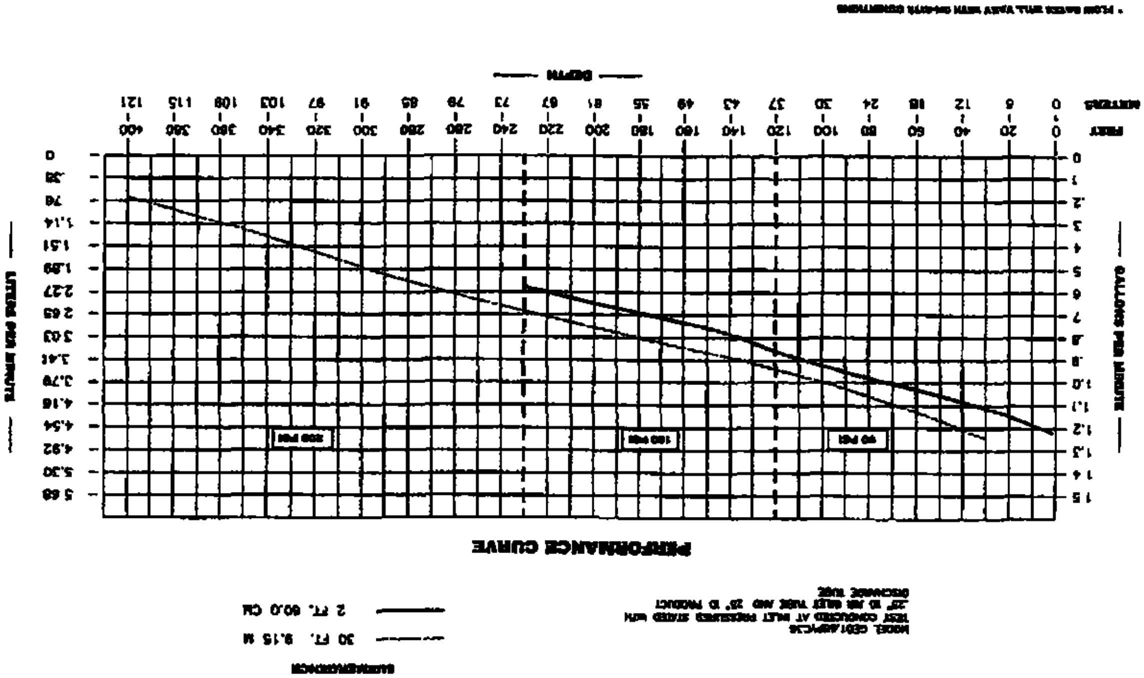
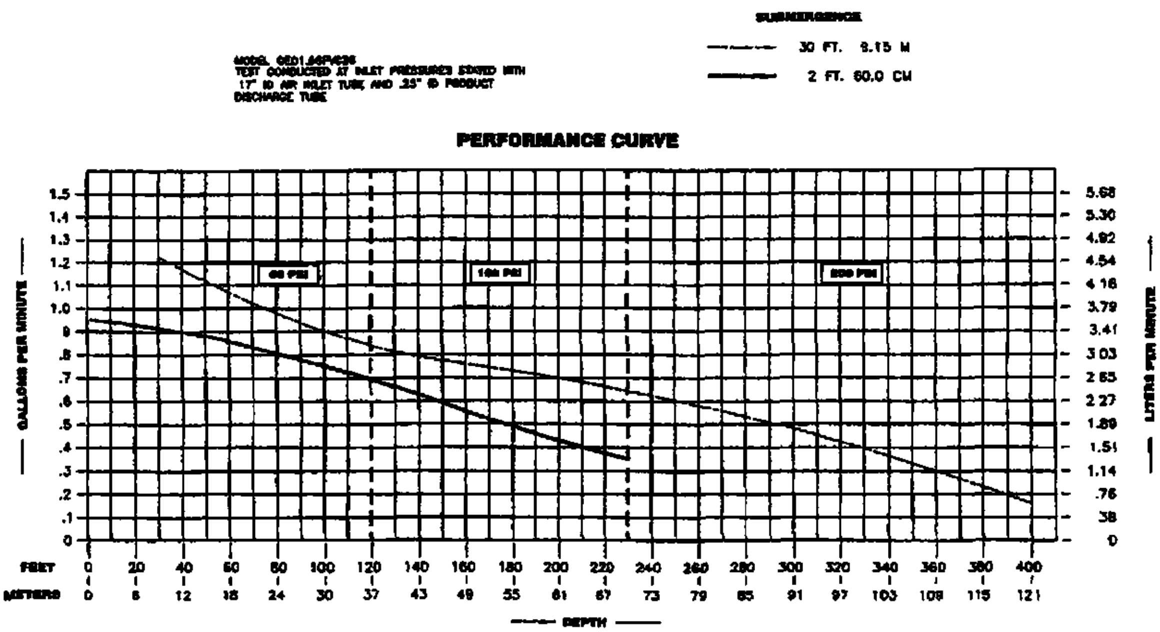


Figure 8 – Performance Curve

13



* FLOW RATES WILL VARY WITH ON-SITE CONDITIONS

Figure 7 – Performance Curve

12

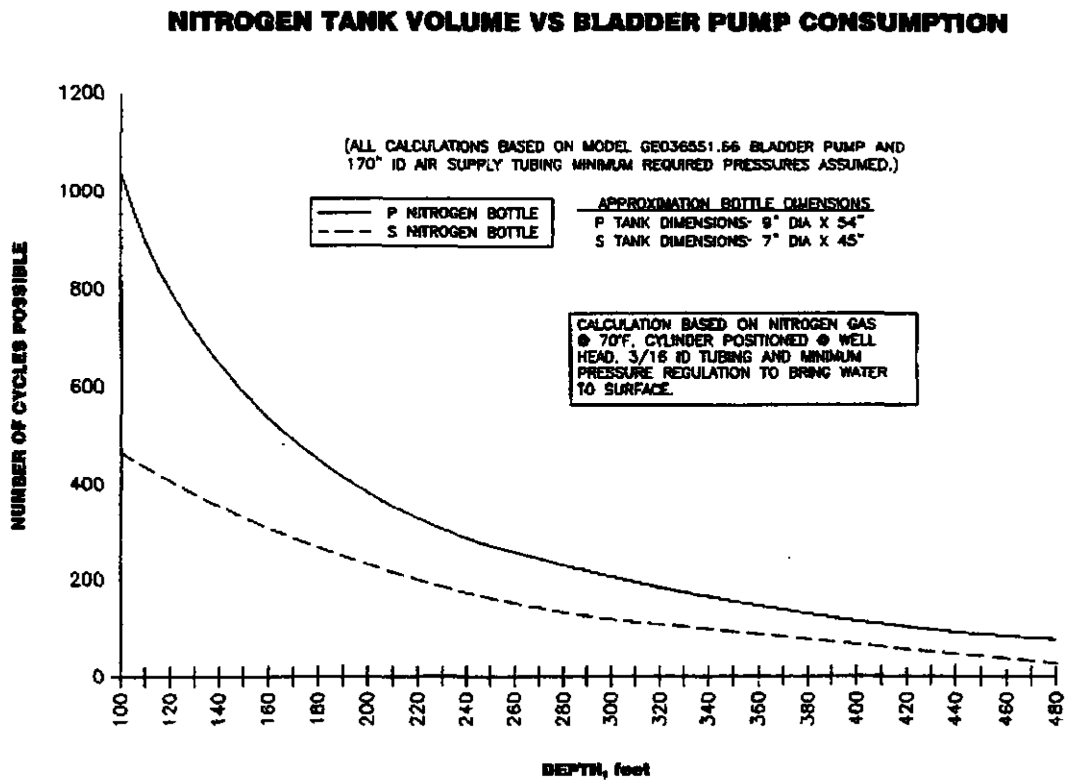


Figure 10 -- Nitrogen Tank vs. Bladder Pump Consumption

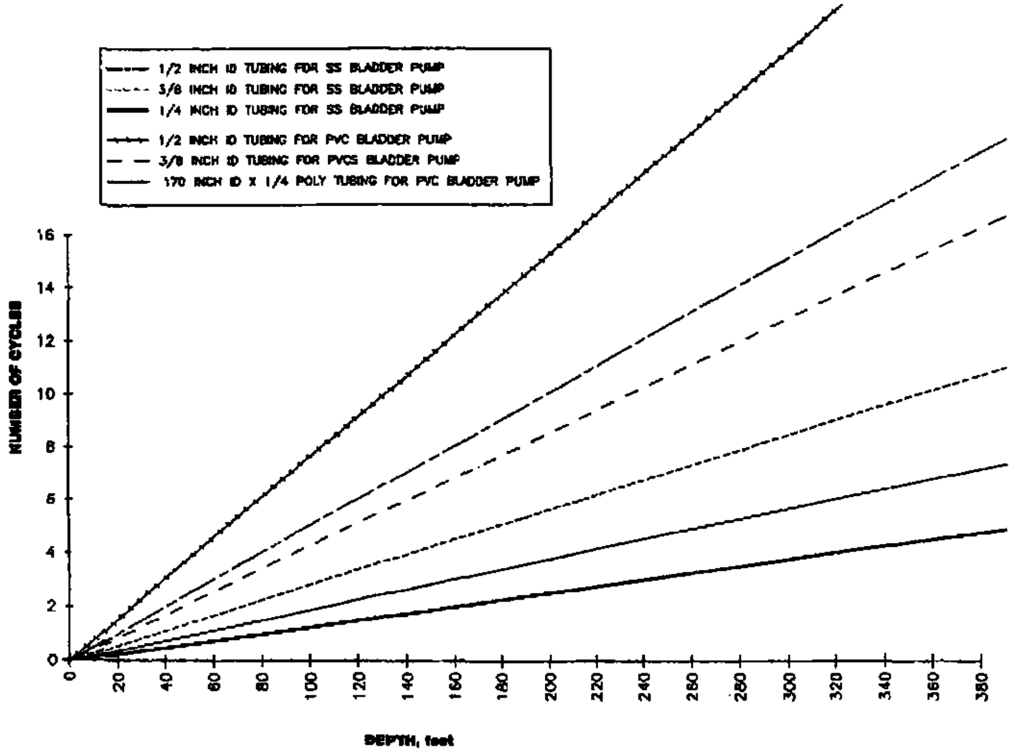


Figure 9 -- Cycles vs. Depth

Bladder Pump

As with any pump, scheduled or periodic maintenance should be performed, according to your sampling program and specific site conditions. Generally, the more turbid or sandy your water, the more often you should maintain and clean your pumps. (See System components, Bladder Cartridge Assembly). Disassemble Bladder Pump per instructions, decontaminate or replace as needed, then reassemble. Inspect all check balls for wear and replace as necessary. Inspect all O-rings for splits or cracks and replace as necessary.

Bladder Cartridge

When installing a new bladder cartridge, or performing maintenance on an existing cartridge use the following instructions:

- Pull pump from the well, it is not necessary to remove the air and sample lines from the pump.
- (Models w/screens) Using an Allen head tool, remove the shoulder bolts from the Intake screen cap (see figure 1).
- Using the Spanner tool, while holding pump body, with your hand or with a strap wrench, use a spanner tool to turn lower head in a counter clockwise direction and remove. Pump head will be very snug due to the high pressure O-ring seal. Once the seal is broken, the lower head will turn very easily (see figure 12).
- The internal bladder cartridge can now be removed for maintenance or replacement. Gently tap the tube housing on a firm wood like surface until the cartridge drops from the upper head seal. Reach into the tube with one or two fingers and pull the cartridge free.
- Before replacing lower pump head, always check o-rings for rips or cracks and replace as necessary.
- For models without Intake screens, use the Spanner tool provided for lower head removal (see figure 12).

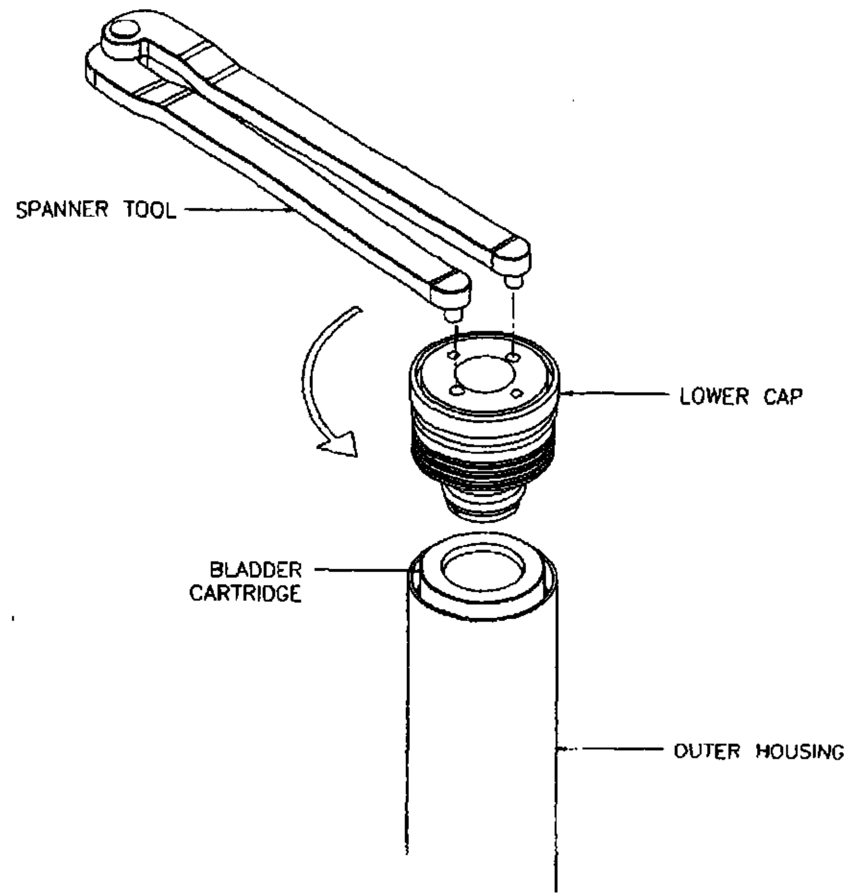


Figure 11

Chapter 5: System Troubleshooting

Bladder Pump; *Troubleshooting*

Problem:	Solutions:
Air is cycling thru controller, but will not pump…	1) Charge and exhaust times are not set correctly. Check and adjust charge and exhaust cycle times (i.e. if charge time is too long or if exhaust and charge time is too short). 2) Possible compromise in air line tubing. Check air line pump for leaks. If needed, repair using compression union or replace tubing. 3) Check pump intake screen for blockage and clean as needed.
Controller is cycling but the pump stops producing water ..	1) Check drawdown level of water in the well. Ensure the pump is fully submerged and off of the bottom of the well. 2) Check psi at the regulator and adjust as necessary (see page 8). 3) Check for kinks in the discharge line. 4) Check pump intake screen for obstructions. 5) Charge time is too long or exhaust time is too short; causes pressure build up in pump, causing the pump not to fill. 6) Check power source, assure a strong reliable power supply. If using and old or weak battery, the control valves may not operate properly.

Getting air bubbles in sample line…	1) Over charging pump. Reduce charge cycle time so that charge cycle ends as fluid discharge trails off. Inspect pump for compromised bladder or o-rings. 2) Pump is being over pressurized (PVC pump). Reduce psi to what is necessary to overcome pumping head (see page 8 for determining psi). 3) Check discharge line for holes or kinks. Repair using compression union or replace tubing.
Discharge line drains back into pump…	1) Remove Hosebarb on pump discharge outlet. Check the check ball seat for debris. Clean and re-install.

(pter 6: System Specifications

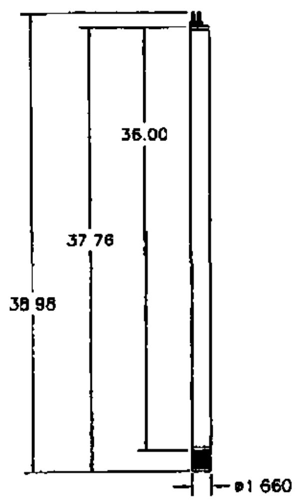
	GEO1.66SS36	GEO1.66SS18	GEO1.66PVC36
Pump Housing	SS, 316	SS, 316	PVC
Pump Ends	Virgin PTFE	Virgin PTFE	PVC
Bladder Matl.	Virgin PTFE Proprietary resin Grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE (Proprietary resin grade G303)
O.D.:	1.66"/4.2cm	1.66"/4.2cm	1.66"/4.2cm
Length: w/o screen	36"/91.4cm	18"/45.7cm	36"/91.4cm
Length: w/screen	38"/96.5cm	20"/51cm	—
Weight	6lb/1.8Kg.	2.6lb/0.93Kg	3.6lb/1.3Kg
Volume/Cycle	21.1oz./625ml	10.6oz./313ml	13.8oz.408ml
Max. Flowrate*	1.25gpm/4.7lpm	.65gpm/2.4lpm	.97gpm/3.7lpm
Min. Well I.D.	2"/50mm	2"/50mm	2"/50mm
Operating Press.	10-450psi/.7-31 bar	10-450psi/.7-31bar	10-110psi/.7-7.5 bar
Min. Operating Range	5psi/.34bar above static head	5psi/.34bar above static head	5psi/.34bar above static head
Maximum Depth **	1000'/305m	1000'/305m	250'/76.2M

* Flow rate determined @ 2ft/60cm submergence

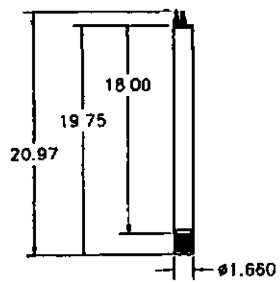
** With the use of a drop tube, maximum depth is increased

System Specifications

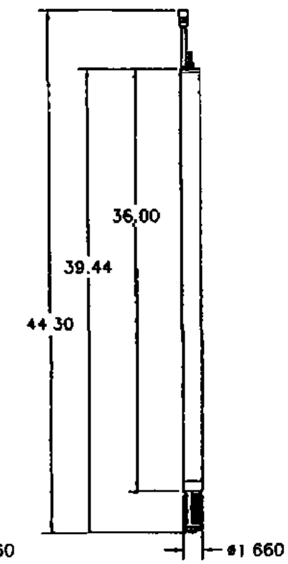
	GEO1.66PVC18	GEO850.SS24	GEO675.SS18
Pump Housing	PVC	SS, 316	SS, 316
Pump Ends	PVC	Virgin PTFE	Electropolished SS 316
Bladder Matl.	Virgin PTFE (Proprietary resin grade G303)	Virgin PTFE (Proprietary resin grade G303)	Virgin PTFE (Proprietary resin grade G303)
O.D.:	1.66"/4.2cm	.850"/2.2cm	.675"/1.7cm
Length: w/o screen	18"/45.7cm	24"/61cm	N/A
Length: w/screen	22"/55.9cm	25"/63.5cm	18"
Weight	1.8lb/.67Kg	1 6/.60Kg	.83lb/.38Kg
Volume/Cycle	6.9oz./204ml	2.1oz./59.6ml	1.35oz./38.4ml
Max. Flowrate*	.53gpm/2.0lpm	.10gpm/.36lpm	.05gpm/.19lpm
Min. Well I.D.	2"/25mm	1.00"/25mm	.75"/19mm
Operating Press.	10-110psi/.7-7.5bar	10-110psi/.7-7.5bar	10-110psi/.7-7.5bar
Min. Operating Range	5psi/.34bar above static head	5psi/.34bar above static head	5psi/.34bar above static head
Maximum Depth **	250'/76.2m	250'/76.2m	250'/76.2m



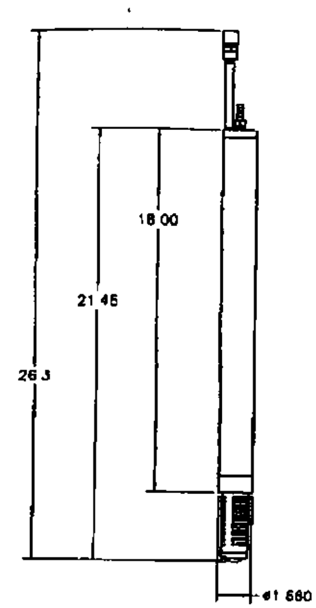
GEO1.66SS36



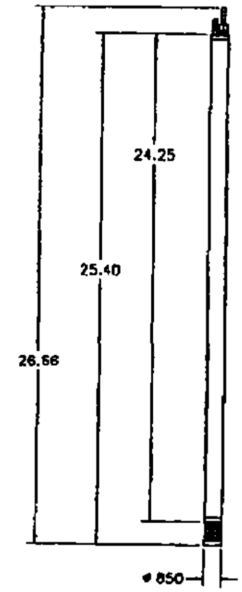
GEO1.66SS18



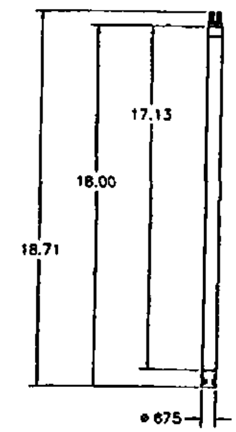
GEO1.66PVC36



GEO1.66PVC18



GEO850.SS24



GEO675.SS18

Chapter 8: Replacement Parts List

Model GEO1.66SS36

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150100
1	Cap, Upper	11150104
1	Cap, Lower	11150107
1	Screen, Intake	11150109
2	Bolts, Shoulder	17200241
1	Hose barb, Sample out	11150106
1	Hose barb, Air in	17200241
1	Check ball, Upper	17500081
1	Check ball, Lower	17500082
1	O-Ring Viton cap/upper lower	17500104
2	O-Ring Viton cap/upper head interface	17500103
2	O-Ring Viton cap/lower head interface	17500106

MODEL GEO1.66SS18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150106
1	Cap, Upper	11150104
1	Cap, Lower	11150107
1	Screen, Intake	11150109
2	Bolts, Shoulder	17200241
1	Hose barb, Sample out	11150106
1	Hose barb, Air in	21150019
1	Check ball Upper	17500081
1	Check ball Lower	17500082
1	O-Ring Viton cap/upper lower	17500104
2	O-Ring Viton cap/upper head interface	17500103
2	O-Ring Viton cap/lower head interface	17500106

Model GEO1.66PVC36

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150107
1	Cap, Upper	11150128
1	Cap, Lower	11150129
1	Screen, Intake	11150109
2	Cap Screen Intake	11150131
1	Hose barb, Sample out	11150134
1	Hose barb, Air in	17200248
1	Check ball, PVC Upper/lower	17500115
1	O-Ring, Viton cap/upper/lower	17500120
1	O-Ring Viton cap/head Interface	17500119

MODEL GEO1.66PVC18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150108
1	Cap, Upper	11150128
1	Cap, Lower	11150129
1	Screen, Intake	11150130
2	Cap, screen intake	11150131
1	Hose barb, Sample out	11150134
1	Hose barb, Air in	17200248
1	Check, PVC Upper/lower	17500115
1	O-Ring Viton cap/upper lower	17500120
2	O-Ring Viton cap/head interface	17500119

Model GEO850.SS24

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150103
1	Cap, Upper	11150111
1	Cap, Lower	11150112
1	Screen, Intake	11150119
2	Screw 4-40 x 1	17200246
1	Hose barb, Sample out	11150118
1	Hose barb, Air in	17200245
1	Check ball	17500079
1	O-Ring, Viton cap/upper/lower	17500112
2	O-Ring Viton cap/upper head interface	17500119
2	O-Ring Viton cap/lower head interface	17500111

MODEL GEO.675SS18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150116
1	Cap, Upper	21150030
1	Cap, Lower	21150031
2	Hose barb, air sample	17200245
1	Check ball, upper	ppm130001
1	Check ball, lower	17500079
1	Disc Teflon	21150033
1	Snapring	11150182
1	O-Ring, Bladder Cap, Upper	11150183
1	O-Ring, Bladder Cap, Lower	17500183
2	O-Ring, cap housing	11150184

Notes

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abuse, misuse, or inability to use this product. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR SERVICE DEPARTMENT AT 1-800-833-7958 OR 1-800-275-5325.

Model Number: ________________

Serial Number: ________________

Date: ________________

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used.

Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate equipment for a fee, which will be applied to the repair order invoice.

