NFESC

Naval Facilities Engineering Service Center
Port Hueneme, California

Contract No. 47408-04-C-7526

Draft
Remedial Design (RD) for IR Site 70 Enhanced In Situ Bioremediation
Naval Weapons Station Seal Beach
Seal Beach, California

22 August 2006

Prepared by:

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EXECUTIVE SUMMARY

This Remedial Design (RD) defines the technical and operational requirements for remediation of groundwater contaminated with chlorinated solvents at Installation Restoration (IR) Program Site 70, Naval Weapons Station (NAVWPNSTA) Seal Beach, California (Figure 1.1). GeoSyntec Consultants, Inc. (GeoSyntec) prepared this document for Southwest Division, Naval Facilities Engineering Command (NFECSW) under a contract with Naval Facilities Engineering Service Center (NFESC). The Department of Navy (DON) NFECSW directs this remedial action in accordance with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). NAVWPNSTA Seal Beach is located in the City of Seal Beach, California. Surrounding municipalities include Los Alamitos to the north, Westminster to the east, Huntington Beach to the southeast, and Long Beach to the west. The Pacific Ocean borders NAVWPNSTA Seal Beach to the south (Figure 1.1). The Seal Beach National Wildlife Refuge (SBNWR) is located southeast of the site within the Station boundaries. IR Site 70, also known as the Research, Testing, and Evaluation (RT&E) area, consists of multistory office and production buildings, asphalt-paved parking areas, an assortment of aboveground tanks and attendant above- and below-ground piping distribution systems, several concrete-lined sumps, and underground storage tanks (USTs).

Groundwater contamination exists in two distinct areas: (i) a suspected source area which may contain residual dense, non-aqueous phase liquid (DNAPL) source with dissolved trichloroethene (TCE) concentrations exceeding 1,000 µg/L at shallow depths (within 60 ft below ground surface; bgs); and (ii) a dissolved phase plume extending downgradient in a south-southeasterly direction from the source. The areal extent of the volatile organic compound (VOC) plume in groundwater is approximately 4,000 ft by 1,500 ft, with vertical migration exceeding 160 ft from the water table (approximately 13 feet below ground surface (ft bgs)). The highest TCE concentrations in the source area were reported at 130,000 µg/L, with much lower TCE concentrations (<1,000 µg/L) observed throughout the majority of the plume. Low levels of cis-1,2-dichloroethene (cis-1,2-DCE; < 100 µg/L) and vinyl chloride (VC; <10 µg/L) are primarily seen near the source area and at lower concentrations throughout the plume. Preliminary results from the natural attenuation microcosm study portion of the Pilot Study (Appendix D) confirm that intrinsic biological attenuation of the plume is minimal. An analysis of natural attenuation of TCE within the plume, presented in Appendix A, suggests that the natural attenuation half life rate of TCE is on the order of 5 years.

The Extended Removal Site Evaluation (ERSE; BNI, 1999) concluded that no complete exposure pathway exists between chemicals in groundwater and ecological receptors at IR Site 70. The groundwater plume is approximately 60 feet below ground surface at the leading edge where it approaches the SBNWR boundary. The human-health risk screening for IR Site 70 groundwater estimated a total cancer risk of 1.2 x 10^{-1} and a hazard index of 4,600, resulting primarily from TCE, which exceeds the NCP-defined generally acceptable range. Upon review of the operational history and site-specific groundwater data, the DON has determined that this site contains elevated concentrations of TCE in groundwater which threatens multiple aquifers, thus requiring a response action. As a result, the DON has initiated the remedial action described herein for the impacted groundwater at IR Site 70 to reduce any potential threats to human health and the surrounding environment.

The following Remedial Action Objectives (RAOs) were developed for IR Site 70 groundwater cleanup (GeoSyntec, 2005b):

- Consistent with United States Environmental Protection Agency (EPA), State Water Resources Control Board (SWRCB), California Environmental Protection Agency (Cal/EPA), and Regional Water Quality Control Board (RWQCB) Santa Ana Region policies and regulations, protect existing beneficial uses of the shallow aquifer underlying NAVWPNSTA Seal Beach to the extent practicable while preventing or minimizing VOC migration beyond the current NAVWPNSTA Seal Beach boundaries at concentrations exceeding site remediation goals;
- Prevent further degradation of groundwater quality (e.g., through DNAPL mobilization and/or spreading of dissolved phase contamination related to remedial activities); and
- Protect human health by preventing extraction of VOC-impacted shallow groundwater for domestic use until site remediation goals are achieved.

Chloroform, 1,1-dichloroethene, TCE, 1,1-dichloroethane, cis-1,2-DCE, trans-1,2-dichloroethene, tetrachloroethene and VC were identified as the primary contaminants of concern (COCs) at IR Site 70 based on their contribution to the screening-level carcinogenic risk and frequency of occurrence at the site. The target cleanup goals (TCGs) for IR Site 70 groundwater are as follows:

Analyte VOCs	**Performance Criteria (μg/L)**
Chloroform	100
1,1-Dichloroethene	6
cis-1,2-Dichloroethene	6
trans-1,2-Dichloroethene	10
Trichloroethene	5
Vinyl chloride	0.5

The values listed in the table are federal Maximum Contaminant Levels (MCLs) for drinking water promulgated by EPA or California MCLs established by the Department of Health Services, whichever is lower for a given constituent (GeoSyntec, 2005b). While MCLs have generally been established as TCGs for the purposes of developing the full-scale bioremediation design, this should not be construed as an acceptance by the DON of final remediation goals at IR Site 70. The DON believes establishing final remediation goals is an iterative process, taking into account site-specific factors such as aquifer classification and designated use, technical practicability to achieve the stated cleanup goals, and the site- and chemical-specific nature of the groundwater requiring remedial action.

The selected remedy for groundwater at IR Site 70 is enhanced *in situ* bioremediation (EISB), monitored natural attenuation (MNA), and land-use controls (LUCs). Site remedial activities will contain the following major components:

- Utility clearance through review of existing public works maps and drawings for gas, electrical, communication, water, sewer, fiber optic, and other buried utilities.
- A geophysical survey to assist in locating and marking any underground utilities or features and to provide utility clearance.
- Submittal and approval of a dig authorization form from the NAVWPNSTA Seal Beach Facilities Department will precede any subsurface activity at IR Site 70.
- Construction of a network of groundwater monitoring wells.
- Installation of a grid of emulsified vegetable oil (EVO) injection wells in the source area to deliver electron donor (i.e. EVO) throughout and subsequently maximize enhancement of DNAPL dissolution.
- Construction of six biobarriers (one to contain ongoing mass flux from the source, five to treat the plume) along the plume through installation of lines of EVO injection wells transecting the plume at select locations and depths. Dissolved phase contaminants will be treated as groundwater flows through each biobarrier under ambient groundwater flow (i.e., passive treatment).
- Initial injections of EVO to accelerate natural biodegradation of VOCs in groundwater.
- Injection of a commercially available *Dehalococcoides* (DHC) culture to stimulate complete dechlorination of VOCs to ethene.
- Comprehensive performance monitoring throughout the EISB process to monitor remedial performance and assess the need for biobarrier maintenance.

- Periodic maintenance of the biobarriers in the form of EVO reinjections, re-bioaugmentation, etc. as needed.
- Monitoring of contaminant concentrations and natural attenuation parameters until remediation goals are achieved.

Active remediation will be conducted within areas of TCE concentrations exceeding 250 µg/L. Active treatment consists of continued re-injection of EVO within the treatment areas (ie. within the biobarriers or source zone). Active treatment will be terminated once the TCE concentrations within the plume and source area reduce below 200 µg/L. Monitored natural attenuation will be employed throughout the remainder of the plume not actively treated (i.e., where TCE concentrations are below 200 µg/L) and after the active treatment phase until final cleanup goals are achieved. It is estimated that active treatment of the plume will be required for a maximum of 16 years (with shorter operation times for some biobarriers), followed by 35 years of MNA to achieve TCGs. The duration of source treatment cannot be predicted due to the lack of information regarding the mass of DNAPL phase TCE present in the subsurface. Due to the minimal seepage velocity of the plume, natural attenuation processes, and retardation of VOC migration, the plume is not expected to expand much beyond its current boundaries, and is not anticipated to impact potential ecological or human receptors during the 50 year treatment timeframe. A component of the MNA program includes monitoring of sentinel wells situated at strategic locations that will allow for corrective measures to be taken if plume migration and attenuation levels are unacceptable. Monitoring of the MNA will be done during the active treatment phase to determine the trends of MNA in the dissolved phase plume. Based on these results the DON will propose modifications and/or discontinuing MNA as evidence is gathered that the plume is naturally degrading to meet the TCGs.

A monitoring program will be initiated to track progress towards achievement of the following performance criteria:

- Complete dechlorination of TCE to ethene within the biobarriers;
- Localized and/or minimal secondary groundwater quality impacts; and
- *DHC* growth to concentrations exceeding 10^7 cells/L, and migration of the augmented culture throughout the active treatment zones.

Similarly, criteria for MNA performance include indications of reducing TCE concentrations with time and minimal expansion of the plume beyond the current extents. Monitoring programs were developed for the first five years of monitoring, at which point we recommend that the sampling locations, frequency and analytes monitored be optimized for the long-term monitoring program. The sampling program may be refined as necessary within the initial five year period and through subsequent five year periods as needed, based on the data collected.

Key locations within each biobarrier/treatment area will be monitored to assess EISB performance. These locations were selected from those areas that will provide early indications of EVO consumption (and thus the need to reinject) and/or locations where biobarrier performance is most likely to be lowest (e.g., due to insufficient residence time, higher initial TCE concentrations requiring more degradation half-lives to meet TCGs, etc.). In this way, the sampling and analytical costs may be minimized while continuing to collect critical information. Vertical monitoring intervals will be confined to 10 ft intervals, per U.S. EPA guidance (U.S. EPA, 1986), and nested wells will be used to monitor treatment zones that exceed 25 ft in vertical depth. If at any time decreasing EISB performance is detected at these "sentinel" wells indicating the need for biobarrier maintenance, then selected other locations will be sampled to evaluate the extent of the region within the treatment area that requires maintenance and appropriate corrective action will be taken.

A number of parameters will be sampled from wells located within active treatment zones on a quarterly basis for the first year of operation (to confirm the successful stimulation of desired bioactivity levels), followed by semi-annual monitoring (to assess ongoing treatment levels and the need for biobarrier maintenance) for the initial five year period. Targeted analytes include VOCs, dissolved hydrocarbon gases (DHGs; innocuous end products of the dechlorination reaction, including ethene and ethane, and methane), inorganic anions (particularly chloride, which is another daughter product of the dechlorination process), polymerase chain reaction (PCR) assays specific to DHC, depth to water (to monitor changes in groundwater flow direction) and field parameters [particularly pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO), which are measures of geochemical conditions required for anaerobic microbial activity].

To assess the continuing presence of EVO within the treatment zone, qualitative measures of EVO presence will also be monitored in these locations on a semi-annual basis, including total organic carbon (TOC) and volatile fatty acids (VFAs) acetic, butyric, lactic and propionic acids (breakdown products of EVO fermentation). To evaluate the potential impact on secondary groundwater quality and the contaminant distribution in the plume, samples will be obtained from targeted locations downgradient of the biobarriers on a semi-annual basis. To provide a baseline comparison, samples will also be obtained from up-gradient locations at similar sampling intervals. Targeted analytes include all of the bioremediation performance indicators listed above (i.e., VOCs, DHGs, inorganic anions, DHC, depth to water, and field parameters including total dissolved solids and specific conductance), as well as secondary groundwater quality parameters including dissolved metals (e.g., iron, manganese, arsenic), and sulfide.

MNA sampling locations were chosen to provide one of two forms of information: (i) "sentinel" wells were selected to provide early indications of undesired plume migration (which may warrant corrective action) and to provide information with regards to attenuation of lower concentrations of TCE on the fringe of the plume; and (ii) performance assessment wells located along the core of the plume between biobarriers to provide some indication of potential biobarrier operation timeframe. Vertical monitoring intervals will be confined to 10 ft intervals, per U.S. EPA guidance (U.S. EPA, 1986), with screened intervals corresponding to the approximate center of the targeted treatment depth interval.

Sampling frequencies for each MNA well were selected in consideration of the attenuation rate of TCE as well as considering the potential plume migration rate in each hydrogeologic unit. Accordingly, both sentinel and biobarrier MNA wells will be sampled annually for the first five years of operation. Targeted analytes include VOCs, DHGs, DHC PCR assays (to assess potential migration of dechlorinating microorganisms outside of the active treatment zone and any related impact to the attenuation rate in these areas; between biobarrier wells only), depth to water (to monitor changes in groundwater flow direction) and field parameters.

DON has defined the point of compliance as the base boundary and has agreed to provide a point of compliance (POC) well network for the Site 70 plume. These wells are located outside the current extent of the plume based on the 2005 groundwater data (BNI, 2005). The POC will have sentinel wells located within the respective zones. A baseline sampling event will be completed for all of the POC network wells to define existing conditions. Subsequent sampling of the POC wells will be based on an assessment of baseline data, solute transport time (from the model), distance from the edge of the plume, and historic groundwater flow rates for each unit.

Annual reviews of monitoring data will be conducted to assess biobarrier performance and the need for maintenance, plume migration, dechlorination activity, extent of microbial migration, changes to monitoring program based on trend analysis of monitoring data, and the adequacy of the remedial action to meet RAOs. Annual reviews will be documented in a summary report issued to appropriate regulatory agencies. These reports may include suggested modifications to the cleanup program to optimize remedial performance, changes to the monitoring program, and suggestions minimize O&M costs.

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ACRONYMS

AOCs	areas of concern
ARARs	applicable or relevant and appropriate requirements
BNI	Bechtel National Inc
Cal EPA	California Environmental Protection Agency
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeters per second
COC	chain of custody
COPCs	chemicals of potential concern
˚F	degrees Fahrenheit
DHC	*Dehalococcoides*
DHG	dissolved hydrocarbon gases
DHS	Department of Health Services
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DON	Department of the Navy
DOT	Department of Transportation
DTSC	Department of Toxic Substances Control
EISB	enhanced *in situ* bioremediation
EMI	electromagnetic induction
ERSE	Extended Removal Site Evaluation
EVO	emulsified vegetable oil
EVS	Environmental Visualization Systems
Freon TF	trichlorotrifluoroethene
FS	Feasibility Study
Ft	feet
ft/ft	feet per foot
ft bgs	feet below ground surface
GPR	ground-penetrating radar
HWCA	Hazardous Waste Control Act
IR	Installation Restoration
ISB	*in situ* bioremediation
JEG	Jacobs Engineering Group
KB-1™	mixed constortia of dehalorespiring bacteria
Kg	kilograms
L	liters
LDR	Land Disposal Restriction
LUC	land use controls
MCLs	maximum contaminant levels
MCLGs	maximum contaminant level goals
µg/L	microgram per liter

ACRONYMS

Mg/L	milligrams per liter
MNA	monitored natural attenuation
MSDS	material safety data sheet
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Control
NAVFACCO	Naval Facilities Engineering Command Contracts Office
NAVWPNSTA	Naval Weapons Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFECSW	Naval Facility Engineering Command Southwest Division
OCEHS	Orange County Environmental Health Services
O&M	operation and maintenance
ORP	oxidation reduction potential
OSHA	occupational safety and health administration
PA	Preliminary Assessment
PCR	polymerase chain reaction
PE	professional engineer
PPE	personal protective equipment
PRGs	preliminary remediation goals
PVC	polyvinyl chloride
QA	quality assurance
QAO	quality assurance officer
QC	quality control
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDO	Remedial Design Optimization
RFS	Revised Feasibility Study
RI	Remedial Investigation
ROI	radius of injection
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
RRSEM	Relative Risk Site Evaluation Model
RSE	Remedial Site Evaluation
RT&E	Research, Testing, and Evaluation
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SBNWR	Seal Beach National Wildlife Refuge
SDWA	Safe Drinking Water Act
SHSO	Site Health and Safety Officer
SWRCB	California State Water Resources Control Board
TCE	trichloroethene
TCGs	target cleanup goals
TCLP	Toxicity Characteristic Leaching Procedure

ACRONYMS (cont.)

TDS	total dissolved solids
TSDF	treatment, storage, and disposal facility
USCS	Unified Soil Classification System
U.S. EPA	United States Environmental Protection Agency
USTs	underground storage tanks
VCs	vinyl chloride
VFA	volatile fatty acids
VOCs	volatile organic compounds
WET	Waste Extraction Test
WQCP	water quality control plan
WQOs	water quality objectives
WRD	Water Replenishment District of Southern California

1. INTRODUCTION

1.1 Purpose and Scope

This Remedial Design (RD) defines the technical and operational requirements for remediation of groundwater contaminated with chlorinated solvents at Installation Restoration (IR) Program Site 70, Naval Weapons Station (NAVWPNSTA) Seal Beach, Seal Beach, California (Figure 1.1).

NAVWPNSTA Seal Beach is an active federal facility that is being remediated under the IR Program. The station is not on the National Priorities List. The lead agency for remedial investigation (RI) and remedial action at this station is the Department of the Navy (DON). Regulatory agencies providing support and oversight include the Department of Toxic Substance Control (DTSC) and the Regional Water Quality Control Board (RWQCB) Santa Ana Region.

The DON, Naval Facility Engineering Command Southwest Division (NFECSW), directs this remedial action in accordance with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Upon review of the site's operational history and site-specific groundwater data, the DON has determined that this site contains elevated concentrations of trichloroethene (TCE) in groundwater, thus requiring a response action. The DON has initiated the remedial action for the impacted groundwater at IR Site 70 to reduce potential threats to human health and the surrounding environment.

The purpose of this RD is to define the technical and functional requirements for remediation of groundwater contaminated with chlorinated solvents at IR Site 70. The scope of work for this RD consists of an aggressive biostimulation/bioaugmentation *in situ* treatment option for the high concentration source area, a passive *in situ* biobarrier treatment of the dissolved-phase contamination, monitored natural attenuation, and land use controls. The implementation, inspection, reporting, and enforcement of the land use controls will be conducted in accordance with the current NAVWPNSTA Seal Beach procedures, and as outlined below.

1.2 Overview of Remedial Approach

The remediation approach for IR Site 70 consists of two distinct methods one for the source area and the other for the dissolved plume phase. The enhanced treatment approach for the high concentration source area will consist of a grid of injection wells that cover the source area. These wells will be constructed so that electron donor (emulsified vegetable oil; EVO) injections can be made at future dates as needed. Injection of the EVO will create a reduced environment conducive to microbial growth. KB-1™ (mixed dehalorespiring bacteria including *DHC*) will be amended to the subsurface in the middle of EVO injections, with a pre- and post-injection flush of anoxic and reduced water that will provide the required geochemical environment for *DHC* growth and activity. The population density of the *DHC* will be monitored along with electron donor and contaminant concentrations. Monitoring data will be used to determine the need for additional electron donor injections, growth and dispersion of *DHC,* and groundwater quality. At start up, the monitoring program will be more frequent to identify the dechlorination rate and to demonstrate the complete dechlorination to ethene within the target timeframe.

The conceptual approach for the dissolved phase plume is to construct permeable biobarriers through the use of multiple well points that will transect the plume at selected locations. These transects will consist of individual well points that will allow multiple dosing of EVO on an as needed basis. EVO and KB-1™ injections will be performed in a similar manner to that used in the source area. Dispersion of the *DHC* will be monitored along with electron donor and contaminant concentrations as outlined above for the source treatment.

Documents consulted in order to develop this design document include the following documents:

- Extended Site Removal Evaluation (ERSE) [Bechtel National Inc. (BNI), 1999];
- Groundwater Feasibility Study Report (FS) (BNI, 2002);
- Revised Groundwater Feasibility Study Report (RFS) (GeoSyntec, 2005a); and,
- Pilot Study (Appendix D), previously referred to as the Remedial Design Optimization (RDO) Investigation and Report.

The remainder of this document is organized as follows:

- Section 2 - Site Conditions
- Section 3 - Regulatory Framework
- Section 4 - Remedial System Design
- Section 5 - Pre-Remediation Construction Activities
- Section 6 - Remediation Operations, Performance Monitoring and Reporting
- Section 7 - Waste Management Plan
- Section 8 - Project Management
- Section 9 - References

2. SITE CONDITIONS

2.1 Facility and Site Description

IR Site 70, also known as the Research, Testing, and Evaluation (RT&E) area, consists of multistory office and production buildings, asphalt-paved parking areas, an assortment of aboveground tanks and attendant above- and below-ground piping distribution systems, several concrete-lined sumps, and underground storage tanks (USTs). From 1962 to 1973, the National Aeronautics and Space Administration (NASA) utilized the area for the design and manufacture of the Saturn II launch vehicle for the Apollo Program. Subsequent to NASA leaving the area, the United States Department of Energy and Garrett Engineering (Allied Signal) conducted pilot test assembly operations for a classified uranium enrichment process in portions of Building 112. These tests were conducted from 1980 to 1985 but did not include either the manufacture or enrichment of uranium. Currently, the building is used for storage, communications research, and office space.

The Removal Site Evaluation (RSE) Report from Bechtel National, Inc. (BNI 1996a) for the IR Site 70 area addressed potential waste sources from:

- Bulkhead Fabrication Building 128;
- Vertical Assembly and Hydrotest Building 112;
- Pneumatic Test, Paint, and Packaging Building 122;
- Tool and Maintenance Building 130;
- Structural Test Tower; and
- Water Conditioning Plant.

Operations at these facilities included the use of dilute acids, volatile organic compounds (VOCs) including chlorinated solvents such as TCE, phenolic compounds, petroleum oils, sodium dichromate containing hexavalent chromium, detergents, metals containing paint wastes, and machine lubricating oil. Discharged wastewater contained high total dissolved solids (TDS), sodium, chloride, and had high or low pH.

IR Site 70 is located just south of Westminster Boulevard and east of Seal Beach Boulevard (Figure 2.1). IR Site 70 encompasses approximately 40 acres, but the groundwater plume extends beyond the site boundaries. Groundwater at the site is impacted by the past use of chlorinated solvents (primarily TCE), with possible dense non-aqueous phase liquid (DNAPL) and dissolved phase chlorinated solvents reported by Bechtel National Inc. (BNI, 2002). Groundwater contamination extends from the water table near the source area to approximately 170 feet below ground surface (ft bgs).