Appendix C
Table of EALs

TABLE C-1a. GROUNDWATER ACTION LEVELS FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS (volatile chemicals only)

			Residential Land Use		Commercial/Industrial Land Use	
			Vadose-Zone Soil Type		Vadose-Zone Soil Type	
CONTAMINANT	Physical State		[2]High Permeability (ug/L)	[3]Low/Moderate Permeability (ug/L)	[2]High Permeability (ug/L)	[3]Low/Moderate Permeability (ug/L)
#ACENAPHTHENE	V	S	4.2E+03	4.2E+03	4.2E+03	4.2E+03
ACENAPHTHYLENE	V	S	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
#ACETONE	V	L	2.1E+08	2.8E+08	7.5E+08	1.0E+09
ALDRIN	NV	S				
#ANTHRACENE	V	S	4.3E+01	4.3E+01	4.3E+01	4.3E+01
ANTIMONY	NV	S				
ARSENIC	NV	S				
BARIUM	NV	S				
#BENZENE***	V	L	1.6E+03	5.7E+03	6.7E+03	2.4E+04
BENZO(a)ANTHRACENE	NV	S				
BENZO(a)PYRENE	NV	S				
BENZO(b)FLUORANTHENE	NV	S				
BENZO(g,h,i)PERYLENE	NV	S				
BENZO(k)FLUORANTHENE	NV	S				
BERYLLIUM	NV	S				
BIPHENYL, 1,1-	V	S	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
BIS(2-CHLOROETHYL)ETHER	V	L	1.0E+02	1.4E+02	4.4E+02	5.8E+02
BIS(2-CHLOROISOPROPYL)ETHER	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
BIS(2-ETHYLHEXYL)PHTHALATE	NV	S				
BORON	NV	S				
BROMODICHLOROMETHANE	V	L	2.7E+02	5.1E+02	1.1E+03	2.2E+03
BROMOFORM	NV	S				
BROMOMETHANE	V	G	2.3E+03	8.0E+03	8.2E+03	2.8E+04
CADMIUM	NV	S				
CARBON TETRACHLORIDE	V	L	2.1E+01	8.9E+01	8.8E+01	3.8E+02
CHLORDANE	NV	S				
CHLOROANILINE, p-	NV	S				
CHLOROBENZENE	V	L	5.3E+04	1.7E+05	1.9E+05	4.7E+05
CHLOROETHANE	V	G	6.5E+02	2.6E+03	2.8E+03	1.1E+04
CHLOROFORM	V	L	6.2E+01	2.1E+02	2.6E+02	9.0E+02
CHLOROMETHANE	V	G	9.5E+03	4.2E+04	3.4E+04	1.5E+05
CHLOROPHENOL, 2-	V	L	2.1E+04	6.3E+04	7.5E+04	2.2E+05
CHROMIUM (Total)	NV	S				
CHROMIUM III	NV	S				
CHROMIUM VI	NV	S				
CHRYSENE	NV	S	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
COBALT	NV	S				
COPPER	NV	S				
CYANIDE (Free)	NV	S	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
DIBENZO(a,h)ANTHTRACENE	NV	S				
DIBROMO-3-CHLOROPROPANE, 1,2-	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
DIBROMOCHLOROMETHANE	V	S	1.6E+02	3.7E+02	1.2E+03	2.7E+03
DIBROMOETHANE, 1,2-	V	S	1.6E+01	2.5E+01	6.9E+01	1.1E+02
DICHLOROBENZENE, 1,2-	V	L	1.6E+05	1.6E+05	1.6E+05	1.6E+05
DICHLOROBENZENE, 1,3-	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
DICHLOROBENZENE, 1,4-	V	S	4.9E+02	1.4E+03	2.1E+03	5.9E+03
DICHLOROBENZIDINE, 3,3-	NV	S				
DICHLORODIPHENYLDICHLOROETHANE (DDD)	NV	S				
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	NV	S				
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	NV	S				
DICHLOROETHANE, 1,1-	V	L	2.8E+05	9.5E+05	9.8E+05	3.4E+06
DICHLOROETHANE, 1,2-	V	L	1.3E+02	3.2E+02	5.5E+02	1.4E+03
DICHLOROETHYLENE, 1,1-	V	L	2.5E+04	1.1E+05	8.8E+04	3.7E+05
DICHLOROETHYLENE, Cis 1,2-	V	L	2.4E+04	7.7E+04	8.6E+04	2.7E+05
DICHLOROETHYLENE, Trans 1,2-	V	L	2.7E+04	9.7E+04	9.4E+04	3.4E+05
DICHLOROPHENOL, 2,4-	NV	S				

TABLE C-1a. GROUNDWATER ACTION LEVELS FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS (volatile chemicals only)

CONTAMINANT	Physical State		[1,4]Residential Land Use — Vadose-Zone Soil Type: [2]High Permeability (ug/L)	[1,4]Residential Land Use — Vadose-Zone Soil Type: [3]Low/Moderate Permeability (ug/L)	Commercial/Industrial Land Use — Vadose-Zone Soil Type: [2]High Permeability (ug/L)	Commercial/Industrial Land Use — Vadose-Zone Soil Type: [3]Low/Moderate Permeability (ug/L)
DICHLOROPROPANE, 1,2-	V	L	1.2E+02	3.6E+02	5.0E+02	1.5E+03
DICHLOROPROPENE, 1,3-	V	L	1.6E+02	6.2E+02	6.6E+02	2.6E+03
DIELDRIN	NV	S				
DIETHYLPHTHALATE	NV	S				
#DIMETHYLPHENOL, 2,4-	V	S				
DIMETHYLPHTHALATE	NV	S				
DINITROPHENOL, 2,4-	NV	S				
DINITROTOLUENE, 2,4-	NV	S				
DIOXANE, 1,4-	NV	L				
DIOXIN (2,3,7,8-TCDD)	NV	S				
ENDOSULFAN	NV	S				
ENDRIN	NV	S				
#ETHYLBENZENE* **	V	L	1.7E+05	**1.7E+05**	1.7E+05	1.7E+05
FLUORANTHENE	NV	S				
#FLUORENE	V	S	1.9E+03	1.9E+03	1.9E+03	1.9E+03
HEPTACHLOR	NV	S				
HEPTACHLOR EPOXIDE	NV	S				
HEXACHLOROBENZENE	NV	S				
HEXACHLOROBUTADIENE	NV	S				
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	NV	S				
HEXACHLOROETHANE	NV	S				
INDENO(1,2,3-cd)PYRENE	NV	S				
LEAD* **	NV	S				
MERCURY	NV	S				
METHOXYCHLOR	NV	S				
#METHYL ETHYL KETONE	V	L	2.7E+08	2.7E+08	2.7E+08	2.7E+08
#METHYL ISOBUTYL KETONE	V	L	1.9E+07	1.9E+07	1.9E+07	1.9E+07
METHYL MERCURY	NV	S				
METHYL TERT BUTYL ETHER* **	V	L	1.9E+04	**3.8E+04**	8.0E+04	1.6E+05
METHYLENE CHLORIDE	V	L	4.2E+03	1.2E+04	1.8E+04	5.3E+04
#METHYLNAPHTHALENE (total 1- & 2-)	V	S	2.6E+04	2.6E+04	2.6E+04	2.6E+04
MOLYBDENUM	NV	S				
#NAPHTHALENE* **	V	S	3.1E+04	**3.1E+04**	3.1E+04	3.1E+04
NICKEL	NV	S				
PENTACHLOROPHENOL	NV	S				
PERCHLORATE	NV	S				
PHENANTHRENE	V	S	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
PHENOL	NV	S				
POLYCHLORINATED BIPHENYLS (PCBs)	NV	S				
#PYRENE	V	S	1.4E+02	1.4E+02	1.4E+02	1.4E+02
SELENIUM	NV	S				
SILVER	NV	S				
#STYRENE	V	L	3.1E+05	3.1E+05	3.1E+05	3.1E+05
tert-BUTYL ALCOHOL			(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
TETRACHLOROETHANE, 1,1,1,2-	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
TETRACHLOROETHANE, 1,1,2,2-	V	L	1.5E+02	2.5E+02	6.4E+02	1.0E+03
TETRACHLOROETHYLENE	V	L	9.9E+01	4.0E+02	4.2E+02	1.7E+03
THALLIUM	NV	S				
#TOLUENE* **	V	L	5.3E+05	**5.3E+05**	5.3E+05	5.3E+05
TOXAPHENE	NV	S				
TPH (gasolines)* **	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
TPH (middle distillates)* **	V	L	(Use soil gas)	(Use soil gas)	(Use soil gas)	(Use soil gas)
TPH (residual fuels)* **	NV	L/S				
TRICHLOROBENZENE, 1,2,4-	V	L	1.0E+04	1.8E+04	3.6E+04	6.4E+04
TRICHLOROETHANE, 1,1,1-	V	L	5.0E+05	1.3E+06	1.3E+06	1.3E+06
TRICHLOROETHANE, 1,1,2-	V	L	2.8E+02	6.3E+02	1.2E+03	2.7E+03

TABLE C-1a. GROUNDWATER ACTION LEVELS
FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS
(volatile chemicals only)

CONTAMINANT	Physical State		[1]Residential Land Use Vadose-Zone Soil Type [2]High Permeability (ug/L)	[1]Residential Land Use Vadose-Zone Soil Type [3]Low/Moderate Permeability (ug/L)	Commercial/Industrial Land Use Vadose-Zone Soil Type [2]High Permeability (ug/L)	Commercial/Industrial Land Use Vadose-Zone Soil Type [3]Low/Moderate Permeability (ug/L)
TRICHLOROETHYLENE	V	L	7.4E+01	2.9E+02	3.1E+02	1 2E+03
TRICHLOROPHENOL, 2,4,5-	V	S	1 2E+06	1.2E+06	1.2E+06	1 2E+06
TRICHLOROPHENOL, 2,4,6-	NV	S				
VANADIUM	NV	S				
VINYL CHLORIDE	V	G	2.2E+01	9.9E+01	2 2E+02	9 8E+02
#XYLENES***	V	L	1.6E+05	1.6E+05	1.6E+05	1 6E+05
ZINC	NV	S				

Notes:

1 "Residential" action levels generally considered adequate for other sensitive uses (e.g , day-care centers, hospitals, etc).
2. High permeability soil model: One meter dry sandy soil (92% sand, 5% silt, 3% clay) over one meter moist clayey loam (33% sand, 34% silt, 33% clay).
3 Low/Moderate permeability soil model: One meter dry loamy sand (83% sand, 11% silt, 6% clay) over one meter moist silt (7% sand, 87% silt, 6% clay).
4 For inclusion in Tier 1 action levels, all groundwater assumed to potentially migrate under a residential area. Action levels for protection of indoor air under a residential exposure scenario carried forward for use at both residential and commercial/industrial sites (see Table D series).

Action level for high-permeability vadose zone soils and residential land use used as default for screening purposes (refer to Table D-1a and D-1b).
Action levels calculated using spreadhseet provided with *User's Guide for the Johnson and Ettinger Indoor Air model (1991) for Subsurface Vapor* Intrusion Into Buildings (USEPA 2001). Assumed vadose-zone thickness/depth to groundwater three meters. See Appendix 1 text for model details.
Physical state of chemical at ambient conditions (V - volatile, NV - nonvolatile, S -solid, L - liquid, G - gas)
Chemical considered to be "volatile" if Henry's number (atm m3/mole) >0.00001 and molecular weight <200.
Dibromochloromethane, dibromochloropropane and pyrene considered volatile for purposes of modeling (USEPA 2002)
Target cancer risk = 1E-06 unless otherwise noted, Target Hazard Quotient = 1 0; TCE target cancer risk = 1E-05.
"#"- Nonchlorinated VOCs (except MTBE) adjusted upwards by factor of ten to account for assumed biodegradation in vadose-zone prior to emission at surface.
(Use Soil Gas): Chemical constants not available for modeling Use soil gas data to evaluate potential indoor-air impact concerns

Notes for Red Hill Site
*** Indicates petroleum-related or potentially petroleum-related EAL
Numbers in shaded column to be used for screening

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TABLE C-1b. SOIL ACTION LEVELS
FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS
(volatile chemicals only)
(Use with Soil Gas Screening Levels for sites with significant VOC releases)

CONTAMINANT	Physical State		[1]Residential Exposure (mg/kg)	Commercial/Industrial Exposure (mg/kg)
#ACENAPHTHENE	V	S	1.3E+02	1.3E+02
ACENAPHTHYLENE	V	S	(Use soil gas)	(Use soil gas)
#ACETONE	V	L	5 6E+03	1.6E+04
ALDRIN	NV	S		
#ANTHRACENE	V	S	6.1E+00	6.1E+00
ANTIMONY	NV	S		
ARSENIC	NV	S		
BARIUM	NV	S		
#BENZENE* **	V	L	5.3E-01	1.9E+00
BENZO(a)ANTHRACENE	NV	S		
BENZO(a)PYRENE	NV	S		
BENZO(b)FLUORANTHENE	NV	S		
BENZO(g,h,i)PERYLENE	NV	S		
BENZO(k)FLUORANTHENE	NV	S		
BERYLLIUM	NV	S		
BIPHENYL, 1,1-	V	S	(Use soil gas)	(Use soil gas)
BIS(2-CHLOROETHYL)ETHER	V	L	6.7E-03	2.8E-02
BIS(2-CHLOROISOPROPYL)ETHER	V	L	(Use soil gas)	(Use soil gas)
BIS(2-ETHYLHEXYL)PHTHALATE	NV	S		
BORON	NV	S		
BROMODICHLOROMETHANE	V	L	2.3E-02	8.2E-02
BROMOFORM	NV	S		
BROMOMETHANE	V	G	8.6E-01	2.5E+00
CADMIUM	NV	S		
CARBON TETRACHLORIDE	V	L	2.7E-02	9.6E-02
CHLORDANE	NV	S		
CHLOROANILINE, p-	NV	S		
CHLOROBENZENE	V	L	1.0E+01	3.1E+01
CHLOROETHANE	V	G	5.0E-01	1.8E+00
CHLOROFORM	V	L	1.8E-02	6.3E-02
CHLOROMETHANE	V	G	1.6E+01	4.7E+01
CHLOROPHENOL, 2-	V	L	3.4E+00	1.2E+01
CHROMIUM (Total)	NV	S		
CHROMIUM III	NV	S		
CHROMIUM VI	NV	S		
CHRYSENE	NV	S	(Use soil gas)	(Use soil gas)
COBALT	NV	S		
COPPER	NV	S		
CYANIDE (Free)	NV	S	(Use soil gas)	(Use soil gas)
DIBENZO(a,h)ANTHTRACENE	NV	S		
DIBROMO-3-CHLOROPROPANE, 1,2-	V	L	(Use soil gas)	(Use soil gas)
DIBROMOCHLOROMETHANE	V	S	1.7E-02	1.1E-01
DIBROMOETHANE, 1,2-	V	S	7 2E-04	2.5E-03
DICHLOROBENZENE, 1,2-	V	L	3.5E+01	1.0E+02
DICHLOROBENZENE, 1,3-	V	L	(Use soil gas)	(Use soil gas)
DICHLOROBENZENE, 1,4-	V	S	6.5E-02	2.3E-01
DICHLOROBENZIDINE, 3,3-	NV	S		
DICHLORODIPHENYLDICHLOROETHANE (DDD)	NV	S		
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	NV	S		
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	NV	S		
DICHLOROETHANE, 1,1-	V	L	8.6E+01	2.5E+02

TABLE C-1b. SOIL ACTION LEVELS
FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS
(volatile chemicals only)
(Use with Soil Gas Screening Levels for sites with significant VOC releases)

CONTAMINANT	Physical State		[1]Residential Exposure (mg/kg)	Commercial/Industrial Exposure (mg/kg)
DICHLOROETHANE, 1,2-	V	L	1.6E-02	5.6E-02
DICHLOROETHYLENE, 1,1-	V	L	3.5E+01	1.0E+02
DICHLOROETHYLENE, Cis 1,2-	V	L	6.2E+00	1.8E+01
DICHLOROETHYLENE, Trans 1,2-	V	L	1.2E+01	3.6E+01
DICHLOROPHENOL, 2,4-	NV	S		
DICHLOROPROPANE, 1,2-	V	L	2.1E-02	7.5E-02
DICHLOROPROPENE, 1,3-	V	L	1.0E-01	3.6E-01
DIELDRIN	NV	S		
DIETHYLPHTHALATE	NV	S		
#DIMETHYLPHENOL, 2,4-	V	S		
DIMETHYLPHTHALATE	NV	S		
DINITROPHENOL, 2,4-	NV	S		
DINITROTOLUENE, 2,4-	NV	S		
DIOXANE, 1,4-	NV	L		
DIOXIN (2,3,7,8-TCDD)	NV	S		
ENDOSULFAN	NV	S		
ENDRIN	NV	S		
#ETHYLBENZENE* **	V	L	3.9E+02	**3.9E+02**
FLUORANTHENE	NV	S		
#FLUORENE	V	S	1.6E+02	1.6E+02
HEPTACHLOR	NV	S		
HEPTACHLOR EPOXIDE	NV	S		
HEXACHLOROBENZENE	NV	S		
HEXACHLOROBUTADIENE	NV	S		
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	NV	S		
HEXACHLOROETHANE	NV	S		
INDENO(1,2,3-cd)PYRENE	NV	S		
LEAD* **	NV	S		
MERCURY	NV	S		
METHOXYCHLOR	NV	S		
#METHYL ETHYL KETONE	V	L	1.9E+04	3.4E+04
#METHYL ISOBUTYL KETONE	V	L	1.7E+04	1.7E+04
METHYL MERCURY	NV	S		
METHYL TERT BUTYL ETHER	V	L	1.6E+00	5.6E+00
METHYLENE CHLORIDE	V	L	9.0E-01	3.2E+00
#METHYLNAPHTHALENE (total 1- & 2-)	V	S	1.1E+02	1.1E+02
MOLYBDENUM	NV	S		
#NAPHTHALENE* **	V	S	1.8E+01	**6.1E+01**
NICKEL	NV	S		
PENTACHLOROPHENOL	NV	S		
PERCHLORATE	NV	S		
PHENANTHRENE	V	S	(Use soil gas)	(Use soil gas)
PHENOL	NV	S		
POLYCHLORINATED BIPHENYLS (PCBs)	NV	S		
#PYRENE	V	S	8.5E+01	8.5E+01
SELENIUM	NV	S		
SILVER	NV	S		
#STYRENE	V	L	1.5E+03	1.5E+03
tert-BUTYL ALCOHOL	V	L	(Use soil gas)	(Use soil gas)
TETRACHLOROETHANE, 1,1,1,2-	V	L	(Use soil gas)	(Use soil gas)
TETRACHLOROETHANE, 1,1,2,2-	V	L	7.2E-03	2.5E-02

TABLE C-1b. SOIL ACTION LEVELS
FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS
(volatile chemicals only)
(Use with Soil Gas Screening Levels for sites with significant VOC releases)

CONTAMINANT	Physical State		[1]Residential Exposure (mg/kg)	Commercial/Industrial Exposure (mg/kg)
TETRACHLOROETHYLENE	V	L	6.9E-02	2.4E-01
THALLIUM	NV	S		
#TOLUENE* **	V	L	6.5E+02	6.5E+02
TOXAPHENE	NV	S		
TPH (gasolines)* **	V	L	(Use soil gas)	(Use soil gas)
TPH (middle distillates)* **	V	L	(Use soil gas)	(Use soil gas)
TPH (residual fuels)* **	NV	L/S		
TRICHLOROBENZENE, 1,2,4-	V	L	1.6E+00	5.3E+00
TRICHLOROETHANE, 1,1,1-	V	L	3.9E+02	1.1E+03
TRICHLOROETHANE, 1,1,2-	V	L	2.6E-02	9.1E-02
TRICHLOROETHYLENE	V	L	3.6E-02	1.3E-01
TRICHLOROPHENOL, 2,4,5-	V	S	9.5E+01	3.1E+02
TRICHLOROPHENOL, 2,4,6-	NV	S		
VANADIUM	NV	S		
VINYL CHLORIDE	V	G	3 9E-02	1.6E-01
#XYLENES* **	V	L	1.8E+02	4.2E+02
ZINC	NV	S		

Notes:

1. "Residential" action levels generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.).

Action levels calculated using spreadhseet provided with *User's Guide for the Johnson and Ettinger Indoor Air Model (1991) for Subsurface Vapor Intrusion Into Buildings* (USEPA 2000 and updates).
Soil model: Two meters dry sandy soil (92% sand, 5% silt, 3% clay) directly underlying building foundation.
Physical state of chemical at ambient conditions (V - volatile, NV - nonvolatile, S -solid, L - liquid, G - gas).
Chemical considered to be "volatile" if Henry's number (atm m3/mole) >0.00001 and molecular weight <200.
Dibromochloromethane, dibromochloropropane and pyrene considered volatile for purposes of modeling (USEPA 2002).
Target cancer risk = 1E-06 unless otherwise noted, Target Hazard Quotient = 1.0; TCE target cancer risk = 1E-05.
"#": Nonchlorinated VOCs (except MTBE) adjusted upwards by factor of ten to account for assumed biodegradation in vadose-zone prior to emission at surface.
(Use Soil Gas): Chemical constants not available for modeling. Use soil gas data to evaluate potential indoor-air impact concerns.