A Site conceptual model was generated from the remedial investigation data and presented in the Feasibility Study (BNI, 2002).

2.2 Previous Investigations

In 1993, Jacobs Engineering Group (JEG) conducted a Preliminary Assessment (PA) of IR Site 70 (JEG 1994). Ten Areas of Concern (AOCs) were identified for further evaluation to assess the presence or absence of chemicals of potential concern (COPCs). These ten AOCs were identified based on historical activities, use of chemicals, and the likelihood of a potential threat to human health and the environment. The PA identified major COPCs as hexavalent chromium, TCE, phenolic compounds, trichlorotrifluoroethane (Freon TF), and heavy metals.

BNI conducted an RSE for the RT&E area (BNI 1996a) to address potential waste sources from IR Site 70. The RSE report recommended that process piping systems and facilities be decommissioned and that soil and groundwater in the area be investigated further (BNI 1996a). These facilities were decommissioned in 1998, as documented in the decommissioning report (Battelle, 1998). The report also recommended soil investigations for the presence of hexavalent chromium, vinyl chloride (VC), and heavy metals. Groundwater investigations were recommended to delineate the TCE plume and to determine a potential vadose zone source, as well as the nature and extent of hexavalent chromium, phenolic compounds, and heavy metals.

In 1996, soil and groundwater samples were collected at IR Site 70 to obtain analytical data necessary to populate a Relative Risk Site Evaluation Model (RRSEM, BNI 1996b). By using data collected at NAVWPNSTA Seal Beach and 14 other bases, the RRSEM was used to assist in prioritizing funding for sites in the IR Program. The samples indicated the presence of VOCs, semivolatile organic compounds, polychlorinated biphenyls, pesticides, and metals. Based on this and subsequent studies, including the ERSE of IR Sites 40 and 70 (BNI, 1999), the Navy determined that there was no immediate threat to the environment from groundwater at IR Site 70. The Remedial Investigation/Feasibility Study (RI/FS) (BNI, 2002) determined that groundwater at IR Site 70 was impacted and a remedial action was required to address the source area and dissolved phase plume, based on a human health risk evaluation.

A RFS was developed for the DON in response to a DON directive for optimizing remedial actions (GeoSyntec, 2005a). Based on advancements in bioremediation of source area and dissolved phase VOCs, the RFS evaluated the use of *in situ* bioremediation alternatives for remediating the site. *In situ* biobarriers to treat the dissolved plume and *in situ* bioremediation of the source area rated highest overall among the five balancing criteria. Based on these results, the DON decided to proceed with this alternative in order to remediate the site. Subsequently, a Pilot Study was conducted in which field studies were carried out to optimize the design of the remediation. The results of these field studies are presented in Appendix D. The Pilot study demonstrated that site soil and groundwater samples from Site 70 could be dechlorinated through enhanced bioremediation.

2.3 Physical Setting

NAVWPNSTA Seal Beach is situated at latitude 33° 45’ 27” N and longitude 118° 4’ 22” W, San Bernardino Baseline and Meridian. NAVWPNSTA Seal Beach is located within the Los Angeles-Orange County coastal plain. This northwest-trending structural basin is approximately 50 miles long and 20 miles wide with deposits as much as 20,000 feet thick. Basin morphology was developed through the mechanisms of folding, faulting, erosion, and fluctuating sea levels (JEG, 1994).

Most of the NAVWPNSTA Seal Beach lies on predominantly flat alluvial deposits in the southeastern portion of the Los Angeles Basin. The Los Angeles Basin is bounded on the north by the Santa Monica Mountains; on the northeast by the Repetto and Puente Hills; on the east and southeast by the Santa Ana Mountains and the San Joaquin Hills; and on the south, southwest, and west by the Palos Verdes Hills and the Pacific Ocean. The land at NAVWPNSTA Seal Beach slopes evenly from approximately 20 feet above sea level in the northwestern part of the NAVWPNSTA Seal Beach to sea level in the tidal flats of the Seal Beach National Wildlife Refuge (SBNWR) in the southeast (Figure 2.2). The most pronounced topographic feature at the NAVWPNSTA is part of Landing Hill on the southwest. Landing Hill reaches a maximum elevation of about 50 feet (JEG, 1994).

The area climate is classified as a marine-influenced southern California coastal region with mild winters that average 52 degrees Fahrenheit (°F) and summers that average 68 °F. Temperature ranges from winter lows in the 30s °F to summer highs in the 90s °F. Annual precipitation averages 12.5 inches, with approximately 90 percent occurring between the months of November and April. Although precipitation is low, a high humidity level is sustained because of the proximity of the Pacific Ocean (JEG, 1994). Prevailing winds average 3.8 miles per hour from the west. Occasional strong, dry winds from the northeast, known as the “Santa Anas,” occur in the fall, winter, and early spring (JEG, 1994). Periodically, the region is subjected to a phenomenon called “El Nino,” which brings unusually high precipitation, flooding, high winds, and temperatures outside the expected range. The NAVWPNSTA was subjected to this El Nino weather pattern in 1997 and 1998, resulting in extremely high winds, higher than normal tidal cycles, a rise in groundwater level, flooding, and ponding in otherwise dry areas.

2.4 Regional Geology/Hydrogeology

Two faults, the Seal Beach Fault and the Los Alamitos Fault, traverse portions of the station. These two faults are part of the Newport-Inglewood Fault zone. The Seal

Beach Fault is located in the southern portion of the Newport-Inglewood Fault zone. It is a right lateral oblique fault with the south side displaced upward relative to the north side. Vertical displacement is approximately 5 feet in the upper Pleistocene units (Ebersold, 1997). Movement along the fault since or during recent alluvium deposition has not displaced recent sediments. On the station, the Seal Beach Fault has uplifted Upper Pleistocene deposits at Landing Hill and Hog Island, cutting diagonally across the station and parallel to the coast (JEG 1995a). Apparent movement is nearly vertical with the south side displaced upward relative to the north side. There is also evidence of apparent right lateral motion (Ebersold, 1997). The Los Alamitos Fault lies parallel to the Seal Beach Fault and about 2.25 miles northeast of the Alamitos Gap. The Los Alamitos Fault has little effect on the movement and quality of groundwater in the Lower Pleistocene San Pedro Formation and is older than the active Seal Beach Fault (JEG 1995a).

Soils at the station contain abundant clay and silt and are poorly drained. Six soil types have been identified. The Bolsa series (JEG, 1995b; SCS, 1978) covers approximately two-thirds of NAVWPNSTA Seal Beach including IR Site 70 (Figure 2.3). These soils are moderately alkaline and calcareous and have developed from largely flat alluvial and coastal deposits. The soils extend to approximately 49 inches below ground surface (bgs) and have moderate to slow permeability.

The sequence of the stratigraphy underlying NAVWPNSTA Seal Beach, from youngest to oldest, is:

- Recent Alluvium;
- Upper Pleistocene Lakewood Formation;
- Lower Pleistocene San Pedro Formation; and
- Pliocene Pico Formation.

The maximum thickness of Recent Alluvium deposits in the region is approximately 80 to 100 feet. The upper 50 feet consists of fine sands, silty clays, and clays, while the lower unit consists of sands and gravels, silty sands, silty clays, and clays.

Transitional, shallow marine and fluvial deposits of great variability are part of the Upper Pleistocene sand and clay deposits, starting at approximately 80 to 100 feet and continuing to depths beyond the scope of investigations at IR Site 70. Units are discontinuous and contain zones of high and low permeability. The maximum thickness of the Lakewood Formation is approximately 350 feet in the city of Lakewood (DWR, 1961).

NAVWPNSTA Seal Beach is located at the southwestern corner of the Orange County Basin. The Orange County Basin contains the Artesia, Gage, Hollydale, Jefferson, Lynwood, and Silverado aquifers. The Lynwood and Silverado aquifers are merged across most of the station (JEG, 1995a). There are four general aquifer zones at the station (JEG, 1995a):

- a semiperched, unconfined zone within the upper Recent Alluvium deposits;
- a confined fresh groundwater zone contained in lower Recent Alluvium deposits;
- Late and Early Pleistocene deposits of the Lakewood and San Pedro Formations, respectively, and in some parts, deposits of the Late Pliocene Pico Formation; and

- a confined zone of saline water underlying the freshwater zone.

Shallow groundwater underlying the station (upper Recent Alluvium deposits) is within the Lower Santa Ana River Basin (Orange County management zone) (RWQCB, 1995, with Amendment R8-2004-0001). Beneficial uses of groundwater within the Orange County management zone include municipal and domestic supply, agriculture, industrial service supply, and industrial process supply. Shallow groundwater underlying IR Site 70 currently does not serve as a water source for any of the beneficial uses designated in the Water Quality Control Plan, Santa Ana River Basin (Basin Plan) (RWQCB, 1995).

The principal freshwater body (lower Recent Alluvium deposits and Upper Pleistocene Lakewood Formation) is a large confined aquifer occupying two zones. The first zone is approximately 75 to 200 feet deep and saline. The second zone is approximately 250 to 1,000 feet deep and freshwater. This aquifer is the primary water supply source for neighboring cities. Groundwater levels in the principal freshwater zone fluctuate from year to year due to variations in pumping, infiltration, and recharge. Recharge to this aquifer is primarily from unconfined areas upgradient and from unlined rivers that are hydraulically connected to the aquifer. Seasonal variations occur with highs in the wet winter months and lows in the dry summer months when large quantities of water are used for irrigation (JEG, 1995a).

2.5 Site Conditions at IR Site 70

2.5.1 Observed Geologic Units

The information presented within this section is based upon the refined site conceptual model that was developed from the results of the Pilot Study activities. See Appendix D for more details. The local geology, based upon groupings of higher hydraulic conductivity soils and lower conductivity soils into separate units to better represent hydrogeological behavior, is shown in cross-section view in Figure 2.4. This conceptual site model consists of six separate hydrostratigraphic units or model layers. Working down from ground surface, these are:

- **Upper Fines Unit (ground surface to approximately 60 ft bgs).** Comprises three zones: a shallow zone of surficial soils and recent clayey sediments; an intermediate zone of interbedded silts, clays, and sandy silts and clays that includes the semi-perched zone; and a lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands. A zone of organic material, mainly wood chips, was encountered in a number of boreholes at a depth of approximately 45 to 50 ft bgs.
- **First Sand (approximately 60 to 105 ft bgs).** Poorly-graded fine-grained sands and silty sands. A coarse sand/fine gravel layer was encountered in

several borings between 80 and 95 ft bgs. This coarse layer lies just above or slightly within the Shell Horizon. The First Sand varies in thickness from approximately 30 to 50 feet.

- **Shell Horizon (approximately 105 to 135 ft bgs).** Characterized by a sequence of interbedded clays, silts, sands, and gravels below the source area grading to predominantly fine-grained sand in the vicinity of RDO-6A/B. This Unit has been subdivided into the Shell Horizon (Interbedded Clays) and Shell Horizon (Fine-grained Sands) to reflect differences in the plume migration behavior and hydrogeologic characteristics. Shell and gravel layers were encountered in some but not all borings, comprising interbeds within the Shell Horizon that do not appear to be spatially extensive. Wood chips were encountered in several borings at a depth of about 110 feet.
- **Second Sand (approximately 135 to 170 ft bgs).** Similar in character to the First Sand; however, this lower unit appears to be slightly coarser in its upper section.
- **Deep Clay (approximately 170–190 ft bgs).** Regional geological trends suggests that this Deep Clay Unit is likely continuous throughout the area of IR Site 70. Where it has been encountered on Site, it is described as a fat clay and is described in the literature as an interbedded unit (BNI, 2002).
- **Deep Sand (approximately 190 ft bgs and below).** Appears to be similar in character to the First and Second Sand Units; however, it has been logged in only a few sample points on Site (BNI, 2002).

2.5.2 Hydraulic Conductivities and Heterogeneity

The hydraulic conductivities of screened intervals in selected groundwater monitoring wells were determined on the basis of aquifer (slug and continuous discharge pumping) tests (BEI, 2003). Local relative vertical variability in hydraulic conductivities (indicating degree of soil heterogeneity) was evaluated using electromagnetic borehole flowmeter surveys in selected groundwater monitoring wells installed as part of the Pilot Study activities (Appendix D). Results of the tests may be summarized as follows:

- **Upper Fines Unit:** Relatively low horizontal hydraulic conductivity, based on limited lateral migration of dissolved phase contaminants within this Unit. Vertical variability of hydraulic conductivities an order of magnitude or higher within a distance of a few feet was observed during Pilot Study activities (Appendix D), indicating significant heterogeneity in this Unit.
- **First Sand Unit:** Represented by a horizontal hydraulic conductivity of 2.4×10^{-2} cm/sec (centimeter per second) based on a slug test (BEI, 2003) this unit varies dramatically across the transect wells. The zone of highest relative permeability within this unit (at minimum an order of magnitude

higher) in the area of the transect of wells installed during Pilot Study activities (RDO-1 to RDO-5) appears to be between 65 to 80 ft bgs.

- **Shell Horizon:** Estimated hydraulic conductivities range from $1x10^{-7}$ cm/sec horizontal and $1x10^{-7}$ cm/sec vertical near the source area where the Shell Horizon is predominantly interbedded clays, to $1x10^{-2}$ cm/sec horizontal and $8x10^{-4}$ cm/sec vertical for the area where the Shell Horizon is predominantly fine-grained sand (BEI, 2003). Localized variability in K in the region of the Shell Horizon where it grades to predominantly fine-grained sand ranges by an order of magnitude between layers with thicknesses typically on the order of one to two feet (GeoSyntec 2006).
- **Second Sand Unit:** The bulk hydraulic conductivity of the Second Sand Unit is approximately $2.3x10^{-2}$ cm/sec horizontally and $1.5x10^{-3}$ cm/sec vertically based on the 2003 pump test (BEI, 2003). Vertical characterization of K variability in the upper coarser area of this Unit, showed a smaller degree of heterogeneity than the Shell Horizon (GeoSyntec, 2006).

The hydraulic conductivities of the Deep Sand range from 10 to 100 feet per day based on information from the Geologists Report Alamitos Barrier Improvement Project Construction Unit 12, Los Angeles and Orange Counties, California (December 30, 1997, Section 2.2, page 13). This is based on correlation of the Deep Sand Unit to the B aquifer. The hydraulic conductivities of the Deep Clay Unit are unknown.

2.5.3 Groundwater Flow

The First and Second Sands are laterally continuous and are both of sufficient horizontal and vertical conductivities to allow for both vertical and horizontal migration to occur. The Upper Fines, Shell Horizon (Interbedded Clays) Units and the Deep Clay exhibit geologic layers that significantly hamper the migration of contaminants, likely due to their predominantly fine-grained character and a lack of connected layers of high permeability. However as the Shell Horizon grades to a slightly coarser unit to the southeast, it provides vertical continuity between the First and Second Sands allowing for vertical migration of contaminants. The Deep Sand appears separated from the Second Sand in the study area by the Deep Clay.

Groundwater flow in the First Sand Unit is nearly south near the source area (averaging approximately 170° from north), which is the direction of plume migration in the upgradient portion of the plume where it is primarily confined to this unit. Groundwater flow in the Second Sand Unit is more southeasterly, resulting in a shift in the plume migration direction where the plume migrates vertically into this Unit. Downgradient of this location, the groundwater flow direction within the First Sand Unit also appears to shift to a more southeasterly direction, although limited data is available in this area. The vertical head difference between hydrogeologic units indicates consistent downward migration of groundwater throughout the plume and source area, with some localized areas (primarily near the RDO-6 well nest see Figure 2.5) with slight head differences that imply at least transient localized areas of upward migration of groundwater between the Second and First Sand Units.

The general groundwater flow direction in each hydrogeologic unit is consistent over time, with little seasonal variation. The magnitude of the average horizontal hydraulic gradients in each of the units also appears to remain consistent with time, although seasonal variations between summer and winter months are observed along with seasonal fluctuations in the water elevations ranging up to 7 feet (ft) in all layers. The gradients in the winter months are generally a factor of two to three lower than those in the summer months. The horizontal gradients are highest in the First Sand Unit, by approximately a factor of three in comparison to those in the Upper Fines Unit and the Second Sand. The average horizontal hydraulic gradient in each unit ranges from 0.0006 feet per foot (ft/ft) in the Upper Fines Unit, 0.0007 ft/ft in the Second Sand, up to 0.002 ft/ft in the First Sand/Shell Horizon (Fine-Grained Sands).

Potential external factors that may influence local gradients and vertical migration of groundwater include groundwater pumping (regional water supply wells) and aquifer recharge (e.g., Alamitos Injection Barrier) activities. Groundwater pumping and aquifer recharge in the Orange County Groundwater Basin cause significant temporal fluctuations in the local groundwater elevations; however, the temporal consistency in the gradients and groundwater flow direction indicate that the overall impact to local groundwater flow migration is minimal. Tidal influences appear negligible in areas within the Site that will be impacted by remediation activities (BEI, 2003).

In the long-term, variability in the groundwater migration behavior on Site may be caused by changes in operation of the Alamitos Injection Barrier. The Alamitos Injection Barrier, to the Northwest of IR Site 70, is operated jointly by Los Angeles County, Department of Public Works, Water Replenishment District of Southern California (WRD) and Orange County Water District as a seawater barrier. This Barrier includes the injection of fresh water at depths as shallow as 27 ft bgs. The shallowest injection may affect the southeasterly gradient in the Second Sand Unit as well as the gradient. The injection barrier may affect the direction of flow in the First Sand Unit to a lesser extent, due to lower injection rates. According to the WRD, the operation of the barrier is not likely to change within the next 30 years in such a way so as to affect groundwater flow in the aquifers of interest. However, future changes will be monitored and evaluated under the long-term evaluation monitoring program.

2.5.4 General Groundwater Chemistry

General groundwater chemistry data (BNI, 1999) indicate:

- Groundwater at IR Site 70 appears to vary from fresh to brackish, based upon total dissolved solids (TDS) data.
- Chloride appears to be the major anion present in groundwater.
- Major cations include sodium, calcium, and magnesium.
- Minor amounts of dissolved gases (methane and ethene) are present.
- Based on alkalinity values, groundwater appears to be generally hard to very hard.
- Dissolved iron is locally present up to about 6 milligrams per liter (mg/L).
- Total organic carbon is present locally; the highest concentrations were reported in a center-of-plume location within the defined boundary of the VOC plume.
- Specific conductance indicates that shallow groundwater underlying the site ranges from fresh to brackish to slightly saline;
- pH values suggest that the groundwater is slightly basic.
- Dissolved oxygen (DO) and oxidation reduction potential (ORP) data indicate moderately reduced to reduced conditions.
- Ferrous iron is locally present.
- X-ray diffraction mineralogical data obtained from eight IR Site 70 soil samples during the Pilot Study showed calcite to be present at 1% to 5% by weight in all of the samples and dolomite ($CaMg(CO_3)_2$) in over 50% of the samples.

2.5.5 Nature and Extent of Contamination

The spatial distribution of contaminants at IR Site 70, based on groundwater sampling data collected during the 3rd quarter 2005 groundwater sampling event and the Pilot Study activities, was modeled by GeoSyntec using the 3D plume generator contained in Environmental Visualization Systems (EVS) software (Appendix D). Figure 2.5 shows the distribution of sampling locations for the data included in the dataset, including well screen interval depths. The contaminant distribution at IR Site 70, based upon the interpretation of this data, is illustrated in a number of figures as described below:

i) **TCE.** Figures 2.6 to 2.10 show the interpreted vertical and lateral extents of the 100 micrograms per liter (µg/L), 250 µg/L, and 1,000 µg/L concentration isosurfaces (Figures 2.6, 2.7 and 2.8 respectively), as well as the estimated contours of TCE distribution along vertical cross-sections oriented along the axis of the plume (Figure 2.9) and perpendicular to the axis of the plume as measured in the Pilot Study transect along Kitts Highway (Figure 2.10);

ii) **Cis-1,2-Dichloroethene (cis-1,2-DCE).** Figures 2.11 to 2.14 show the interpreted vertical and lateral extents of the 70 µg/L and 200 µg/L concentration isosurfaces (Figures 2.11 and 2.12 respectively), as well as the estimated contours of cis-1,2-DCE distribution along vertical cross-sections oriented along the axis of the plume (Figure 2.13) and perpendicular to the axis of the plume as measured in the Pilot Study transect (Figure 2.14);

iii) **VC.** Figures 2.15 to 2.17 show the interpreted vertical and lateral extents of the 0.5 µg/L concentration isosurface (Figure 2.15) as well as the estimated contours of VC distribution along vertical cross-sections oriented along the axis of the plume (Figure 2.16) and perpendicular to the axis of the plume as measured in the Pilot Study transect (Figure 2.17); and

iv) **Total plume mass**. Figures 2.18 to 2.22 show the interpreted vertical and lateral extents of the 50%, 75% and 90% total dissolved phase mass isosurfaces (Figures 2.18 to 2.20 respectively), as well as the estimated TCE plume mass envelopes along vertical cross-sections oriented along the axis of the plume (Figure 2.21) and perpendicular to the axis of the plume as measured in the Pilot Study transect along Kitts Highway (Figure 2.22). For the 2005 dataset, 50% of the plume mass corresponds to the 1,680 µg/L isosurface, 75% of the plume mass corresponds to the 560 µg/L isosurface, and 90% of the plume mass corresponds to the 180 µg/L isosurface.

These figures show high TCE concentrations (>1,000 µg/L) near the source area, suggesting the presence of TCE in the form of residual DNAPL, with a dissolved phase plume extending to the south-southeast. The ERSE (BNI, 1999) data represented in the 3D RFS data set (GeoSyntec, 2005a) suggest the presence of a localized high concentration (>10,000 µg/L) area down plume near MW-70-40; however, the 3rd quarter 2005 groundwater monitoring data do not (BEI, 2005). The Remedial Design field investigation did detect TCE concentrations above 5,000 µg/L (Figure 2.10) in the same vicinity (GeoSyntec, 2006). Given the more complete coverage (i.e., more depth discrete data points) in the ERSE (BNI, 1999) data set, the potential for the existence of localized higher concentrations in this area should be considered.