Notes for Red Hill Site

*** Indicates petroleum-related or potentially petroleum-related EAL

Numbers in shaded column to be used for screening

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TABLE C-2. [1]SHALLOW SOIL GAS ACTION LEVELS FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS (volatile chemicals only)

CONTAMINANT	Physical State		[2]Residential Exposure			Commercial/Industrial Land Use		
			Lowest Residential (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)	Lowest C/I (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)
ACENAPHTHENE	V	S	2.2E+05		2.2E+05	6.1E+05		6.1E+05
ACENAPHTHYLENE	V	S	1.5E+05		1.5E+05	4.1E+05		4.1E+05
ACETONE	V	L	3.3E+06		3.3E+06	9.2E+06		9.2E+06
ALDRIN	NV	S						
ANTHRACENE	V	S	1.1E+06		1.1E+06	3.1E+06		3.1E+06
ANTIMONY	NV	S						
ARSENIC	NV	S						
BARIUM	NV	S						
BENZENE***	V	L	2.5E+02	2.5E+02	3.1E+04	1.1E+03	1.1E+03	8.8E+04
BENZO(a)ANTHRACENE	NV	S						
BENZO(a)PYRENE	NV	S						
BENZO(b)FLUORANTHENE	NV	S						
BENZO(g,h,i)PERYLENE	NV	S						
BENZO(k)FLUORANTHENE	NV	S						
BERYLLIUM	NV	S						
BIPHENYL, 1,1-	V	S	1.8E+05		1.8E+05	5.1E+05		5.1E+05
BIS(2-CHLOROETHYL)ETHER	V	L	5.6E+00	5.6E+00		2.4E+01	2.4E+01	
BIS(2-CHLOROISOPROPYL)ETHER	V	L	1.9E+02	1.9E+02	1.5E+05	8.2E+02	8.2E+02	4.1E+05
BIS(2-ETHYLHEXYL)PHTHALATE	NV	S						
BORON	NV	S						
BROMODICHLOROMETHANE	V	L	1.1E+02	1.1E+02	7.3E+04	4.6E+02	4.6E+02	2.0E+05
BROMOFORM	NV	S						
BROMOMETHANE	V	G	5.1E+03		5.1E+03	1.4E+04		1.4E+04
CADMIUM	NV	S						
CARBON TETRACHLORIDE	V	L	1.3E+02	1.3E+02	2.6E+03	5.4E+02	5.4E+02	7.2E+03
CHLORDANE	NV	S						
CHLOROANILINE, p-	NV	S						
CHLOROBENZENE	V	L	6.2E+04		6.2E+04	1.7E+05		1.7E+05
CHLOROETHANE	V	G	2.3E+03	2.3E+03	1.1E+07	9.9E+03	9.9E+03	3.0E+07
CHLOROFORM	V	L	8.3E+01	8.3E+01	5.1E+04	3.5E+02	3.5E+02	1.4E+05
CHLOROMETHANE	V	G	9.5E+04		9.5E+04	2.7E+05		2.7E+05
CHLOROPHENOL, 2-	V	L	1.8E+04		1.8E+04	5.1E+04		5.1E+04
CHROMIUM (Total)	NV	S						
CHROMIUM III	NV	S						
CHROMIUM VI	NV	S						
CHRYSENE	NV	S						
COBALT	NV	S						
COPPER	NV	S						

TABLE C-2. [1]SHALLOW SOIL GAS ACTION LEVELS
FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS
(volatile chemicals only)

CONTAMINANT	Physical State		[2]Residential Exposure			Commercial/Industrial Land Use		
			Lowest Residential (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)	Lowest C/I (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)
CYANIDE (Free)	NV	S						
DIBENZO(a,h)ANTHTRACENE	NV	S						
DIBROMO-3-CHLOROPROPANE, 1,2-	V	L	2.1E+02	2.8E+03	2.1E+02	5.8E+02	1.2E+04	5.8E+02
DIBROMOCHLOROMETHANE	V	S	8.0E+01	8.0E+01	7.3E+04	3.4E+02	3.4E+02	2.0E+05
DIBROMOETHANE, 1,2-	V	S	3.4E+00	3.4E+00	9.5E+03	1.4E+01	1.4E+01	2.7E+04
DICHLOROBENZENE, 1,2-	V	L	2.1E+05		2.1E+05	5.8E+05		5.8E+05
DICHLOROBENZENE, 1,3-	V	L	1.1E+05		1.1E+05	3.1E+05		3.1E+05
DICHLOROBENZENE, 1,4-	V	S	3.1E+02	3.1E+02	1.1E+05	1.3E+03	1.3E+03	3.1E+05
DICHLOROBENZIDINE, 3,3-	NV	S						
DICHLORODIPHENYLDICHLOROETHANE (DDD)	NV	S						
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	NV	S						
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	NV	S						
DICHLOROETHANE, 1,1-	V	L	5.1E+05		5.1E+05	1.4E+06		1.4E+06
DICHLOROETHANE, 1,2-	V	L	7.4E+01	7.4E+01	5.1E+03	3.1E+02	3.1E+02	1.4E+04
DICHLOROETHYLENE, 1,1-	V	L	2.1E+05		2.1E+05	5.8E+05		5.8E+05
DICHLOROETHYLENE, Cis 1,2-	V	L	3.7E+04		3.7E+04	1.0E+05		1.0E+05
DICHLOROETHYLENE, Trans 1,2-	V	L	7.3E+04		7.3E+04	2.0E+05		2.0E+05
DICHLOROPHENOL, 2,4-	NV	S						
DICHLOROPROPANE, 1,2-	V	L	9.9E+01	9.9E+01	4.0E+03	4.2E+02	4.2E+02	1.1E+04
DICHLOROPROPENE, 1,3-	V	L	4.8E+02	4.8E+02	2.1E+04	2.0E+03	2.0E+03	5.8E+04
DIELDRIN	NV	S						
DIETHYLPHTHALATE	NV	S						
DIMETHYLPHENOL, 2,4-	V	S						
DIMETHYLPHTHALATE	NV	S						
DINITROPHENOL, 2,4-	NV	S						
DINITROTOLUENE, 2,4-	NV	S						
DIOXANE, 1,4-	NV	L						
DIOXIN (2,3,7,8-TCDD)	NV	S						
ENDOSULFAN	NV	S						
ENDRIN	NV	S						
ETHYLBENZENE* **	V	L	1.1E+06		1.1E+06	**3.0E+06**		3.0E+06
FLUORANTHENE	NV	S						
FLUORENE	V	S	1.5E+05		1.5E+05	4.1E+05		4.1E+05
HEPTACHLOR	NV	S						
HEPTACHLOR EPOXIDE	NV	S						
HEXACHLOROBENZENE	NV	S						
HEXACHLOROBUTADIENE	NV	S						
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	NV	S						

TABLE C-2. [1]SHALLOW SOIL GAS ACTION LEVELS FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS

(volatile chemicals only)

CONTAMINANT	Physical State		[2]Residential Exposure			Commercial/Industrial Land Use		
			Lowest Residential (ug/m^3)	Carcinogenic Effects (ug/m^3)	Noncarcinogenic Effects (ug/m^3)	Lowest C/I (ug/m^3)	Carcinogenic Effects (ug/m^3)	Noncarcinogenic Effects (ug/m^3)
HEXACHLOROETHANE	NV	S						
INDENO(1,2,3-cd)PYRENE	NV	S						
LEAD***	NV	S						
MERCURY	NV	S						
METHOXYCHLOR	NV	S						
METHYL ETHYL KETONE	V	L	5 1E+06		5 1E+06	1 4E+07		1 4E+07
METHYL ISOBUTYL KETONE	V	L	3 1E+06		3 1E+06	8 8E+06		8 8E+06
METHYL MERCURY	NV	S						
METHYL TERT BUTYL ETHER***	V	L	7 4E+03	7 4E+03	3 1E+06	3 1E+04	3 1E+04	8 8E+06
METHYLENE CHLORIDE	V	L	4 2E+03	4 2E+03	3 1E+06	1 8E+04	1 8E+04	8 8E+06
METHYLNAPHTHALENE (total 1- & 2-)	V	S	1 5E+05		1 5E+05	4 1E+05		4 1E+05
MOLYBDENUM	NV	S						
NAPHTHALENE	V	S	3 1E+03		3 1E+03	8 8E+03		8 8E+03
NICKEL	NV	S						
PENTACHLOROPHENOL	NV	S						
PERCHLORATE	NV	S						
PHENANTHRENE	V	S	1 5E+05		1 5E+05	4 1E+05		4 1E+05
PHENOL	NV	S						
POLYCHLORINATED BIPHENYLS (PCBs)	NV	S						
PYRENE	V	S	1 1E+05		1 1E+05	3 1E+05		3 1E+05
SELENIUM	NV	S						
SILVER	NV	S						
STYRENE	V	L	1 1E+06		1 1E+06	3 0E+06		3 0E+06
tert-BUTYL ALCOHOL	V	L	2 2E+03	2 2E+03		9 5E+03	9 5E+03	
TETRACHLOROETHANE, 1,1,1,2-	V	L	2 6E+02	2 6E+02	1 1E+05	1 1E+03	1 1E+03	3 1E+05
TETRACHLOROETHANE, 1,1,2,2-	V	L	3 4E+01	3 4E+01	2 2E+05	1 4E+02	1 4E+02	6 1E+05
TETRACHLOROETHYLENE	V	L	3 2E+02	3 2E+02	3 7E+04	1 4E+03	1 4E+03	1 0E+05
THALLIUM	NV	S						
TOLUENE***	V	L	4 0E+05		4 0E+05	1 1E+06		1 1E+06
TOXAPHENE	NV	S						
TPH (gasolines)***	V	L	5 1E+04		5 1E+04	1 4E+05		1 4E+05
TPH (middle distillates)***	V	L	5 1E+04		5 1E+04	1 4E+05		1 4E+05
TPH (residual fuels)***	NV	L/S						
TRICHLOROBENZENE, 1,2,4-	V	L	3 7E+03		3 7E+03	1 0E+04		1 0E+04
TRICHLOROETHANE, 1,1,1-	V	L	2 3E+06		2 3E+06	6 4E+06		6 4E+06
TRICHLOROETHANE, 1,1,2-	V	L	1 2E+02	1 2E+02	1 5E+04	5 1E+02	5 1E+02	4 1E+04
TRICHLOROETHYLENE	V	L	1 7E+02	1 7E+02	3 7E+04	7 2E+02	7 2E+02	1 0E+05
TRICHLOROPHENOL, 2,4,5-	V	S	3 7E+05		3 7E+05	1 0E+06		1 0E+06

TABLE C-2. [1]SHALLOW SOIL GAS ACTION LEVELS FOR EVALUATION OF POTENTIAL VAPOR INTRUSION CONCERNS (volatile chemicals only)

CONTAMINANT	Physical State		[2]Residential Exposure Lowest Residential (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)	Commercial/Industrial Land Use Lowest C/I (ug/m³)	Carcinogenic Effects (ug/m³)	Noncarcinogenic Effects (ug/m³)
TRICHLOROPHENOL, 2,4,6-	NV	S						
VANADIUM	NV	S						
VINYL CHLORIDE (nonresidential exposure)	V	G	4 2E+02	4 2E+02	1 0E+05	1 8E+03	1 8E+03	2 9E+05
VINYL CHLORIDE (residential exposure)	V	G	9 3E+01	9 3E+01	1 0E+05	9 2E+02	9 2E+02	2 9E+05
XYLENES***	V	L	1 1E+05		1 1E+05	3 0E+05		3 0E+05
ZINC	NV	S						

Notes:

1 Shallow soil gas defined as soil gas sample data collected within 1 5 meters (five feet) from a building foundation or the ground surface Assumes very permeable (e g , sandy) fill material is present below building foundation or could be present below future buildings following redevelopment Evaluation of deeper soil gas data (e g , >1 5m bgs) should be carried out on a site-specific basis

2 "Residential" action levels generally considered adequate for other sensitive uses (e g , day-care centers, hospitals, etc)

Soil gas action levels intended to be protective of indoor air quality, calculated for volatile chemicals only

Physical state of chemical at ambient conditions (V - volatile, NV - nonvolatile, S - solid, L - liquid, G - gas)

Chemical considered to be "volatile" if Henry's number (atm m3/mole) >0 00001 and molecular weight <200

Dibromochloromethane, dibromochloropropane and pyrene considered volatile for purposes of modeling (USEPA 2002)

Target cancer risk = 1E-06 unless otherwise noted, Target Hazard Quotient = 1 0, TCE target cancer risk = 1E-05

Residential soil gas indoor air attenuation factor = 0 001 (1/1000) Commercial/industrial soil gas indoor air attenuation factor = 0 0005 (1/2000)

Soil gas action levels do not address mass-balance issues May be overly conservative for sites with low permeability shallow soils or limited soil impacts and no groundwater source of VOCs

Indoor-air sampling and/or passive vapor mitigation measures may be prudent for sites where concentrations of chemicals in soil gas approach but do not exceed screening levels.

Notes for Red Hill Site

*** Indicates petroleum-related or potentially petroleum-related EAL

Numbers in shaded column to be used for screening

TABLE D-2. SUMMARY OF DRINKING WATER ACTION LEVELS FOR HUMAN TOXICITY
(ug/L)

CONTAMINANT	Final Action Level	Basis	USEPA Primary MCL	USEPA Region IX Tapwater Goal (Table D-4)	Basis
ACENAPHTHENE	3.7E+02	noncarcinogenic effects		3.7E+02	noncarcinogenic effects
ACENAPHTHYLENE	2.4E+02	noncarcinogenic effects		2.4E+02	noncarcinogenic effects
ACETONE	5.5E+03	noncarcinogenic effects		5.5E+03	noncarcinogenic effects
ALDRIN	4.0E-03	carcinogenic effects		4.0E-03	carcinogenic effects
ANTHRACENE	1.8E+03	noncarcinogenic effects		1.8E+03	noncarcinogenic effects
ANTIMONY	6.0E+00	HI DOH Primary MCL	6.0E+00	1.5E+01	noncarcinogenic effects
ARSENIC	1.0E+01	HI DOH Primary MCL	1.0E+01	4.5E-02	carcinogenic effects
BARIUM	2.0E+03	HI DOH Primary MCL	2.0E+03	2.6E+03	noncarcinogenic effects
BENZENE*	5.0E+00	HI DOH Primary MCL	5.0E+00	3.5E-01	carcinogenic effects
BENZO(a)ANTHRACENE	9.2E-02	carcinogenic effects		9.2E-02	carcinogenic effects
BENZO(a)PYRENE	2.0E-01	HI DOH Primary MCL	2.0E-01	9.2E-03	carcinogenic effects
BENZO(b)FLUORANTHENE	9.2E-02	carcinogenic effects		9.2E-02	carcinogenic effects
BENZO(g,h,i)PERYLENE	1.5E+03	noncarcinogenic effects		1.5E+03	noncarcinogenic effects
BENZO(k)FLUORANTHENE	9.2E-01	carcinogenic effects		9.2E-01	carcinogenic effects
BERYLLIUM	4.0E+00	HI DOH Primary MCL	4.0E+00	7.3E+01	noncarcinogenic effects
BIPHENYL, 1,1-	3.0E+02	noncarcinogenic effects		3.0E+02	noncarcinogenic effects
BIS(2-CHLOROETHYL)ETHER	9.5E-03	carcinogenic effects		9.5E-03	carcinogenic effects
BIS(2-CHLOROISOPROPYL)ETHER	2.7E-01	carcinogenic effects		2.7E-01	carcinogenic effects
BIS(2-ETHYLHEXYL)PHTHALATE	6.0E+00	HI DOH Primary MCL	6.0E+00	4.8E+00	carcinogenic effects
BORON	7.3E+03	noncarcinogenic effects		7.3E+03	noncarcinogenic effects
BROMODICHLOROMETHANE	1.8E-01	carcinogenic effects		1.8E-01	carcinogenic effects
BROMOFORM	1.0E+02	HI DOH Primary MCL	1.0E+02	8.5E+00	carcinogenic effects
BROMOMETHANE	8.5E+00	noncarcinogenic effects		8.5E+00	noncarcinogenic effects
CADMIUM	5.0E+00	HI DOH Primary MCL	5.0E+00	1.8E+01	noncarcinogenic effects
CARBON TETRACHLORIDE	5.0E+00	HI DOH Primary MCL	5.0E+00	1.7E-01	carcinogenic effects
CHLORDANE	2.0E+00	HI DOH Primary MCL	2.0E+00	1.9E-01	carcinogenic effects
CHLOROANILINE, p-	1.5E+02	noncarcinogenic effects		1.5E+02	noncarcinogenic effects
CHLOROBENZENE	1.0E+02	HI DOH Primary MCL	1.0E+02	1.1E+02	noncarcinogenic effects
CHLOROETHANE	3.9E+00	carcinogenic effects		3.9E+00	carcinogenic effects
CHLOROFORM	1.0E+02	HI DOH Primary MCL	1.0E+02	1.7E-01	carcinogenic effects
CHLOROMETHANE	1.6E+02	noncarcinogenic effects		1.6E+02	noncarcinogenic effects
CHLOROPHENOL, 2-	3.0E+01	noncarcinogenic effects		3.0E+01	noncarcinogenic effects
CHROMIUM (Total)	1.0E+02	HI DOH Primary MCL	1.0E+02	0.0E+00	carcinogenic effects
CHROMIUM III	5.5E+04	noncarcinogenic effects		5.5E+04	noncarcinogenic effects
CHROMIUM VI	1.1E+02	noncarcinogenic effects		1.1E+02	noncarcinogenic effects
CHRYSENE	9.2E+00	carcinogenic effects		9.2E+00	carcinogenic effects
COBALT	7.3E+02	noncarcinogenic effects		7.3E+02	noncarcinogenic effects
COPPER	1.3E+03	HI DOH Primary MCL	1.3E+03	1.5E+03	noncarcinogenic effects
CYANIDE (Free)	2.0E+02	HI DOH Primary MCL	2.0E+02	7.3E+02	noncarcinogenic effects
DIBENZO(a,h)ANTHTRACENE	9.2E-03	carcinogenic effects		9.2E-03	carcinogenic effects
DIBROMO-3-CHLOROPROPANE, 1,2-	4.0E-02	HI DOH Primary MCL	4.0E-02	4.8E-02	carcinogenic effects
DIBROMOCHLOROMETHANE	1.3E-01	carcinogenic effects		1.3E-01	carcinogenic effects
DIBROMOETHANE, 1,2-	5.6E-03	carcinogenic effects		5.6E-03	carcinogenic effects
DICHLOROBENZENE, 1,2-	6.0E+02	HI DOH Primary MCL	6.0E+02	3.7E+02	noncarcinogenic effects
DICHLOROBENZENE, 1,3-	1.8E+02	noncarcinogenic effects		1.8E+02	noncarcinogenic effects
DICHLOROBENZENE, 1,4-	7.5E+01	HI DOH Primary MCL	7.5E+01	5.0E-01	carcinogenic effects
DICHLOROBENZIDINE, 3,3-	1.5E-01	carcinogenic effects		1.5E-01	carcinogenic effects
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.8E-01	carcinogenic effects		2.8E-01	carcinogenic effects
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.8E-01	carcinogenic effects		2.8E-01	carcinogenic effects
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	2.0E-01	carcinogenic effects		2.0E-01	carcinogenic effects
DICHLOROETHANE, 1,1-	8.0E+02	noncarcinogenic effects		8.0E+02	noncarcinogenic effects

TABLE D-2. SUMMARY OF DRINKING WATER ACTION LEVELS FOR HUMAN TOXICITY
(ug/L)

CONTAMINANT	Final Action Level	Basis	USEPA Primary MCL	USEPA Region IX Tapwater Goal (Table D-4)	Basis
DICHLOROETHANE, 1,2-	1.2E-01	carcinogenic effects		1 2E-01	carcinogenic effects
DICHLOROETHYLENE, 1,1-	7.0E+00	HI DOH Primary MCL	7 0E+00	3 4E+02	noncarcinogenic effects
DICHLOROETHYLENE, Cis 1,2-	7.0E+01	HI DOH Primary MCL	7 0E+01	6 1E+01	noncarcinogenic effects
DICHLOROETHYLENE, Trans 1,2-	1.0E+02	HI DOH Primary MCL	1 0E+02	1 2E+02	noncarcinogenic effects
DICHLOROPHENOL, 2,4-	1.1E+02	noncarcinogenic effects		1 1E+02	noncarcinogenic effects
DICHLOROPROPANE, 1,2-	5.0E+00	HI DOH Primary MCL	5 0E+00	1.6E-01	carcinogenic effects
DICHLOROPROPENE, 1,3-	4.0E-01	carcinogenic effects		4 0E-01	carcinogenic effects
DIELDRIN	4.2E-03	carcinogenic effects		4 2E-03	carcinogenic effects
DIETHYLPHTHALATE	2.9E+04	noncarcinogenic effects		2.9E+04	noncarcinogenic effects
DIMETHYLPHENOL, 2,4-	7.3E+02	noncarcinogenic effects		7 3E+02	noncarcinogenic effects
DIMETHYLPHTHALATE	3.7E+05	noncarcinogenic effects		3 7E+05	noncarcinogenic effects
DINITROPHENOL, 2,4-	7.3E+01	noncarcinogenic effects		7 3E+01	noncarcinogenic effects
DINITROTOLUENE, 2,4-	3.4E+01	carcinogenic effects		3 4E+01	carcinogenic effects
DIOXANE, 1,4-	6.1E+00	carcinogenic effects		6.1E+00	carcinogenic effects
DIOXIN (2,3,7,8-TCDD)	3.0E-05	HI DOH Primary MCL	3 0E-05	4 5E-07	carcinogenic effects
ENDOSULFAN	2.2E+02	noncarcinogenic effects		2 2E+02	noncarcinogenic effects
ENDRIN	2.0E+00	HI DOH Primary MCL	2 0E+00	1.1E+01	noncarcinogenic effects
ETHYLBENZENE***	**7.0E+02**	HI DOH Primary MCL	7 0E+02	1 3E+03	noncarcinogenic effects
FLUORANTHENE	1.5E+03	noncarcinogenic effects		1.5E+03	noncarcinogenic effects
FLUORENE	2.4E+02	noncarcinogenic effects		2 4E+02	noncarcinogenic effects
HEPTACHLOR	4.0E-01	HI DOH Primary MCL	4.0E-01	1.5E-02	carcinogenic effects
HEPTACHLOR EPOXIDE	2.0E-01	HI DOH Primary MCL	2 0E-01	7 4E-03	carcinogenic effects
HEXACHLOROBENZENE	1.0E+00	HI DOH Primary MCL	1 0E+00	4.2E-02	carcinogenic effects
HEXACHLOROBUTADIENE	8.6E-01	carcinogenic effects		8 6E-01	carcinogenic effects
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	2.0E-01	HI DOH Primary MCL	2 0E-01	5 2E-02	carcinogenic effects
HEXACHLOROETHANE	4.8E+00	carcinogenic effects		4 8E+00	carcinogenic effects
INDENO(1,2,3-cd)PYRENE	9.2E-02	carcinogenic effects		9 2E-02	carcinogenic effects
LEAD***	**1.5E+01**	HI DOH Primary MCL	1 5E+01	0 0E+00	carcinogenic effects
MERCURY	2.0E+00	HI DOH Primary MCL	2 0E+00	5 8E+00	noncarcinogenic effects
METHOXYCHLOR	4.0E+01	HI DOH Primary MCL	4 0E+01	1.8E+02	noncarcinogenic effects
METHYL ETHYL KETONE	7.0E+03	noncarcinogenic effects		7 0E+03	noncarcinogenic effects
METHYL ISOBUTYL KETONE	2.0E+03	noncarcinogenic effects		2 0E+03	noncarcinogenic effects
METHYL MERCURY	3.7E+00	noncarcinogenic effects		3.7E+00	noncarcinogenic effects
METHYL TERT BUTYL ETHER***	**1.1E+01**	carcinogenic effects		1 1E+01	carcinogenic effects
METHYLENE CHLORIDE	4.3E+00	carcinogenic effects		4.3E+00	carcinogenic effects
METHYLNAPHTHALENE (total 1- & 2-)	2.4E+02	noncarcinogenic effects		2.4E+02	noncarcinogenic effects
MOLYBDENUM	1.8E+02	noncarcinogenic effects		1 8E+02	noncarcinogenic effects
NAPHTHALENE***	**6.2E+00**	noncarcinogenic effects		6.2E+00	noncarcinogenic effects
NICKEL	1.0E+02	HI DOH Primary MCL	1 0E+02	7 3E+02	noncarcinogenic effects
PENTACHLOROPHENOL	1.0E+00	HI DOH Primary MCL	1 0E+00	5 6E-01	carcinogenic effects
PERCHLORATE	3.7E+00	noncarcinogenic effects		3.7E+00	noncarcinogenic effects
PHENANTHRENE	2.4E+02	noncarcinogenic effects		2 4E+02	noncarcinogenic effects
PHENOL	1.1E+04	noncarcinogenic effects		1.1E+04	noncarcinogenic effects
POLYCHLORINATED BIPHENYLS (PCBs)	5.0E-01	HI DOH Primary MCL	5.0E-01	3 4E-02	carcinogenic effects
PYRENE	1.8E+02	noncarcinogenic effects		1 8E+02	noncarcinogenic effects
SELENIUM	5.0E+01	HI DOH Primary MCL	5.0E+01	1 8E+02	noncarcinogenic effects
SILVER	1.8E+02	noncarcinogenic effects		1 8E+02	noncarcinogenic effects
STYRENE	1.0E+02	HI DOH Primary MCL	1 0E+02	1 6E+03	noncarcinogenic effects
tert-BUTYL ALCOHOL	3.7E+00	carcinogenic effects		3.7E+00	carcinogenic effects
TETRACHLOROETHANE, 1,1,1,2-	4.3E-01	carcinogenic effects		4 3E-01	carcinogenic effects
TETRACHLOROETHANE, 1,1,2,2-	5.6E-02	carcinogenic effects		5 6E-02	carcinogenic effects

TABLE D-2. SUMMARY OF DRINKING WATER ACTION LEVELS FOR HUMAN TOXICITY
(ug/L)

CONTAMINANT	Final Action Level	Basis	USEPA Primary MCL	USEPA Region IX Tapwater Goal (Table D-4)	Basis
TETRACHLOROETHYLENE	5.0E+00	HI DOH Primary MCL	5.0E+00	1.0E-01	carcinogenic effects
THALLIUM	2.0E+00	HI DOH Primary MCL	2.0E+00	2.4E+00	noncarcinogenic effects
TOLUENE*	**1.0E+03**	*HI DOH Primary MCL*	1.0E+03	7.2E+02	noncarcinogenic effects
TOXAPHENE	3.0E+00	HI DOH Primary MCL	3.0E+00	5.6E-02	carcinogenic effects
TPH (gasolines)*	**1.0E+02**	noncarcinogenic effects		1.0E+02	noncarcinogenic effects
TPH (middle distillates)*	**1.0E+02**	noncarcinogenic effects		1.0E+02	noncarcinogenic effects
TPH (residual fuels)*	**1.0E+03**	noncarcinogenic effects		1.0E+03	noncarcinogenic effects
TRICHLOROBENZENE, 1,2,4-	7.0E+01	HI DOH Primary MCL	7.0E+01	7.2E+00	noncarcinogenic effects
TRICHLOROETHANE, 1,1,1-	2.0E+02	HI DOH Primary MCL	2.0E+02	3.2E+03	noncarcinogenic effects
TRICHLOROETHANE, 1,1,2-	5.0E+00	HI DOH Primary MCL	5.0E+00	2.0E-01	carcinogenic effects
TRICHLOROETHYLENE	5.0E+00	HI DOH Primary MCL	5.0E+00	2.8E-02	carcinogenic effects
TRICHLOROPHENOL, 2,4,5-	6.1E+02	noncarcinogenic effects		6.1E+02	noncarcinogenic effects
TRICHLOROPHENOL, 2,4,6-	3.7E+00	noncarcinogenic effects		3.7E+00	noncarcinogenic effects
VANADIUM	3.7E+01	noncarcinogenic effects		3.7E+01	noncarcinogenic effects
VINYL CHLORIDE	2.0E+00	HI DOH Primary MCL	2.0E+00	8.1E-02	carcinogenic effects
XYLENES*	**1.0E+04**	HI DOH Primary MCL	1.0E+04	2.1E+02	noncarcinogenic effects
ZINC	1.1E+04	noncarcinogenic effects		1.1E+04	noncarcinogenic effects

Notes:
Used for development of groundwater and soil screening levels
TPH -Total Petroleum Hydrocarbons. Default toxicity-based action levels rounded to 100 ug/L or 1,000 ug/L, as shown
USEPA MCL. USEPA Primary Maximum Concentration Level
Final health-based action level for drinking water. USEPA Primary MCL or USEPA Region IX Tapwater goal if no Primary MCL

Notes for Red Hill Site
*** Indicates petroleum-related or potentially petroleum-related EAL
Numbers in bolded column to be used for screening

TABLE G-1. GROUNDWATER GROSS CONTAMINATION CEILING LEVELS
(groundwater IS a current or potential source of drinking water)
(ug/L)

CONTAMINANT	Final Ceiling Level	Basis	Solubility (1/2)	Taste And Odor Threshold	Basis	Upper Limit
ACENAPHTHENE	2.0E+01	Taste & Odors	2.1E+03	2.0E+01	Ontario MOEE	5.0E+04
ACENAPHTHYLENE	2.0E+03	Solubility	2.0E+03	-	-	5.0E+04
ACETONE	2.0E+04	Taste & Odors	5.0E+08	2.0E+04	Amoore & Hautala	5.0E+04
ALDRIN	8.5E+00	Solubility	8.5E+00	1.7E+01	Ontario MOEE	5.0E+04
ANTHRACENE	2.2E+01	Solubility	2.2E+01	-	-	5.0E+04
ANTIMONY	5.0E+04	Upper Limit		-	-	5.0E+04
ARSENIC	5.0E+04	Upper Limit		-	-	5.0E+04
BARIUM	5.0E+04	Upper Limit		-	-	5.0E+04
BENZENE* **	1.7E+02	Taste & Odors	8.8E+05	1.7E+02	Amoore & Hautala	5.0E+04
BENZO(a)ANTHRACENE	5.0E+00	Solubility	5.0E+00	-	-	5.0E+04
BENZO(a)PYRENE	1.9E+00	Solubility	1.9E+00	-	-	5.0E+04
BENZO(b)FLUORANTHENE	7.0E+00	Solubility	7.0E+00	-	-	5.0E+04
BENZO(g,h,i)PERYLENE	1.3E-01	Solubility	1.3E-01	-	-	5.0E+04
BENZO(k)FLUORANTHENE	4.0E-01	Solubility	4.0E-01	-	-	5.0E+04
BERYLLIUM	5.0E+04	Upper Limit		-	-	5.0E+04
BIPHENYL, 1,1-	5.0E-01	Taste & Odors	3.8E+03	5.0E-01	Amoore & Hautala	5.0E+04
BIS(2-CHLOROETHYL)ETHER	3.6E+02	Taste & Odors	8.6E+06	3.6E+02	Amoore & Hautala	5.0E+04
BIS(2-CHLOROISOPROPYL)ETHER	3.2E+02	Taste & Odors	8.5E+05	3.2E+02	Ontario MOEE	5.0E+04
BIS(2-ETHYLHEXYL)PHTHALATE	6.5E+02	Solubility	6.5E+02	-	-	5.0E+04
BORON	5.0E+04	Upper Limit		-	-	5.0E+04
BROMODICHLOROMETHANE	5.0E+04	Upper Limit	3.4E+06	-	-	5.0E+04
BROMOFORM	5.1E+02	Taste & Odors	1.6E+06	5.1E+02	Amoore & Hautala	5.0E+04
BROMOMETHANE	5.0E+04	Upper Limit	7.6E+06	-	-	5.0E+04
CADMIUM	5.0E+04	Upper Limit		-	-	5.0E+04
CARBON TETRACHLORIDE	5.2E+02	Taste & Odors	4.0E+05	5.2E+02	Amoore & Hautala	5.0E+04
CHLORDANE	2.5E+00	Taste & Odors	2.8E+01	2.5E+00	Ontario MOEE	5.0E+04
CHLOROANILINE, p-	5.0E+04	Upper Limit	1.3E+06	-	-	5.0E+04
CHLOROBENZENE	5.0E+01	Taste & Odors	2.4E+05	5.0E+01	Amoore & Hautala	5.0E+04
CHLOROETHANE	1.6E+01	Taste & Odors	2.9E+06	1.6E+01	Amoore & Hautala	5.0E+04
CHLOROFORM	2.4E+03	Taste & Odors	4.0E+06	2.4E+03	Amoore & Hautala	5.0E+04
CHLOROMETHANE	5.0E+04	Upper Limit	4.1E+06		-	5.0E+04
CHLOROPHENOL, 2-	1.8E-01	Taste & Odors	1.1E+07	1.8E-01	Ontario MOEE	5.0E+04
CHROMIUM (Total)	5.0E+04	Upper Limit		-	-	5.0E+04
CHROMIUM III	5.0E+04	Upper Limit		-	-	5.0E+04
CHROMIUM VI	5.0E+04	Upper Limit		-	-	5.0E+04
CHRYSENE	8.0E-01	Solubility	8.0E-01	-	-	5.0E+04
COBALT	5.0E+04	Upper Limit		-	-	5.0E+04
COPPER	1.0E+03	Taste & Odors		1.0E+03	USEPA 2nd MCL	5.0E+04
CYANIDE (Free)	1.7E+02	Taste & Odors	5.0E+08	1.7E+02	Amoore & Hautala	5.0E+04
DIBENZO(a,h)ANTHTRACENE	2.5E-01	Solubility	2.5E-01	-	-	5.0E+04
DIBROMO-3-CHLOROPROPANE, 1,2-	1.0E+01	Taste & Odors	6.0E+05	1.0E+01	Amoore & Hautala	5.0E+04
DIBROMOCHLOROMETHANE	5.0E+04	Upper Limit	2.2E+06	-	-	5.0E+04
DIBROMOETHANE, 1,2-	5.0E+04	Upper Limit	1.7E+06	-	-	5.0E+04
DICHLOROBENZENE, 1,2-	1.0E+01	Taste & Odors	7.8E+04	1.0E+01	USEPA 2nd MCL	5.0E+04
DICHLOROBENZENE, 1,3-	5.0E+04	Upper Limit	7.8E+04	-	-	5.0E+04
DICHLOROBENZENE, 1,4-	5.0E+00	Taste & Odors	3.7E+04	5.0E+00	USEPA 2nd MCL	5.0E+04
DICHLOROBENZIDINE, 3,3-	1.6E+03	Solubility	1.6E+03	-	-	5.0E+04
DICHLORODIPHENYLDICHLOROETHANE (DDD)	8.0E+01	Solubility	8.0E+01	-	-	5.0E+04
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	2.0E+01	Solubility	2.0E+01	-	-	5.0E+04
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.5E+00	Solubility	1.5E+00	3.5E+02	Ontario MOEE	5.0E+04
DICHLOROETHANE, 1,1-	5.0E+04	Upper Limit	2.5E+06	-	-	5.0E+04
DICHLOROETHANE, 1,2-	7.0E+03	Taste & Odors	4.3E+06	7.0E+03	Amoore & Hautala	5.0E+04
DICHLOROETHYLENE, 1,1-	1.5E+03	Taste & Odors	1.1E+06	1.5E+03	Amoore & Hautala	5.0E+04

TABLE G-1. GROUNDWATER GROSS CONTAMINATION CEILING LEVELS
(groundwater IS a current or potential source of drinking water)
(ug/L)

CONTAMINANT	Final Ceiling Level	Basis	Solubility (1/2)	Taste And Odor Threshold	Basis	Upper Limit
DICHLOROETHYLENE, Cis 1,2-	5.0E+04	Upper Limit	1.8E+06	-	-	5.0E+04
DICHLOROETHYLENE, Trans 1,2-	2.6E+02	Taste & Odors	3.2E+06	2.6E+02	Amoore & Hautala	5.0E+04
DICHLOROPHENOL, 2,4-	3.0E-01	Taste & Odors	2.3E+06	3.0E-01	Ontario MOEE	5.0E+04
DICHLOROPROPANE, 1,2-	1.0E+01	Taste & Odors	1.4E+06	1.0E+01	Ontario MOEE	5.0E+04
DICHLOROPROPENE, 1,3-	5.0E+04	Upper Limit	1.4E+06	-	-	5.0E+04
DIELDRIN	4.1E+01	Taste & Odors	9.3E+01	4.1E+01	Ontario MOEE	5.0E+04
DIETHYLPHTHALATE	5.0E+04	Upper Limit	4.5E+05	-	-	5.0E+04
DIMETHYLPHENOL, 2,4-	4.0E+02	Taste & Odors	3.9E+06	4.0E+02	Cal DHS AL	5.0E+04
DIMETHYLPHTHALATE	5.0E+04	Upper Limit	2.5E+06	-	-	5.0E+04
DINITROPHENOL, 2,4-	5.0E+04	Upper Limit	2.8E+06	-	-	5.0E+04
DINITROTOLUENE, 2,4-	5.0E+04	Upper Limit	1.4E+05	-	-	5.0E+04
DIOXANE, 1,4-	5.0E+04	Upper Limit	5.0E+08	2.3E+05	Amoore & Hautala	5.0E+04
DIOXIN (2,3,7,8-TCDD)	7.0E+03	Solubility	7.0E+03	-	-	5.0E+04
ENDOSULFAN	7.5E+01	Solubility	7.5E+01	-	-	5.0E+04
ENDRIN	4.1E+01	Taste & Odors	1.3E+02	4.1E+01	Ontario MOEE	5.0E+04
ETHYLBENZENE* **	**3.0E+01**	Taste & Odors	8.5E+04	3.0E+01	USEPA 2nd MCL	5.0E+04
FLUORANTHENE	1.3E+02	Solubility	1.3E+02	-	-	5.0E+04
FLUORENE	9.5E+02	Solubility	9.5E+02	-	-	5.0E+04
HEPTACHLOR	2.0E+01	Taste & Odors	2.8E+01	2.0E+01	Ontario MOEE	5.0E+04
HEPTACHLOR EPOXIDE	1.8E+02	Solubility	1.8E+02	-	-	5.0E+04
HEXACHLOROBENZENE	5.5E+01	Solubility	5.5E+01	3.0E+03	Ontario MOEE	5.0E+04
HEXACHLOROBUTADIENE	6.0E+00	Taste & Odors	1.0E+03	6.0E+00	Ontario MOEE	5.0E+04
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	3.5E+03	Solubility	3.5E+03	1.2E+04	Ontario MOEE	5.0E+04
HEXACHLOROETHANE	1.0E+01	Taste & Odors	2.5E+04	1.0E+01	Amoore & Hautala	5.0E+04
INDENO(1,2,3-cd)PYRENE	2.7E-01	Solubility	2.7E-01	-	-	5.0E+04
LEAD* **	**5.0E+04**	Upper Limit		-	-	5.0E+04
MERCURY	5.0E+04	Upper Limit		-	-	5.0E+04
METHOXYCHLOR	2.0E+01	Solubility	2.0E+01	4.7E+03	Amoore & Hautala	5.0E+04
METHYL ETHYL KETONE	8.4E+03	Taste & Odors	1.3E+08	8.4E+03	Amoore & Hautala	5.0E+04
METHYL ISOBUTYL KETONE	1.3E+03	Taste & Odors	9.5E+06	1.3E+03	Amoore & Hautala	5.0E+04
METHYL MERCURY	5.0E+04	Upper Limit		-	-	5.0E+04
METHYL TERT BUTYL ETHER* **	**5.0E+00**	Taste & Odors	7.5E+07	5.0E+00	Cal DHS 2nd MCL	5.0E+04
METHYLENE CHLORIDE	9.1E+03	Taste & Odors	6.6E+06	9.1E+03	Ontario MOEE	5.0E+04
METHYLNAPHTHALENE (total 1- & 2-)	1.0E+01	Taste & Odors	1.3E+04	1.0E+01	Ontario MOEE	5.0E+04
MOLYBDENUM	5.0E+04	Upper Limit		-	-	5.0E+04
NAPHTHALENE* **	**2.1E+01**	Taste & Odors	1.6E+04	2.1E+01	Amoore & Hautala	5.0E+04
NICKEL	5.0E+04	Upper Limit		-	-	5.0E+04
PENTACHLOROPHENOL	3.0E+01	Taste & Odors	7.0E+06	3.0E+01	Amoore & Hautala	5.0E+04
PERCHLORATE	5.0E+04	Upper Limit	1.0E+08	-	-	5.0E+04
PHENANTHRENE	4.1E+02	Solubility	4.1E+02	1.0E+03	Ontario MOEE	5.0E+04
PHENOL	5.0E+00	Taste & Odors	4.0E+07	5.0E+00	Cal DHS AL	5.0E+04
POLYCHLORINATED BIPHENYLS (PCBs)	1.6E+01	Solubility	1.6E+01	-	-	5.0E+04
PYRENE	6.8E+01	Solubility	6.8E+01	-	-	5.0E+04
SELENIUM	5.0E+04	Upper Limit		-	-	5.0E+04
SILVER	1.0E+02	Taste & Odors		1.0E+02	USEPA 2nd MCL	5.0E+04
STYRENE	1.0E+01	Taste & Odors	1.6E+05	1.0E+01	USEPA 2nd MCL	5.0E+04
tert-BUTYL ALCOHOL	5.0E+04	Upper Limit	5.0E+08	-	-	5.0E+04
TETRACHLOROETHANE, 1,1,1,2-	5.0E+04	Upper Limit	1.5E+06	-	-	5.0E+04
TETRACHLOROETHANE, 1,1,2,2-	5.0E+02	Taste & Odors	1.5E+06	5.0E+02	Amoore & Hautala	5.0E+04
TETRACHLOROETHYLENE	1.7E+02	Taste & Odors	1.0E+05	1.7E+02	Amoore & Hautala	5.0E+04
THALLIUM	5.0E+04	Upper Limit		-	-	5.0E+04
TOLUENE* **	**4.0E+01**	Taste & Odors	2.6E+05	4.0E+01	USEPA 2nd MCL	5.0E+04

TABLE G-1. GROUNDWATER GROSS CONTAMINATION CEILING LEVELS (groundwater IS a current or potential source of drinking water) (ug/L)

CONTAMINANT	Final Ceiling Level	Basis	Solubility (1/2)	Taste And Odor Threshold	Basis	Upper Limit
TOXAPHENE	1.4E+02	Taste & Odors	1.5E+03	1.4E+02	USEPA 2nd MCL	5.0E+04
TPH (gasolines)* **	**1.0E+02**	Taste & Odors	7.5E+04	1.0E+02	USEPA SNARL	5.0E+04
TPH (middle distillates)* **	**1.0E+02**	Taste & Odors	2.5E+03	1.0E+02	USEPA SNARL	5.0E+04
TPH (residual fuels)* **	**1.0E+02**	Taste & Odors	2.5E+03	1.0E+02	USEPA SNARL	5.0E+04
TRICHLOROBENZENE, 1,2,4-	3.0E+03	Taste & Odors	1.5E+05	3.0E+03	USEPA (1995)	5.0E+04
TRICHLOROETHANE, 1,1,1-	9.7E+02	Taste & Odors	6.7E+05	9.7E+02	Amoore & Hautala	5.0E+04
TRICHLOROETHANE, 1,1,2-	5.0E+04	Upper Limit	2.2E+06	-	-	5.0E+04
TRICHLOROETHYLENE	3.1E+02	Taste & Odors	5.5E+05	3.1E+02	Amoore & Hautala	5.0E+04
TRICHLOROPHENOL, 2,4,5-	2.0E+02	Taste & Odors	6.0E+05	2.0E+02	Ontario MOEE	5.0E+04
TRICHLOROPHENOL, 2,4,6-	1.0E+02	Taste & Odors	4.0E+05	1.0E+02	Ontario MOEE	5.0E+04
VANADIUM	5.0E+04	Upper Limit		-	-	5.0E+04
VINYL CHLORIDE	3.4E+03	Taste & Odors	1.4E+06	3.4E+03	Amoore & Hautala	5.0E+04
XYLENES* **	**2.0E+01**	Taste & Odors	8.1E+04	2.0E+01	USEPA 2nd MCL	5.0E+04
ZINC	5.0E+03	Taste & Odors		5.0E+03	USEPA 2nd MCL	5.0E+04

References:

Unless otherwise noted, criteria for drinking water taste and odor threshhold from summary in *A Compilation of Water Quality Goals* (RWQCBCV 1998) or Ontario MOEE if not available (MOEE 1996).

Upper limit of 50000 ug/L intended to limit general groundwater resource degradation (MOEE 1996).

1/2 solubility based on solubility constants in USEPA Region IX (USEPA 1998) or Ontario MOEE (MOEE 1996) if not available.

Notes:

Ceiling Level: lowest of 1/2 solubility, taste and odor threshhold and 50000 ug/L maximum level

TPH -Total Petroleum Hydrocarbons. See text for discussion of different TPH categories.

TPH ceiling levels after Massachusetts DEP (MADEP 1997a).

TPH Taste and Odor Thresholds based on USEPA Suggested-No-Adverse-reaction (SNARL) level for TPH diesel.

Notes for Red Hill Site

*** Indicates petroleum-related or potentially petroleum-related EAL

Numbers in shaded column to be used for screening

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Red Hill Bulk Fuel Storage Facility
Final – Field Sampling Plan Addendum
Attachments B Through E
Pearl Harbor, Hawaii

May 2006

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
Pearl Harbor, HI 96860-3134

NAVFAC PACIFIC

Indefinite Delivery/ Indefinite Quantity Contract
Contract Number N62742-02-D-1802, CTO 007

Red Hill Bulk Fuel Storage Facility
Final – Field Sampling Plan Addendum
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Pearl Harbor, Hawaii

May 2006

Prepared for:

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite #100
Pearl Harbor, HI 96860-3134

Prepared by:

TEC Inc.
1001 Bishop Street,
American Savings Bank Tower, Suite 1400
Honolulu, Hawaii 96813

Prepared under:

Indefinite Delivery/ Indefinite Quantity Contract
Contract Number N62742-02-D-1802, CTO 007

ATTACHMENT B – INSTALLATION OF DEDICATED EQUIPMENT

1.1 Installation of Dedicated Pumps

Dedicated sampling pumps will be installed in five wells (RHMW01 through -04 and 2254-01) at the Red Hill Storage Facility (RHSF). Table B-1 lists the well design specifications and the pump model to be installed in each well. The pumps will be ordered pre-fabricated to a tubing length to ensure the pump suction remains below the water table throughout the expected range of water elevations in these wells. Installation will consist of unpacking the pump assemblies, opening the monitoring wells, decontamination of pump assemblies, installation of the pump assemblies in the wells, and testing the pumps.

Table B-1 Pump Installation Summary

Well Data/ID	RHMW01	RHMW02	RHMW03	RHMW04	2254-01
Well Depth	100	103	118	320	120
Well Diameter	1-inch	2-inch	2-inch	2-inch	2-inch
Pump Model	GEO850.SS24	GEO1.66SS36			

It is extremely important that accurate distances between the well top of casing and the lowest expected water level be known before ordering the pump assembly packages. The tubing lengths should be long enough so that the top of the pump is just beneath the water when the water table is at the lowest expected elevation. This elevation could be estimated by comparing current water levels in the monitoring wells selected for pump installation with long term water level data from the Moanaula Monitoring Well, (well number 2153-09) and the Halawa Deep Monitoring Well (well number 2255-33). Water levels during the drought years of 1998 though 2001 will be extremely helpful for this assessment.

1.2 Unpacking Pump Assemblies

Sheet plastic shall be laid down prior to opening the packages to prevent contaminating the pumps and hosing. Care shall be taken so the tubing is not damaged when opening the package. An inventory shall be taken immediately upon opening the packages to ensure all parts are present.

1.3 Opening the Monitoring Wells

Prior to unlocking or removing the cover for the wells, the area around the well shall be clean to prevent the introduction of debris into the well. Immediately after opening the vapor cap on the well a PID measurement inside well bore will be taken and recorded. After the PID reading is taken, the depth to water level and depth to bottom of the well screen will be taken.

1.4 Decontamination of Pump Assemblies

Prior to installation of the pump assemblies into the well, all pumps and tubing will be cleaned in accordance with Appendix H, Standard Operating Procedures, Decontamination, of the Red Hill Bulk Fuel Storage Facility Work Plan (TEC 2005) to prevent the introduction of contamination into the well.

1.5 Installation of the Pump Assemblies in the Wells

Installation of the pumps are described in Geotech's Bladder Pumps Installation and Operations Manual. This document can be found in Appendix B of the Work Plan Addendum.

1.6 Testing the Pumps

The pumps are bladder pumps that operate with compressed air. Inside of the RHFSF tunnel compressed air is currently available. An air line from the Geocontroller 2 will be connected to air service line and to the pump. For wells RHMW04 and 2254-01 a compressed gas bottle containing either clean and dry nitrogen or carbon dioxide will be used to power the pumps. A regulator will be used to ensure that the pressure to the pump controller does not exceed 125 pounds per square inch (psi). The Geocontroller 2 will be used with all pumps. The specific operating procedures for each piece of equipment are listed below and presented at the end of this section:

- When working with compressed air always wear eye protection and secure compressed air hoses.
- Do not disable the pneumatic pumps when they are connected to compressed air.
- Do not pump sand with these bladder pumps as this will damage the bladder.
- Operating pressure is 0.5 estimated by:
    - PSI operating = ½(dtw) + 10PSI,

    where
    - PSI operating is the expected operating pressure needed, dtw is the depth to water from the controller box, 10PSI is added to overcome the friction.

ATTACHMENT C – GROUNDWATER SAMPLING

1.1 Groundwater Sampling

Groundwater sampling will continue on wells RHMW01 through -04, and 2254-01. The groundwater samples will be analyzed for petroleum-related constituents. The sampling will be completed with dedicated pumps, and is outlined below.

1.2 Field Equipment

Field equipment that may be used during groundwater field activities for monitoring purposes include:

- A water quality analyzer monitoring pH, specific conductivity, temperature, and oxidation-reduction potential;
- A colorimeter monitoring dissolved oxygen and turbidity,
- Electronic water level indicator; and
- A dedicated sampling pump and associated equipment at each well.

The water quality analyzer will be calibrated daily according to manufacturer's guidelines and procedures for each item of equipment stated. The accuracy of the turbidity function of the colorimeter will be checked prior to each round of sampling and zeroed prior to reading each sample.

1.3 Pre-Sample Operations

Prior to sampling, the well caps will be removed and the organic vapor concentration at the top of well bore will be measured. The organic vapor content in well will be measured with a 2020 photo-ionization detector (PID). The sample line of the PID will be inserted into the water level indicator (WLI) and the display of the PID will be monitored until the display stabilizes. The highest reading of the PID will be recorded on the Groundwater Sampling Log data sheet found in Appendix H of the original work plan (TEC 2005). Once the PID sample line is removed from the well, a depth from the top of the well casing to the water table will be measured. This will be done by lowering the cable of an electronic WLI until the audio and visual indicators signify that the WLI probe has reached the water. The water-level measurement will be read to the nearest 0.01 ft. Total depth (TD) will not be measured to prevent the WLI cable from becoming entangled with the dedicated pump installed in each well. It is assumed that the TD value will have not changed from that value measured prior to pump installation.