The lateral migration of contaminants within the Upper Fines Unit is mostly confined to the source area, due to the downward hydraulic gradients and the low horizontal hydraulic conductivity. Further downward migration of the dissolved phase is prevented in areas of the Site where the Shell Horizon predominantly consists of interbedded clay layers (i.e., beneath the source area and the upgradient portion of the plume). The plume migrates in a horizontal south-southeasterly direction within the First Sand Unit. Further downgradient where the Shell Horizon grades to predominantly fine-grained sands, downward migration of the plume is observed into the Second Sand Unit (Figure 2.6). Figure 2.6 shows further horizontal migration of the plume within both the First and Second Sand Units.

The dissolved phase plume extends from just below ground surface to at least 160 ft bgs, approximately 4,000 ft long in a northwest-southeast direction, and approximately 1,500 ft wide in a northeast-southwest direction. Of the total plume mass, 50% is confined to the upgradient portion of the plume within the source area and the First Sand Unit. The area comprising 90% of the total plume mass extends to the toe of the plume into the Second Sand Unit.

VC is primarily detected at low concentrations (a few µg/L) within the source area, with sporadic detections further downgradient in the plume at concentrations just above the detection limit. Similarly, cis-1,2-DCE is detected at low concentrations (few hundred µg/L) throughout the plume, indicating a low level of natural biological attenuation. Preliminary results from the natural attenuation microcosm study (provided in GeoSyntec, 2006) confirm that biological attenuation of the plume is minimal. An analysis of natural attenuation of TCE within the plume, based on concentration trends with distance along the axis of the plume, is presented in Appendix A. This analysis suggests that the natural attenuation rate of TCE is on the order of 5 years.

2.6 Risk Assessment

The ERSE (BNI, 1999) concluded that no complete exposure pathway exists between chemicals in groundwater and ecological receptors at IR Site 70. Thus, chemicals reported in groundwater were not evaluated further for ecological risk.

For the human-health screening risk assessment, COPCs were screened by comparing their maximum reported concentrations in soil and groundwater with concentrations representing a level of acceptable risk. The basic tenet of this approach is that the risk presented by a given concentration of a chemical is acceptable when it does not exceed the concentration established by regulatory agencies.

Screening was conducted as follows.

- COPCs were matched to the respective tap water preliminary remediation goal (PRG) values and were evaluated as two groups. The first group was composed of those COPCs with cancer-based PRG values; and the second was composed of the COPCs with noncancer hazard-based PRG values.

- The ratio of the maximum reported chemical concentration and cancer/ noncancer/saturation-based PRG were calculated for each COPC.
- The ratio of each carcinogen was multiplied by 1×10^{-6} to obtain a cancer risk estimate.
- The cancer risk estimates were summed to obtain an estimate of total cancer risk.
- The ratios for the noncarcinogens were summed to obtain an estimate of total chronic toxicity. The sum of these ratios is called the hazard index.
- The human-health risk screening for IR Site 70 groundwater estimated a total cancer risk of 1.2×10^{-1}, and a hazard index of 4,600, resulting primarily from TCE.

3. REGULATORY FRAMEWORK

3.1 Regulatory Overview

Cleanup at IR Site 70 is being conducted as part of the IR Program. The program identifies, assesses, characterizes, and cleans up or controls pollutants from past hazardous waste disposal operations and spills. The program was established to comply with federal requirements regarding cleanup of hazardous waste sites. These federal requirements are outlined in CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA).

CERCLA and NCP Requirements are as follows:

- Section 121(d) of the CERCLA (1980) states that remedial actions on CERCLA sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate.
- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to the conditions at the site. If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed response action and are well suited to the conditions of the site (United States Environmental Protection Agency [U.S. EPA] 1988a). The criteria for determining relevance and appropriateness are listed in Title 40, *Code of Federal Regulations* (CFR), Section 300.400(g)(2) (40 CFR 300.400[9][2], and include the following:
  - the purpose of the requirement and the purpose of the CERCLA action;
  - the medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site;
  - the substances regulated by the requirement and the substances found at the CERCLA site;

- any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site;
- the type of place regulated and the type of place affected by the release or CERCLA action;
- the type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and
- any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

The DON, under the Defense Environmental Restoration Program, follows the U.S. EPA RI and FS protocols. An RI/FS involves characterizing the nature and extent of risk posed by hazardous waste sites and evaluating options for cleanup. The NCP [Title 40 Code of Federal Regulations (CFR) 300] provides the RI/FS protocols.

3.2 Applicable or Relevant and Appropriate Requirements (ARARs)

3.2.1 Chemical Specific ARARs

ARARs are used to develop remediation goals for the groundwater affected by VOCs at IR Site 70.

Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of numerical values. Many potential ARARs associated with particular remedial alternatives (such as closure or discharge) can be characterized as action-specific ARARs, but include numerical values or methodologies to establish them so they fit in both categories of ARARs. To simplify the comparison of numerical values, some action-specific ARARs with numerical values are discussed in this section.

The substantive provisions of the following requirements are the most stringent of the potential federal and state groundwater ARARs and TBCs for the action:

- Water Quality Control Plan (WQCP) for the Santa Ana River Basin (8) (RWQCB 1995) (water quality objectives [WQOs], beneficial uses, waste discharge limitations);
- federal maximum contaminant levels (MCLs) and nonzero maximum contaminant level goals (MCLGs) for organic compounds;
- state primary MCLs for organic compounds in Title 22 California Code of Regulations (CCR); and

- Resource Conservation and Recovery Act (RCRA) groundwater protection standards in Title 22 CCR Section 66264.94(a)(1),(a)(3), (c), (d), and (e).

It is not technically or economically feasible to achieve background (i.e., nondetect) levels of VOCs in the contaminant plume as required under the RCRA groundwater protection standards. Therefore, as provided for in 22 CCR 66294.94(c), concentration limits based on MCLs, nonzero MCLGs, and health-based criteria have been set as the remedial goals for IR Site 70.

The Point of Compliance (POC) for MCLGs and MCLs under the Safe Drinking Water Act (SDWA) is at the tap. For CERCLA remedies, however, U.S. EPA indicates that nonzero MCLGs or MCLs should be attained throughout the contaminated plume, or at and beyond the edge of the waste management area when the waste is left in place *(55 Federal Register* 8753). The CERCLA POC is consistent with that specified under the RCRA groundwater protection standards, which state that the POC at which the protection standards apply is a vertical surface, located at the hydraulically downgradient limit of the waste management area that extends throughout the uppermost aquifer underlying the regulated unit (22 CCR 66264.95). The POC for IR Site 70 will be the NAVWPNSTA Seal Beach site boundary or the existing groundwater point of use, whichever is hydraulically most upgradient.

The California State Water Resources Control Board (SWRCB) Resolution No 68-16 establishes the policy that high-quality waters of the state “shall be maintained to the maximum extent possible” consistent with the “maximum benefit to the people of the state.” This has been interpreted by the SWRCB to include a prohibition on the continued migration of existing groundwater contaminant plumes at levels that exceed background for the aquifer (SWRCB, 1994). The DON has considered this position, and determined that further migration of already contaminated groundwater is not a discharge governed by the language in SWRCB Resolution No. 68-16. More specifically, the language indicates that it is prospective in intent, applying to new discharges in order to maintain existing high-quality waters. It is not intended to apply to restoration of waters that have already degraded.

For construction of monitoring and EVO injection wells, federal and state requirements for characterizing wastes will be applicable to the drill cuttings and contaminated personal protective equipment generated from the implementation of the remedial action.

3.2.2 Location Specific ARARs

Pertinent and substantive provisions of the following potential ARARs were reviewed to determine whether they are potential federal ARARs for the IR Site 70 groundwater RFS:

- Title 22 CCR 66264.18 (a), (b), and (c) (Hazardous Waste Control Act [HWCA])
- 40 CFR Part 6, 6.302 and Appendix B, excluding Sections 6(a)(2), 6(a)(4), and 6(a)(6); Executive Order 11988, Protection of Floodplains; and Executive Order 11990, Protection of Wetlands
- 36 CFR Part 65 (National Archeological and Historical Preservation Act)
- 36 CFR Part 800 (National Historic Preservation Act, Section 106)
- 16 USC Section 1536(a) (Endangered Species Act of 1973)
- 40 CFR 230.10, 231, 231.1, 231.2, 231.7, and 231.8 (Clean Water Act Section 404)
- 50 CFR Section 35.1 et seq. (Wilderness Act)
- 50 CFR Part 27 (National Wildlife Refuge System)
- 16 USC Section 662 (Fish and Wildlife Coordination Act)
- 16 USC 1271 et seq. and Section 7(a) (Wild and Scenic Rivers Act)
- 16 USC Section 307(c) and Section 1456(c); 15 CFR part 930 and Section 723.45 (Coastal Zone Management Act)
- 16 USC 3504 (Coastal Barrier Resource System)
- 16 USC 461-467 (Historic Sites, Buildings, and Antiquities Act)
- 16 USC 403 (Rivers and Harbors Act of 1890)
- 16 USC Section 703 (Migratory Bird Treaty Act of 1972)
- 16 USC Section 1372(2) (Marine Mammal Protection Act)
- 16 USC Section 1801 et seq. (Magnuson Fishery Conservation and Management Act)

Requirements that are determined to be ARARs or TBCs are identified in Table 3.1 in the column denoted by the heading ARAR Determination. Determinations of status for location-specific ARARs were generally based upon consultation of maps or lists included in the regulation or prepared by the administering agency. References to the document or agency consulted are provided in the Comments column and in footnotes to the table. Specific issues concerning some of the requirements are discussed in the following sections.

3.2.2.1 Floodplains

The requirements of actions taken within a floodplain (40 CFR Part 6[b], 6.302, and Appendix B) address the potential impacts on floodplain beneficial use (flood control, water quality, and habitat) that could be affected by site remediation.

NAVWPNSTA Seal Beach is outside the study area and is designated “Area Not Included.” Therefore, the areas are in a location for which flood hazards are undetermined. However, it is noted that areas directly adjacent to NAVWPNSTA Seal Beach IR Site 70 within the Seal Beach city boundary are mapped as “Zone X” – areas lying outside the 500-year floodplain.

3.2.2.2 Historic and Cultural Resources

The National Historic Preservation Act requires federally funded projects to identify and mitigate impacts of project activities on properties included in or eligible for the National Register of Historic Places.

The National Archeological and Historical Preservation Act requires federally funded projects to identify and mitigate the impacts of project activities on significant scientific, prehistoric, historic, or archeological data. An archeological survey was conducted for portions of NAVWPNSTA Seal Beach (Ogden, 1995). As indicated, a total of 186 of the 250 structures addressed in the survey (including IR Site 70) were eligible for nomination to the National Register of Historic Places as contributing elements to a historic district. Structures included at IR Site 70 were designated as eligible.

3.2.2.3 Critical Habitats and Endangered or Threatened Species

Biological resources and sensitive habitats at NAVWPNSTA Seal Beach were identified through field reconnaissance surveys performed in May 1992 and 1994. Personnel from the California Department of Fish and Game and the U.S. Fish and Wildlife Service were also contacted. Two published databases were consulted: the California Natural Diversity Data Base and the California Wildlife Habitat Relationships System. Based on these surveys, none of the IR Site 70 areas were identified to contain habitat that may support special-status species. However, five species of birds and one species of salt marsh habitat plant (classified as endangered either by federal or state agencies) are known to inhabit NAVWPNSTA Seal Beach (BNI, 1999).

Owl and/or hawk nests are known to exist in the RTE buildings; however, remedial activities are unlikely to impact these birds as industrial activities already exist in the area. No federal- or state-listed species or species proposed as rare, threatened, or endangered are known to live in the immediate project area. The requirements pertaining to biological resources are therefore not ARARs.

3.2.3 State ARARs

Potential state location-specific ARARs are presented in Table 3.2. Potential location-specific ARARs identified from the state include the WQCP (RWQCB 1995), the Ocean Plan (SWRCB 1997), the Coastal Act of 1976, and the Endangered Species Act. These have been discussed in previous sections.

3.2.4 Action Specific ARARs

Federal and State ARARs are addressed above. The South Coast Air Quality Management District mandates that no VOCs should be discharged from the groundwater, EVO, and KB-1™ blending operation. The blending operation treatment approach is intended to develop an anaerobic condition, and thus groundwater will not be exposed to the atmosphere.

3.3 Remedial Action Objectives (RAOs) and Cleanup Goals

The following RAOs were developed for IR Site 70 groundwater cleanup (GeoSyntec, 2005b):

- Consistent with EPA, SWRCB, California Environmental Protection Agency (Cal/EPA), and RWQCB Santa Ana Region policies and regulations, protect existing beneficial uses of the shallow aquifer underlying NAVWPNSTA Seal Beach to the extent practicable while preventing or minimizing VOC migration beyond the current NAVWPNSTA Seal Beach boundaries at concentrations exceeding site remediation goals;
- Prevent further degradation of groundwater quality (e.g., through DNAPL mobilization and/or spreading of dissolved phase contamination related to remedial activities); and
- Protect human health by preventing extraction of VOC-impacted shallow groundwater for domestic use until site remediation goals are achieved.

Chloroform, 1,1-dichloroethene, TCE, 1,1-dichloroethane, cis-1,2-DCE, trans-1,2-DCE, tetrachloroethene and VC were identified as COCs at IR Site 70 based on their contribution to the screening-level carcinogenic risk and frequency of occurrence at the site. The attainment area for this remedial action is the footprint of the TCE plume at IR Site 70 as defined by the area exceeding the MCL of 5 µg/L (see Figure 3.1).

The DON intends to establish a POC boundary along the station boundary to monitor the plume during the remedial action. POC monitoring wells will be identified at appropriate depth intervals for the respective zones (Upper Fines, First Sand, and Second Sand) outside the current plume boundaries. In addition the DON proposes to provide POC wells within the Deep Sand down gradient and cross gradient of the current extent of the TCE plume. Some point of compliance wells will be outside the plume limit but will not be located at the boundary of the base. These wells will be used to verify the groundwater gradients and monitor the potential migration of the plume during the remedial action.

Because of the levels of contamination encountered, the affected medium (i.e., groundwater) will be addressed as two separate areas within the plume: (i) a suspected source area, and (ii) a dissolved-phase plume. Cleanup goals were evaluated accordingly.

Table 3.3 lists the target cleanup goals (TCGs) that are applicable to IR Site 70, based on an analysis of federal and state ARARs (see Section 3.2 above). The values listed in the table are federal MCLs for drinking water promulgated by EPA or California MCLs established by the Department of Health Services, whichever is lower for a given constituent (GeoSyntec, 2005b). While MCLs have generally been established as TCGs for the purposes of developing the full-scale bioremediation design, this should not be construed as an acceptance by the DON of final remediation goals at IR Site 70. The DON believes establishing final remediation goals is an iterative process, taking into account site-specific factors such as aquifer classification and designated use, equal application of the remedial goal, and the site- and chemical-specific nature of the groundwater requiring remedial action.

4. REMEDIAL SYSTEM DESIGN

The subsections below outline the conceptual design of the proposed full-scale remedial program for IR Site 70, including a brief overview of the design concept (Section 4.1), a summary of the process through which the remedial designs were developed (Section 4.2), the resulting proposed remedial approach (Section 4.3) and an overview of the proposed performance assessment program (Section 4.4).

4.1 Design Concept

Based on the analysis performed as part of the Revised Feasibility Study (GeoSyntec, 2005a), a remedy of enhanced bioremediation was selected for full-scale treatment of dissolved phase and source area contamination at IR Site 70. The proposed bioremediation approach consists of the following:

- Enhanced destruction of residual DNAPL phase through stimulating bioactivity within close proximity to the DNAPL/water interface to enhance the DNAPL dissolution rate.
- Dissolved phase mass treated passively using linear biobarriers spaced along the plume and allowing ambient groundwater flow to flush contaminated groundwater through the biobarriers.
- Bioaugmentation with a commercially available dechlorinating culture (KB-1^{TM}) used to reduce uncertainty in biological performance and to reduce the time required to achieve measurable results.
- Monitored natural attenuation (MNA) incorporated into the remedy wherever contaminants can be naturally assimilated by the aquifer to reach treatment goals within a reasonable time frame (assumed to be 35 years after termination of the active treatment phase for design purposes).
- Ongoing operation and maintenance (O&M) of the enhanced bioremediation remedy consisting of periodic reinjections of electron donor (as required to maintain biological activity) and monitoring to assess the ongoing biobarrier and MNA performance, the need for biobarrier maintenance, evidence for growth and dispersion of *DHC*, and monitor the secondary water quality impacts.
- Land Use Controls are designed to prevent exposure to VOC-contaminated groundwater on the property overlying Site 70.
- Contingency measures incorporated into the bioremediation remedy to protect downgradient potential human and ecological receptors per U.S. EPA guidance (U.S. EPA 1998, 1999).

The RAOs, which the remedial design has been developed to address, are outlined in Section 3.3 above. For design purposes, it was assumed that the lower of State and Federal MCLs was the ultimate TCG for remediation of the plume and source area within the attainment area. Based on discussions with the RWQCB, the regions of the plume and source area to be targeted for active enhanced bioremediation treatment (i.e., areas amended with EVO and bioaugmented) will be confined to regions with TCE concentrations that exceed 250 µg/L for the dissolved phase plume and 1,000 µg/L for the source area. The active treatment phase will be terminated once concentrations within the dissolved phase plume and source area are reduced below 200 µg/L, after which MNA will be used to treat regions of the attainment area that contain TCE concentrations between the TCGs and 200 µg/L. Final Site TCGs will be determined through an iterative process, taking into account site-specific factors such as aquifer classification and designated use, MNA performance, and the site- and chemical-specific nature of the groundwater requiring remedial action.

4.2 Remedial System Design Development Process

The subsections below outline the remedial design development process, including a summary of the basis of the design (Section 4.2.1), an overview of the design approach (Section 4.2.2), a summary of uncertainties in the assumptions used to develop the designs and their potential impact on the design (Section 4.2.3), and an overview of the evaluation of various design alternatives considered (Section 4.2.4).

4.2.1 Design Basis

The design for the full-scale bioremediation system was developed based on the Site hydrogeological conceptual model (see Section 2.5) that was developed as a result of the Pilot Study activities (Appendix D) and the ERSE (BNI, 1999) and the FS (BNI, 2002). The relevant features of the Site hydrogeologic conceptual model that impact the remedial design of the source and plume treatment system include the following:

- The distribution of contaminants within the RAO attainment area, including the likely presence of residual DNAPL in the source area;
- The predominant groundwater flow directions in each unit, as indicated by plume morphology, groundwater elevation contours, and vertical head differences between hydrogeologic units; and
- Spatial and/or temporal variability in the plume migration pathways, hydraulic gradients, hydraulic conductivities, and soil heterogeneity.

Details on each of these features are included in Section 2.5. Other factors that were considered during the design process include the following:

- The achievable radius of injection (ROI) for the EVO within each of the targeted units, as determined during Pilot Study activities (Appendix D), which ranged from a minimum of 12 ft ROI in the First and Second Sand Units, down to ≤10 ft in the Shell Horizon (Fine-Grained Sands) and the Upper Fines Unit.
- The apparent rate of biologically induced natural attenuation and the enhanced biodegradation rates within bioremediation treatment zones as determined from the microcosm study (see Section 2.5 above and GeoSyntec, 2006).
- Potential reductions in soil hydraulic conductivity related to injection of the EVO in each unit, which are expected to be minor in the coarser-grained units (i.e., First and Second Sand Units) and are not expected to exceed 50% reductions in finer-grained soils (i.e., Shell Horizon and Upper Fines Units); (GeoSyntec 2006).

- The achievable rates of injection for electron donor amendment, which are expected to range from 2 to 5 gpm per 10 ft screened interval in a well in finer-grained units up to 12 gpm per 10 ft screened interval in a well in the more permeable units (GeoSyntec, 2006).

Specific design assumptions for the source treatment design are summarized in Table 4.1. Design assumptions upon which the dissolved phase plume design is based are summarized in Appendix A. These assumptions were incorporated into a numerical model to evaluate the impact and effect on design parameters (see Section 4.2.2 below).

4.2.2 Design Approach

The design approach was developed to account for the nature of the contaminant distribution, the soil lithology, groundwater flow behavior, access constraints, and with consideration of the RAOs. In the source area, the design approach was developed with the goals of: (i) treating residual DNAPL in a manner that will enhance the removal of the DNAPL phase and significantly reduce the required treatment duration and persistence of the DNAPL, and (ii) contain any untreated mass flux out of the DNAPL source area to remove the source of the plume, which will aid in reducing dissolved phase plume treatment duration.

In the downgradient dissolved phase plume, the size of the plume and the distribution of contaminants in various lithological units increases the complexity of the treatment approach. The design approach for plume treatment was developed with the goals of designing a robust treatment system that will attenuate dissolved phase contamination to meet the RAOs (see Section 4.1) within a total 50 year timeframe, while minimizing costs for implementation and maintenance over the treatment lifespan.

MNA will be incorporated into the remedy design where appropriate (i.e., where risk to potential receptors is acceptable and where contaminants will naturally attenuate to meet RAOs within the targeted 35 year post-active-treatment timeframe) to further minimize treatment costs. It is assumed that the DON would retain administrative control of the Site and that institutional controls would remain in effect until RAOs are achieved to protect existing monitoring wells, treatment infrastructure, and grant access for sampling, installing new monitoring wells, and implementing any additional remedial measures needed in the future.

Sections 4.2.2.1 and 4.2.2.2 below outline the design approach for the source and downgradient dissolved phase plume respectively.

4.2.2.1 Source Area

The duration of treatment of source zones is typically required for as long as the source area remains, due to continuing dissolution of the DNAPL phase causing dissolved phase mass flux that can continue to migrate downgradient and sustain the plume. Treatment duration may be shortened significantly through enhancement of the rate of DNAPL dissolution. For bioremediation systems, this is encouraged through the biodegradation of dissolved phase mass within the vicinity of the DNAPL/water interface, which increases the concentration gradient between the DNAPL and groundwater, thus enhancing the dissolution rate. DNAPL dissolution enhancements on the order of 2 to 14 times have been observed in both field and lab settings within active bioremediation zones, resulting in 2 to >6 times reduction in the DNAPL lifespan (ESTCP, 2005).