1.4 Purging Prior to Sampling

Wells will be sampled using a dedicated pump system. This system will require a source of compressed air. Inside of the RHFS tunnel, a compressed air supply line is usually available and will be used. The Model MP10 Controller for the dedicated pumps will be connected to the compressed air system with a filter and water trap in-line. QED information bulletin, MicroPurge Basics – Model MP10 Controller (Attachment B) gives details on setting up and operating the controller. Outside of the tunnel and if compressed air is unavailable inside the tunnel, a 200 scf compressed gas cylinder containing clean dry nitrogen or carbon dioxide will be used. The compressed gas pressure will be reduced to 125 psig by use of a regulator with high and low pressure gages attached to the cylinder. One cylinder should be sufficient to sample two wells. The Geocontroller 2 will be connected to the dedicated bladder pumps. Operation of the bladder pumps are described in Appendix B of the Work Plan.

Table C-1 lists the wells to be sampled and the pump type in each well.

Prior to collecting a groundwater sample, the in situ groundwater in each monitoring well will be removed, or purged via a dedicated bladder pump fitted with dedicated Teflon lined polyethylene tubing. The purge water will be disposed in the RHSF oil/water separator system. Field parameters such as pH, temperature, specific conductivity, dissolved oxygen, reduction-oxidation potential, and turbidity will be measured using a water quality analyzer and recorded at approximate five minute intervals on a Groundwater Sampling Log data sheet. Purging shall be considered complete when field parameter measurements (i.e.: pH, conductivity, etc.) stabilize within approximately 10% of the last three consecutive recorded measurements for each well and turbidity is less than 5 NTU.

1.5 Sample Collection

Immediately following purging, each monitoring well will be sampled. The field sampling report form to be used is provided in Appendix H of the original WP (TEC 2005). Information regarding analyses is presented in Table 4-2 of the original WP (TEC 2005). All wells will be sampled directly from the dedicated bladder pumps systems. Dissolved lead samples will be placed in preservative-free bottles, and filtered at the lab. Sample containers will be labeled with the date, sample identification number, type of analysis, and sampler's name. The containers will then be placed on ice in sample coolers and transported under chain-of-custody procedures to the certified laboratory for analysis. Groundwater samples will be labeled and documented in accordance with SOPs presented in Appendix H of the original WP (TEC 2005).

Table C-1 Summary of Groundwater Sampling Requirements

Well	RHMW01	RHMW02	RHMW03	RHMW04	2254-01
Sampling Method	Dedicated pump	Dedicated pump	Dedicated pump	Dedicated pump	Dedicated pump
Pump Model	GEO850.SS 24	GEO1.66SS36			
Location	Lower Tunnel, By Tank 1	Lower Tunnel, By Tank 6	Lower Tunnel, By Tank 4	Access Rd, Near Adit 6	Lower Tunnel, Near Adit 3
dtw (ft)	88	88	103	293	88
Controller Pressure (psi)	54	54	61.5	156.5	54

dtw = depth to water
PSI = pounds per square inch

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ATTACHMENT D – INSTALLATION OF ADDITIONAL SOIL VAPOR MONITORING POINTS

1.1 Installation of Soil Vapor Monitoring Points

Soil Vapor Monitoring Points (SVMPs) will be installed in angled borings beneath tanks to aide in the assessment of vapors. The soil vapor MPs will be installed inside each of the chosen angled borings in the outer third, middle third, and inner third of the vadose zone below the bottom of certain USTs. Typical construction details for installation are depicted at the end of this section.

Since the existing casing ranges from 1.5 to 2 inches in diameter, construction of the SVMPs will require close attention to the sizes of the required tremie pipe, MP diameters and lengths in comparison to the existing slant boring casing inside diameters. Also, the casing should be evaluated for contamination that may have entered through the screen and pooled at the bottom. In general, the screens are 15 feet long and located at the outer third of the borings. The screens will be cut, the casing removed and bentonite seals placed at approximately 100 feet, 66 feet, 33 feet, sealing off the respective SVMPs. A bentonite seal, steel identifier tags and a steel cap will also be placed at the surface.

The following steps should be taken when installing the MPs.

1. Ensure that instrumentation, material, and tools are onsite to complete each installation;

    a. approximately 200 feet of 1/4–inch soft copper tubing (100-foot, 60-foot, and 25-foot sections [make sure each section is marked with depth using metal tag labels]), with the bottom 10 feet drilled with 3/16-inch holes to allow vapor to enter, and three check valves;
    b. 120 feet of swabbing and casing assessment pipe (3/4-inch diameter), flush-threaded;
    c. casing swabs, 1.5- and 2-inch swabs to fit on the end of the tremie pipe for initial cleaning of casing;
    d. 120 feet of tremie pipe (3/4-inch diameter) flush-threaded;
    e. cement, bentonite, and grout pump;
    f. casing puller for 1.5- and 2-inch casing;
    g. down-hole casing cutter to cut 1.5- to 2-inch casing at approximately 110 feet from the point of entry (POE);
    h. two 55-gallon drums to mix grout and to clean tremie

2. Insert swab and assessment pipe to end of casing and draw vacuum to determine if product is at bottom of casing. Collect product in 1-liter amber sampling jar. Remove pipe and save swab for evaluation.

3. Insert downhole pipe cutter to endpoint of UST and cut internal casing at approximately 110 feet from POE. Remove Pipe cutter from casing.

4. Break casing from surface seal and pull 5 feet into tunnel.

5. Insert grout tremie pipe to 110 feet from POE and plug end with approximately 4 gallons of grout (at 3.5 inch diameter borehole, 0.5 gallons per foot). Remove tremie pipe and rinse.

6. Pull casing to 80 feet from POE, cut off stick-up and discard.

7. Insert 100-foot MP to 95 feet from POE, and insert foam borehole plug to 76 feet from POE to stop bentonite.

8. Pull casing to 65 feet from POE, cut off stick-up and discard.

9. Insert grout tremie pipe to 63 feet from POE and plug end with approximately 7 feet of #16-sized granular bentonite. Remove tremie pipe and rinse.

10. Pull casing to 60 feet from POE, cut off stick-up and discard.

11. Insert 60-foot MP to 60 feet from POE.

12. Pull casing to 42 feet from POE, cut off stick-up, discard and insert foam borehole plug to 42 feet from POE to stop bentonite.

13. Insert grout tremie pipe to 35 feet from POE and plug end with approximately 7 feet of #16-sized granular bentonite. Remove tremie pipe and rinse.

14. Pull casing to 25 feet from POE, cut off stick-up and discard.

15. Insert 25-foot MP to 25 feet from POE.

16. Pull remaining casing out of hole and discard.

17. Ensure steel well cover is in place.

18. Grout steel well cover in-place to 5 feet from POE.

19. Install check valves on each MP and metal labels on each point with depth indicated.

20. Allow at least 24 hours for grout to cure before sampling.

The SVMP details will be documented in field notebooks.

ATTACHMENT E – AQUIFER TESTING & FATE AND TRANSPORT

1.1 Aquifer Testing and Fate and Transport

Aquifer testing will be performed at the Red Hill Shaft (RHS) and monitored at various wells in the vicinity. The University of Hawaii (UH) will review relevant aquifer test data and in consultation with TEC Inc. (TEC), Naval Facilities Engineering Command (NAVFAC), Honolulu Board of Water Supply (BOWS), and the Commission of Water Resources Management (CWRM) of the Department of Natural Resources (DLNR) provide technical specifications for performing the aquifer tests. The information listed below contains the general process for completing the physical testing. All information will be recorded on forms (as appropriate) found in Appendix H of the original HSAP (TEC 2005), or in field log books.

1.2 Personnel Required For Pump Test Activities.

TEC will be the main contractor coordinating pump test activities. TEC will utilize a field crew consisting of staff and senior level geologists to set up monitoring equipment, take measurements and communicate with the project manager. The project manager will coordinate pumping efforts between the pumping station operators and field crew. The project manager will also coordinate information required to run the pump test successfully, as provided from UH researchers. A preliminary listing of staff is listed below:

- Jeff Hart, TEC Project Manager
- Bob Whittier, TEC Hydrogeologist
- Nicole Griffin, TEC Geologist
- Shawn MacMillan, TEC Geologist
- Paul Eyre, PWC Hydrogeologist
- Chester Lau, BOWS Hydrogeologist
- Kolja Rotzoll, UH Hydrogeologist

1.3 Equipment Required for Pump Tests

The aquifer testing will be accomplished by pumping from the RHS well 2254-01, and possibly other wells. Water discharge will go directly into the storage system of the respective water distribution systems. No additional pumps or storage equipment will be required. TEC will provide water level monitoring equipment (data loggers and water level meters) for the pumping and observations wells. Equipment and its use is listed below.

Recording Water Level Elevations in Monitoring Wells. Water level elevations will be monitored with pressure recording data loggers. Prior to deployment of the data loggers they will be calibrated by challenging the data logger output against know depths of submersion of the data logger sensor. This will be done at a minimum of five points with the data logger secured so that the distance between the sensor and the measurement datum does not change during the test. If the data loggers have been in storage for a prolonged period, the sensor portion of the data loggers should be submerged in water for two to three days to recondition the sensing element. The water level in the reconditioning container should be changed frequently to exercise the sensing element.

Data Loggers. It is important that during the data logger recording period, the distance between the data logger pressure sensor and the measurement datum does not change. For these tests, the measurement datum will be the top of casing (TOC) of the well. Two approaches can be taken depending on the geometry of the well.

The first approach is used in wells that are screened at the water table and only penetrate the aquifer a short distance (as is the case in most environmental monitoring wells). The distance between the TOC and the bottom of the screen will be measured accurately. The data logger pressure sensor will be attached to stainless rod with the pressure sensing element a measured distance from the bottom of the screen (0.05 ft has been used in previous installations). The rod will have centralizers to keep the assembly approximate in the center of the well bore. This will prevent the assembly from hanging up on the screen should the data logger be removed to download data (which will be the case if the total depth of the well is greater than the length of the data logger cable). Enough line will be attached to supporting rod to reach to the top of the well. This line will attached to the well cap so the vapor cap can seal the well from atmospheric pressure changes. One-eight inch braided nylon cord provides a strong but light cord for deploying and retrieving the data logger. Care must be taken to ensure that cord length is not too long as this result in it becoming entangled in when a water level indicator is lowered to do measure the initial water level to synchronize the data logger depths to actual depths. The starting data logger recorded water level will be calculated using the following formula:

WLdl = TOCelev-DTW

Where:

WLdl = Water level elevation (ft msl)
TOCelev = The elevation of the top of well casing (ft msl)

Also:

WLdl = DLdpth+DLfctr

Where:

DLdpth = water depth measured by the data logger
DLfctr = a correction factor added to DLdpth to make the sum equal to WLdl

Also DLfctr should be very close to the follow formula:

DLfctr = TOC-TD+DLdpth+0.05 ft

Where:

TD = the distance between the TOC and bottom of the well screen.

The DLfctr will be added to all depths recorded by the data logger to convert depth to water level elevation.

In wells where the distance from the water surface to the bottom of the well exceeds the length of data logger cable (thus submerging the connector and damaging the data logger) the data logger must be suspended in the water column. In this case the data logger will again be attached to a rod with centralizers, but the line to the top of well will consisted of 3/32 stainless steel cable. This limits errors induced into the water level calculations due to cable stretching after data logger deployment to negligible values.

All data loggers should be installed about a week before the pumping test to ensure proper operation and to measure background changes in water levels due to factors such as barometric pressure changes, tidal fluctuations, and pumping from wells other than the wells under test. This will require downloading and analyzing the background data before the performing the pumping test. If possible an air tight cap will be placed on the wells with data loggers to minimize the effect that barometric pressure changes will have on the water level in the well.

Manual Measurements. To ensure capture of data in the event of an equipment malfunction, and to capture data from wells that do not have data loggers installed, a depth from the top of the well casing to the water table will be measured manually. This will be done by lowering the cable of an electronic WLI until the audio and visual indicators signify that the WLI probe has reached the water. The water-level measurement will be read to the nearest 0.01 ft. Total depth (TD) will not be measured to prevent the WLI cable from becoming entangled with the dedicated pump installed in each well.

1.4 Attain Equilibrium Conditions

The pump test will most likely be run under conditions negotiated during the Pre-test Design and Modeling. It is likely that conditions may include the following: pumps shut off/equilibrium, from a designated pumping rate, etc. To achieve these conditions, the following may be done: a shut down of the pumps, reduction of pumping rate, reduction of water storage in systems, water level monitoring, etc. The days/hours required to achieve this will be calculated prior to field activities.

1.5 Step Test

A step test would be done to observe the efficiency of the wells, predict the response of the aquifer, and test/correct operation of the equipment. The step test would occur after attaining equilibrium conditions. Utilizing agreed-upon rates determined during Pre-test Design and Modeling, the step test would start at the lowest rate and move to the highest rate, with each rate being performed for a designated number of hours. Rebound would be monitored for a designated number hours or until a certain percent recovery is achieved. The time requirements and/or percent recovery will be calculated prior to field activities.

1.6 Aquifer Test

Utilizing information obtained from Pre-test Design and Modeling, as well as the step test, the aquifer test will be conducted for a designated amount of time after the step test or when equilibrium conditions have been achieved again. In order to initiate the aquifer test, the TEC project manager will coordinate the field staff and pump station personnel to ensure the precise rate and time of commencement for the pump test. The TEC project manager will also ensure that optimum conditions are present (i.e., optimum water levels are present in the storage system, the pumps are capable of running at the rate and duration required, the monitoring equipment is correctly setup and operable, and staff are prepared). The days/hours required to perform the aquifer test will be calculated prior to field activities.

Table E-1 Aquifer Test Monitoring Points

Well	Elevation (ft msl) (TOC)	DTW (ft)	TD (ft)	Dist. From (2254-001) (ft)	Monitored during pumping of	Method of Monitoring
Red Hill Navy[(1)] Pumping Station (2254-001)	105.76 (shaft entrance)	88	210	NA	2254-001 & 2354-001	Data Logger
Halawa Shaft (HS) (2354-001)	165 (shaft entrance)	NA	183	4,070	2254-001 & 2354-001	Manual
RHMW01[(1)]	102.51	88	100	2,498	2254-001 & 2354-001	Data Logger
RHMW02[(1)]	106.57	88	103	3,090	2254-001	Manual
RHMW03[(1)]	122.11	103	118	3,878	2254-001 & 2354-001	Data Logger
RHMW04[(1)]	313.03	293	320	5,090	2254-001 & 2354-001	Data Logger
OWDFMW1[(1)]	138.94	120		573	2254-001 & 2354-001	Manual
OWDFMW2[(1)]	119.35	101		827	2254-001 & 2354-001	Data Logger
Halawa Deep Monitoring Well (2253-003)	225	210	1575	3,700	2254-001 & 2354-001	Data logger by the CWRM
Mont. Well near TAMC	*170*	*150*	*180*	4,500	2254-001	Data logger
2254-02	200	176	210	300	2254-001	Data logger

Notes:
DTW = Distance to water (ft)
TD = Total depth of well
msl = Mean sea level
170 = Probable elevations
TOC = Top of Casing
[(1)] = Closed loop survey conducted on March 21,22, 2006 (Central Point Survey, Inc.)

Red Hill Bulk Fuel Storage Facility
Final - Quality Assurance Project Plan (QAPP) Addendum
Tables A1-2 through A5-1

Pearl Harbor, Hawaii

May 2006

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
Pearl Harbor, HI 96860-3134

NAVFAC
Naval Facilities Engineering Command
NAVFAC PACIFIC

Indefinite Delivery/ Indefinite Quantity Contract

Contract Number N62742-02-D-1802, CTO 007

Red Hill Bulk Fuel Storage Facility Final - Quality Assurance Project Plan (QAPP) Tables A1-2 through A5-1

Pearl Harbor, Hawaii

May 2006

Prepared for:

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite #100
Pearl Harbor, HI 96860-3134

Prepared by:

TEC Inc.
1001 Bishop Street,
American Savings Bank Tower, Suite 1400
Honolulu, Hawaii 96813

Prepared under:

Indefinite Delivery/ Indefinite Quantity Contract
Contract Number N62742-02-D-1802, CTO 007

QAPP Addendum Tables

Table A1-2
Summary of Analytical Program for Groundwater Samples
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Sample Description	Sample Type	Matrix	TPH-DRO 8015B	TPH-GRO 8015B	VOCs 8260B	SVOC's 8270C SIM	Total Lead 6010B	Tetraethyl Pb ASTM D3341 87M	Dissolved Pb 6010B	Alkalinity E310.1	Methane RSK-175	Silica, Dissolved EPA370.1/ SM19 4500SID	Anions[1] E300	Cations[2] 6010B	Field Measurements: Ferrous Iron	Field Measurements: Dissolved Oxygen	Field Measurements: Carbon Dioxide	Comments
RHMW01	N	WG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
RHMW02	N	WG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
RHMW03	N	WG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
RHMW04	N	WG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
RHMW225401	N	WG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Totals - Environmental samples			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
QC Samples*																		
Duplicates (RHGWA01)	FD	WQ	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	FD (RHMW02)
Trip Blanks**	TB	WQ	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
MS/MSD	MS/SD	WQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Equipment Blanks	EB	WQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Total QC samples			1	1	2	1	1	1	1	1	1	1	1	1	0	0	0	
Grand Total			6	6	7	6	6	6	6	6	6	6	6	6	5	5	5	

Notes

N	Normal Sample	EB	Equipment Blank	RHGWA01 = (Duplicate Designation) Red Hill, Groundwater, Duplicate, Sequential Number
FD	Field Duplicate	WG	Groundwater	
TB	Trip blank	WQ	Water Quality Sample	
Pb	Lead			

1 = Anions by Method E300 include Phosphate, Nitrate, Sulfate, Chloride, and Fluoride
2 = Cations by Method SW846 6010B include Sodium Magnesium, Calcium, Potassium, and Strontium
* Number of QC samples are estimated
**One trip blank per cooler containing VOCs Amount is estimated

Table A1-3
Summary of Analytical Program for Soil Vapor Samples
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Sample Description	Sample Type	Matrix	VOCs TO-3*	Comments
RHSV01-25	N	GS	1	
RHSV01-45	N	GS	1	
RHSV01-80	N	GS	1	
RHSV02-25	N	GS	1	
RHSV02-45	N	GS	1	
RHSV02-80	N	GS	1	
RHSV12-25	N	GS	1	
RHSV12-45	N	GS	1	
RHSV12-80	N	GS	1	
RHSV13-25	N	GS	1	
RHSV13-45	N	GS	1	
RHSV13-80	N	GS	1	
RHSV17-25	N	GS	1	
RHSV17-45	N	GS	1	
RHSV17-80	N	GS	1	
RHSV19-25	N	GS	1	
RHSV19-45	N	GS	1	
RHSV19-80	N	GS	1	
RHSV20-25	N	GS	1	
RHSV20-45	N	GS	1	
RHSV20-80	N	GS	1	
Totals - Environmental samples			21	
QC Samples (estimated numbers)				
Duplicates	FD	AQ	2	RHSV21-0
Trip Blanks	TB	WQ	-	
MS/MSD	MS/SD	AQ	-	
Equipment Blanks	EB	WQ	-	
Totals - QC samples			2	
Grand Total			23	

N Normal Sample
GS Soil Gas
FD Field Duplicate
TB Trip blank
MS/MSD
EB
AQ
WQ
*With Naphthalene

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Reporting Limits and EALs for Method SW8015B
Volatile and Extractable Total Petroleum Hydrocarbons (TPH)

Analyte	Water Reporting Limit		EAL - Drinking Water Final Action Level (ug/L)	EAL - Groundwater Final Ceiling Level (ug/L)	EAL - Groundwater to Indoor Air Low/Moderate Permeability (ug/L)
	RL	Unit			
Gasoline	0.1	mg/L	100	100	(Use soil gas)
Diesel	1	mg/L	100	100	
Jet Fuel (Jet A, JP-4, JP-8)	1	mg/L	100	100	

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Reporting Limits and EALs for Method SW8260B Volatile Organics

Analyte	Water Reporting Limit		EAL - Drinking Water Final Action Level (ug/L)	EAL - Groundwater Final Ceiling Level (ug/L)	EAL - Groundwater to Indoor Air Low/Moderate Permeability (ug/L)
	RL	Unit			
1,1,1,2-Tetrachloroethane	0.5	µg/L	0.431005398	50000	(Use soil gas)
1,1,1-TCA	1	µg/L	200	970	1330000
1,1,2,2-Tetrachloroethane	0.5	µg/L	0.056030702	500	246.0307555
1,1,2-TCA	1	µg/L	5	50000	632.9079709
1,1-DCA	1	µg/L	798.4375	50000	948022.452
1,1-DCE	1	µg/L	7	1500	105339.4428
1,1-Dichloropropene	1	µg/L	0.395510836	50000	619.7351072
1,2,3-Trichlorobenzene	1	µg/L			
1,2,3-Trichloropropane	1	µg/L			
1,2,4-Trichlorobenzene	1	µg/L	70	3000	18043.36313
1,2,4-Trimethylbenzene	1	µg/L			
1,2-DCA	0.5	µg/L	0.123144399	7000	324.2467239
1,2-DCB	1	µg/L	0.00560307	50000	25.10158025
1,2-Dibromo-3-chloropropane	2	µg/L	0.04	10	(Use soil gas)
1,2-Dichloropropane	1	µg/L	5	10	360.7266883
1,2-Dibromoethane (EDB)	1	µg/L	0.00560307	50000	25.10158025
1,3,5-Trimethylbenzene	1	µg/L			
1,3-DCB	1	µg/L	182.5	50000	(Use soil gas)
1,3-Dichloropropane	0.4	µg/L			
1,4-DCB	0.5	µg/L	75	5	1391.59028
1-Chlorohexane	1	µg/L			
2,2-Dichloropropane	1	µg/L			
2-Chlorotoluene	1	µg/L			
4-Chlorotoluene	1	µg/L			
Acetone	10	µg/L	5475	20000	281250060.4
Benzene	0.4	µg/L	5	170	5653.750291
Bromobenzene	1	µg/L			
Bromochloromethane	1	µg/L			
Bromodichloromethane	0.5	µg/L	0.180744199	50000	509.8753841
Bromoform	1	µg/L	100	510	
Bromomethane	3	µg/L	8.516666667	50000	8007.323929
Carbon tetrachloride	1	µg/L	5	520	88.60322709

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Chlorobenzene	0.5	µg/L	100	50	168152.8788
Chloroethane	1	µg/L	3.864186328	16	2578.467839
Chloroform	0.3	µg/L	100	2400	211.0949543
Chloromethane	1	µg/L	158.1666667	50000	41517.76778
cis-1,2-DCE	1	µg/L	70	50000	77348.5103
cis-1,3-Dichloropropene	0.5	µg/L	0.395510836	50000	619.7351072
Dibromochloromethane	0.5	µg/L	0.133406433	50000	372.1063516
Dibromomethane	1	µg/L			
Dichlorodifluoromethane	1	µg/L			
Ethylbenzene	1	µg/L	700	30	169000
Hexachlorobutadiene	0.6	µg/L	0.862010796	6	
Isopropylbenzene	1	µg/L			
Methylene chloride	1	µg/L	4.337860781	9100	12417.3004
Methyl t-butyl ether (MTBE)	5	µg/L	10.58847907	5	37699.82926
MEK (2-Butanone)	10	µg/L	6968.181818	8400	268000000
MIBK (methyl isobutyl ketone)	10	µg/L	1993.015873	1300	19000000
n-Butylbenzene	1	µg/L			
n-Propylbenzene	1	µg/L			
m,p-Xylene	2	µg/L	10000	20	161000
Naphthalene	1	µg/L	6.224469562	21	31000
o-Xylene	1	µg/L	10000	20	161000
p-Isopropyltoluene	1	µg/L			
sec-Butylbenzene	1	µg/L			
Styrene	1	µg/L	100	10	310000
TCE	1	µg/L	5	170	402.2093393
tert-Butylbenzene	1	µg/L			
Tetrachloroethene	1	µg/L	5	170	402.2093393
Toluene	1	µg/L	1000	40	526000
trans-1,2-DCE	1	µg/L	100	260	96961.00231
trans-1,3-Dichloropropene	1	µg/L	0.395510836	50000	619.7351072
Trichlorofluoromethane	1	µg/L			
Vinyl chloride	1	µg/L	2	3400	98.79099838

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Reporting Limits and EALs for Method SW8270C

Semivolatile Organics

Analyte	Water Reporting Limit		EAL - Drinking Water Final Action Level (ug/L)	EAL - Groundwater Final Ceiling Level (ug/L)	EAL - Groundwater to Indoor Air Low/Moderate Permeability (ug/L)
	RL	Unit			
Base/Neutral Extractables					
1,2,4-Trichlorobenzene	10	µg/L	7.0E+01	3.0E+03	1.8E+04
1,2-DCB	10	µg/L	6.0E+02	1.0E+01	1.6E+05
1,3-DCB	10	µg/L	1.8E+02	5.0E+04	(Use soil gas)
1,4-DCB	10	µg/L	7.5E+01	5.0E+00	1.4E+03
2,4-DNT	10	µg/L	3.4E+01	5.0E+04	
2,6-DNT	10	µg/L			
2-Chloronaphthalene	10	µg/L			
2-Methylnaphthalene	10	µg/L	2.4E+02	1.0E+01	2.6E+04
2-Nitroaniline	50	µg/L			
3-Nitroaniline	50	µg/L			
3,3'-Dichlorobenzidine	20	µg/L	1.5E-01	1.6E+03	
4-Bromophenyl phenyl ether	10	µg/L			
4-Chloroaniline	20	µg/L			
4-Chlorophenyl phenyl ether	10	µg/L			
4-Nitroaniline	50	µg/L			
Acenaphthylene	10	µg/L	2.4E+02	2.0E+03	(Use soil gas)
Acenapthene	10	µg/L	3.7E+02	2.0E+01	4.2E+03
Anthracene	10	µg/L	1.8E+03	2.2E+01	4.3E+01
Benzo(a)anthracene	10	µg/L	9.2E-02	5.0E+00	
Benzo(a)pyrene	10	µg/L	2.0E-01	1.9E+00	
Benzo(k)fluoranthene	10	µg/L	9.2E-01	4.0E-01	
Benzo(b)fluoranthene	10	µg/L	9.2E-02	7.0E+00	
Benzo(g,h,i)perylene	10	µg/L	1.5E+03	1.3E-01	
Benzyl alcohol	20	µg/L			
Bis(2-chloroethoxy)methane	10	µg/L			
Bis(2-chloroethyl) ether	10	µg/L	9.5E-03	3.6E+02	1.4E+02
Bis(2-chloroisopropyl) ether	10	µg/L	2.7E-01	3.2E+02	(Use soil gas)
Bis(2-ethylhexyl) phthalate	10	µg/L	6.0E+00	6.5E+02	
Butyl benzyl phthalate	10	µg/L			
Chrysene	10	µg/L	9.2E+00	8.0E-01	(Use soil gas)
Di-n-butyl phthalate	10	µg/L			
Di-n-octyl phthalate	10	µg/L			

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Dibenzo(a,h)anthracene	10	µg/L	9.2E-03	2.5E-01	
Dibenzofuran	10	µg/L			
Diethyl phthalate	10	µg/L	2.9E+04	5.0E+04	
Dimethyl phthalate	10	µg/L	3.7E+05	5.0E+04	
Fluoranthene	10	µg/L	1.5E+03	1.3E+02	
Fluorene	10	µg/L	2.4E+02	9.5E+02	1.9E+03
Hexachlorobenzene	10	µg/L	1.0E+00	5.5E+01	
Hexachlorobutadiene	10	µg/L	8.6E-01	6.0E+00	
Hexachloroethane	10	µg/L	4.8E+00	1.0E+01	
Indeno(1,2,3-cd)pyrene	10	µg/L	9.2E-02	2.7E-01	
Isophorone	10	µg/L			
N-Nitrosodiphenylamine	10	µg/L			
N-Nitrosodi-n-propylamine	10	µg/L			
Naphthalene	10	µg/L	6.2E+00	2.1E+01	3.1E+04
Nitrobenzene	10	µg/L			
Phenanthrene	10	µg/L	2.4E+02	4.1E+02	(Use soil gas)
Pyrene	10	µg/L	1.8E+02	6.8E+01	1.4E+02
Acid Extractables					
2,4,5-Trichlorophenol	50	µg/L	6.1E+02	2.0E+02	1.2E+06
2,4,6-Trichlorophenol	10	µg/L	3.7E+00	1.0E+02	
2,4-Dichlorophenol	10	µg/L	1.1E+02	3.0E-01	
2,4-Dimethylphenol	10	µg/L	7.3E+02	4.0E+02	
2,4-Dinitrophenol	50	µg/L	7.3E+01	5.0E+04	
2-Chlorophenol	10	µg/L	3.0E+01	1.8E-01	6.3E+04
2-Methylphenol	10	µg/L			
2-Nitrophenol	10	µg/L			
4,6-Dinitro-2-methylphenol	50	µg/L			
4-Chloro-3-methylphenol	20	µg/L			
4-Methylphenol	50	µg/L			
4-Nitrophenol	50	µg/L			
Benzoic acid	100	µg/L			
Pentachlorophenol	50	µg/L	1.0E+00	3.0E+01	
Phenol	10	µg/L	1.1E+04	5.0E+00	

Table A2-1
Laboratory Reporting Limits and EALs
Red Hill Bulk Fuel Storage Facility
Pearl Harbor, Hawaii

Reporting Limits and EALs for Method SW6010B

	Water Reporting Limit				
Analyte	RL	Unit	EAL - Drinking Water Final Action Level (ug/L)	EAL - Groundwater Final Ceiling Level (ug/L)	EAL - Groundwater to Indoor Air Low/Moderate Permeability (ug/L)
Lead	0.025	mg/L	15	50000	

Reporting Limits and EALs for Method TO-3

	Water Reporting Limit		
Analyte	RL	Unit	EAL - Soil Gas to Indoor Air Lowest Comm/Ind (ug/m^3)
Benzene	0.001	ug/m^3	0.33
Ethylbenzene	0.001	ug/m^3	683
Toluene	0.001	ug/m^3	298
Xylenes	0.001	ug/m^3	68
TPH-GRO (Assume MW=100)	0.025	ug/m^3	35
Naphthalene		ug/m^3	1.7

TABLE A2-2
Sensitivity Goals
Red Hill Bulk Storage Facility

Method	Analyte	Groundwater (mg/L)	Solid (mg/Kg)
SW-8468260B[1]	Benzene	0.005	0 05
	Toluene	1 0	16
	Ethylbenzene	0 14	0.50
	Xylene	10	23
	MTBE	0 02	0 05
SW-846 8310 or SW-846 8270SIM[1]	Benzo(a)pyrene	0 0002	1 0
	Acenaphthene	0 32	18
	Fluoranthene	0.013	11
	Naphthalene	0 24	41
SW-846 6010B[1]	Lead (total)	0 0056	400
SW-846 8015[1]	Gasolıne-range organics	NS	5000
	Diesel-range organics	NS	2000
ASTM D3341[2]	Tetraethyl lead	0 010	2.0

NS No standard.

[1] Hawaii Administrative Rules, Underground Storage Tanks, Department of Health, Title 11, Chapter 281, and MTBE DOH UST Policy Update dated Oct 16, 1998

[2] ASTM D3311, Standard Method for Lead in Gasoline- Iodine Monochlorine Method, ASTM International.

TABLE A4-1
Sample Containers, Preservatives, and Holding Times
Red Hill Bulk Storage Facility

Analysis	Method	Container[1]	Preservative	Holding Time
Solid				
GRO	8015B	4 or 9 oz Glass Jar[2]	Cool to 4°C	14 days
DRO	8015B	4 or 9 oz Glass Jar[2]	Cool to 4°C	14/40 days[3]
BTEX/MTBE	8260B	4 or 9 oz Glass Jar[2]	Cool to 4°C	14 days
PAH	8310 or 8270 SIM	4 or 9 oz Glass Jar[2]	Cool to 4°C	14/40 days[3]
Lead	6010B	4 or 9 oz Glass Jar[2]	Cool to 4°C	6 months
Tetraethyl Lead	ASTM D3341	4 or 9 oz Glass Jar[2]	Cool to 4°C	NS
Water Samples				
GRO	8015B	3 – 40 mL Glass Vials, no headspace	HCl to pH<2, cool to 4°C	14 Days
DRO	8015B	2 – 1 L Amber Glass Bottles	HCl to pH<2, cool to 4°C	14/40 days[3]
BTEX/MTBE	8260B	3 – 40 mL Glass Vials, no headspace	HCl to pH<2, cool to 4°C	14 Days
PAH	8310	2 – 1 L Amber Glass Bottles	Cool to 4°C	7/40 days[3]
	8270 SIM	2 – 1 L Amber Glass Bottles		
Total Lead	6010B	1 – 250 or 500 mL HDPE	HNO_3 to pH<2, cool to 4°C	6 months
Dissolved Lead		1 – 250 or 500 mL HDPE, field filtered		
Tetraethyl Lead	ASTM D3341	1 - 250 mL HDPE	Cool to 4°C	NS

BTEX Benzene, Toluene, Ethylbenzene, Xylenes
DRO Diesel-range organics
GRO Gasoline-range organics
MTBE Methyl tert-butyl ether
NS Not specified
PAH Polynuclear aromatic hydrocarbons

Notes
1 Double sample volume collected for MS/MSD
2 Multiple tests may be performed from the sample 4 or 9 oz Jar, so a jar is not needed for each individual test.
3 Number of days from collection until extraction/number of days from time of extraction until analysis

TABLE A5-1
Laboratory Quality Control Samples
Red Hill Bulk Storage Facility

Method	Method Blanks[1]	Duplicate Analyses[1,2]	MS[1]	LCS[1] (Blank Spike)	Surrogate	Initial Calibration	Initial Calibration Verification	Continuing Calibration Standard
GRO	1/Batch	1/Batch	1/Batch	1/Batch	All Samples	5-point	1/curve	Every 10 samples
DRO	1/Batch	1/Batch	1/Batch	1/Batch	All Samples	5-point	1/curve	Every 10 samples
BTEX/MTBE	1/Batch	1/Batch	1/Batch	1/Batch	All Samples	5-point	1/curve	Every 12 hours
PAH	1/Batch	1/Batch	1/Batch	1/Batch	All Samples	5-point	1/curve	Every 12 hours
Lead	1/Batch	1/Batch	1/Batch	1/Batch	NA	Instrument Specific	1/curve	Every 10 samples
Tetraethyl Lead	1/Batch	1/Batch	1/Batch	1/Batch	NA	Instrument Specific	1/curve	Every 10 samples

[1] Batch is equivalent to 20, or fewer, samples prepared and anlyzed together with common QC samples.
[2] Duplicate analyses might be laboratory duplicates, LCS/LCSD, and/or MS/MSD.

BTEX Benzene, Toluene, Ethylbenzene, Xylenes
DRO Diesel-range organics
GRO Gasoline-range organics
LCS Laboratory control sample
MS Matrix spike
MTBE Methyl tert-butyl ether
NA Not Applicable
PAH Polynuclear aromatic hydrocarbons

Red Hill Bulk Fuel Storage Facility
Final - Health and Safety Plan Addendum
Pearl Harbor, Hawaii

May 2006

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
Pearl Harbor, HI 96860-3134

NAVFAC
Naval Facilities Engineering Command
NAVFAC PACIFIC

Indefinite Delivery/ Indefinite Quantity Contract
Contract Number N62742-02-D-1802, CTO 007

Red Hill Bulk Fuel Storage Facility
Final - Health and Safety Plan Addendum
Pearl Harbor, Hawaii

May 2006

Prepared for:

NAVFAC
Naval Facilities Engineering Command
NAVFAC PACIFIC

Department of the Navy
Commander
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite #100
Pearl Harbor, HI 96860-3134

Prepared by:

TEC Inc.
1001 Bishop Street,
American Savings Bank Tower, Suite 1400
Honolulu, Hawaii 96813

Prepared under:

Indefinite Delivery/ Indefinite Quantity Contract
Contract Number N62742-02-D-1802, CTO 007

FINAL HEALTH AND SAFETY PLAN ADDENDUM
US NAVY FLEET AND INDUSTRIAL SUPPLY CENTER
RED HILL BULK FUEL STORAGE FACILITY
OAHU, HAWAII

Prepared for:

Department of the Navy, Commander
Naval Facilities Engineering Command Pacific
Environmental Contracts Division
Pearl Harbor, Hawaii 96860-3134

REVIEW AND APPROVALS:

Prepared by:

____

Onsite Health and Safety Coordinator:

____

Date: ______________

Approved by: ______________________________

TEC Health and Safety Manager

____

Date: ______________

Corporate Health and Safety Manager

____

Date: ______________

TEC Project Manager: ______________________________

Date: ______________

This Site-specific Health and Safety Plan has been developed in accordance with OSHA 29 CFR 1910.120.

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SUMMARY OF EMERGENCY INFORMATION

Emergency Phone Numbers

Ambulance (Honolulu)	911
Fire Department	911
Police Department	911
Poison Control Center	(808) 941-4411
Civil Defense (Honolulu)	(808) 523-4121
Jeff Hart (TEC PM)	(808) 528-1445
Karl Bromwell (TEC HSM)	(808) 528-1445
Glenn Yoshinaga (NAVFAC Pacific PM)	(808) 472-1416
Victor Peters CIV FISC (Red Hill Health & Safety)	(808) 473-2690

*Additional numbers in Sections 1.1 and 7.11.

Hospital Information

CIVILIAN HOSPITAL	
Name:	Kaiser Permanente Medical Center, Moanalua
Telephone:	834-5333
Address:	3288 Moanalua Road
Directions:	Exit and turn right onto Ala Kapuna Street. Use the east onramp to the Moanalua Fwy. (#78) as if you were heading back to Honolulu town. Take the Puuloa Road Exit and turn left at the stop light. Use the on-ramp to your left to get back onto the Moanalua Fwy. going west and take the first exit, Moanalua Road. Follow the blue Hospital signs, the hospital will be on your right. **Directions are included with Figure 3.**

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LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Government Industrial Hygienists
AMEC	AMEC Earth and Environmental, Inc.
ANSI	American National Standards Institute
CD	Civil Defense
CFR	Code of Federal Regulations
CHRIS	Chemical Hazard Response Information System
CIH	Certified Industrial Hygienist
CLEAN	Comprehensive Long-Term Environmental Action Navy
COR	Condition of Readiness
CPR	Cardio-Pulmonary Resuscitation
CRZ	Contamination Reduction Zone
CSIR	Contractor Significant Incident Report
CTO	Contract Task Order
dBA	Decibels (A-weighted scale)
DI	Deionized (water)
DOT	Department of Transportation
EAP	Emergency Action Plan
EC	Emergency Coordinator
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
ESA	Emergency Services Account (PWC)
eV	Electronvolt
EZ	Exclusion Zone
FISC	Fleet Industrial Supply Center
FM	Field Manager
FP	Field Procedure
ft	Feet
GFCI	Ground Fault Circuit Interrupter
GIS	Geographic Information System
H&S	Health and Safety
HazCom	Hazard Communication
HAZWOPER	Hazardous Waste Operations and Emergency Response
HBV	Hepatitis B Virus
HEPA	High Efficiency Particulate Airfilter
HIV	Human Immunodeficiency Virus (AIDS)
HMIS	Hazardous Materials Information System
HSM	Health and Safety Manager
HSMP	Health and Safety Management Plan
HSP	Health and Safety Plan
IDLH	Immediately Dangerous to Life and Health
IDW	Investigative-Derived Waste
IP	Ionization Potential (eV)
LCDR	Lieutenant Commander
LEL	Lower Explosive Limit
mgal	Million Gallons
MOGAS	Motor Gasoline

mph	miles per hour
MSDS	Material Safety Data Sheet
NAVFAC	Naval Facilities
NE	None Established
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OHSC	Onsite Health and Safety Coordinator
OSHA	Occupational Safety and Health Administration
OV/AG	Organic Vapor/Acid Gas
PAO	Public Affairs Officer (Navy)
PEL	Permissible Exposure Level (OSHA)
PID	Photoionization Detector
PM	Project Manager
PMO	Program Management Organization
POC	Point of Contact
PPE	Personal Protective Equipment
ppm	parts per million
PWC	Public Works Center (Navy)
QA/QC	Quality Assurance/Quality Control
RHBFSF	Red Hill Bulk Fuel Storage Facility
ROC	Record of Change (HSP)
RPM	Remedial Project Manager (formerly EIC)
SARA	Superfund Amendments and Reauthorization Act
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SOW	Scope of Work
STEL	Short Term Exposure Limit
SZ/CZ	Support Zone/Clean Zone
TBD	To Be Determined
TEC	TEC Inc.
TLV	Threshold Limit Value (ACGIH)
TWA	Time Weighted Average
TZ	Transition Zone
UEL	Upper Explosive Limit
UST	Underground Storage Tank
VWD	Valley Well Drilling

1.0 INTRODUCTION

This site-specific Health and Safety Plan (HSP) Addendum has been prepared by TEC Inc. (TEC) for Naval Facilities (NAVFAC) Pacific under Contract N62742-02-D-1802, Task Order 0007. It has been prepared under Contract No. N62742-02-D-1802, Amendment 6, Revision 3 Dated 12 October 2005 for Contract Task Order 007 (CTO 007).The project consists of a Site Investigation and Risk Assessment at the Red Hill Bulk Fuel Storage Facility, herein referred to as RHBFSF, operated by the Fleet and Industrial Supply Center, (FISC), Pearl Harbor, Hawaii.

This HSP Addendum has been prepared to perform site activities regulated by 29 Code of Federal Regulations (CFR) 1910.120. Work conducted at the site will be in conformance with this plan unless formally modified and approved via a Record of Change (ROC) form found in **Appendix 3**: Project Forms.

This addendum presents Phase II work activities. The following portions of the document that do not have significant changes from Phase I activities will be listed as "No Change" with a reference to the original document. Portions of the report that will change with Phase II activities will have the changes listed.

1.1 Background/Site History

No Change. Please refer to Section 1.1 of the original HSP (TEC 2005).

1.2 Site Description

No Change. Please refer to Section 1.2 of the original HSP (TEC 2005).

1.3 Scope of Work/Planned Site Activities

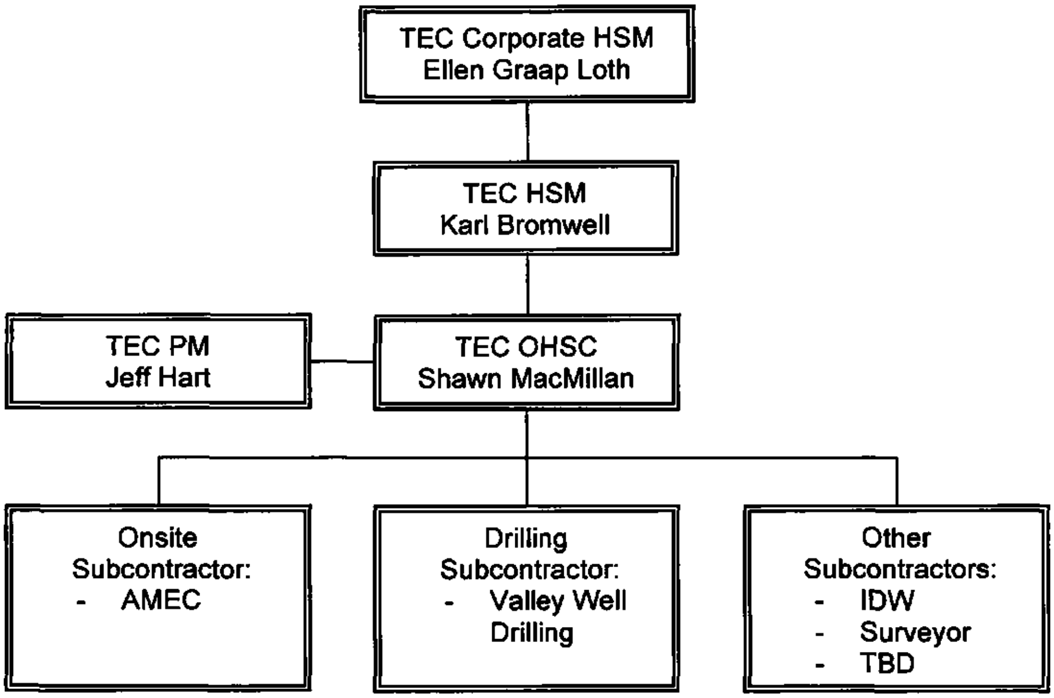
The objectives of Phase II is to complete the following tasks:

- Install dedicated sampling pumps and water-level read-out equipment in the wells.
- Install additional soil vapor monitoring points (SVMPs)
- Sample SVMPs
- Continue groundwater monitoring (water levels, and sampling)
- Conduct a closed-loop survey of sample points.
- Conduct aquifer tests
- Continue with data compilation and reporting tasks (fate and transport modeling, database and reporting tasks).

Field duration for Phase 2 is undetermined at this time. TEC is the prime subcontractor, and will coordinate necessary subcontractors, as required.

1.4 General Information, Key Personnel and Responsibilities

SITE INFORMATION	
Contract Task Order (CTO) Number:	007
Site Name:	RHBFSF
Location:	Red Hill, Oahu, Hawaii
Contact Number:	Lee Uyeda (808) 473-7830 (Pass and I.D.) Sgt Grey (808) 471-4798 (Firing Range Supervisor)
CLIENT INFORMATION	
Navy Remedial Project Manager (RPM):	Glenn Yoshinaga, NAVFAC Pacific
Contact Number:	(808) 472-1416
Activity Contact:	Victor Peters CIV FISC
Contact Number:	(808) 473-2690
Safety Officer:	Victor Peters CIV FISC
Contact Number:	(808) 473-2690
PRIME CONTRACTOR INFORMATION	
TEC Corporate H&S Manager.	Ellen Graap Loth
Contact Number	Tel (434) 295-4446 Fax (434) 295-5355
TEC Program H&S Manager:	Karl Bromwell, M.P.H.
Contact Number:	(808) 528-1445
TEC OHSC:	Shawn MacMillan
Contact Number:	(808) 528-1445
TEC PM Manager:	Jeff Hart
Contact Number:	(808) 528-1445
SUBCONTRACTOR INFORMATION	
Valley Well	Mike Sober 682-1767
Additional Subcontractors	TBD


TEC Corporate HSM
Ellen Graap Loth
TEC HSM
Karl Bromwell
TEC PM
Jeff Hart
TEC OHSC
Shawn MacMillan
Onsite Subcontractor:
- AMEC
Drilling Subcontractor:
- Valley Well Drilling
Other Subcontractors:
- IDW
- Surveyor
- TBD

TEC Corporate Health and Safety Manager (TEC Corporate HSM) – Ellen Graap Loth, C.H.M.M.

Responsible for the general health and safety of all TEC employees and subcontractors. The TEC Corporate Health and Safety Manager is responsible for approving and ensuring implementation of the site HSP.

TEC Regional Health and Safety Manager (TEC HSM) – Karl Bromwell, M.P.H.

Responsible for the general health and safety of TEC employees and subcontractors for project within the region. The TEC Health and Safety Manager (TEC HSM) is responsible for approving and ensuring implementation and enforcement of the site HSP. The TEC HSM has the authority to stop work activities if conditions become hazardous. Duties include approving the Project Manager's selection of health and safety managers for job sites; coordinating with subcontractor health and safety personnel, conflict resolution that cannot be resolved in the field by the Onsite Health and Safety Coordinator.

Onsite Health and Safety Coordinator (OHSC) – Shawn MacMillan

Reports to the TEC HSM and has the responsibility and the authority to develop, implement, and verify compliance with the site HSP. The Onsite Health and Safety Coordinator (OHSC) advises the TEC PM on all matters related to health and safety and has the authority to stop all work if conditions are judged to be hazardous to onsite personnel or the public. The OHSC is responsible for verifying personnel training and medical certifications; regularly inspecting the site for hazardous conditions; and for assisting the Field Manager (FM) with accident and near-miss investigations. Duties include recordkeeping; establishing work zones, evacuation routes, and assembly areas; determining whether to maintain or modify levels of protection provided in the HSP based on site conditions and monitoring data; ensuring that protective clothing and equipment are properly selected, used, stored and maintained.