To encourage DNAPL dissolution to the extent possible, it is proposed that electron donor be delivered throughout the source area through a grid of injection wells within the area containing >1,000 µg/L TCE shown on Figure 4.1. A low solubility, long-lasting electron donor (EVO) will be used to allow for stimulation of continuous bioactivity over long periods of time with infrequent reinjections. EVO also has the added benefit of being an immiscible organic compound, and thus may either partition into the DNAPL phase, thus providing electron donor directly to the DNAPL/water interface, or may sorb some of the DNAPL phase, thus potentially reducing mass flux from the source zone.

In addition to the grid of injection wells to directly treat the DNAPL phase, a downgradient biobarrier will be installed within the First Sand Unit to contain any untreated mass flux from the source area through biodegradation of remaining contaminants (see Figure 4.1). This biobarrier will essentially cut off the source of mass that is sustaining the dissolved phase plume, which will help shorten the duration of plume treatment.

To avoid spreading contamination within the plume during electron donor injection events, the EVO injection will use source area groundwater as the amendment water for injecting the EVO (i.e., the net fluid balance remains fairly constant). Groundwater will be extracted from wells located within close proximity to EVO injection wells, thus minimizing mounding and enhancing the distribution of the EVO around the injection points. EVO injections will be staged such that groundwater is extracted and reinjected into areas of similar contaminant concentration profiles (i.e., groundwater containing higher concentrations of TCE will not be reinjected into areas with significantly lower concentrations; see Section 6.3.1.1 for details).

Bioaugmentation will be implemented during electron donor amendment to minimize mobilizations to the site, enhance the *DHC* distribution around the injection well, and reduce labor costs. To provide the appropriate geochemical environment for the *DHC* (the group of microorganisms responsible for reductive dechlorination of chlorinated ethenes) in the KB-1™ culture are known to grow, the KB-1™ injection will be conducted mid-way through the EVO injection, preceded and followed by a flush of anoxic water according to the procedure outlined in Section 6.3.1.1.

Because of the long-term persistence of DNAPL, it is possible that multiple reinjections of electron donor may be required before the targeted treatment level is achieved in the source area. Electron donor will be reinjected as needed to sustain bioactivity levels (see Section 6.3.1.1 for details). Enhanced *in situ* bioremediation (EISB) performance will be monitored throughout the active remediation period, concurrent with MNA monitoring in areas where MNA is being employed, to track remedial progress and optimize remedial performance (see Sections 4.4.2.1 and 4.4.3.1 below for details).

4.2.2.2 Downgradient Plume

For treatment of the plume, the size of the plume containing >250 µg/L TCE (1800 ft long and up to 700 ft wide) and the migration of contaminants within multiple hydrogeologic units across vertical intervals exceeding 160 ft in depth in some locations is the primary challenge for development of a bioremediation design for the dissolved phase plume. Due to the sheer size of the treatment area, stimulating bioremediation throughout the targeted treatment area as proposed for source treatment is prohibitively expensive. To minimize the costs of plume treatment, MNA will be incorporated into the remedy where applicable, and the extent of the EISB zones will be minimized to provide cost effective treatment of the plume to meet RAOs within a total 50-year timeframe.

The plume treatment design will be a passive treatment approach consisting of linear transects of enhanced bioremediation zones (biobarriers) spaced across the plume and oriented perpendicular to the general direction of groundwater flow (see Figures 4.2, 4.3, and 4.4 for example treatment system layout). Biodegradation of the contaminants within the plume will occur through a combination of MNA between biobarriers and ambient groundwater flow flushing contaminated groundwater through the biobarriers, where dissolved phase mass is biodegraded to innocuous end products such as ethene and chloride.

The optimal treatment design will consist of a balance between the number of biobarriers and the treatment duration. More biobarriers will reduce the treatment duration (and thus minimize the number of electron donor reinjection events and the duration of monitoring), but will increase capital costs related to increased well installations and annual operations and maintenance (O&M) costs (i.e., higher electron donor volumes and labor costs per reinjection event). To optimize the treatment design, the treatment duration and overall costs for installation and maintenance of the biobarrier system were evaluated for multiple biobarrier layouts. The biobarrier design selected for full-scale implementation will be the lowest cost option of the evaluated designs.

Because of the complexity of the contaminant distribution and the variability in the soil geology and hydrogeological properties within the plume, a numerical model of the site was developed that incorporated the site complexity and other factors that could impact remedial performance (e.g., potential permeability reductions within biobarriers). The model was used to assess whether RAOs could be achieved within a total 50 year timeframe for each biobarrier option evaluated, as well as assess the required duration of active operation for each biobarrier and associated MNA monitoring program. This information was used to develop estimates for remedial costs for each design option, which provided the basis of selection of the full-scale remedy design (see Section 4.2.4 below for more details). The numerical model was also used to perform sensitivity analyses to evaluate the impact of variability in particular parameters (e.g., seasonal variability in hydraulic gradient) on remedial effectiveness and treatment duration. The design of the biobarrier layouts were adjusted to account for potential parameter variability, thus providing a more robust treatment system. More details on the modeling process are included in Section 4.2.4 below and Appendix A.

The design of each biobarrier was developed considering the local vertical and lateral extent of TCE concentration above 250 µg/L, the general direction of groundwater flow, the groundwater residence time, the ability to distribute electron donor (EVO) within the aquifer, and the enhanced rate of biodegradation within each biobarrier. In addition, ease of implementation and protection of downgradient receptors through acceptable plume migration under MNA were included in the final selection criteria. The biobarriers will be constructed of a line of injection wells oriented perpendicular to the general direction of groundwater flow and spaced at a distance that is slightly less than the achievable ROI of the electron donor distribution (based on Pilot Test of the ROI), to ensure lateral continuity of the bioactive zones. The width of the biobarriers will be designed to provide sufficient groundwater residence time within the EISB zone such that downgradient groundwater flux out of the biobarriers will meet treatment goals. The screened interval of the well screens will be confined to unique hydrogeological units to avoid the potential for vertical migration of contaminants through injection wells. The selected plume treatment approach consists of a total of 6 biobarriers transecting the plume in the various depth intervals (3 biobarriers in the First Sand Unit, 2 biobarriers in the Shell Horizon, and 1 biobarrier in the Second Sand Unit). More details on injection well layouts and construction details are included in Section 4.3.2.1 and Section 5.5.3 below.

Similar to the Source Area treatment, EVO will be used as the electron donor due to its long-term persistence in the treatment zone. To avoid spreading contamination within the plume during electron donor injection events, the EVO injection will use local groundwater as the source of amendment water for injecting the EVO (i.e., the net fluid balance remains fairly constant). Groundwater will be extracted from wells located within close proximity to EVO injection wells, thus minimizing mounding and enhancing the distribution of the EVO around the injection points. EVO injections will be staged such that groundwater is extracted and reinjected into areas of similar contaminant concentration profiles (i.e., groundwater containing higher concentrations of TCE will not be reinjected into areas with historically lower concentrations).

Bioaugmentation will be implemented during electron donor amendment to minimize mobilizations to the site, enhance the *DHC* distribution around the injection well, and reduce labor costs. To provide the appropriate geochemical environment for which the *DHC* (the group of microorganisms responsible for reductive dechlorination of chlorinated ethenes) in the KB-1™ culture are known to grow, the KB-1™ injection will be conducted mid-way through the EVO injection, preceded and followed by a flush of anoxic water according to the procedure outlined in Section 6.3.2.1.

Depending upon the spacing of the biobarriers and the groundwater migration rate, multiple reinjections of electron donor may be required before the targeted treatment level is achieved in the downgradient plume. Electron donor will be reinjected as needed to sustain bioactivity levels within the biobarriers (see Section 6.3.2.2 below for details). EISB performance will be monitored throughout the active remediation period, concurrent with MNA monitoring in areas where MNA is being employed, to track remedial progress and optimize remedial performance (see Sections 4.4.2.2 and 4.4.3.2 below for details).

4.2.3 Design Uncertainties

Design uncertainties vary with the design approach and the nature of the contamination. Sections 4.2.3.1 and 4.2.3.2 below provide an overview of the uncertainties associated with the source area and downgradient plume designs respectively, and address the potential impact on the estimated treatment duration, and required design modifications that may be required.

4.2.3.1 Source Area

Uncertainties that impact the remedial design for the source area include:

- The total mass of DNAPL present in the subsurface. The amount of DNAPL mass present will govern the remediation duration, as more mass will require more time to effectively dissolve and biodegrade.
- The distribution of DNAPL in the subsurface. DNAPL present as residual phase will be treated more quickly than pools of DNAPL and/or DNAPL diffused into low permeability layers, which is limited by the rate of back-diffusion, due to the higher interfacial area available for mass transfer.
- The depth of migration of the DNAPL phase within the source area. The vertical distribution of TCE concentrations in both groundwater and soil within the source area to depths of 60 ft bgs is well characterized from

previous site characterization activities (GeoSyntec, 2006; BNI, 1999, 2002). However, elevated TCE concentrations (>1,000 µg/L) are seen within the First Sand Unit below. The elevated concentrations at depth may be present as a result of vertical migration of dissolved phase from the Upper Fines Unit.

- The potential for preferential pathways due to stream channels and/or anthropogenic induced pathways in the subsurface may have affected the distribution of DNAPL within the source area.

The source area will need to be treated continuously for as long as required to reduce mass flux from the source area to levels that may be naturally assimilated by the aquifer, which is impacted by the continuing presence of DNAPL. Due to this uncertainty, the required duration of source treatment cannot be predetermined.

For design purposes, it was assumed that DNAPL phase is present only in the Upper Fines Unit. However, source grid treatment may need to be expanded vertically if DNAPL phase is also present within the First Sand Unit. A biobarrier downgradient of the source will be included as part of the source treatment program to contain any potential ongoing mass flux from the source area.

4.2.3.2 Downgradient Plume

From the Pilot Study activities (Appendix D), a number of data gaps in interpretation of the contaminant distribution within the plume and the plume extents were noted. These included:

- A lack of concentration data in the area between the RDO-6 well cluster and the MW-70-42 well cluster located approximately 800 ft downgradient. This data gap creates uncertainty in the width of the plume in this area, particularly for the higher TCE concentration portion of the plume.
- A lack of concentration data for the area downgradient of the MW-70-42 well cluster (i.e., the leading edge of the plume) and MW-70-15, an approximate distance of 1,100 ft downgradient, where low detections of TCE are found. The location of the leading edge of the plume will impact the placement of the biobarrier that is intended to contain further downgradient mass flux and may require an additional biobarrier.
- A lack of concentration data within the First Sand Unit in areas downgradient of MW-70-08, which limits our knowledge of the upper vertical extent of contamination in the downgradient half of the plume. This will impact the screened depths over which plume biobarriers must be constructed.

- To the south of MW-70-08, there is a lack of concentration or water elevation data that can indicate whether a portion of the plume is continuing to migrate in this direction within the First Sand Unit. If the plume is continuing to migrate in this direction, then additional biobarrier(s) may be needed in this area to contain and prevent further plume migration in this area.
- With the exception of the Pilot Study transect (RDO-1 through RDO-5 Figure 2.5), the lateral distribution of TCE across downgradient regions of the plume is unknown. Biobarrier lengths were selected based on the interpreted extents of the 250 µg/L TCE contours, but modifications may be required if more data becomes available.
- Little data exists concerning concentrations of TCE below the deep clay. This lack of data inhibits our evaluation of the plume's vertical extent, and our evaluation of vertical remediation required. Further investigation will be needed to evaluate the vertical extent of the plume.

To address these data gaps in the biobarrier design, the following were assumed for design purposes:

- In the region of the plume between the MW-70-08/09/31 well cluster and the MW-70-42A/B well cluster, it was assumed that contamination was present at similar concentration to that found in these well clusters. Additional characterization of the contaminant distribution in this area may result in changes to the proposed biobarrier design.
- Biobarriers located to the southeast of MW-70-08 were assumed to require installation in both the First Sand Unit as well as the Second Sand Unit. This may require adjustment of biobarrier well screen intervals and/or modification of biobarriers if further delineation of the plume in this area indicates that the current interpretation of the upper vertical extent of the plume in this area varies from the conceptual model.
- The location of the biobarrier at the leading edge of the plume was assumed to be at the extents of the current interpretation of the downgradient edge of the plume (i.e., near the MW-70-41A/B, MW-70-42A/B and MW-70-43A/B well clusters). The width of the biobarrier was assumed to extend over much of the distance between MW-70-41A/B and MW-70-43A/B. The location and width of this biobarrier may need to be adjusted prior to full-scale implementation if additional data in this area becomes available, or an additional biobarrier may need to be installed.

Other design uncertainties noted from the results of the Pilot Study activities include: (i) the potential reduction in permeability of the aquifer within the biobarriers due to injection of the EVO, which may result in the plume bypassing the biobarrier if the reduction is sufficient; and (ii) the seasonal variability in hydraulic gradient, which may result in an alteration of the residence time within each barrier. The potential impact of these design uncertainties were addressed in the modeling through sensitivity studies (see Appendix A for details). It was concluded that these factors did not significantly impact the remedial design or overall treatment effectiveness. Should a reduction of conductivity occur during emplacement of the EVO, the natural degradation properties of the EVO will allow the aquifer to return to its initial state. As this process occurs, subsequent water will flow through the barrier and be treated as planned. Other possible corrective actions may consist of push-pull pumping within the barrier wells, addition of more groundwater for flushing, use of extraction wells to increase flow, or the addition of surfactants to reduce oil globule size. To detect an impermeable barrier effect groundwater level measurements upgradient, within, and downgradient of biobarriers will be used to determine if mounding, a possible sign of reduced flow through the barriers, is observed during performance monitoring events.

4.2.4 Evaluation of Design Alternatives

Several design alternatives were considered for treatment of the dissolved phase plume, to evaluate whether any cost savings could be achieved through installing more biobarriers and thus reducing treatment duration (lower O&M costs but higher capital costs) *versus* fewer biobarriers with an extended active treatment duration (higher O&M costs, but lower capital costs). The base case scenario was developed to target active treatment of the plume to a maximum concentration of 200 µg/L within an approximate 15 year timeframe (for portions of the plume), followed by MNA. Optimal biobarrier placements and number of biobarriers to reach this goal were evaluated through running several simulations with various biobarrier layouts and evaluating the required timeframe to achieve a maximum concentration of 200 µg/L throughout the Site (see Appendix A for details). Once the base case scenario was developed, one other alternative scenario was simulated by adding two additional biobarriers and reevaluating the required treatment duration of each biobarrier (Alternative 1). A second alternative design (Alternative 2) was not simulated, but was developed from the results of the Alternative 1 and the Base Case scenario simulations for purposes of evaluating the cost benefit of more biobarriers and lower remediation duration. In all design scenarios, once a maximum concentration of 200 µg/L was achieved within the active treatment zones, biobarrier operation was terminated and MNA was implemented to achieve TCGs. The results of the modeling analysis are summarized in Table 4.2 for each design alternative, and the details regarding the modeling assumptions, resulting concentration distributions, biobarrier layouts, etc. may be found in Appendix A. The design alternatives may be described as follows:

- *Base Case Scenario:* The design for this scenario consists of 5 biobarriers in total to treat the plume, with a maximum active biobarrier operation time of 16 years.
- *Design Alternative 1:* Based upon the base case scenario, but with two additional biobarriers, one each screened within the Shell Horizon and First Sand Units, for a total of 7 biobarriers and a maximum active biobarrier operation time of 11 years.
- *Design Alternative 2:* Based upon the base case scenario, but with one additional biobarrier, screened within the First Sand Unit, for a total of 6 biobarriers and a maximum active biobarrier operation time of 13 years.

The source treatment configuration for each scenario was the same, and consisted of a grid treatment approach within the Upper Fines Unit and a downgradient biobarrier targeting the First Sand Unit for containment of mass flux from the source (see Section 4.3.1 below for details).

Estimated costs for implementation of each scenario were developed and compared to determine which option provided the highest cost benefit. The results of the analysis are illustrated in Figure 4.5. From this analysis, it appears that the base case scenario provides the optimal design from a cost-benefit point of view. It is also the alternative with the highest ease of implementation, and thus represents less risk due to potential problems arising with access constraints, etc. None of the design alternatives posed unacceptable risk to potential receptors, as plume migration was confined to the Site and the maximum extent of plume migration in each case is not expected to extend significantly beyond the area of MW-70-15. For all design alternatives, TCGs were obtained under MNA within approximately 50 years following startup of the active treatment phase (Appendix A).

4.3 Proposed Remedial Approach

4.3.1 Source Area

The subsections below outline the proposed remedial approach for treating DNAPL and dissolved phase contaminants within the source area (Section 4.3.1.1), as well as presenting contingency measures that may need to be implemented as a result of data uncertainties (Section 4.3.1.2).

4.3.1.1 Proposed Remedial Design for the Source Area

The source area treatment system was developed following the design process outlined in Section 4.2.2.1 above and considering design uncertainties discussed in Section 4.2.3.1 above. The source treatment consists of a grid of EVO injection wells, used to directly target DNAPL phase, combined with a downgradient source containment biobarrier, which will contain any untreated mass flux from the source area and mitigate continuing mass contribution to the plume (see Figure 4.1 for source treatment configuration). Table 4.1 contains a listing of the assumptions used to develop the source area design and the basis for the assumptions. Table 4.2 contains a summary of the total number of EVO injection wells, EVO amendment concentrations, and required amendment volumes for both the source treatment area and the source containment biobarrier. The source treatment EVO injection wells will be screened within the Upper Fines Unit only and distributed within the estimated 1,000 µg/L TCE contour on approximate 20 ft spacings as shown in Figure 4.1. The area directly beneath this targeted treatment zone contains a large number of buried utilities, which may require modification of the locations of the wells to avoid interference with these utilities during drilling activities. Source containment biobarrier wells will be screened within the First Sand Unit only as shown on Figure 4.1, and will consist of 14 wells spaced 24 ft apart across the width of the plume containing >250 µg/L TCE.

Section 6.3.1.2 provides a description of the long-term maintenance program for the source treatment zones. During injection of the EVO, injection rates and pressures will be limited to avoid any potential mobilization of DNAPL phase. Details on the injection protocols and procedures, the specific design of the various components of the remedial system (e.g., injection equipment, bioaugmentation equipment, etc.), and injection well construction details are included in Sections 6.2.1, 6.2.2, and 5.5.3, respectively.

4.3.1.2 Source Treatment Contingency Measures

There are several factors that may impact the success of source area treatment, related to uncertainties in our understanding of the contaminant mass distribution in this area, as well as the current level of natural attenuation and the potential impact of implementation of EISB on natural attenuation (related to migration of amended dechlorinating microorganisms outside of the EISB zone of influence). To address these uncertainties, we recommend implementing the proposed remedial system as outlined in Section 4.3.1.1 above and monitoring system performance for a five year period, at which point source treatment performance will be evaluated and modifications to the source treatment program may be incorporated as outlined below:

- If mass flux from the source area does not appear to have reduced significantly after five years of treatment, then the presence of DNAPL phase TCE within the First Sand Unit may be inferred. This will require extension of the source grid treatment to the First Sand Unit.
- Ongoing low levels of natural attenuation within the Upper Fines Unit around the grid treatment zone may result in a halo of elevated TCE concentrations (>100 µg/L) persisting around the treatment zone for an extended period of time (>30 years). The potential for horizontal migration

of TCE within this unit is low, given the tightness of the formation and the low seepage velocity. The rate of vertical migration is unknown. If the resulting mass flux from this unit to the First Sand Unit below is above the assimilative capacity of the aquifer, the treatment area may need to be expanded to target areas of lower TCE concentrations.

4.3.2 Dissolved Phase Plume

4.3.2.1 Proposed Remedial Design for the Downgradient Plume

The downgradient plume treatment approach was developed following the design process outlined in Section 4.2.2.2, and considering design uncertainties discussed in Section 4.2.3.2. Several design options were evaluated as outlined in Section 4.2.4, and a cost-benefit analysis was performed to select the optimal design. Other considerations in the design selection process included ease of implementation and protection of downgradient receptors through acceptable plume migration under MNA. The selected plume treatment approach consists of a total of 5 biobarriers transecting the plume in the various depth intervals (2 biobarriers in the First Sand Unit, 2 biobarriers in the Shell Horizon, and 1 biobarrier in the Second Sand Unit). The length of each biobarrier was chosen to effectively intercept the portion of the plume containing >250 µg/L TCE. Table 4.2 contains a summary of the total number of EVO injection wells, EVO amendment concentrations, and required amendment volumes for each biobarrier.

Section 6.3.2.2 provides a description of the long-term maintenance program for the plume biobarriers. Details on the injection protocols and procedures, the specific design of the various components of the remedial system (e.g., injection equipment, bioaugmentation equipment, etc.), and injection well construction details are included in Sections 6.2.1, 6.2.2 and 5.5.3 respectively.

4.3.2.2 Plume Treatment Contingency Measures

There are several factors that may impact the success of plume treatment, related to uncertainties in our understanding of the contaminant mass distribution in this area, as well as the current level of natural attenuation and the potential impact of implementation of EISB on natural attenuation (related to migration of amended dechlorinating microorganisms outside of the EISB zone of influence). In particular, uncertainties in the contaminant distribution within the downgradient half of the plume are significant, and may potentially require substantial changes to the biobarrier designs in the area (including potentially a reduction or increase in the number of biobarriers and/or biobarrier widths). We recommend improved vertical and lateral delineation of the plume in this area and reevaluating the current design prior to installation of the system. We also recommend baseline sampling of every fourth EVO injection well for VOCs and field parameters prior to the initial EVO injection to confirm the need for EVO amendment throughout the entire biobarrier width, and to provide a baseline for any future sampling. The potential impacts to the Deep Sand will be investigated during the placement of the POC wells within the Deep Sand.

To address the remaining uncertainties, we recommend implementing the remedial system and monitoring system performance for a five year period, at which point plume treatment performance will be evaluated and modifications to the program may be incorporated as outlined below:

- If plume migration in the MNA areas is more extensive than originally estimated and/or MNA rates are not as favorable, additional biobarriers and/or extensions to existing biobarriers may be required.
- If natural attenuation rates are lower than originally estimated, longer operation of the active treatment phase may be required.