TEC Project Manager (TEC PM) – Jeff Hart, R.G.

Hires all subcontractors for the project and provides technical and Health and Safety (H&S) control for the project. Provides and supervises OHSC. He is responsible for review and approval of this HSP.

TEC Subcontractors

Subcontractors – Valley Well Drilling, and Others TBD

Subcontractors report to the FM and are required to comply with this HSP and to correct any unsafe acts/conditions that are identified by the OHSC and FM. Subcontractor's work practices must also conform to standard industry practices and OSHA regulations for their respective professions. Equipment operators are responsible for the pre-use certification, safe use, maintenance and daily inspection of their equipment. Subcontractors must not begin work at a site until an orientation of site hazards and precautionary measures is received by the OHSC and FM; the HSP has been reviewed and signed; and until job-related medical conditions or restrictions (e.g., allergies, diabetes, lifting restrictions, etc.) have been communicated to the OHSC.

Each subcontractor is responsible for participating in and enforcing the safety and loss prevention programs established for the project that will cover all work performed by them and their sub-subcontractors (if any). Each subcontractor shall designate a responsible member of its organization whose duties shall include loss and accident prevention and who shall have the responsibility and full authority to enforce the program. This person shall ensure that all Subcontractor and Sub-Subcontractor employees understand and comply with the safety programs. Subcontractor shall cooperate fully with TEC, other subcontractors, and all insurance carriers and loss prevention engineers on loss and accident prevention.

In order to maintain a safe work place for individuals working and visiting the project site, the following items establish the minimum Subcontractor responsibilities toward achieving the project safety goals. Each Subcontractor is responsible for the content listed in this policy:

1. Subcontractor shall perform all parts of its contract while assuming total responsibility for complying with all applicable federal, state, local and U.S. Army Corps of Engineers safety, health and environment standards, regulations, rules or guidelines.
2. Subcontractor shall maintain documentation at the project site and/or home office that verifies that its safety, health and environment program is on-going and is in current compliance with applicable federal, state, local, and project safety regulations, rules or guidelines. Documentation shall be made available upon request by TEC.
3. Subcontractor shall ensure that all places where members of the Project work force are directed or permitted to perform work shall be constructed, equipped, arranged, operated and conducted to provide reasonable and adequate protection to the safety and health of employees and others and protection of the environment.
4. Subcontractor shall not direct, or permit an employee to work under conditions that are not in compliance with or that are prohibited by any applicable federal, state, and local safety standards, regulations, rules or guidelines.

5. Subcontractor shall initiate and maintain an accident (injury and illness) prevention program for the duration of the project which shall include, but not be limited to, active participation by the Subcontractor's project managers, superintendents, office staff and foremen. Subcontractor shall be responsible for this program's implementation and continued compliance.
6. Subcontractor shall initiate and maintain a Safety, Health and Environment training program which shall include active participation by the Subcontractor's project managers, superintendents, office staff and foremen. Subcontractor shall be responsible for this program's implementation and continued compliance therewith.
7. Subcontractor shall provide initial safety orientations to new employees upon arrival to the job-site. At a minimum, orientations shall include training on principle safety hazards, personal protective equipment requirements, rules and limitations on equipment operations and what to do in case of injury or illness and location of medical station(s). Orientations shall also record each employee's required attendance at weekly (at least) "tool box" safety meetings and each employee's obligation to report observed or known unsafe conditions or practices to the employees' immediate supervisors and to TEC. (Depending on a Subcontractor's chain of command, a Subcontractor's employees shall report their safety findings to the next level of supervision or management).
8. Subcontractor Safety and Accident Prevention Representative shall investigate as a minimum all incidents resulting in personal injury and/or hospitalization as well as all incidences of property damage, fire and any third-party claim in an effort to determine the causes thereof. Subcontractor's follow-up in connection with such investigations shall consist of immediate corrective action to prevent similar re-occurrences and a written report submitted to TEC within forty-eight (48) hours of the event describing the same and detailing the corrective action taken. Such report shall provide all relevant information regarding the accident in question, including but not limited to, a fully detailed description of the incident and all relevant statements of witnesses. However, if death or serious injury or damage has occurred, the accident shall be reported to TEC immediately by telephone or messenger. Subcontractor shall maintain documentation related to injuries.
9. Subcontractor shall evaluate accident exposures that may arise from every portion of the work prior to the start of the operation and follow-up with appropriate action where required.
10. Subcontractor shall establish safety methods and good practices to be carried out by its workers. Subcontractor shall have a written safety program and have it made available to all of its employees. This written safety program shall be available for review by the OHSC.
11. Subcontractor shall conduct daily inspections of its contracted activities and report unsafe practices and/or conditions found, corrective recommendations, corrective action taken and list all previous recommendations that may not have been complied with at the time of inspection. Copies of said reports are to be available for review by the OHSC.
12. Subcontractor shall provide adequate safety measures against occupational disease exposures such as gases, fumes, dusts and chemicals that may be injurious to the project work-force.

13. Subcontractor shall provide personal protective equipment at the work area where needed and required. Subcontractor personnel who have been provided personal protective equipment by the subcontractor shall be instructed in proper equipment use and be mandated by the subcontractor to utilize all such equipment. Subcontractor shall be prepared to take immediate corrective action for noncompliance that shall include dismissal if subcontractor's employee(s) refuses to utilize the provided safety equipment.
14. Subcontractor shall not direct or permit an employee to use machinery or equipment of which he has knowledge is not in good repair and/or in safe working condition.
15. Subcontractor shall ensure that all safety devices and safeguards in use are sound and operable.
16. Subcontractor shall ensure that damaged or unsafe equipment is removed from service until it is repaired and restored to a safe operating condition. Unsafe operations shall immediately be corrected to ensure protection of personnel and property.
17. Subcontractor shall include all of its personnel (including office staff) in the project's safety program.
18. Subcontractor shall designate a competent and responsible member of its organization whose duties shall include loss and accident prevention and who shall have the obligation and full authority to enforce the program. Subcontractor will be required to provide a specific name of that individual for each project. (For definition purposes - "competent" shall mean one who is trained and capable of identifying existing hazards in the surrounding working conditions which are hazardous or dangerous to employees and who has authorization to take prompt corrective measures to eliminate them.)
19. Federal and State regulations require each employer to have a Hazardous Communications program in place. The project requires a complete library of manufacturer's Material Safety Data Sheets (MSDSs) for all material incorporated into the project process. The Subcontractor shall submit all MSDSs for materials provided/used in the performance of this subcontract to TEC to ensure completeness of this library. The Subcontractor shall maintain on site a copy of hazardous communications program and a library of MSDSs for materials provided/used in the performance of this subcontract. Subcontractor shall submit its written HazCom program to TEC for record keeping purposes.
20. In connection with all work performed hereunder, subcontractor shall include provisions for and shall comply with all Safety and Health Regulations of the Occupational Safety and Health Act of 1970 (29 CFR 1926 and 1910), including all amendments and modifications thereto (hereinafter "OSHA"). In the event there is a conflict between the safety and health provisions of federal, state/provincial or local regulations, the more stringent applicable provision shall prevail. Subcontractor acknowledges and agrees that with respect to the scope of its work under this subcontract, it shall comply with all obligations and assume all responsibilities imposed upon the "controlling contractor" as such term is defined and construed under all US OSHA rules and regulations.

21. TEC reserves the right to withhold payment or to take other action as may be necessary when the subcontractor or any tier of a sub-subcontractor is not in compliance, non-receptive or uncooperative with the terms of these safety requirements. Any and all direct or indirect costs associated with any action taken by TEC as a result of subcontractor or sub-subcontractor non-compliance with these safety requirements will be at the subcontractor's expense.
22. Subcontractor's principles, project manager, superintendent or foreman to whose attention the existence of any unsafe device, operation, safeguard or equipment is called, shall take immediate steps to remedy or remove the unsafe condition in question.

In an emergency affecting the safety of life, the work, or adjoining property, the subcontractor, without special instructions or authorization from TEC or other parties, shall take any action necessary to prevent such threatened loss or injury.

Prior to the start of their work, all subcontractors shall submit the names of their authorized and qualified Project Safety Representatives to the TEC Project Manager and OHSC. All Subcontractor Project Safety Representatives shall be held accountable by their Companies for the immediate correction of hazards and unsafe acts and compliance with their Company Safety and Health and Hazardous Communication (HazCom) Programs, the project documents, standards and all other federal, state, provincial and local codes, laws and regulations by their employees and their subcontractors and suppliers, regardless of tier.

All subcontracting personnel are responsible for compliance with this HSP in its entirety. Technical staff is expected to perform only those tasks they believe can be done safely and for which they have been adequately trained. They are responsible for taking all reasonable precautions to prevent injury to themselves and to their fellow employees; for being alert to potentially harmful situations; and to immediately report any accidents, near misses and/or unsafe conditions to the OHSC or FM.

1.5 Required Onsite Postings

No Change. Please refer to Section 1.5 of the original HSP (TEC 2005).

1.6 Project Logs, Records and Reports

No Change. Please refer to Section 1.6 of the original HSP (TEC 2005).

2.0 HAZARD EVALUATION

No Change. Please refer to Section 2.0 of the original HSP (TEC 2005).

2.1 Chemical Exposure

No Change. Please refer to Section 2.1 of the original HSP (TEC 2005).

2.2 Hazard Communication

No Change. Please refer to Section 2.2 of the original HSP (TEC 2005).

2.3 Physical or Operating Hazards and Control Measures

No Change. Please refer to Section 2.3 of the original HSP (TEC 2005).

2.4 Field Task-Specific Hazard and Risk Analysis

Below are the tasks required to achieve the project objective. Each field task is analyzed for its principal steps or subtask(s) and the specific methods, tools, and equipment necessary for accomplishing the work. Based on this information, a task-specific hazard and risk analysis has been prepared for each and is included in **Appendix 5**. Prior to beginning project activities each work day, a safety briefing will be conducted to ensure that each member of the project team is aware of the site-specific hazards and mitigation measures.

2.4.1 Mobilization and Demobilization

Mobilization of surveyors, site investigators with minimal additional equipment to locations inside and outside the access tunnels will be required.

All mobilization/demobilization to be conducted within the access tunnels will anticipate the following hazards:

- Explosive hazards associated with bulk fuel storage, therefore activities that will create a spark or potential explosive hazard will not occur within the Red Hill Tunnel without the written concurrence of the FISC Operations Manager.
- Low or potentially nonexistent lighting, therefore intrinsically safe flashlights or other appropriate lighting should be available for use at all times;
- Specialized equipment will be utilized to transport supplies and equipment into the access tunnel (such as hoists at Adit 3, use of the mechanized train system, and use of the mechanized elevator system), therefore assistance from FISC personnel or specialized training will be required ensure proper and safe use of this equipment;
- Working near other FISC Contractors in confined areas, therefore proper communication with FISC supervisors and well-defined and delineated work-space, with orderly marshalling and storage of supplies will be conducted;
- Limited ventilation, therefore, intrinsically safe fans will be provided to ensure proper ventilation in locations where strenuous activity is required;

- Low overhead piping and superstructure along the access route to the work space, as well as similar hazards within the workspace, therefore,
    i. Hard hats will be worn at all times with the Access Tunnel
    ii. Specific low lying hazard points will be clearly marked with bright paint or caution tape.
- High-voltage overhead power conduit are energized along access routes and within work space, therefore these active lines should be identified and marked with appropriate signage
- Floor and near-floor areas along access route and work space is frequently interrupted by metal grates, piping, train rails, and uneven flooring, therefore routes to work areas should be well-defined, and slips, trips and fall hazards should be identified and marked with the appropriate signage.

All mobilization/demobilization activities associated with work at the sampling location adjacent to the active US Navy firing range will anticipate the following site-specific hazards:

- Live ammunition fire may be ongoing at the firing range during activities, therefore
    i. open communication lines between the project team leader and the firing range marshal will be maintained when entering the gated facility;
    ii. project related activities will be located in a protected area that is not directly down-range from the live fire
- Vehicular and possibly pedestrian traffic may pass adjacent to the project area, therefore an access route must be adequate for traffic to utilize the firing range without interfering with project activities
- Intrusive activities are anticipated to occur in a grassy open area, therefore materials will be marshaled in a well-defined level area and stored on pallets or racks instead of directly on the ground.

2.4.2 Soil Vapor Monitoring Installation Activities

Soil vapor monitoring point (SVMP) installation and sampling activities will occur at three locations within the lower access tunnel. All hazards and mitigation measures described in Section 2.4.1 should be anticipated during these activities.

In addition, the following task-specific hazards may be anticipated:

- Noise associated with heavy equipment operation within close quarters of the lower access tunnel, therefore ear plugs or muffs will be required while the drill rig is in operation;
- Sampling locations within the access tunnel are inadequately lighted, therefore intrinsically safe working lights will be located to fully illuminate the work space but not impede the actions of the sampler;
- Sample locations are within the access tunnel are inadequately ventilated, therefore intrinsically safe working fans will be located to circulate fresh air through the work space;
- Any activities that will require high pressure and high volume air compressor fittings that may become loose and flail under the force of the emitted gas,

therefore each hose coupling will be attached to a secure stable piece of equipment using metal cables;

- Organic vapors from petroleum hydrocarbon releases will be encountered when installing the soil vapor MPs and may be encountered when drilling rock borings to install basal aquifer monitor wells, therefore borehole and work space breathing zone will be monitored using a calibrated organic vapor detector, such as a PID 2020 or similar.
- Benzene may be encountered in the organic vapors, therefore if vapor levels are elevated above 5 ppm, a sample of the air will be tested using a Drager tube to determine if benzene is present.
- Organic vapors may become explosive if concentrated enough, therefore borehole and work space will be tested using a lower explosive limit (LEL) meter and mitigation will occur when 10 percent of the LEL is observed.
- Sampling locations within the tunnel are highly restricted in the space available, therefore all area within 15 ft of the equipment must remain clear when not in use and a clear escape path must be available at all times.
- Tunnel sample locations are inadequately lit and/or ventilated, therefore portable lights and fans will be set up to reduce the potential accidents. This equipment will be set up 2 feet off the ground, 2 feet from the ceiling, and not under a pipeline flange. The atmosphere will also be monitored so that it is not operated under explosive conditions;
- Groundwater wells located within the lower access tunnel present a hazard for fuels spilled in the tunnel to migrate into the basal aquifer inside the well casing, therefore groundwater wells will be protected with a threaded steel cap over the pressure cap.
- All wells inside the tunnel will be flush-mounted to eliminate mobility hazards.

2.4.3 Groundwater Sampling and Water Table Elevation Measurements

Groundwater sampling will occur at three distinct Red Hill locations:

1. At three wells located within the lower access tunnel;
2. At the Red Hill Navy Pumping Station Well 2354.001; and
3. At wells located at ground surface.

Wells located with the Lower access tunnel are small diameter wells. V1D is a 1-inch inside-diameter (ID) well that is currently sampled with a bailer. It is anticipated that the two proposed wells will be 2-inch ID wells. Depth to water will range from about 100 feet to 120 feet. The following site-specific hazards can be anticipated at these locations:

- Equipment decontamination presents a hazard associated with exposure to onsite chemicals and disposal of decontamination fluids, therefore, single-use disposable equipment will be used such as bailers, filters, pressurized syringes;
- Pumping presents a hazard of exposure to contaminated groundwater via splash; therefore Modified level D PPE will be utilized, including Tyvek suits, taped outer gloves and water-proof footwear;
- Pumping presents a hazard associated with back strain at these depths as well as exposure to contaminated groundwater via splash, therefore effort will

be made to use correct lifting techniques when installing or removing the equipment.

- Dedicated water level readout equipment will be installed for long-term monitoring.
- Tunnel sample locations are inadequately lit and/or ventilated, therefore portable lights and fans will be set up to reduce the potential accidents. This equipment will be set up 2 feet off the ground, 2 feet from the ceiling, and not under a pipeline flange. The atmosphere will also be monitored so that it is not operated under explosive conditions;
- Exposure to potentially contaminated groundwater via volatilization to breathing space presents a hazard, therefore air monitoring will be conducted during the sampling event at wells that indicate high VOC readings when the cap is removed;
- IDW purge water presents a hazard if left onsite in drums, therefore purge water will be disposed of after each sampling event in the Red Hill Facility Oil Water Separator.

The Red Hill Navy Pumping Station is located hydraulically downgradient from the Red Hill Fuel Storage Facility and is a shaft well. Groundwater may be drawn from the onsite pumps which feed the Navy consumers at between 4 mgal per day and 16 mgal per day or it may be drawn from the manhole located in the floor of the pumphouse. Water that is collected from the pump station may be influenced by the pumping system and not be representative of the natural formation, especially for organic compounds. The following site-specific hazards can be anticipated at this location in addition to the hazards mentioned above:

- Collecting water from the manhole may present a hazard of contaminating the drinking water shaft if chemicals or contaminated equipment were to fall through the manhole, therefore all equipment and chemicals will be stored at least 15 feet away from the manhole opening, including sample bottles;
- Currently, sampling is done using a single-use disposable bailer that requires the installation of a casing to ensure that groundwater is not contaminated from the bailer as it touches the steel ladder frame, which presents a hazard for dropping equipment, therefore effort will be made to install dedicated pumps in these wells if long-term monitoring is recommended;
- Collecting groundwater in the pump room that may be occupied by onsite workers presents a hazard to onsite workers, therefore prior communication with the PWC technical lead will be part of the mobilization process to ensure that sampling activities will not interfere with normal work routines.

Sampling at the ground surface wells will follow the general SOPs, however, activities at the upgradient well located adjacent to the US Navy firing range must account for the particular hazards that are associated with activities at the firing range. The following site-specific hazards can be anticipated at this location in addition to the hazards mentioned above:

- To avoid the potential hazards associated with live fire ammunition
    - Field Crew will inform the range manager 24-hours prior to accessing site;
    - All field equipment will be located in an area that is blocked from live fire by valley wall.

2.4.4 Field Tasks, Methods and Equipment

The following tasks, methods and equipment are required for Phase II activities.

Field Task Description	Principle Steps or Subtasks	Required Methods, Tools & Equipment
1. Mobilization and Demobilization	a) Move equipment from dock area to work station b) Access the tunnels and set drill rig up c) Stabilize drill d) Breakdown rig, move to second site, and re-stabilize e) Equipment breakdown and movement from tunnels to the dock.	• Flatbed truck • Use of Hoist • Use of elevator • Use of diesel/ electric train • Use of supplied electric and water
2. Equipment Decontamination	a) Set up small decon area inside the tunnels b) Use a series of deionized water washes with an isopropyl alcohol final rinse to clean bore tube. c) Discharge decon water to floor drains	• Deionized (DI) water • Spray bottles
3. Soil Vapor Installation	a) Mobilize equipment and supplies b) Installation of pre-casing and screen c) Cut and remove existing PVC sleeve during installation d) Perform grouting through tremie pipe e) Equipment breakdown and cleanup	• Tremie pipe • Grout pump • Casing puller • PVC puller • PVC cutter (inner/outer) • Air monitoring equipment
4. Ground Water Sampling	a) Mobilize equipment and supplies b) Calibrate and setup equipment c) Monitor air during sampling event d) Remove cap and take water level elevation measurements e) Utilize single-use disposable bailers for ground water sampling f) Dispose of IDW purge water in floor drain	• Single-use disposable bailer, filters, and pressurized syringes • Air monitoring equipment
5. Surveying	a) Mobilize equipment and supplies	• Air monitoring

Field Task Description	Principle Steps or Subtasks	Required Methods, Tools & Equipment
	b) Calibrate and setup equipment c) Monitor air during sampling event d) Complete a closed-loop survey	equipment • Survey equipment
6. Soil Vapor Sampling	e) Mobilize equipment and supplies f) Calibrate and setup equipment g) Monitor air during sampling event h) Sample vapor points with Summa canister	• Air monitoring equipment • Summa canisters
7. Aquifer Testing	a) Mobilize equipment and supplies b) Calibrate and setup equipment c) Monitor air during sampling event d) Remove cap and take water level elevation measurements e) Utilize dedicated pumps and water level readout equipment f) Dispose of IDW purge water in floor drain	• Dedicated pumps and water level readout equipment • Air monitoring equipment • Data loggers

3.0 PERSONNEL PROTECTION

No Change. Please refer to Section 3.0 of the original HSP (TEC 2005).

3.1 Administrative Controls

3.1.1 Training

No Change. Please refer to Section 3.1.1 of the original HSP (TEC 2005).

3.1.2 Medical Surveillance

No Change. Please refer to Section 3.1.2 of the original HSP (TEC 2005).

3.1.3 Verification of Certifications

No Change. Please refer to Section 3.1.3 of the original HSP (TEC 2005).

3.1.4 Safe Work Practices (see also Appendix 7)

No Change. Please refer to Section 3.1.4 of the original HSP (TEC 2005).

3.1.5 Sanitation and Illumination

Supply potable drinking water in tightly closed containers that are clearly marked for their intended use. Common drinking cups are prohibited; single-use disposable cups are required. Provide or make available onsite toilet(s) and a field washing area with potable water. Since the nature of this project is mobile and of a duration less than six months, no permanent shower/change facility will be provided.

For outdoor work, it is anticipated that all site work will be conducted during daylight hours. If circumstances arise in which field work is to be conducted before or after daylight, or sunlight is obstructed, maintain illumination within all general site areas at or above 5 foot-candles. All lights, cords, and power sources must be rated for outdoor use.

For indoor work, tunnel sample locations are inadequately lit, therefore portable lights will be set up to reduce potential accidents. This equipment will be set up 2 feet off the ground, 2 feet from the ceiling, and not under a pipeline flange. The atmosphere will also be monitored so that it is not operated under explosive conditions.

3.2 Engineering Controls

Barriers and Signs

Erect barricades, traffic cones, and/or marking/caution tape at a safe distance from excavations, pits, hazardous areas, and moving equipment in order to prevent unauthorized access to work areas from vehicular and pedestrian traffic. Barriers will be appropriate for the level of work activities and anticipated traffic. Signs will be conspicuously posted as:

("Hearing Protection Required Beyond This Point") or equivalent.

Ventilation

Ventilation in the tunnel is supplied by large fans. The tunnel ventilation of tanks 1 through 16 consists of an air intake shaft between tanks 15 and 17, and four large fans. Eight small fans at the cross tunnels of the upper tunnel provide air through ducts to the gauger platforms on top of tanks 1 to 16. Supply air for these fans comes from the upper tunnel. For tunnel ventilation of tanks 17 to 20, supply air comes from an air intake vestibule. The hoistway of elevator 73 also serves as an air supply shaft to the upper and lower tunnels. There are ducts from the extremes of both tunnels back to an air plenum in the elevator shaft, which leads to an exhaust fan above the machine room of the elevator. This exhaust fan exhausts the upper and lower tunnels through a vertical exhaust shaft above the tanks to daylight. The gauger platforms of tanks 17 to 20 are ventilated with ducts, which are connected to the exhaust ducts that lead to the plenum.

The reconnaissance visit showed that there is an adequate air flow in the tunnels, and that a blower would not be necessary for the scheduled drilling work. However, tunnel sample locations may be inadequately ventilated, and therefore portable fans will be set up to reduce potential accidents. This equipment will be set up 2 feet off the ground, 2 feet from the ceiling, and not under a pipeline flange. The atmosphere will also be monitored so that it is not operated under explosive conditions.

An oxygen meter will be kept on site to monitor the oxygen levels, and prevent injury from low oxygen.

Shoring/Sloping/Benching

Trenching and shoring is not applicable for this project.

Dust Suppression

Dust suppression techniques will be employed to the greatest extent possible to minimize the generation of dust/particulates and associated contaminates into the atmospheres. Water is available at the site, from water spigots located on the side walls of the FISC tunnel.

Rinsate Collection/Containment

Aquifer water and decontamination fluids will be directed into the drainage system contained in the tunnels. The drainage system consists of a drainage pipe that runs the length of the tunnels, covered by a grated metal top. Decon water has been approved to be diverted into the drainage system as long as no soaps or detergents are in the water. Large equipment will be decontaminated utilizing a steam cleaner outside of the tunnel and a deionized water wash with isopropyl alcohol inside of the tunnels. There will be no collection point for the water. Decon water will flow directly to the water station at the Red Hill facilities. Decon water will be directed and disposed of in the same manner.