4.3.3 Criteria for Termination of EISB Activities

Based on the results of the modeling studies, it appears that TCE concentrations on the order of 200 µg/L may be successfully attenuated below TCGs 35 years after termination of the active treatment phase. Therefore, the initial criteria to switching from active EISB treatment to MNA will be based upon achievement of 200 µg/L throughout upgradient areas (i.e., for termination of operation of each biobarrier, the region of the aquifer that is upgradient of that biobarrier and downgradient of the next biobarrier should have maximum TCE concentrations on the order of 200 µg/L prior to termination of active treatment). This evaluation will be made from the upgradient monitoring well for each biobarrier. Ongoing monitoring and evaluation of natural attenuation rates and plume migration behavior will provide data to allow for a periodic reevaluation of this active treatment goal, as changing conditions and/or model refinement may require either a lower or higher target active treatment goal to achieve similar results.

Similarly, the initial criteria (TCGs) for termination of MNA are State MCLs. Final Site MNA TCGs will be determined through an iterative process, taking into account site-specific factors such as aquifer classification and designated use, MNA performance, equal application of TCGs for remedial sites, and the site- and chemical-specific nature of the groundwater requiring remedial action.

4.4 Performance Assessment

The following subsections outline the design of the monitoring program including a summary of performance metrics (Section 4.4.1) and evaluation of ongoing EISB (Section 4.4.2) and MNA (Section 4.4.3) performance in both the source and downgradient plume areas, including rationale for selection of the sampling locations/depths, analytes, and sampling frequency. More details on the sampling schedules and sampling implementation procedures are included in Section 6.3.3.

4.4.1 Performance Metrics

Certain criteria should be met for maintaining optimal EISB performance, including the following:

- Complete dechlorination of TCE to ethene within the biobarriers;
- Localized and/or minimal secondary groundwater quality impacts; and
- *DHC* growth to concentrations exceeding 10^7 cells/L, and migration of the augmented culture throughout the active treatment zones.

Similarly, criteria for MNA performance include indications of reducing TCE concentrations with time and minimal expansion of the plume beyond the current extents. Indicators of these success measures will be tracked throughout the remediation program as outlined in Sections 4.4.2 and 4.4.3 below.

4.4.2 Assessment of Enhanced *In Situ* Bioremediation Performance

The EISB performance monitoring program was developed with the primary objectives of minimizing long-term monitoring costs while collecting sufficient data to assess long-term EISB performance and the need for EISB maintenance and/or implementation of contingency measures. In developing the monitoring program, the following factors were considered:

- *Environmental risk.* The risk to potential ecological and human receptors created by periods of decreased biobarrier performance (e.g., related to consumption of the EVO) at IR Site 70 is negligible as long as current groundwater use restrictions remain in place on the Site. The results of the numerical modeling suggest that the potential plume migration prior to attenuation to achieve Site TCGs is not expected to impact any nearby extraction wells.
- *Groundwater seepage velocity.* Seepage velocities in all known impacted units on IR Site 70 are fairly low (not exceeding 85 ft /year), and the expected plume migration will be lower due to retardation of the contaminants. As a result, decreased biobarrier performance for a period of 6 months will likely only result in plume migration to a maximum extent of 20 to 30 ft downgradient.
- *Natural attenuation.* From an analysis of the concentration trends with distance in the plume, it appears that the natural attenuation half-life of TCE is on the order of 5 years (see Appendix A for details). Any contaminant mass that is not fully treated within the active treatment zones will continue to attenuate naturally.

- *EVO consumption rate.* From a preliminary estimate, it appears that the EVO is likely to persist for a minimum of 5 years in most treatment areas (see Table 4.2 and Appendix B for details). Geochemical trends should be monitored fairly closely for at least one EVO consumption cycle to evaluate changes in various geochemical parameters with EVO consumption, which will allow for more accurate determination of biobarrier maintenance.

- *Potential adverse impacts to secondary groundwater quality.* Stimulation of biodegradation in an anaerobic and reducing environment may lead to production of undesirable compounds, including methane, dissolved metals (e.g., iron, manganese), hydrogen sulfide, and elevated groundwater turbidity and specific conductance. Some of these compounds represent a potential health and safety risk; others impact the groundwater aesthetics (i.e., appearance, odor and taste).

- *Growth and migration of the dechlorinating culture.* The indigenous bacteria at IR Site 70 do not appear to possess the ability to completely dechlorinate TCE to innocuous end products such as ethene. Sustained growth and migration of the amended dechlorinating culture is necessary to achieve TCGs. Microorganisms tend to be fairly robust and can typically withstand adverse conditions for limited periods of time. For example, endogenous decay of biomass upon consumption of the EVO will result in a slow decrease in biobarrier performance over time. Even if reamendment of more culture is necessary, the associated costs may be lower than implementation of a monitoring program that would prevent failure of the culture.

Sections 4.4.2.1 and 4.4.2.2 below outline the proposed EISB performance monitoring programs in more detail for the source and downgradient plume treatment zones respectively. Monitoring programs have been developed for only the first five years of monitoring (approximately corresponding to one EVO consumption cycle in at least one biobarrier), at which point we recommend that the sampling locations, frequency and analytes monitored be optimized for the long-term monitoring program. Passive sensors tracking key geochemical parameters may also be incorporated into the monitoring program at that time, if appropriate, to further minimize sampling and analytical costs. The sampling program may be refined as necessary within this timeframe and/or extended as appropriate, based on the data collected.

In general, the number of EISB performance monitoring sampling locations per treatment area will be confined to one or two locations selected from those areas that will provide early indications of EVO consumption (and thus the need to reinject) and/or locations where biobarrier performance is most likely to be lowest (e.g., due to insufficient residence time, higher initial TCE concentrations requiring more degradation half-lives to meet TCGs, etc.). In this way, the sampling and analytical costs may be minimized while continuing to collect critical information. Vertical monitoring intervals will be confined to 10 ft intervals, per U.S. EPA guidance (U.S. EPA, 1986), and nested wells will be used to monitor treatment zones that exceed 25 ft in vertical depth. If at any time decreasing EISB performance is detected at these "sentinel" wells indicating the need for biobarrier maintenance, then selected other locations will be sampled to evaluate the extent of the region within the treatment area that requires maintenance and appropriate corrective action will be taken.

Table 4.3 summarizes the parameters that will be monitored during the initial five year monitoring program and the information that may be obtained from each analyte. A number of parameters will be sampled from wells located within active treatment zones on a quarterly basis for the first year of operation (to confirm the successful stimulation of desired bioactivity levels), followed by semi-annual monitoring (to assess ongoing treatment levels and the need for biobarrier maintenance) for the remainder of the five year period. Targeted analytes include VOCs, dissolved hydrocarbon gases (DHGs; innocuous end products of the dechlorination reaction, including ethene and ethane, and methane), inorganic anions (particularly chloride, which is another daughter product of the dechlorination process), polymerase chain reaction (PCR) assays specific to DHC; the microorganisms responsible for complete dechlorination of TCE to ethene, depth to water (to monitor groundwater flow direction) and field parameters (particularly pH, ORP and DO, which are measures of geochemical conditions required for anaerobic microbial activity).

To assess the continuing presence of EVO within the treatment zone, qualitative measures of EVO presence will also be monitored in these locations on a semi-annual basis, including total organic carbon (TOC) and volatile fatty acids (VFAs) acetic, butyric, lactic and propionic acids (breakdown products of EVO fermentation). Typical concentration trends of these analytes are an initial increase shortly after EVO injection, then slow decreases to an asymptotic level as the biomass grows with a corresponding increase in the rate of the soluble organic released from the EVO. Depending on the sustained level of bioactivity, the asymptotic TOC and VFA concentrations may or may not be above background levels, and thus the usefulness of these parameters in providing a surrogate indicator of EVO presence may be limited. The information gained from these analytes will be evaluated on an ongoing basis and modifications to the sampling program may be made as appropriate.

To evaluate the potential impact on secondary groundwater quality and the contaminant distribution in the plume, samples will be obtained from targeted locations downgradient of the biobarriers on a semi-annual basis. To provide a baseline comparison, samples will also be obtained from upgradient locations at similar sampling intervals. Targeted analytes include all of the bioremediation performance indicators listed above (i.e., VOCs, DHGs, inorganic anions, DHC, depth to water, and field parameters including total dissolved solids and specific conductance), as well as secondary groundwater quality parameters including dissolved metals (e.g., iron, manganese, arsenic), and sulfide.

4.4.2.1 Source Area EISB Performance Monitoring Program

The monitoring program for the source area treatment was developed to meet the following specific objectives:

- Monitor bioremediation performance and assess the need for treatment system maintenance, which could consist of reamendment of EVO, rebioaugmentation, etc. (see Section 6.3.1.2 for details);
- Monitor the continuing flux of contaminant mass from the source area upgradient of the Source Containment biobarrier, to evaluate the need to expand the source grid treatment to the First Sand Unit;
- Monitor for occurrence and persistence of adverse impacts (e.g., mobilization of metals, excessive methane generation, etc.); and
- Collect sufficient data to evaluate whether EISB activities may be terminated and MNA initiated.

The wells to be used for monitoring system performance in the Source area treatment are outlined in Table 4.4. The locations of these wells are shown on Figure 4.1. For the source grid treatment area, EISB performance will be monitored at two key locations using two well nests (proposed new well installations PMW-1A/B and existing well nest MW-70-27 and MW-70-28). These locations were selected as they represent locations where both the electron donor demand and the EVO consumption rate is likely to be highest, due to the presence of elevated TCE concentrations and DNAPL. For the Source Containment Biobarrier, EISB performance will be monitored at a location within the core of the plume along a transect of three well nests through the biobarrier. The transect of wells will consist of PMW-2A/B (upgradient wells), EVO injection well IW-SC-6, and PMW 3A/B (downgradient wells). The location of this transect was chosen to approximately coincide with the higher concentration core of the plume, where the EVO is likely to be consumed first.

If changes in VOCs and other EISB indicators suggest lowering of bioactivity levels in the monitored locations (e.g., related to consumption of the EVO), then further investigation of selected other regions of the source grid treatment area or Source Containment Biobarrier will be undertaken to evaluate the extent of the source area treatment system that require further maintenance and only those areas will be targeted. In this way, it is hoped that maintenance of the EISB treatment system may be focused and optimized to minimize remediation costs while maximizing effectiveness.

4.4.2.2 Downgradient Plume Performance Monitoring Program

The monitoring program for the downgradient plume area treatment was developed with the following objectives:

- Monitor bioremediation performance and assess the need for biobarrier maintenance, which could consist of reamendment of EVO, rebioaugmentation, etc. (see Section 6.3.2.2 for details);
- Monitor for adverse impacts that may require further action;
- Collect sufficient data to evaluate whether EISB activities may be terminated and MNA initiated; and
- Collect sufficient data for evaluating the need for implementation of contingency measures.

The wells to be used for monitoring system performance in the downgradient plume are outlined in Table 4.5. The locations of these wells are shown on Figures 4.2, 4.3, and 4.4 for the First Sand Unit, Shell Horizon, and Second Sand Unit, respectively. For each biobarrier, EISB performance will be monitored at a location within the core of the plume along a transect of three well nests through the biobarrier. The transect of wells will consist of upgradient, EVO injection, and downgradient wells. The location of each transect was chosen to approximately coincide with the higher concentration core of the plume, where the EVO is likely to be consumed first. The only exception to this is the second transect through Biobarrier FS-1 situated to the southwest end of the biobarrier (i.e., transect of PMW-4A/B, IW-FS1-8, and PMW-5A/B). This second biobarrier was included in the monitoring program due to the extended length of this biobarrier and to provide one monitoring location with a lower influx of TCE to provide a secondary measure of EVO longevity in areas with a lower electron donor demand.

If changes in VOCs and other EISB indicators suggest lowering of bioactivity levels in the monitored locations (e.g., related to consumption of the EVO), then further investigation of other regions of the impacted biobarrier will be undertaken to evaluate the extent of the biobarrier that requires further maintenance and only those areas will be targeted. In this way, it is hoped that maintenance of the EISB treatment system may be focused and optimized to minimize remediation costs while maximizing effectiveness.

4.4.3 Assessment of Monitored Natural Attenuation

The natural attenuation monitoring program was developed with the primary objectives of minimizing long-term monitoring costs while assessing progress of the attenuation of contaminants and the need for implementation of contingency measures. In developing the monitoring program, the following factors were considered:

- *Environmental risk.* The risk to potential ecological and human receptors created by periods of decreased biobarrier performance (e.g., related to consumption of the EVO) at IR Site 70 is negligible as long as current groundwater use restrictions remain in place on the Site. The results of the numerical modeling suggest that the potential plume migration prior to attenuation to achieve Site TCGs is not expected to impact any nearby extraction wells.
- *Groundwater seepage velocity.* Seepage velocities in all known impacted units on IR Site 70 are fairly low (not exceeding 85 ft /year), and the expected plume migration will be lower due to retardation of the contaminants.
- *Natural attenuation.* From an analysis of the concentration trends with distance in the plume, it appears that natural attenuation is occurring on site with a TCE half-life on the order of 5 years (see Appendix A for details).

Sections 4.4.3.1 and 4.4.3.2 below outline the proposed MNA monitoring programs in more detail for the source and downgradient plume treatment zones respectively. Monitoring programs have been developed for only the first five years of monitoring, at which point we recommend that the sampling locations, frequency and analytes monitored be optimized for the long-term monitoring program. Passive sensors tracking key geochemical parameters may also be incorporated into the monitoring program at that time, if appropriate, to further minimize sampling and analytical costs. The sampling program may be refined as necessary within the initial five year period, based on the data collected.

In general, the MNA sampling locations were chosen to provide one of two forms of information: (i) "sentinel" wells were selected to provide early indications of undesired plume migration (which may warrant corrective action) and to provide information with regards to attenuation of lower concentrations of TCE on the fringe of the plume; and (ii) performance assessment wells located along the core of the plume between biobarriers to provide some indication of potential biobarrier operation timeframe. Vertical monitoring intervals will be confined to 10 ft intervals, per U.S. EPA guidance (U.S. EPA, 1986), with screened intervals in monitored natural attenuation wells corresponding to the approximate center of the targeted treatment depth interval.

Table 4.3 summarizes the parameters that will be monitored during the initial five-year MNA monitoring program and the information that may be obtained from each analyte. Sampling frequencies for each well was selected in consideration of the attenuation rate of TCE (targeting a minimum of two samples per half-life), as well as considering the potential plume migration rate in each hydrogeologic unit. Accordingly, both sentinel and biobarrier MNA wells will be sampled annually during the initial five-year program. Targeted analytes include VOCs, DHGs, DHC PCR assays (to assess potential migration of dechlorinating microorganisms outside of the active treatment zone and any related impact to the attenuation rate in these areas; between biobarrier wells only), depth to water (to monitor changes in groundwater flow direction) and field parameters.

4.4.3.1 Monitored Natural Attenuation in the Source Area

The MNA monitoring program for the source area was developed with the following objectives:

- Monitor MNA trends and evaluate the need for more aggressive treatment outside of the 1,000 µg/L source treatment zone; and
- Collect sufficient data for evaluating the need for implementation of contingency measures.

The critical areas for evaluating MNA performance in the source area are: (i) within the Upper Fines Unit outside of the grid treatment area but within the area of elevated (>100 µg/L) TCE concentrations; (ii) within the Upper Fines Unit at a location downgradient of the grid treatment area and within an area of lower (<100 µg/L) TCE concentrations; and (iii) within the First Sand Unit and upgradient of the source containment biobarrier but downgradient of the area in which mass flux from the Upper Fines Unit is expected to enter the First Sand Unit. Figure 4.1 illustrates the proposed sampling locations in relation to the TCE concentrations within the Upper Fines Unit and the proposed grid treatment area and downgradient source containment biobarrier location.

4.4.3.2 Monitored Natural Attenuation in the Downgradient Plume

The MNA monitoring program for the downgradient plume was developed with the following specific objectives:

- Monitor temporal MNA trends and evaluate the effectiveness of natural attenuation processes at reducing VOC concentrations within the plume; and
- Monitor VOC trends in critical monitoring locations to evaluate impact to the plume size and mass distribution over time.

The critical areas for evaluating MNA performance in the downgradient plume are: (i) at the outer edges of each biobarrier to evaluate plume bypass related to decreased permeability in the biobarrier, as well as evaluate impacts to the plume due to EVO injection activities; (ii) at the toe of the plume to evaluate downgradient plume migration rate during the treatment duration; and (iii) between biobarriers to evaluate plume attenuation rate between the treatment zones. Figures 4.2, 4.3 and 4.4 illustrate the proposed sampling locations in relation to the TCE concentrations within the First Sand, Shell Horizon and Second Sand Units respectively and the proposed biobarrier locations.

The evaluation of the MNA data during the initial 5 year active treatment phase may be continued, reduced, or increased based on the results of the concentration trend analyses.

4.4.4 Land Use Controls

The objectives of the land-use controls are to prevent exposure to VOC-contaminated groundwater and maintain the integrity of the remedial action until remediation goals are achieved. The following are land-use controls on property overlying the IR Site 70 groundwater plume:

- No new groundwater extraction, injection, or drinking water wells shall be installed within the IR Site 70 groundwater plume or associated buffer zone inside the Station without prior review and written concurrence from the DON, DTSC, and RWQCB.
- Injection and monitoring wells and associated piping and equipment that are included in the remedial action shall not be altered, disturbed, or removed without the prior review and written concurrence from the DON, DTSC, and RWQCB.

The land use controls required by this alternative will be applied to the overlying footprint of the existing areas of contamination, approximately 50 acres, and two associated buffer zones (Figure 4.6) that will extend from and encircle the interpreted limits of the VOC plume. A half-mile-radius buffer zone will be established for groundwater from the surface to a depth of approximately 495 feet bgs and a 250-foot-radius buffer zone for groundwater beneath the deep aquitard at depths greater than 495 feet bgs (Figure 4.6). This dual zone thereby creates a three-dimensional buffer zone by depth.

County of Orange Ordinance 2607 authorizes the Orange County Health Care Agency (OCHA) to regulate the construction and destruction of wells. Section 4-5-14 of the Ordinance States, "It is the purpose of this article to control the construction and reconstruction of wells to the end that the groundwater of this County will not be impaired in quality and that water obtained from such wells will be suitable for the purpose for which used and will not jeopardize the health, safety or welfare of the people of this County…" (OCHA, 2002).

These land use controls will be implemented by restricting well permits via the Orange County Health Care Agency Environmental Health Department in a manner similar to what exists for the nearby Alamitos Barrier. The permit restrictions will require that OCHA, the DON, and other appropriate stake holders (identified by the DON) review well permit applications prior to the granting said permits within the controlled area to determine compliance with applicable sections of the County of Orange

Ordinance 2607 (OCHA, 2002). This restriction will apply to water supply wells and injection wells within the buffer zones.

The DON will provide necessary information to appropriate local and county agencies to identify off-Base areas impacted by groundwater contamination. The DON will support these agencies with technical information required in order to implement restrictions on construction and use of wells in the affected areas.

4.4.5 POC Monitoring

The POC for Site 70 will be the boundary of Naval Weapons Station Seal Beach. In order to determine if the plume is migrating off the station, a monitoring well network will be established. This network will be comprised of existing wells that have no or very low previous detections of TCE. Wells will be selected such that the contaminated groundwater zones will each have a POC well network. Additionally, POC wells will be installed into the Deep Sand. The proposed POC network is shown in Figure 4.7. Since no TCE has been detected in the deeper aquifers immediately upgradient to the source zone and there is a consistent southeasterly gradient supported by the Alamitos barrier injection to the northwest, only the Upper Fines and First Sand units will be monitored for POC along the northwestern base boundary. The POC wells will be monitored for groundwater gradient in addition to groundwater chemistry, should the groundwater flow direction change significantly in the lower aquifers, additional wells may be installed. Should TCE be detected in POC wells above the MCL (confirmed by two subsequent samples), the DON will consider additional remedial actions and/or new POC wells.

The POC monitoring program will provide an initial baseline sampling event to define existing conditions. Subsequent sampling of the POC wells will be based on an assessment of baseline data, solute transport time (from the model), distance from the edge of the plume, groundwater flow direction, and historic groundwater flow rates for each unit. Sampling and groundwater levels will be measured within each respective zone during each sampling event. The analyses will be defined in the sampling analysis plan.

5. PRE-REMEDIATION CONSTRUCTION ACTIVITIES

5.1 Subcontracting/Procurement

All field activities will be performed under the direct supervision of the DON contractor with assistance from several specialty subcontractors. The procurement of appropriate subcontractors and required services and materials will be performed in a manner consistent with the terms of the contract and applicable Federal Acquisition Regulations.

Prior to the intrusive field activities, a geophysical surveyor will be retained. The geophysical surveyor will assist in locating and marking any underground utilities or features and provide utility clearance. Subsequent to well installation, a land surveyor will be retained. The land surveyor will assist in locating and marking the proposed well locations in the field.

Specialty subcontractors will be procured to assist in the specific aspects of the construction activities. These subcontractors include a fencing subcontractor, drilling and well installation subcontractor (including well development activities), a hazardous waste hauler/transporter, a treatment, storage, and disposal facility (TSDF), an analytical laboratory, and a groundwater sampling company. The groundwater sampling company will conduct all purging and sampling activities for groundwater. The analytical laboratory will perform the required chemical analysis on the soil and groundwater samples during waste characterization and verification sampling. The laboratory also will perform liquid analyses on any groundwater samples collected during monitored natural attenuation. The hazardous waste hauler/transporter will provide proper manifests signed by the DON representative prior to the transport of the soil cuttings from the well drilling to the identified regulatory-approved TSDF. DON will determine the TSDF. A fencing subcontractor will be retained for installing the necessary security fencing and gates around the temporary equipment and material storage area.

Other subcontracting services will be used to provide waste containers, a vacuum truck, and wastewater treatment and disposal services. Waste containers include 21,000-gallon capacity Baker Tank (or equivalent) and 55-gallon drums for storage of decontamination wastewater and a dumpster for storage of trash/solid waste and used polyethylene liners/personal protective clothing. Vacuum truck services may be used to transport the decontamination water to an off-site CERCLA-approved wastewater treatment and disposal facility.

Vendor procurement will involve an emulsified vegetable oil vendor, leasing an office trailer, generators, portable toilets, groundwater pumps, and health and safety monitoring equipment. Other miscellaneous equipment such as sampling and testing equipment, construction tools, PVC pipe and fittings, sandbags, and so forth, will be procured on an as-needed basis.

5.2 Notifications

Prior to the start of field activities at the Site, the following interested parties will be notified:

- The Navy (SWDIV) Project Manager;
- Naval Weapons Station Seal Beach;
- California Environmental Protection Agency (Cal-EPA);
- Department of Toxic Substance Control (DTSC);
- RWQCB; and
- Orange County Environmental Health Services (OCEHS).

In addition, the United States Fish and Wildlife Service will be notified prior to any work being conducted in and around the Seal Beach National Wildlife Refuge (within 50 feet of the boundary).

Signed dig permits will be obtained from the Public Works Department on base before any excavation or drilling work begins. The names of all personnel conducting work on the base will be submitted to the Resident Officer in Charge of Construction (ROICC) at least 48 hours prior to commencement of work. Prior to entering the base for the first time, all personnel will report to the Seal Beach Naval Weapons Station Pass office located at 800 Seal Beach Blvd in Seal Beach, CA with photo identification and vehicle registration and proof of insurance. Camera permits will be obtained from the pass office with proper endorsement from the ROICC prior to use of any cameras on Site. Camera permits will be required to allow photographs of the continuous core samples.

5.3 Kickoff Meeting

Prior to work commencing on Site, a kickoff meeting will be held, including representatives of the following:

- NAVWPNSTA Public Works Department;
- Explosives Safety Department;
- Ordnance Department;
- Fire Department;
- Security Department;
- Environmental Department;
- ROICC – on base; and

- NAVFAC – Si Le, PE, RPM.

The kickoff meeting will go over base operating procedures, safety issues, cell phone use, restricted areas, and other issues as needed.

5.4 Mobilization

Mobilization activities include site preparation, movement of equipment and materials to the site, as well as training and site orientation of field personnel. At least 2 weeks prior to mobilization, the appropriate DON personnel, including the RPM and the NAVWPNSTA IR Program Coordinator, will be notified about the planned schedule for mobilization and the remediation activities.

Prior to mobilization, photographs (with approved camera pass) will be taken of all work areas in order to ensure work areas are returned to acceptable conditions upon completion of work activities. This shall be done in accordance with all base photography regulations.

Upon receipt of appropriate records and authorizations, the field personnel and temporary facilities will be mobilized to the site. Mobilization of temporary facilities will involve the establishment of a suitable staging area to support the project activities. The support facilities to be installed in the staging area will include an office trailer, restroom facilities, and equipment and material laydown area. Once support facilities are transferred to the site, utility connections will be furnished for power, water, and communications. The laydown area and layout are discussed further in section 6.

Prior to any equipment being taken out on site, the equipment will be added to a log of all field equipment. The equipment shall be inspected and photographed. The equipment log will contain a record of the type of equipment, the condition of the equipment and the date of mobilization to the field.

Equipment mobilization will be initiated with site preparation activities. In order to minimize storage requirements, equipment and materials will be mobilized to the site on an as-needed basis. A dedicated laydown area will be used for short-term storage of equipment and materials. If needed, a secure storage trailer will be mobilized to the site for short- and long-term storage of materials, small equipment, and tools required for the project. All construction equipment will be delivered to the site in a clean condition.

5.5 Field Construction Activities

5.5.1 Marking Locations

Prior to the start of intrusive activity, all well locations shall be clearly marked using either white spray paint or stakes marked with the well names as appropriate. To expedite the process of marking locations, a map with all well names, utilities, buildings, roads and other landmarks shall be produced. This same map shall be used in order to obtain permits from the base.

5.5.2 Geophysical Survey of Locations

Underground utility clearance will be completed prior to drilling at all new groundwater monitoring well and injection well installation locations. A site reconnaissance will be conducted to locate utilities on as-built drawings to find evidence of any undocumented utilities. Active utilities present within the areas where wells will be drilled will be located prior to any intrusive work. A 10-foot by 10-foot area around each well location will be swept using ground-penetrating radar (GPR) and/or an electromagnetic induction (EMI) instruments and marked as clear where appropriate. The GPR and EMI will produce an image of the subsurface conditions identifying discontinuities in the soil column. These discontinuities can be identified as non-native objects such as metallic pipes or debris. Utility lines in the immediate vicinity will be marked in the field, using color-coded surveyor paint. The results of the geophysical survey will be compared to the latest available versions of as-built drawings to determine if any undocumented utilities or other features exist in the survey area.

Wherever possible, a transmitter/receiver unit will be attached to the exposed pipe or utility to trace metallic pipes or utilities that are either indicated on NAVWPNSTA utility maps or are obvious *via* surface expression. The location of the utility will be marked on the ground using color-coded surveyor paint.

If a utility is identified within 3 feet of the proposed drilling location, the drilling point will be moved and the clearance procedures will be repeated. The clearance of each boring location will be documented in the field logbook.

Drilling at each well location will be initiated by hand auguring or air knifing to a depth of approximately 10 ft bgs to minimize the risk of encountering underground utility lines that may have escaped detection during the utility and geophysical clearance efforts. Access into tight or confined areas will be reviewed with the ROICC and base personnel to determine if additional safeguards are required (lockout, tagout, blast reduction zone, etc.)

5.5.3 Injection and Monitoring Well Installation

The proposed locations of source area injection and monitoring wells are shown in Figure 4.1. In the downgradient plume, the proposed locations for injection and monitoring wells screened in the First Sand Unit, Shell Horizon and Second Sand Unit are shown in Figures 4.2, 4.3 and 4.4 respectively. Proposed well locations may change depending on locations of utilities and other physical impediments including access.

Injection and monitoring well boreholes will be drilled using hollow-stem auger and/or sonic drilling methods for source area and first sand biobarrier wells. Deeper biobarrier injection wells will be drilled using sonic, mud rotary, or other appropriate drilling methods. Continuous cores will be obtained from every sixth injection well and the detailed lithology from the cores will be recorded on borehole logs. The drill cuttings of all other injection wells and monitoring wells will be observed as the boreholes are drilled for soil classification, and the lithology encountered during drilling of the soil borings will be recorded on boring logs. Borehole logging will be conducted by a geologist under supervision of a State of California Professional Geologist. Soil samples will be classified using Unified Soil Classification System (USCS). Soil classification will consist of an evaluation of physical characteristics such as grain size, soil type, and moisture content.

Soil samples will be obtained from continuous cores for visual analysis and chemical screening using photoionization detectors (source grid treatment area only) for more detailed delineation of the DNAPL distribution in the source area. Samples will be obtained from drill cuttings taken from the remainder of the boreholes for sieve analysis only. Photographic logs of the drill cuttings will be made for all continuous core borings.

Injection wells will be constructed of 4-inch diameter schedule 80 polyvinyl chloride (PVC) as shown in Figure 5.1. The screen intervals for each of the injection wells are shown in Table 5.1. All injection wells will have 0.020-inch screens. Injection wells in paved areas will be completed with minimum 17 inch diameter traffic rated flush mount surface completions. Injection wells will be completed at surface with a flange fitting (for attachment of the EVO injection well-head fitting) and flange cap (9 inches OD) that will terminate just below the top of the well vault. Other injection wells will be completed as above or with above ground surface completions (also with flange fitting), based on traffic in the area and Navy approval. The well head construction will be according to the surface type. Flush mount wells will be used for paved surfaces and monument boxes will be used for wells for depressed or low lying areas. Wells immediately adjacent to roadways will be flush mounted to limit traffic hazards. Wells constructed in low lying areas will have a minimum of 2 feet stick up to avoid flooding the well head.

Monitoring wells will be constructed of 4-inch diameter PVC as shown in Figure 5.2. Monitoring wells with a total depth less than 100 ft shall be constructed of schedule 40 PVC and monitoring wells with a total depth of greater than 100 ft shall be constructed of schedule 80 PVC. The screen intervals for each of the injection wells are shown in Table 5.2. All monitoring wells will have 0.020-inch screens. Monitoring wells in paved areas will be completed with flush mount surface completions. Other monitoring wells will be completed with flush mount or above ground surface completions based on traffic in the area and Navy approval. Wells constructed in low lying areas will have a minimum of 2 feet stick up to avoid flooding the well head. The biobarrier wells adjacent to roadways and within roadways will be flush mount to minimize the traffic hazard.

The filter pack for all injection and monitoring wells will be Monterey #2/16 sand and will extend to approximately 2 feet above the top of screen. One foot of fine silica sand will be placed on top of the filter pack as transition sand. Two feet of bentonite chips will be placed on top of the transition sand as a seal and allowed to hydrate prior to placement of the grout. The injection wells shall be grouted from three ft or less below the surface to the top of the bentonite seal. All well construction details may be changed in the field as required by lithology encountered during drilling and due to any construction changes to the injection wells. The top of the well casings will be secured with watertight, locking well caps and locks to help deter unauthorized entry. The well designations will be marked on the well vault.

5.5.4 Injection and Monitoring Well Development

The proposed groundwater monitoring wells and injection wells will be developed to improve hydraulic conductivity between the wells and the surrounding formations after the well seal has cured for at least 24 hours. Development typically consists of surging during construction and then removing approximately five well volumes of water from each well while noting changes in turbidity, pH, conductivity, and temperature. Development will be performed using a well development rig capable of bailing, surging, and pumping groundwater. Well development will be completed as described in the appropriate SOP (see Appendix C). Based on previous well development experience an estimated 3,000 gallons of development water per well will be generated. A waste water management plan will be developed to properly dispose of this water.

Following profiling and characterization activities, development water will be disposed of in accordance with applicable state and federal laws and as described in Section 7.0.

5.5.5 Decontamination of Field Equipment

All field equipment shall be decontaminated prior to removal from the site. Decontamination shall be carried out in accordance with the SOPs (Appendix C) at the decontamination area on base. The decontamination area will be maintained in a clean and orderly manner. Waste will be removed at periodic intervals to limit the volume of waste on site.

5.5.6 Management of Investigation Derived Waste

All waste will be handled and disposed of as described in Section 7.0.

5.6 Demobilization

Demobilization will consist of decontamination of all heavy equipment, cleaning the project site, inspection, and certification of completion. The activities will include decontamination and removal of all construction equipment and materials, as well as collection and disposal of all contaminated material including decontamination wastewater and disposable equipment. Transportation and disposal of waste generated from the construction and remediation activities are discussed in Section 7.0.

Heavy equipment will be decontaminated using heavy brushes to remove soil and dirt attached to the equipment surfaces. Special attention will be paid to removing material from the drill rig and auger flights. Tools and items for which decontamination is difficult or impossible to verify will remain on site until completion of the work for subsequent packing and off-site disposal at an approved disposal facility. Decontamination of temporary facilities located within the support zone will be limited to exterior cleaning.

Prior to removal from site, all decontaminated equipment and material will be inspected and accepted by the Site Health and Safety Officer (SHSO) and the Project Superintendent. These individuals will certify that decontamination was performed for all equipment and materials in their daily field logs.

Site restoration work will include repair of any erosion or runoff-related damage; removal of all materials such as excess construction material, wood, debris and other foreign material; and removal of all construction equipment. The site administrative support complex will be disconnected from electrical, telephone, and water lines. All office and storage trailers will be removed and returned to the rental company.

6. REMEDIATION OPERATIONS, PERFORMANCE MONITORING, AND REPORTING

6.1 Amendment Procurement and Storage

6.1.1 EVO

Newman's Zone (standard product) EVO will be procured from Remediation and Natural Attenuation Services, Inc. The product contains 49 percent (%) by volume soybean oil and 6% sodium lactate.

The EVO will be shipped to site in 1,000 L (264 gal) totes. EVO totes for near-term use will be kept in a designated area at each site as shown in Figures 6.1, 6.2, 6.3, and 6.4 in a shaded area to mitigate product spoilage during hot weather. The totes stored onsite will be loaded onto a trailer or a stabled truck and transported over to the active injection area. The totes will be off loaded by an all terrain forklift. A refrigerated warehousing facility in the greater LA area will be used for longer-term storage of the EVO totes.

6.1.2 KB-1™

KB-1™ dechlorinating culture will be procured from SiREM (Guelph, Ontario, Canada), shipped to the site in stainless-steel pressure vessels and stored on-site for a maximum of 14 days prior to injection. The KB-1™ dechlorinating culture is capable of completely dechlorinating TCE to VC and ethene and requires anaerobic conditions for growth and survival.

Cylinders of pressurized argon gas will be required to create an anaerobic blanket within each injection well during KB-1™ injection activities to mitigate oxygen exposure during injection activities. Argon cylinders will be procured from local suppliers shortly before the KB-1™ injections and stored on site for limited periods of time in secure areas.

6.1.3 Anaerobic Water

To provide ideal conditions for KB-1™ survival and growth *in situ*, anaerobic water will be injected before and after KB-1™ addition. Two 6,500 gallon Baker tanks, located as shown on Figures 6.1 to 6.4, will be filled with either potable water supplied from a fire hydrant or groundwater several days prior to the KB-1™ injection. The oxygen within this water will be consumed by indigenous microorganisms through the addition of appropriate amounts of a soluble electron donor, such as sodium lactate, and seeding of oxygen-consuming bacteria through either the addition of a septic tank bacterial puck or groundwater containing indigenous bacteria. The water will be ready for injection when the DO value drops below 0.5 ml/L and ORP decreases below –

100 mV. Both tanks will be replenished immediately upon draining to ensure a constant supply of anoxic water as needed during KB-1 injections.

6.2 EVO Injection Process and Equipment

6.2.1 Process Overview

EVO will be added to the subsurface to achieve a target oil saturation of 0.5% for both the source area and downgradient plume biobarrier treatment areas. The concentrated Newman Zone EVO (49% oil) will be diluted with groundwater to produce a 1% emulsion (equivalent to 0.5% oil). Groundwater will be extracted from adjacent or nearby wells with similar groundwater contaminant levels using submersible pumps and a multi-channel manifold. The groundwater will be pumped to a central dosing unit, amended with concentrated emulsified oil and reinjected through a multi-channel manifold into the same number of injection wells. A simplified process flow schematic is provided in Figure 6.5.

Fifty percent of the 1% EVO target volume will be injected into each well before the introduction of KB-1™. To provide ideal conditions for the KB-1™ *in situ*, 200 to 300 gallons of anoxic water will be injected before and after KB-1™ injection. A trash pump will be used to transfer anaerobic water from a 6,500-gallon Baker tank to the injection wells *via* the same multi-channel EVO manifold. After addition of the anaerobic water, the injection well will be flushed with argon gas to purge any residual oxygen from the water in the well and from the air standing in the well bore. The argon gas will then be used to transfer the desired volume of culture from the shipping vessel to the delivery vessel. Three liters of KB-1™ will be delivered through a drop line to the middle of the screened interval of each injection well, using argon gas to push solution from the delivery vessel into the well. Following KB-1™ injection, an additional 200-300 gallons of anaerobic water will be injected into each injection well before proceeding with the injection of the remaining EVO. The standard operating procedure for EVO injection and KB-1™ addition is detailed in Appendix C.

6.2.2 Equipment

The EVO injection equipment includes EVO totes, transfer hoses, injection skid (manifolds and dosing pumps), and amendment point well-head fittings as illustrated in Figure 6.6 and detailed in Table 6.1. In addition to the EVO injection equipment, a 2 L KB-1™ delivery vessel, 80 ft^3 argon gas cylinders and two 6,500 gallon Baker tanks are required for bioaugmentation. The individual components of the EVO injection system are discussed below (Figure 6.6).

EVO Totes. The totes each contain approximately 1,000 L [2,100 pounds (954 kg)] of emulsion. Each tote has two access ports, one on the top and one at the base. Each tote is attached to a pallet for shipment.

Injection skid. A trailer-mounted injection system will be constructed as illustrated in Figure 6.6 to receive source water *via* a multi-channel manifold, dose in the EVO at a selected rate using one or more Dosmatic pumps and then distribute the emulsion to another multi-channel manifold used to direct the dilute emulsion to the injection wells. The specifications of the dose pumps are selected based on the expected flow rate of source water and the target injection flow rates. The manifolds and/or well-head fittings will be capable of measuring both positive and negative pressures (vacuum and compound gauge). The equipment required is listed in Table 6.1.

Amendment Well Head Fittings. The injection well head fittings will be equipped with a flange to connect to the injection well flange, which will be sealed with bolts and a rubber gasket (Figure 6.6). The remainder of the well head fitting will consist of a 2-inch diameter clear PVC riser tube and a 2-inch PVC cross fitted with a vent valve, vacuum/pressure gauge and a flow control valve with cam-and-groove fittings to which the amendment injection manifold will be connected to the injection well. All connections will be solvent welded with the possible exception of threaded fittings for the ball valves (2-inch) and the pressure gauge (1/4-inch) brass.

6.3 Remediation Operations

6.3.1 Source Area and Source Containment Biobarrier

6.3.1.1 EVO and KB-1™ Injection Staging

EVO and KB-1™ will be injected in stages into the 57 source area wells in the source grid treatment area within the Upper Fines Unit, as well as into the 14 injection wells that form the Source Containment Biobarrier in the First Sand as shown in Figure 6.1. The EVO injection for these two areas may not occur concurrently. For both areas, the targeted oil amendment rate will be 0.5% or approximately 1% EVO. The system layout for anaerobic water, oil, and dosing equipment for the source area is shown in Figure 6.1. The required total EVO, EVO dilution water, anaerobic water and KB-1™ culture volumes, as well as the estimated injection duration for each area of the source treatment are summarized in Table 6.2.

The EVO injection of the source grid treatment area will require approximately 59 working days, assuming sustained injection rates of 10 gpm per well and based on injection of a total of 51 totes of EVO and 1,313,000 gal of groundwater. KB-1™ injections will require 171 L of KB-1™, 22,800 gal anoxic water, and 10 argon gas cylinders (80 ft^3 size cylinders). The EVO injection will be conducted in 7 stages, in a manner that will permit a 2-person team to effectively manage the injection of up to 10 wells simultaneously. The staging of the injections is summarized in Table 6.2 and illustrated in Figure 6.1. The staging process includes extraction of groundwater from one set of wells while reinjecting into nearby wells after mixing with the EVO with the goal of minimizing the net fluid balance in the subsurface to mitigate spreading of the contamination. Groundwater will be extracted from wells with similar contaminant profiles as that of the injection wells, and injections will work inwards and upgradient to the extent possible. Injection will commence with Group 1 wells, with Group 2 wells acting as extraction wells and so on (see Table 6.2 for details). The extracted groundwater to be used for injection into Group 6 and 7 wells will come from wells in which EVO injection has been completed. Although a small percentage of previously injected oil and KB-1™ is expected to be pumped into the Group 6 and 7 injection wells and injection flow rates are anticipated to be lower (assumed to be approximately half), this is preferable to storing large quantities of water on-site for the injection of the last groups of wells. Prior experience with EVO injections indicates that only a small percentage of the EVO remains mobile, and that the majority of the EVO will quickly sorb (within a few days) to the soil and remain bound to the soil.

A similar EVO injection approach will be taken with the Source Containment Biobarrier. The EVO injection of the Source Containment Biobarrier will require approximately 45 days, assuming sustained injection rates of 10 gpm per well, and will require a total of 26 totes of EVO and 655,900 gal groundwater. For the KB-1™ injection, 42 L of KB-1™, 9,000 gal anoxic water, and 3 argon gas cylinders. The EVO injection will be conducted in 3 stages, as detailed in Table 6.2 and illustrated in Figure 6.1, following a similar rationale as that used for the source grid treatment area.

Injection durations were estimated by dividing the total target amendment volume by the total estimated injection flow rate and assuming a 10-hr day. In addition to the actual injection time, it is assumed that one day each will be required for the start-up of each injection stage, for KB-1™ injection and for decontamination. If the total injection time exceeds one five-day work week, then one day for every five days of injection is assumed to be required for cleaning of hose and equipment for storage over the weekend and setup upon return.

During all injections, EVO injection rates, pressures, total EVO and water volumes will be tracked for each of the injection wells. EVO injection monitoring forms can be found in Appendix C. Between each injection stage, the lines, well and filter pack will be injected with unamended groundwater to flush EVO away from the well to minimize biofouling. The system will then be decontaminated.

6.3.1.2 Maintenance of Biotreatment Zone

EVO within the biotreatment zone will gradually dissolve and degrade ultimately producing hydrogen (electron donor), which is used by dechlorinating bacteria to reductively dechlorinate the TCE, cDCE, and VC (electron acceptors). In addition to dechlorinating bacteria, other bacteria that use electron acceptors such as nitrate, ferric iron, and sulfate can compete for the hydrogen produced from the EVO. The longevity of the EVO can be predicted by estimating the electron acceptor demand and using stoichiometry to determine how long the EVO will persist.

The volume of oil amended into the Upper Fines Unit in the source grid treatment area is estimated to be sufficient to biodegrade all contaminant mass currently existing as dissolved phase, including demand on electron donor exerted by other electron acceptors (e.g., oxygen, nitrate, sulfate, etc.) and a safety factor of 2 to account for ferric iron and manganese reduction processes that are not explicitly accounted for in the stoichiometric calculations in Appendix B. If DNAPL is present, additional EVO injections will likely be required. Neither the EVO longevity nor the number of EVO injections required in the source grid treatment area can be determined *a priori* as they depend upon the rate of EVO consumption and the potential mass of TCE DNAPL present.

The longevity of EVO in the Source Containment Biobarrier is estimated to be 6 years as shown in Table 4.2, based upon the current flux of contaminant mass and other electron acceptors (particularly sulfate) through the biobarrier. Detailed stoichiometric calculations and equations can be found in Appendix B. This calculation assumes a safety factor of 2 is appropriate for this site. A safety factor of 2 is used to increase the calculated electron donor demand above the stoichiometric amount to include any mass consumption pathways not specifically accounted for in the equation. Electron donor demand from iron and/or manganese reduction may potentially exceed this, and thus introduces uncertainty in the estimated longevity of the EVO, with probable longevity being somewhere in the range of 2 to 6 years.