3.3 Personal Protective Equipment (PPE)

No Change. Please refer to Section 3.3 of the original HSP (TEC 2005).

4.0 SITE CONTROL

4.1 Site Security

No Change. Please refer to Section 4.1 of the original HSP (TEC 2005).

4.2 Visitor Access

No Change. Please refer to Section 4.2 of the original HSP (TEC 2005).

4.3 Work Zones

No Change. Please refer to Section 4.3 of the original HSP (TEC 2005).

4.4 Communications

No Change. Please refer to Section 4.4 of the original HSP (TEC 2005).

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5.0 AIR SURVEILLANCE

5.1 Site Monitoring with Direct Reading Instruments

No Change. Please refer to Section 5.1 of the original HSP (TEC 2005).

5.2 Equipment and Quality Assurance/Quality Control (QA/QC)

No Change. Please refer to Section 5.2 of the original HSP (TEC 2005).

5.3 Air Sampling in Breathing Zone

No Change. Please refer to Section 5.3 of the original HSP (TEC 2005).

5.4 Action Levels

No Change. Please refer to Section 5.4 of the original HSP (TEC 2005).

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6.0 DECONTAMINATION PROCEDURES

No Change. Please refer to Section 6.0 of the original HSP (TEC 2005).

6.1 *Personnel Decontamination*

No Change. Please refer to Section 6.1 of the original HSP (TEC 2005).

6.2 Emergency Decontamination

No Change. Please refer to Section 6.2 of the original HSP (TEC 2005).

6.3 Disposal Procedures

No Change. Please refer to Section 6.3 of the original HSP (TEC 2005).

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7.0 EMERGENCY CONTINGENCY PLAN

No Change. Please refer to Section 7.0 of the original HSP (TEC 2005).

7.1 Pre-planning and general procedures

No Change. Please refer to Section 7.1 of the original HSP (TEC 2005).

7.2 Injury to Project Personnel or Visitors

7.2.1 First-Aid/CPR

No Change. Please refer to Section 7.2.1 of the original HSP (TEC 2005).

7.2.2 Response Procedures

No Change. Please refer to Section 7.2.2 of the original HSP (TEC 2005).

7.3 Natural Disasters

No Change. Please refer to Section 7.3 of the original HSP (TEC 2005).

7.4 Other Weather Related Emergencies

No Change. Please refer to Section 7.4 of the original HSP (TEC 2005).

7.5 Contingency Plan for Spill and Discharge of Hazardous Materials

No Change. Please refer to Section 3.1.4 of the original HSP (TEC 2005).

7.6 Fire or Explosion

No Change. Please refer to Section 7.6 of the original HSP (TEC 2005).

7.7 Accident Reporting and Recordkeeping

No Change. Please refer to Section 7.7 of the original HSP (TEC 2005).

7.8 Bloodborne Pathogen Exposure Control Plan (see Appendix 9)

7.8.1 Exposure Determination

No Change. Please refer to Section 7.8.1 of the original HSP (TEC 2005).

7.8.2 Exposure Control

No Change. Please refer to Section 7.8.2 of the original HSP (TEC 2005).

7.9 Medical Facilities

No Change. Please refer to Section 7.9 of the original HSP (TEC 2005).

7.10 Emergency Services

No Change. Please refer to Section 7.10 of the original HSP (TEC 2005).

7.11 Call List

TITLE	NAME	TELEPHONE NUMBER
TEC Corporate Health and Safety Manager	Ellen Graap Loth	(434) 295-4446
TEC Regional Health and Safety Manager	Karl Bromwell	(808) 528-1445
Onsite Health and Safety Coordinator	Shawn MacMillan	(808) 528-1445
TEC Project Manager	Jeff Hart	(808) 528-1445
Office HSC		
NAVFAC Pacific RPM	Glenn Yoshinaga	(808) 472-1416
Activity POC (FISC)	Vic Peters CIV FISC	(808) 473-2690
Red Hill Health & Safety	Vic Peters CIV FISC	(808) 473-2690
Navy Firing Range Supervisor	Sgt. Grey	(808) 471-4798
Navy PAO(s)	LCDR John Singley	(808) 471-0281
Explosive Ordinance Disposal (EOD)	Mobile Unit One	(808) 474-3658
HIOSH	State of Hawaii OSHA	(808) 586-9110 (weekday) (808) 586-9102 (weekend)
Add TEC insurance info		
Hartford SRS**	Lisa Rich or Addie Mckenzie	(808) 546-7206 (800) 327-3636

* For TEC employees: In the event of an occupational accident or incident, please indicate to the medical facility that this is a Workers' Compensation case; that your employer is TEC; and that the insurance carrier is Everest National Insurance Company, Policy Number: 5300-00-00-38041. Claims are received and processed at Gallagher Bassett Services, Inc.

** For AMEC employees: In the event of an occupational accident or incident, please indicate to the medical facility that this is a Workers' Compensation case; that your employer is AMEC; and that the insurance carrier is Hartford Specialty Risk Services, Account No. 77281. Claims are received at PO Box 1140, Honolulu, HI 96807.

*** Subcontractors will provide similar internal Workers' Compensation policy information; this should be provided to the OHSC at the pre-work meeting.

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8.0 HEALTH AND SAFETY PLAN ADDENDUM ACCEPTANCE

I have had the opportunity to read and ask questions about this HSP Addendum. My signature certifies that I understand the procedures, equipment, and restrictions of this plan and agree to abide by them.

SIGNATURE*	PRINTED NAME	COMPANY	DATE

* This acceptance form is required for all routine site staff and subcontracting personnel. Visitors and non-routine subcontractors are required to receive and sign the appropriate Health and Safety Orientation Form located in **Appendix 3**.

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APPENDIX 1
TABLES

No Change. Please refer to Appendix 1 of the original HSP (TEC 2005).

APPENDIX 2
FIGURES

No Change. Please refer to Appendix 2 of the original HSP (TEC 2005).

APPENDIX 3
PROJECT FORMS

No Change. Please refer to Appendix 3 of the original HSP (TEC 2005).

APPENDIX 4
MATERIAL SAFETY DATA SHEETS

No Change. Please refer to Appendix 4 of the original HSP (TEC 2005).

APPENDIX 5
TASK SPECIFIC HAZARD AND RISK ANALYSIS

<table>
<tr><td colspan="4">1.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS</td></tr>
<tr><td>Contract: N62742-02-1802 CTO 0007</td><td>Contractor: TEC Inc.</td><td>Evaluated by: Karl Bromwell</td><td>Date: 5/27/05</td></tr>
<tr><td>Task: Mobilization/Demobilization</td><td>Location: Red Hill Tunnel and adjacent to US Navy Active Firing Range, Oahu, HI</td><td colspan="2">Relative Risk Ranking: Low to Moderate</td></tr>
<tr><td>PRINCIPAL STEPS</td><td>POTENTIAL HAZARDS</td><td colspan="2">RECOMMENDED CONTROLS</td></tr>
<tr><td>• Mobilization of supplies and equipment from dock area to work stations.
• Access the tunnels and firing range.
• Set up equipment.
• Equipment breakdown and movement from tunnels/firing range to the dock.

<u>EQUIPMENT TO BE USED</u>
• Diesel/electric train
• Elevator
• Flatbed truck
• Hoist
• Supplied electric and water</td><td><u>Chemical</u>
• Chemical exposure (lubricants, hydraulic fluid)
• Active Fuel lines

<u>Physical</u>
• Biological
• Back strain (i.e. loading equipment)
• Confined working space
• Firing range (active)
• Electrical – energized equipment
• Heat stress
• Heavy equipment operation
• Inadequate lighting
• Noise >(85 dba) exposure
• Overhead/underground utilities
• Physical exertion/strain
• Slick/wet surfaces
• Slips, trips, falls and protruding objects
• Uneven terrain (rail tracks etc.)
• Vehicle/pedestrian traffic</td><td colspan="2"><u>Chemical</u>
• Nitrile gloves -inner
• Nitrile gloves –outer
• Intrinsically safe "sparkless" tools (lights/fans etc.)

<u>Physical</u>
• PPE Level D includes:
o Work shirt and full length cotton pants or coveralls, and leather gloves
o ANSI safety-toed boots
o ANSI hard hat
o ANSI safety glasses
o US EPA hearing protection
• Open communication with Navy personnel
• Portable light sources
• Formal equipment certifications/inspections
• Safe work practices
• Work zone will be taped/coned off and appropriate safety signs posted
• Water/fluids available on-site</td></tr>
<tr><td>OTHER SAFETY EQUIPMENT</td><td>INSPECTION REQUIREMENTS</td><td colspan="2">TRAINING REQUIREMENTS</td></tr>
<tr><td>• Hand/face washing supplies
• Equipment decontamination supplies
• First aid kit
• Fire extinguisher</td><td>• Conduct daily inspection of equipment
• Equipment meets or exceeds specifications in Section 19 of U.S. Army Corp. of Engineers, Safety and Health requirements EM 385 –
• Current U.S. Coast Guard (USCG) Certificate of Inspection</td><td colspan="2">• Current 40 Hour HAZWOPER
• Equipment Operators should have current training for operation
• Daily health and safety tailgate prior to field activities to increase awareness
• Proper lifting technique
• Diesel/electric train and elevator</td></tr>
</table>

2.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS		
Contract: N62742-02-1802 CTO 0007	**Contractor: TEC Inc.**	**Evaluated by: Karl Bromwell** — **Date: 5/27/05**
Task: Equipment Decontamination	**Location: Red Hill Tunnel and adjacent to US Navy Firing Range Oahu, HI**	**Relative Risk Ranking: Low**
PRINCIPAL STEPS	**POTENTIAL HAZARDS**	**RECOMMENDED CONTROLS**

• Set up small decontamination area inside the tunnels
• Use a series of deionized water washes with an isopropyl alcohol final rinse to clean bore tube
• Discharge soap-free decon water into the floor drainage area
 	
EQUIPMENT TO BE USED
• Deionized (DI) water
• Spray bottles
	Chemical
	• Chemical exposure (petroleum, lead, alcohol)
	• Fire/explosion – Flammable materials
	• Material contact
	
	Physical
	• Biological
	• Confined working space
	• Electrical – energized equipment
	• Ground intrusion
	• Heat stress
	• Inadequate lighting
	• Overhead/underground utilities
	• Noise >(85 dba) exposure
	• Physical exertion/strain
	• Slick/wet surfaces
	• Slips, trips, falls and protruding objects
	• Uneven terrain
		Chemical
		• Nitrile gloves – inner
		• Nitrile gloves – outer
		• Intrinsically safe "sparkless" tools (lights/fans etc.)
		• Upgrade to Tyvek (Modified Level D) to minimize skin contact as necessary
		
		Physical
		• PPE Level D includes:
		  o Work shirt and full length cotton pants or coveralls, and leather gloves
		  o ANSI safety-toed boots
		  o ANSI hard hat
		  o ANSI safety glasses
		  o US EPA hearing protection
		• Open communication with Navy personnel
		• Formal equipment certifications/inspections
		• Safe work practices
		• Portable light sources
		• Water/fluids available
		• Work zone will be taped off and appropriate safety signs posted

OTHER SAFETY EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
• Hand/face washing supplies • Equipment decontamination supplies • First aid kit • Fire extinguisher	• Conduct daily inspection of equipment • Equipment meets or exceeds specifications in Section 19 of U.S. Army Corp. of Engineers, Safety and Health requirements EM 385 - • Current USCG Certificate of Inspection	• Current 40 Hour HAZWOPER • Equipment Operators should have current training for operation • Daily health and safety tailgate prior to field activities to increase awareness

3.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS		
Contract: N62742-02-1802 CTO 0007	**Contractor: TEC Inc.**	**Evaluated by: Karl Bromwell** **Date: 5/27/05**
Task: Soil Vapor Installation/Sampling Activities	**Location: Red Hill Tunnel and adjacent to US Navy Firing Range Oahu, HI**	**Relative Risk Ranking: Low**
PRINCIPAL STEPS	**POTENTIAL HAZARDS**	**RECOMMENDED CONTROLS**

• Mobilize equipment and supplies
• Installation of pre-casing and screen
• Cut and remove existing PVC sleeve during installation
• Installation of annular material
• Perform grouting activities through tremie pipe
• Collect sample in Summa canisters
• Equipment breakdown and cleanup
 	
<u>EQUIPMENT TO BE USED</u>
• Tremie pipe
• Grout pump
• Casing puller
• PVC cutter (inner/outer)
• 1 gpm/peristaltic pump
• Summa Canisters
• Air monitoring equipment
    o Model 31 drager pump
    o Hydrocarbon 2 drager tubes
    o PID – 2020IS
    o LEL/O_2 meter – MX25R
	<u>Chemical</u>
	• Chemical exposure (petroleum hydrocarbon releases, lead, calibration gases)
	• Fire/explosion – Flammable materials
	• Active Fuel lines
	• Material contact
	• Organic vapor (benzene)
	
	<u>Physical</u>
	• Biological
	• Confined working space
	• Electrical – energized equipment
	• Firing range (active)
	• Heat stress
	• Inadequate lighting
	• Noise >(85 dba) exposure
	• Overhead/underground utilities
	• Physical exertion/back strain
	• Slick/wet surfaces
	• Slips, trips, falls and protruding objects
	• Uneven terrain
	• Vehicle/Pedestrian traffic
		<u>Chemical</u>
		• LEL/O_2 meter – air monitoring
		• Nitrile gloves – inner
		• Nitrile gloves – outer
		• Intrinsically safe "sparkless" tools (lights/fans etc.)
		• Upgrade to Tyvek (Modified Level D) to minimize skin contact as necessary
		<u>Physical</u>
		• PPE Level D includes:
		    o Work shirt and full length cotton pants or coveralls, and leather gloves
		    o ANSI safety-toed boots
		    o ANSI hard hat
		    o ANSI safety glasses
		    o US EPA hearing protection
		• Open communication with Navy personnel
		• Formal equipment certifications/inspections
		• Safe work practices
		• Portable light sources
		• Water/fluids available
		• Work zone will be taped off and appropriate safety signs posted

OTHER SAFETY EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
• Hand/face washing supplies • Equipment decontamination supplies • First aid kit • Fire extinguisher	• Conduct daily inspection of equipment • Equipment meets or exceeds specifications in Section 19 of U.S. Army Corp. of Engineers, Safety and Health requirements EM 385 - • Current USCG Certificate of Inspection	• Current 40 Hour HAZWOPER • Daily health and safety tailgate prior to field activities to increase awareness • Proper lifting technique

<table>
<tr><th colspan="4">4.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS</th></tr>
<tr><td>Contract: N62742-02-1802 CTO 0007</td><td>Contractor: TEC Inc.</td><td>Evaluated by: Karl Bromwell</td><td>Date: 5/27/05</td></tr>
<tr><td>Task: Ground Water Sampling</td><td>Location: Red Hill Tunnel, Navy Pumping Station Well 2354.001, and adjacent to US Navy Firing Range, Oahu, HI</td><td colspan="2">Relative Risk Ranking: Low to Moderate</td></tr>
<tr><td>PRINCIPAL STEPS</td><td>POTENTIAL HAZARDS</td><td colspan="2">RECOMMENDED CONTROLS</td></tr>
<tr><td>• Mobilize equipment and supplies
• Calibrate and setup equipment (PID near top of casing etc.)
• Monitor air during sampling event
• Remove cap and take water level elevation measurements
• Utilize single-use disposable bailers for ground water sampling or dedicated pump
• Dispose of IDW purge water in oil water separator.

<u>EQUIPMENT TO BE USED</u>
• Single-use disposal bailers, filters, and pressurized syringes
• Air monitoring equipment
o Model 31 drager pump
o Hydrocarbon 2 drager tubes
o PID – 2020IS</td><td><u>Chemical</u>
• Chemical exposure (petroleum hydrocarbon release, lead, alcohol)
• Fire/explosion – Flammable materials
• Material contact
• Cross contamination hazard
• Organic vapor (benzene)

<u>Physical</u>
• Biological
• Confined working space
• Electrical – Energized equipment
• Firing range hazards
• Ground intrusion
• Heat stress
• Inadequate lighting
• Overhead/underground utilities
• Noise >(85 dba) exposure
• Physical exertion/strain
• Slick/wet surfaces
• Slips, trips, falls and protruding objects
• Uneven terrain</td><td colspan="2"><u>Chemical</u>
• Organic Vapor– air monitoring
• Nitrile gloves – inner
• Nitrile gloves – outer
• Dedicated pumps, safe/organized work zone practices
• Intrinsically safe "sparkless" tools (lights/fans…)
• Modified Level D PPE: Tyvek suits, taped outer gloves and water-proof footwear
<u>Physical</u>
• PPE Level D includes:
o Work shirt and full length cotton pants or coveralls and leather gloves
o ANSI Standard steel toed work boots
o ANSI standard hard hat
o ANSI standard safety glasses
o US EPA standard hearing protection
• Safe work practices and proper communication with Navy personnel prior to accessing site.
• Portable light sources
• Work zone will be taped off with hearing, head, eye signs posted</td></tr>
<tr><td>OTHER SAFETY EQUIPMENT</td><td>INSPECTION REQUIREMENTS</td><td colspan="2">TRAINING REQUIREMENTS</td></tr>
<tr><td>• Equipment decontamination supplies
• First aid kit (on-site and in vehicle)
• Fire extinguisher (on-site and in vehicle)
• Hand/face washing supplies</td><td>• Conduct daily inspection of equipment
• Equipment meets or exceeds specifications in Section 19 of U.S. Army Corp. of Engineers, Safety and Health requirements EM 385 -</td><td colspan="2">• Current 40 Hour HAZWOPER
• Equipment operators should have current training for operation
• Daily health and safety tailgate prior to field</td></tr>
</table>

	• Current USCG Certificate of Inspection	activities to increase awareness

5.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS		
Contract: N62742-02-1802 CTO 0007	**Contractor: TEC Inc.**	**Evaluated by: Karl Bromwell**	**Date: 5/27/05**
Task: Closed-loop Survey	**Location: Red Hill Tunnel and adjacent to US Navy Firing Range Oahu, HI**	**Relative Risk Ranking: Low**
PRINCIPAL STEPS	**POTENTIAL HAZARDS**	**RECOMMENDED CONTROLS**

• Mobilize equipment and supplies
• Set-up calibrate equipment
• Perform closed-loop survey
• Equipment breakdown and cleanup
 	
EQUIPMENT TO BE USED
• Transit
• Level
• Other surveying equipment
• Air monitoring equipment
  o Model 31 drager pump
  o Hydrocarbon 2 drager tubes
  o PID – 2020IS
  o LEL/O_2 meter – MX25R
	Chemical
	• Chemical exposure (petroleum hydrocarbon releases, lead, calibration gases)
	• Fire/explosion – Flammable materials
	• Active Fuel lines
	• Material contact
	• Organic vapor (benzene)
	
	Physical
	• Biological
	• Confined working space
	• Electrical – energized equipment
	• Firing range (active)
	• Heat stress
	• Inadequate lighting
	• Noise >(85 dba) exposure
	• Overhead/underground utilities
	• Physical exertion/back strain
	• Slick/wet surfaces
	• Slips, trips, falls and protruding objects
	• Uneven terrain
	• Vehicle/Pedestrian traffic
		Chemical
		• LEL/O_2 meter – air monitoring
		• Nitrile gloves – inner
		• Nitrile gloves – outer
		• Intrinsically safe "sparkless" tools (lights/fans etc)
		• Upgrade to Tyvek (Modified Level D) to minimize skin contact as necessary
		Physical
		• PPE Level D includes
		  o Work shirt and full length cotton pants or coveralls, and leather gloves
		  o ANSI safety-toed boots
		  o ANSI hard hat
		  o ANSI safety glasses
		  o US EPA hearing protection
		• Open communication with Navy personnel
		• Formal equipment certifications/inspections
		• Safe work practices
		• Portable light sources
		• Water/fluids available
		• Work zone will be taped off and appropriate safety signs posted

OTHER SAFETY EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
• Equipment decontamination supplies • First aid kit (on-site and in vehicle) • Fire extinguisher (on-site and in vehicle) • Hand/face washing supplies	• Conduct daily inspection of equipment • Equipment meets or exceeds specifications in Section 19 of U.S Army Corp of Engineers, Safety and Health requirements EM 385 - • Current USCG Certificate of Inspection	• Current 40 Hour/24 Hour HAZWOPER • Equipment operators should have current training for operation • Daily health and safety tailgate prior to field activities to increase awareness

<table>
<tr><th colspan="4">8.0 TASK SPECIFIC ACTIVITY HAZARD AND RISK ANALYSIS</th></tr>
<tr><td>Contract: N62742-02-1802 CTO 0007</td><td>Contractor: TEC Inc.</td><td>Evaluated by: Karl Bromwell</td><td>Date: 5/27/05</td></tr>
<tr><td>Task: Aquifer Testing</td><td>Location: Red Hill Tunnel, Navy Pumping Station Well 2354.001, and adjacent to US Navy Firing Range, Oahu, HI</td><td colspan="2">Relative Risk Ranking: Low to Moderate</td></tr>
<tr><th>PRINCIPAL STEPS</th><th>POTENTIAL HAZARDS</th><th colspan="2">RECOMMENDED CONTROLS</th></tr>
<tr><td>• Mobilize equipment and supplies
• Calibrate and setup equipment (PID near top of casing etc)
• Monitor air during sampling event
• Remove cap and take water level elevation measurements
• Utilize dedicated pumps and water level readout equipment
• Dispose of IDW purge water in oil water separator

<u>EQUIPMENT TO BE USED</u>
• Single-use filters, and pressurized syringes
• Dedicated pumps, water level readout equipment
• Air monitoring equipment
o Model 31 drager pump
o Hydrocarbon 2 drager tubes
o PID – 2020IS</td><td><u>Chemical</u>
• Chemical exposure (petroleum hydrocarbon release, lead, alcohol)
• Fire/explosion – Flammable materials
• Material contact
• Cross contamination hazard
• Organic vapor (benzene)

<u>Physical</u>
• Biological
• Confined working space
• Electrical – Energized equipment
• Firing range hazards
• Ground intrusion
• Heat stress
• Inadequate lighting
• Overhead/underground utilities
• Noise >(85 dba) exposure
• Physical exertion/strain
• Slick/wet surfaces
• Slips, trips, falls and protruding objects
• Uneven terrain</td><td colspan="2"><u>Chemical</u>
• Organic Vapor– air monitoring
• Nitrile gloves – inner
• Nitrile gloves – outer
• Dedicated pumps, safe/organized work zone practices
• Intrinsically safe "sparkless" tools (lights/fans…)
• Modified Level D PPE: Tyvek suits, taped outer gloves and water-proof footwear

<u>Physical</u>
• PPE Level D includes:
o Work shirt and full length cotton pants or coveralls and leather gloves
o ANSI Standard steel toed work boots
o ANSI standard hard hat
o ANSI standard safety glasses
o US EPA standard hearing protection
• Safe work practices and proper communication with Navy personnel prior to accessing site.
• Portable light sources
• Work zone will be taped off with hearing, head, eye signs posted</td></tr>
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<tr><td>• Equipment decontamination supplies
• First aid kit (on-site and in vehicle)
• Fire extinguisher (on-site and in vehicle)
• Hand/face washing supplies</td><td>• Conduct daily inspection of equipment
• Equipment meets or exceeds specifications in Section 19 of U S Army Corp of Engineers, Safety and Health requirements EM 385 -
• Current USCG Certificate of Inspection</td><td colspan="2">• Current 40 Hour HAZWOPER
• Equipment operators should have current training for operation
• Daily health and safety tailgate prior to field activities to increase awareness</td></tr>
</table>

APPENDIX 6
HAZARDOUS COMMUNICATION PROGRAM

No Change. Please refer to Appendix 6 of the original HSP (TEC 2005).

APPENDIX 7
STANDARD SAFE WORK PRACTICES AND SOPS

No Change. Please refer to Appendix 7 of the original HSP (TEC 2005).

APPENDIX 8
NATURAL DISASTER EMERGENCY ACTION PLAN

No Change. Please refer to Appendix 8 of the original HSP (TEC 2005).

APPENDIX 9
BLOODBORNE PATHOGEN EXPOSURE CONTROL PLAN

No Change. Please refer to Appendix 9 of the original HSP (TEC 2005).