To verify and monitor the longevity of EVO in the field, groundwater samples will be taken from 4 monitoring wells (2 sets of 2 nested wells) within the source grid treatment area (PMW-1A, PMW-1B, MW-70-27 and MW-70-28) and 4 monitoring wells and 1 injection well in a transect perpendicular to the source containment biobarrier to analyze for VOCs, TOC, VFAs, DO, ORP, and DHC (see Section 6.3.3 for the detailed monitoring program). DHC levels will provide an indication of *DHC* population levels, with declining levels being indicative of possible electron donor limited conditions. Higher DO and ORP, and less efficient VOC biodegradation are other indications that the electron donor has been consumed. TOC and VFAs may also be depressed in the injection wells.

Because the mass of TCE DNAPL in the source area is unknown, the duration of source treatment (grid treatment and source containment biobarrier) is also unknown. VOC sampling and EVO reinjections will continue until TCE levels have declined to levels below 200 µg/L. Should a subsequent reinjection be required, the area for reinjection will be confined to only those with TCE concentrations above 200 µg/L; thereby reducing EVO and labor costs. This may require further VOC sampling in the source area to assess what area to target.

6.3.2 Dissolved Phase Plume Biobarriers

6.3.2.1 EVO and KB-1™ Injection Staging

To treat the dissolved phase plume, EVO will be injected into 5 biobarriers in the three hydrogeologic units (First Sand, Shell Horizon, and Second Sand). It is anticipated that the biobarriers will be installed in phases over several years as discussed in Section 8.1. Details of the EVO injection staging for the two First Sand biobarriers is presented in Table 6.3 and for the Shell Horizon and Second Sand biobarriers in Table 6.4. The EVO will be injected in a similar manner as that used for the source containment biobarrier, using extraction wells within the biobarrier for makeup groundwater where possible. Anaerobic water and KB-1™ will be amended in the same manner as for the source area. Each biobarrier is discussed briefly below. For each injection well, the EVO injection rates, pressures, total EVO and water volumes will be monitored.

Biobarrier FS-1

Biobarrier FS-1 will consist of 35 injection wells installed on 24 ft centers and spanning the 250 µg/L contour of the plume as shown in Figure 4.2. The injection rate is anticipated to be 10 gpm per well. Each well will require 47,327 gallons of amendment (representing 476 gallons of EVO and 46,851 gallons of water) and 3 L of KB-1™. The entire biobarrier will require 16,660 gallons, or 64 totes of EVO, and 1,639,785 gal groundwater. KB-1™ injections will require a total of 105 L of culture, 22,400 gal of anoxic water, and 6 argon gas cylinders. It is estimated that injection into the biobarrier will require a total of 69 days. EVO equipment staging locations are shown on Figure 6.2. It is anticipated that EVO can be injected into the biobarrier in 4 stages as detailed in Table 6.3 and illustrated in Figure 6.2

Biobarrier FS-2

Biobarrier FS-2 will consist of 29 injection wells installed on 24 ft centers and spanning the 250 µg/L contour of the plume near the toe of the plume in this unit as shown in Figure 4.2. The injection rate is anticipated to be 10 gpm per well. Each well will require 36,810 gallons of amendment (representing 370 gallons of EVO and 36,440 gallons of groundwater) and 3 L of KB-1™. The entire biobarrier will require 10,730 gallons, or 41 totes of EVO, and 1,056,760 gal of groundwater. KB-1™ injections will require 87 L of culture, 14,500 gal of anoxic water, and 5 argon gas cylinders. It is estimated that injection into the biobarrier will require a total of 38 days. EVO equipment staging locations are shown on Figure 6.4. It is anticipated that EVO can be injected into the biobarrier in 3 stages as detailed in Table 6.3 and illustrated in Figure 6.2

Biobarrier SH-1

Biobarrier SH-1 will consist of 37 injection wells on 20 ft centers spanning the 250 µg/L contour of the plume as shown in Figure 4.3. The injection rate is anticipated to be 5 gpm per well. Each well will require 19,304 gallons of amendment (representing 194 gallons of EVO and 19110 gallons of water) and 3 L of KB-1™. The entire biobarrier will require 7,178 gallons, or 28 totes of EVO, and 707,070 gal of groundwater. KB-1™ injections will require 111 L of culture, 12,950 gal of anoxic water, and 7 argon gas cylinders. It is estimated that injection into the biobarrier will require a total of 48 days. EVO equipment staging locations are shown on Figure 6.5. It is anticipated that EVO can be injected into the biobarrier in 4 stages as detailed in Table 6.4 and illustrated in Figure 6.5

Biobarrier SH-2

Biobarrier SH-2 will consist of 32 injection wells on 20-ft centers spanning the 250-µg/L contour of the plume as shown in Figure 4.3. The injection rate is anticipated to be 5 gpm per well. Each well will require 19,304 gallons of amendment (representing 194 gallons of EVO and 19,110 gallons of water) and 3 L of KB-1™. The entire biobarrier will require 6,208 gallons or 24 totes of EVO, 611,520 gal of groundwater. KB-1™ injections will require 96 L of culture, 11,200 gal of anoxic water, and 6 argon gas cylinders. It is estimated that injection into the biobarrier will require a total of 48 days. EVO equipment staging locations are shown on Figure 6.3. It is anticipated that EVO can be injected into the biobarrier in 4 stages as detailed in Table 6.4 and illustrated in Figure 6.3

Biobarrier SS-1

Biobarrier SS-1 will consist of 22 injection wells on 24-ft centers spanning the 250-µg/L contour at the toe of the plume in the Second Sand Unit as shown in Figure 4.4. The injection rate is anticipated to be 25 gpm per well. Each well will require 42,068 gallons of amendment (representing 423 gallons of EVO and 41,645 gallons of water) and 3 L of KB-1™. The entire biobarrier will require 9,306 gallons, or 36 totes of EVO, and 916,190 gal of groundwater. KB-1™ injections will require 66 L of culture, 12,320 gal of anoxic water and 4 argon gas cylinders. It is estimated that injection into the biobarrier will require a total of 22 days. EVO equipment staging locations are shown on Figure 6.4. It is anticipated that EVO can be injected into the biobarrier in 3 stages as detailed in Table 6.4 and shown in Figure 6.4.

6.3.2.2 Maintenance of Biobarriers

The longevity of the EVO can be predicted by estimating the electron acceptor demand and using stoichiometry and calculations of the estimated contaminant mass discharge through each biobarrier to determine how long the EVO will persist. As summarized in Table 4.2, each EVO injection into Biobarriers FS-1, FS-2, SH-1, SH-2, and SS-1 is expected to last approximately 6, 5, 10, 10 and 15 years, respectively. Backup calculations to support these estimates can be found in Appendix B.

To verify and monitor the longevity of EVO in the field, groundwater samples will be taken from 3 to 5 monitoring wells, including an injection well, in transect(s) perpendicular to the biobarrier to analyze for VOCs, TOC, volatile fatty acids, DO, ORP, and DHC (see Section 6.3.3 for the detailed monitoring program). DHC assays will provide an indication of *DHC* population levels, with declining levels being indicative of possible electron donor limitations. Higher DO and ORP and less efficient VOC biodegradation are other indications that the electron donor has been consumed. TOC and VFAs may also be depressed in the injection wells.

Modeling suggests that the biobarriers may require operation periods ranging from 8 to 16 years (see Table 4.2). If the EVO is required to last 5 to 15 years in practice, then only 1 to 3 applications of EVO may be required within each biobarrier.

6.3.3 Groundwater Sampling and Analytical Program

Monitoring of various groundwater parameters is required over the course of the remedial action to ensure that groundwater treatment is occurring as planned. Monitoring and analytical procedures are outlined in the following subsections. Detailed procedures for groundwater sampling and well purging are presented in the SOP (Appendix C).

6.3.3.1 Parameters

Groundwater analyses will include both laboratory sample analyses and field measurements. Field parameters will be monitored using a flow-through cell equipped with multiple monitoring probes for analysis of pH, temperature, conductivity, ORP, and DO.

The groundwater analytes are summarized in Table 6.5 along with the method number, detection limits, sampling volumes, preservatives, and holding times for each of the measurements. The rationale and information gained from each analyte is summarized in Table 4.3. VOCs and DHGs are measured to monitor biodegradation of the TCE through to ethene and ethane. Decreased sulfate, nitrate, and dissolved oxygen concentrations or increased ferrous iron and methane levels are geochemical indicators of reduced conditions. DHC assays track the level of *DHC* organisms to determine whether they are growing and propagating away from the well. A DHC level of 10^7 gene copies/L is indicative of a cell density where ethene production is typically observed. TOC and VFAs will be used as surrogates to track the degradation and consumption of the emulsified oil. Field parameters such as pH, temperature, DO, and ORP are useful to ensure the attainment of reduced conditions and to monitor for changes in pH that may adversely affect the microbial population.

6.3.3.2 Sampling Procedures and Frequency

Groundwater samples for laboratory analysis will be collected according to procedures outlined in the SOP (Appendix C). Field parameters of pH, temperature, conductivity, ORP, and DO will be collected immediately prior to sampling.

The groundwater samples will be collected using low-flow sampling techniques to minimize aquifer disturbances and to obtain a representative sample. The objective of low-flow purging is to remove water from the screened interval at a rate that is comparable to the ambient groundwater flow rate. This minimizes aquifer drawdown in the well and limits the mixing of water within the screened interval with overlying stagnant water in the well casing. Low-flow purging allows for collection of representative groundwater samples with minimal disturbance and low turbidity. During purging, DO, pH, conductivity, ORP, and temperature data will be collected using an appropriate field instrument equipped with a flow-through cell.

The sampling frequency for the initial five years of the remediation program is summarized in Table 6.6, which shows the analytes, wells, and sampling frequency for both the source area and the biobarriers. After five years, the monitoring program will be optimized accounting for the geochemical trends observed during the initial five years of operation. Source area performance monitoring wells and indicated biobarrier injection wells will be sampled prior to EVO injection (baseline) and then quarterly for the first year and semi-annually thereafter after EVO injection. MNA wells will be sampled less frequently, either annually or biannually and for a smaller subset of parameters to track MNA trends.

6.3.4 Reporting

Annual reviews of monitoring data will be conducted to assess biobarrier performance and the need for maintenance, plume migration, dechlorination activity, extent of microbial migration, and the adequacy of the remedial action to meet RAOs. Annual reviews will be documented in a summary report issued to appropriate regulatory agencies. These reports may include suggested modifications to the cleanup program to optimize remedial performance and minimize O&M costs.

7. WASTE MANAGEMENT PLAN

7.1 Waste Characterization

State and federal regulations require waste generators to determine if a waste is hazardous. Soil cuttings and development water generated during drilling operations at IR Site 70 may potentially be classified as hazardous or California non-RCRA hazardous waste.

Waste generated during the field operations will be representatively sampled and analyzed to determine the hazard classification prior to transport off site. Analytical testing will be conducted at a Department of Health Services (DHS)-certified and Naval Facilities Engineering Service Center-evaluated analytical laboratory. The waste profiling (waste classification determination) will be based on the results of the soil sample analyses. Analytical methods used for waste classification may include total metals, Toxicity Characteristic Leaching Procedure (TCLP), and Waste Extraction Test (WET).

7.2 Waste Streams

There are several waste streams that may result from the well installation and associated remediation activities. A description of potential waste streams is presented below:

- Waste soil cuttings and drilling mud from monitoring well and injection well installation;
- Decontamination wastewater from drilling, well development, and groundwater sampling equipment cleaning, purge water and development water from groundwater monitoring wells;
- Used disposable sampling equipment and personal protective equipment (PPE);
- Liquids and solids, including well material debris generated during well installation;
- Residual EVO from totes and decontamination of injection equipment, decontamination water from KB-1^{TM}, and any spills from these items; and
- Inert or non-hazardous solid waste (refuse).

7.2.1 Decontamination Wastewater/Purge and Development Water

Additional wastewater will be generated from development and purging of injection and monitoring wells. Wastewater will be generated from equipment and personnel decontamination. Liquid waste will be placed in temporary storage containers [Baker tanks or Department of Transportation (DOT) 17H 55-gallon drums] on site until their disposal. Upon completion of field activities, the wastewater will be sampled to determine if it is a hazardous waste. If drums are used, the drums of decontamination water will be labeled with respect to contents and will be staged in a predetermined secured area with secondary containment and spill control equipment. Weekly inspections of the drum storage area will be conducted and documented to ensure that drums are properly labeled, sealed, and in good condition. Following completion of the project, the wastewater will be treated on site and disposed of on site in compliance with a general waste discharge permit from RWQCB (as permitted), or properly transported to an appropriately permitted facility for treatment or disposal. For purge and development water meeting the criteria under RWQCB Order R8-2002-0044, disposal will be infiltration back onto the existing aquifer within the footprint of the plume.

7.2.2 Contaminated Drill Cuttings

Solid waste (soil) generated from well installation will be placed in covered portable roll-off bins lined with plastic sheeting or in DOT 17H 55-gallon drums. Solid waste stored in roll-off bins or drums will be temporarily staged on site and transported off site to a permitted disposal facility following characterization and profiling.

Drill cuttings will be transported to an appropriately permitted, CERCLA off-site rule-approved Class I hazardous waste facility or other appropriate facility as determined by waste characterization.

Use of any disposal facility is subject to approval under subcontractor qualification procedures. All manifests and final disposal decisions will be at the direction of the DON on site representative.

7.2.3 Used Personal Protection Equipment

All used PPE and disposable sampling equipment will be placed in DOT-approved 17H 55-gallon drums or waste storage and later disposed of at an appropriate landfill. Construction activities will be performed in Level D or modified Level D. Depending upon air monitoring results, protection level may be upgraded to Level C. Management of the drums of PPE will be similar to management of the drums of decontamination wastewater described above.

7.2.4 Miscellaneous Debris

Clean miscellaneous debris such as concrete and asphalt resulting from coring operations, PVC pipe sections, and others will be transported to an appropriate licensed landfill for disposal. Use of any disposal facility is subject to approval under subcontractor qualification procedures.

Mixing regular trash and/or non-hazardous solid waste with potentially contaminated waste will be avoided.

7.3 Waste Containerization and Accumulation

Potential hazardous waste (soil cuttings, wastewater, and PPE) will be placed in containers on site. DOT-trained personnel will perform container selection based on type and quantity of waste to be generated. Containers may include DOT-specification drums or roll-off bins for regulated hazardous material. DOT-specification containers are not required for non-hazardous material that does not meet a DOT hazard class. An inventory of hazardous and non-hazardous waste containers and quantities will be maintained for future reporting and inspection.

All containerized hazardous waste will be stored in DOT-approved containers at designated temporary accumulation area(s). These areas shall be clearly marked on pre-mobilization site maps. The temporary accumulation area will be equipped with spill containment and a spill kit. Where appropriate and feasible, these areas will include secondary containment. The temporary accumulation area and containers will be inspected weekly. Any deficiencies found during the inspection that require corrective action (unlocked gates, missing or damaged labels, leakage, or missing containers) will be recorded and documented. Containers approaching the 90-day accumulation limit will also be noted.

Containerized hazardous waste must be accumulated in accordance with 22 CCR, Sections 66264.170 through 177 (Use and Management of Containers). Containers of hazardous waste and portable tanks will be inspected and logged weekly while the fieldwork is in progress. Inspections will include an evaluation for proper labeling, secure closure, the condition of each container/tank, number of containers/tanks, and condition of the accumulation area(s). Any signs of deterioration, leaking, or dents will be noted, and containers will be immediately re-packed or the tanks will be drained, if necessary. Standing water will be removed from the containment area within 24 hours. Inspection results will be provided upon request to NAVWPNSTA Seal Beach. All containers will be checked to ensure labels and markings are in good condition. DOT information for hazardous materials, including proper shipping descriptions and hazard class labels, will be added to containers prior to shipping. Hazardous waste may be accumulated on site in containers for a maximum of 90 days. Hazardous waste may be accumulated on site in portable tanks for a maximum of 60 days. The 60 and 90 days begin on the date that the waste is first generated and containerized or stockpiled.

7.3.1 Labeling

At the time of generation, all disposable waste containers will be labeled, by using indelible ink, with the following information:

- Source and location;
- Contents and quantity of material in the container;
- Potential health, safety, and environmental hazards;
- Accumulation start date (the date the material was first put in the container);
- Date container sampled;
- Parameters used for analysis; and
- "ANALYSIS PENDING - POTENTIALLY HAZARDOUS."

The same information shall be recorded in field logs for non-disposable containers. Upon the determination that the material in the waste container is hazardous, the container will immediately be labeled with a completed commercial EPA "HAZARDOUS WASTE" label. The label will include the accumulation start date and other requested information and managed as defined in 22 CCR, Sections 66262.30 through 66262.34, Pre-Transport Requirements.

7.4 Waste Sampling

All waste shall be sampled and profiled prior to arrangements being made for disposal off site. The DON shall be the generator for all waste produced during the course of the work. The DON shall make the final decision as to the hazardous waste facility contracted to accept waste generated during this project.

7.5 Waste Transportation

Hazardous material will be transported by a subcontractor approved under subcontractor qualification procedures. The transporter will have appropriate licenses, including an EPA identification number. Hazardous material including hazardous waste will be properly classified, described, packaged, marked, and labeled for shipment as required by applicable sections of 49 CFR, Parts 171, 172, 173, 178, and 179, and 22 CCR, Sections 66262.10 through 66262.45. Properly DOT-trained personnel will perform DOT functions.

- **Shipping Description –** Material that does not exhibit one of the nine DOT hazard classes (explosive, flammable, poison, combustible, and so forth) is not regulated under DOT rules for the transportation of hazardous material. The Compliance Officer or the DOT Coordinator will confirm this description prior to shipment. The applicable DOT shipping description, EPA hazardous waste number, and the California waste code will be selected based on the results of the waste characterization.

- **Marking and Labeling –** The shipping name, hazard class, identification number, technical names, EPA markings and waste code numbers, and consignee/consignor designations must be marked on packages for shipment in accordance with 49 CFR, Part 172. This information will be marked on each roll-off bin after consultation with the Compliance Officer or DOT Coordinator.
- **Placarding –** Vehicles will be appropriately placarded in accordance with 49 CFR, Part 172.
- **Manifest –** Hazardous materials shipped off site must be properly manifested. Manifests will be completed by and require DON signature before the waste leaves the site. Copies of all manifests will be retained in the project files; original copies are sent with the transporter. All loads will be weighed at the base weigh station prior to DON representative signing the manifest.
- **LDR (Land Disposal Restriction) Certification –** LDR Certification will be prepared and will accompany the manifest if applicable. Copies of all LDR Certifications will be retained in the project files with copies of the signed manifest received from the disposal facility. All original waste disposal paperwork will be maintained by the Environmental office at NAVWPNSTA Seal Beach.

7.6 Waste Disposal

All waste materials will be disposed according to methods described below. This section describes the disposal methods for the waste materials generated at the site including solid waste, EVO wastewater material or excess, wastewater, contaminated soil, and uncontaminated soil and debris.

7.6.1 Solid Waste and Wastewater Disposal

All discarded materials, waste materials, or other objects will be handled in such a manner to control the potential for spreading contamination, creating a sanitary hazard, or causing litter to be left on site. All used PPE materials will be temporarily stored in 55-gallon drums and later disposed at a CERCLA-approved and permitted landfill or TSDF. The wastewater generated from personnel and equipment decontamination will be stored in 55-gallon drums or Baker tanks. A sample of the wastewater will be collected and analyzed to determine if it is a hazardous waste, and then appropriately transported to an off-site disposal and/or treatment facility. Any leftover EVO solution will be removed from the site by an appropriate vendor for recycling.

7.6.2 Contaminated Waste Transportation and Disposal

Following waste classification, all waste material will be disposed of according to the final waste classification. Disposal may be a combination of options determined by the hazardous classifications as follows:

- Soil and debris classified as RCRA hazardous waste will be transported to an appropriately permitted and CERCLA-approved hazardous waste landfill for treatment, if necessary, and disposal.
- Soil and debris classified as non-RCRA hazardous waste will be transported to an appropriately permitted and CERCLA-approved hazardous waste landfill for disposal.

Contaminated drill cuttings will be transported to an appropriate off-site disposal facility. A hazardous waste manifest will be filled out for each load and submitted to the DON to sign as generator. Original copies of the manifest will be provided to the transporter for shipment.

Trucks hauling contaminated waste material for off-site disposal will use Gate Number 9 located on Westminster Avenue to exit NAVWPNSTA Seal Beach. The trucks will travel east on Westminster Avenue to Bolsa Chica Road, then go north on Bolsa Chica Road to enter the 405 Freeway. Trucks hauling contaminated waste for off-site disposal will not be allowed to travel on Seal Beach Boulevard.

7.7 Release Prevention, Response, and Reporting

7.7.1 Spill Prevention

Vehicle fueling, generator fueling, and management of decontamination waste are the three primary activities that may result in a spill. Spill prevention practices are described below for these three activities.

- **Fueling –** All vehicles will be fueled and serviced prior to moving onto the site. Any on-site fueling of equipment will be conducted within a designated controlled area. If generators will be required at remote locations for power, they will be parked on a double layer of visqueen which will be bermed to provide temporary containment. A fuel spill response kit with absorbent material will be staged at the active fueling locations. No bulk quantities of fuel will be stored on site.
- **Wastewater –** Wastewater will be containerized in 55-gallon drums or a Baker tank (or equivalent). A secondary containment will be constructed for

the drums or the Baker tank within areas where a release would impact buildings and structures. All wastewater will have secondary containment until waste profiling is complete. After profiling, all hazardous wastewater will have secondary containment. Therefore, any spills from the drums or the tank will be contained and will not be released to the surrounding areas.

- **EVO –** Any emulsified vegetable oil solution spilled during project activities will be cleaned and containerized in 55-gallon drum(s) or other appropriate containers, and hauled off-site for disposal.

7.7.2 Spill Response

In the event of a release of hazardous material into the environment, field personnel will initiate action, as specified in the HASP, to contain or control the release or evacuate the area if the spill is significant or represents an immediate health threat.

Absorbent pads, shovels, and 55-gallon drums will be kept at the site to address the possibility of spills.

7.7.3 Spill/Release Reporting

The steps below outline the chain of communications to be followed if a significant spill of any hazardous substance occurs.

1. Internal Contact:

   Site personnel involved in the spill should immediately contact the SHSO, who will notify the Project Manager. The Field Manager or the Project Manager will contact the NAVWPNSTA IR Program Coordinator and the ROICC identified below:

NAVWPNSTA IR Program Coordinator:	Pei-Fen Tamashiro (562) 626-7897
ROICC:	David Crawley (562) 626-7964

2. If a release of a waste or hazardous substance, regardless of quantity, could threaten human health or the environment outside the facility, the Project Manager will verify that the following have been notified by the DON:

   - DHS at (800) 852-7550.
   - National Response Center at (800) 424-8802.
   - Local Emergency Response Coordinator (Fire Department, if necessary).
   - Report releases and submit written follow-up emergency notice under Superfund Act and Reauthorization Amendments, Title II requirements.

7.8 PROJECT AND PERSONNEL REQUIREMENTS

Project personnel training requirements and inspection programs applicable to the remedial action at IR Site 70 are described below. Protocols for inspections by regulatory agencies and third parties are also addressed below.

7.8.1 Personnel Training/Certification Requirements

Personnel training and certification requirements include the following:

- Site personnel must have Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety/Emergency Response Hazard Communication and RCRA training.
- Site personnel performing DOT functions (including selecting, packaging, marking, labeling, preparing shipping papers, and loading) must be trained in accordance with the requirements of DOT 49 CFR, Part 172, Subpart H (aka DOT/HM-126F). Subcontractors performing DOT functions must supply proof of training.
- All project personnel (contractor and subcontractors) will be trained according to the project quality assurance compliance policies and procedures. The project Quality Assurance Officer (QAO) (or the on site designate) will verify the project personnel and subcontractors have the proper training prior to beginning project activities.
- All project personnel performing waste management will be certified for in accordance with 40 CFR, Part 265.16 for waste management activities.

7.8.2 Inspection and Audit Procedures

Site inspections and audits may occur during the remedial activities to assure compliance with this RD, applicable state and federal regulations, and the HASP. Internal audits by the contractor QAO will be made to document compliance with sampling procedures, quality assurance sampling, and proper implementation of field procedures. These audits will be documented and provided to the SWDIV QAO or his representative.

8. PROJECT MANAGEMENT

The project management team will be responsible for all technical and administrative aspects of the remedial action. Included among the responsibilities of the team are the project schedule, staffing, data management, quality assurance audits, health and safety audits, document control, project meetings, and reporting.

8.1 Project Schedule

The proposed schedule for implementation of the remedial action is included in this RD as Figure 8.1. The schedule is presented in a GANTT chart format with critical path delineated for the first phase. The schedule is based on a five year initial operation. Upon award of the contract, the schedule will be updated and tracked against plan to monitor project performance. Due to the size of the remedial activities the project has been broken up into discrete phases. A scope of work and specification will be developed for the subsequent phases including a GANNT chart schedule for each phase. These will consist of the following:

- Phase 1: Source Area EISB, which includes the grid of EVO injection wells within the area containing TCE concentrations exceeding 1,000 µg/L within the Upper Fines Unit in the RT&E area, which is defined as the source area. The source area treatment also includes a biobarrier placed immediately down gradient of the source area, within the First Sand. This biobarrier is located at this point to intercept dissolved phase plume emanating from the Source Area. The Phase 1 components are shown in Figure 6.1.
- Phase 2: First Sand Biobarriers FS-1 and FS-2, which are shown in Figure 6.2. Biobarrier FS-1 is located on the west side of Kitts Highway and runs parallel to Kitts Highway for most of its length. Biobarrier FS-2 is located in proximity to 2nd Street.
- Phase 3: Second Sand Biobarrier SS-1, which is located at the leading edge of the plume, at the end of the warehouse area just prior to the wetland area. This biobarrier is shown in Figure 6.4.
- Phase 4: Shell Horizon Biobarrier SH-1 and SH-2, which are shown in Figure 6.3. These biobarriers intercept the plume within the transmissive portion of the Shell Horizon.

The schedule includes preparatory; pre-remediation field construction activities; and remediation operations, performance monitoring, and reporting activities. Construction and remediation activities have been planned to start after approval of the RD, sampling analysis plan, health and safety plan, and procurement of the necessary equipment, materials, and subcontracting services.

Five main activities will be followed during the course of this project:

- **Stage 1 – Project Startup.** This stage includes preparation of project submittals that include the Work Plan, SAP, HASP, Standard Operating Procedures (SOP), and Quality Assurance Project Plan (QAPP).
- **Stage 2 – Preparatory Activities.** This stage includes notifications, dig permit review and submittal, procurement, and mobilization of equipment, materials, fencing staging area, setting up each site layout in accordance with the plan, mobilizing storage tanks, connex box, laydown area for equipment, preparing containment and moving in generator for power at remote locations, and personnel.
- **Stage 3 – Pre-remediation Construction Activities.** This stage includes a preliminary marking of the injection and monitoring well locations (co-ordinate with surveyors to verify correct location), uitility clearance surveys (geophysical survey of all well locations and public works utility document review), air knifing (or hand augering) to 8 to 10 feet for each drilling location, drilling, well installation, well development, installation of dedicated well head equipment, installation of temporary piping, installation of dedicated monitoring well pumps, installation of temporary extraction pumps land survey (post-construction) to verify the well locations, and construction of the EVO and KB-1™ dosing and manifold distribution system.
- **Stage 4 – Remediation Operations, Performance Monitoring, and Reporting Activities.** The first stage of this task will be to conduct a baseline sampling effort of all monitoring wells and every fourth injection well (VOCs and field parameters only) within the monitoring program. Once this data is collected and samples have been accepted at the lab for analysis, the initial EVO injection will be implemented. This will be done in accordance with the specifications in Section 6 and the SOP. Prior to and during the EVO injection a pre-defined set of extraction wells will be pumped to provide the blend water for injection and to maintain a hydraulic balance during the injection phase. Bioaugmentation will be implemented mid-way through electron donor amendment to minimize mobilizations to the site, enhance the *DHC* distribution around the injection well, and reduce labor costs. A slug of anoxic water will be pumped into the injection wells followed by injection of KB-1™, a subsequent slug of anoxic water, and then continuation of the remainder of the EVO injection. The KB-1™ introduces non-indigenous microorganisms to the groundwater (bioaugmentation to complete the dechlorination process). After EVO and KB-1™ injection, the performance groundwater monitoring program will be implemented. The monitored natural attenuation monitoring program will be conducted on an annual basis initially. The EISB sequence will be documented in a report for

each phase (area) of EVO/KB-1™ injection. Annual status reports will be provided over the first 5-year period.

8.2 Project Responsibilities

The DON RPM for this project is Mr. Si T. Le (P.E.). Mr. Le is responsible for project management, budget control, schedule maintenance, and contacting regulatory agencies. Ms. Pei-Fen Tamashiro (P.G.) is the NAVWPNSTA IR Program Coordinator. Ms. Tamashiro will be responsible for community relations activities and ensuring that the field and remedial activities are in compliance with the applicable rules and regulations. Mr. David Crawley is the ROICC and is responsible for the technical oversight of field activities, coordination of field activities with different NAVWPNSTA departments and personnel, base access for equipment, subcontractors, and project personnel, and Quality Control (QC). Mr. Chris Leadon is the DON Remedial Technical Manager, responsible for the technical oversight and review of the project documents. Mr. Narcisco Ancog is the Navy QAO and will provide review and acceptance of the SAP prior to any field work commencing.

Project personnel and responsibilities are outlined in Figure 8.2. The following is a list of key project personnel contacts:

Agency	Contact	Project Title
Southwest Division, Naval Facilities Engineering Command 1220 Pacific Highway San Diego, CA 92132-5190	Mr. Si Le, P.E. (619) 532-2295	DON RPM
NAVWPNSTA Seal Beach 800 Seal Beach Boulevard Building 110 Seal Beach, CA 90740-5000	Ms. Pei-Fen Tamashiro, P.G. (562) 626-7897	NAVWPNSTA IR Program Coordinator
ROICC Los Angeles NAVWPNSTA Seal Beach Building 230 Seal Beach, CA 90740-5000	Mr. David Crawley (562) 626-7964	ROICC
Southwest Division, Naval Facilities Engineering Command 1220 Pacific Highway San Diego, CA 92132-5190	Mr. Chris Leadon (619) 532-3878	Remedial Technical Manager
California Environmental Protection Agency Department of Toxic Substances Control Office of Military Facilities 5796 Corporate Way Cypress, CA 90630	Ms. Katherine Leibel (714) 484-5446	DTSC-RPM
California Regional Water Quality Control Board, Santa Ana Region 3737 Main Street, Suite 500 Riverside, CA 92501-3348	Ms. Patricia Hannon (951) 782-4498	RWQCB-RPM

8.3 Data Management

The following is a summary of the data management tools that will be employed for the duration of this project:

- Microsoft Project software will be used for all schedule tracking.
- Project cost tracking will be done using Microsoft Excel spreadsheets.
- Home and field office staff for technical data management will use Microsoft Excel® spreadsheets and a GIS data base system. Microsoft Word® will be employed for word processing.
- Data management and manipulation will be done using GIS data base management and EVS visualization software.

8.4 Document Control Procedures

GeoSyntec's internal document control procedures will be followed for the duration of the project. Additional guidance provided by the DON will be used for document control, particularly for matters relating to regulatory compliance. Management of internal and external correspondence will be administered at the home office in Huntington Beach, California. Complete project files will be maintained in a secure, dry area at the field office.

Particular attention will be paid to documents related to sampling to obtain data in support of the design and for performance monitoring. In particular, a daily sampling log in a permanent binder will be completed in the field by the sampler(s). One log will be used for soil samples and a different one for groundwater samples. The daily log form will list each sample and QC sample taken that day and will specify the required frequency of duplicate, Matrix Spike and Matrix Spike Duplicate, and other Quality Assurance (QA) samples. All QA and QC samples will be documented on a check list for sample submittals on each day. A copy of the sampling logs from the preceding day will be reviewed daily by a field chemist at the office to coordinate QA samples and sample batches with the laboratory. Audits of this procedure will be completed by the field chemist and/or the project manager (or his designate).

8.5 Meetings and Reports

8.5.1 Field Activity Phase Meetings

Project status meetings will be held weekly (or at less frequent intervals if desired by the DON) at the field office during the field construction activities. The Project Manager, Project Superintendent, SHSO, and other selected individuals will be required to attend these meetings with the ROICC and the NAVWPNSTA IR Program Coordinator. The agenda of the project status meetings will include the following:

- Review and approval of minutes of previous meeting;
- Review of work progress;
- Review of quality/health and safety programs;
- Field observations, problems, and conflicts;
- Problems, which impede construction schedule and proposed corrective actions;
- Review of off-site delivery schedules;
- Corrective measures and procedures to regain projected schedule;
- Revisions to construction schedule;
- Forecast of progress for next succeeding work period;
- Coordination of schedules;
- Review of submittal schedules, if any;
- Pending changes and substitutions;
- Review of proposed changes for effects of construction, completion date, and other aspects of the project; and
- Other project-related business.

Minutes of the meetings will be prepared by the contractor and submitted to the DON. Daily reports will be prepared by the Project Superintendent and the PQCM and submitted to the ROICC during the field construction activities. Weekly reports will be prepared by the Project Manager and submitted to the RPM, NAVWPNSTA IR Program Coordinator, and the ROICC during the field construction activities.

8.5.2 Monthly Project Meetings

The project manager will provide a written status update to the SWDIV RPM prior to each monthly meeting. The meeting notes will succinctly provide the status of each major phase of work, and any new, outstanding, or complete activities. All outstanding and new activities will have a designated party and date for follow-up. The PM (or his designate) will attend the monthly meeting to provide clarification or additional data as needed. The project meetings are attended by the regulatory representatives, the base IR coordinator, the ROICC, the SWDIV technical manager, and the SWDIV RPM as well as other contractors and are an important opportunity to address outstanding issues. These meetings will be scheduled on the GANTT chart.

8.5.3 Quarterly Status Meetings – Project Team

An internal project team teleconference meeting will be scheduled on a quarterly basis. This meeting will provide for a review of the ongoing activities, scheduling issues, staffing needs, and deliverable schedules. These meetings will be documented with meeting notes and will provide action items as needed. These meetings will evaluate system performance issues and provide for interactive communication regarding project issues. Prior to the meeting, a brief agenda will be disseminated to provide some focus to the meeting. These meetings are intended to provide value added input to the project performance and to coordinate activities amongst a far flung project team. Subcontractors may be included on the calls on an as needed basis.

8.5.4 Restoration Advisory Board Meetings

An initial RAB meeting will be scheduled prior to the start of the field work. This meeting will advise the community RAB members of the proposed actions the DON will implement for each phase. The project schedule anticipates one RAB meeting per year during the first 5 year period to maintain communication and to provide updates on the performance monitoring results. Prior to each new phase being implemented, the RAB will be notified and presented with a summary of the activities and schedule. The RAB meeting where the project will be presented will be attended by the PM (or his designate) and other project team members as needed to provide the information. Handouts for the project team presentations will be provided to RAB members. The contractor will note any questions or issues presented by the RAB and make every effort to provide responses to these comments to the DON for their submittal to the RAB.

8.5.5 Yearly Status and Performance Enhancement Report to Navy

The EISB contractor will provide a summary of the performance monitoring results in a technical memo format. This technical memo will document data collection results for the year, summarize field activities, and provide recommendations on ways to enhance the system performance. These evaluations will include an assessment of the monitoring program and its effectiveness in evaluating the system performance. The technical memorandum will document any findings during the year on system performance, failures, or problems. The yearly status report will be prepared as an internal DON document and will be generated in draft and final format.

9. REFERENCES

Battelle Environmental Restoration Department and Foster Wheeler Environmental Corporation. 1998. Final Closeout Report-Decommissioning of Research, Testing, and Evaluation Area Naval Weapons Station, Seal Beach, California.

Bechtel Environmental, Inc. 2005. Draft Fifth Annual Groundwater Monitoring Report IR Sites 40 and 70, Naval Weapons Station, Seal Beach, California, November.

Bechtel Environmental, Inc. 2003. Final IR Site 70 Aquifer Test Report, Naval Weapons Station Seal Beach, Seal Beach, California, February.

Bechtel National, Inc. 1996a. Final Removal Site Evaluation (RSE) Report for the Research, Testing and Evaluation (RT&E) Area, Naval Weapons Station, Seal Beach, California. November.

Bechtel National, Inc. 1996b. Summary of Results for the Relative Risk Site Evaluation Model (RRSEM) Data Collection Effort, Naval Weapons Station, Seal Beach, California. February.

Bechtel National, Inc. 1999. Final Extended Removal Site Evaluation Report, Installation Restoration Site 70, Naval Weapons Station, Seal Beach, Seal Beach, California. October.

Bechtel National, Inc. 2002. Final Groundwater Feasibility Study Report, Installation Restoration Program Sites 40 and 70, Naval Weapons Station, Seal Beach, Seal Beach, California. CTO 0127/0609. June.

Bechtel National, Inc. 2004. Draft Pilot Test Report for *In Situ* Enhanced Bioremediation at IR Site 40, Naval Weapons Station Seal Beach, Seal Beach, California. CTO 0127/0609.

BEI-See Bechtel Environmental Inc.

BNI-See Bechtel National Inc.

California Department of Water Resources. 1961. Planned Utilization of Ground Water Basins of the Coastal Plain of Los Angeles County. Bulletin 104, Appendix B. June.

California State Water Resources Control Board. 1994. Application of State Water Board Resolution No. 68-16 to Cleanup of Contaminated Groundwater. February.

California State Water Resources Control Board. 1997. California Ocean Plan, Functional Equivalent Document. March.

California State Water Resources Control Board. 1997. California Ocean Plan, State Water Resources Control Board Resolution No. 97-026. July.

DWR. See California Department of Water Resources

Ebersold, D., Hacker, M., Herndon, R., and Cardenas, F. 1997. Evaluation of direct injection of reclaimed water in a potable aquifer in the Alamitos Gap Seawater Intrusion Barrier. In: *Conjunctive Use of Water Resources: Aquifer Storage and Recovery*. American Water Resources Association. October.

ESTCP. 2005. Bioaugmentation for Remediation of Chlorinated Solvents: Technology Development, Status and Research Needs.

GeoSyntec Consultants. 2005a. Final Revised Groundwater Feasibility Study Report, Installation Restoration Program Site 70, Naval Weapons Station, Seal Beach, Seal Beach, California. CTO 47408-04-C-7526. August.

GeoSyntec Consultants. 2006. Record of Decision (ROD) Installation Restoration Program Site 70, Naval Weapons Station Seal Beach, Seal Beach, California. August.

Jacobs Engineering Group. 1994. Draft Preliminary Assessment (PA) Report for the Research, Testing and Evaluation Area, Naval Weapons Station, Seal Beach, California. 22 July.

Jacobs Engineering Group. 1995a. Final Preliminary Assessment Report for the Research, Testing and Evaluation Area, Naval Weapons Station, Seal Beach, Seal Beach, California. 09 February.

Jacobs Engineering Group. 1995b. Final Operable Unit 4 Site Inspection (SI) Report, Naval Weapons Station, Seal Beach, California. October.

JEG-See Jacobs Engineering Group

Ogden Environmental and Energy Services. 1995. Draft Phase I Overview Survey and Phase II Archaeological, Historical, and Architectural Evaluation of Cultural Resources on the Naval Weapons Station, Seal Beach. Clevenger et. al. February.

Regional Water Quality Control Board. 1995. Water Quality Control Plan, Santa Ana River Basin (8); with amendment R8-2004-0001, January 2004.

SCS-See Soil Conservation Service

Soil Conservation Service. 1978. *Soil Survey of Orange County and Western Part of Riverside County.* U.S. Department of Agriculture.

SWRCB-See California State Water Resources Control Board.

United States Environmental Protection Agency, 1986. RCRA Ground-water Monitoring Technical Enforcement Guidance Document (TEGD). OSWER-9950.1, September.

United States Environmental Protection Agency, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. OSWER Directive 9355.3-01, 02. October

United States Environmental Protection Agency, 1998. Preliminary Remediation Goals, Region IX. Noncancer Endpoints. August

United States Environmental Protection Agency, 1999. National Recommended Water Quality Criteria-Correction. Office of Water, EPA 822-Z-99-001. April.

U.S. EPA-See United States Environmental Protection Agency

Table 3.1
Potential Federal Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous Waste Control Act					
Within 61 meters (200 feet) of a fault displaced in Holocene time.	New treatment, storage, or disposal of hazardous waste prohibited.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	22 CCR 66264.18(a)	Not an ARAR	The nearest active fault with Holocene movement is the Newport-Inglewood Fault, approximately 8 miles southwest of NAVWPNSTA Seal Beach.
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	22 CCR 66264.18(b)	Not an ARAR	Potential groundwater treatment plant site locations and extraction wells are not within the 100-year floodplain (as defined by FEMA).
Within salt dome formation, underground mine, or cave.	Placement of noncontainerized or bulk liquid hazardous waste prohibited.	RCRA hazardous waste, placement.	22 CCR 66264.18 (c)	Not an ARAR	Based on geologic information presented in ERSE, salt domes, mines, or caves do not exist at or in the vicinity of NAVWPNSTA Seal Beach.
Executive Order 11988, Protection of Floodplains					
Within floodplain.	Actions taken should avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values.	Action that will occur in a floodplain (i.e., lowlands) and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Not an ARAR	Although not surveyed, areas directly adjacent to NAVWPNSTA Seal Beach IR Site 70 within the Seal Beach city boundary are mapped as “Zone X” - areas lying outside of the 500-year floodplain. None of the proposed extraction wells or on-site treatment facilities is within the FEMA-delineated floodplain.
National Archeological and Historical Preservation Act					
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts.	Construction on previously undisturbed land would require an archeological survey of the area.	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archeological data.	Substantive requirements of 36 CFR 65, 40 CFR 6.301(3), 16 USC Section 469	ARAR	An archeological survey for NAVWPNSTA Seal Beach indicates the presence of 186 out of the 250 structures surveyed as eligible for contributing to a historic district. Buildings at IR Site 70 are listed.
National Historic Preservation Act, Section 106					
Historic property owned or controlled by federal agency.	Action to preserve historic properties; planning of action to minimize harm to properties listed on or eligible for listing on the National Register of Historic Places.	Property included in or eligible for the National Register of Historic Places.	Substantive requirements of 36 CFR 800, 40 CFR 6.301(b), 16 USC, Section 470	ARAR	An archaeological survey of NAVWPNSTA Seal Beach indicates the presence of 186 out of 250 structures that are eligible as elements contributing to a historic district. Buildings at IR Site 70 are included.

Table 3.1 (continued)
Potential Federal Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Endangered Species Act of 1973					
Critical habitat upon which endangered species or threatened species depend.	Action to conserve endangered species or threatened species, including consultation with the Department of the interior.	Determination of effect upon endangered or threatened species or its habitat.	16 USC 1536(a), 50 CFR 402	ARAR	IR Site 70 remedial activities may affect the Seal Beach NWR, which supports special status species or habitat.
Executive Order 11990, Protection of Wetlands					
Wetland.	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by EO 11990 Section 7.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	TBC	Jurisdictional wetlands at NAVWPNSTA Seal Beach, identified by U.S. Army Corps of Engineers, are in close proximity to the sites. IR Site 70 remedial actions will include measures to prevent or mitigate any expected impacts on wetlands.
Clean Water Act, Section 404					
Wetland.	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by EO 11990 Section 7.	40 CFR 230.10; 40 CFR 231 (231.1, 231.2,231.7, 231.8)	Not an ARAR	Discharge of dredged or fill material to a wetland is not planned as part of the response action.
Wilderness Act					
Wilderness area.	Area must be administered in such a manner as will leave it unimpaired as wilderness and preserve its wilderness character.	Federally owned area designated as wilderness area.	50 CFR 35.1 et seq. 16 USC, Section 1131	Not an ARAR	NAVWPNSTA Seal Beach is not in a federally owned wilderness area.
National Wildlife Refuge System					
Wildlife	Only actions allowed under the provisions of 16 USC Section 668 dd(c) may be undertaken in areas that are part of the NWR System.	Area designated as part of NWR System.	50 CFR 27; 16 USC, Section 668dd	ARAR	NAVWPNSTA Seal Beach includes the Seal Beach NWR and Bolsa Chica Ecological Reserve. NAVWPNSTA Seal Beach is part of the NWR System.
Fish and Wildlife Coordination Act, Section 662					
Area affecting stream or other water body.	Action taken should protect fish or wildlife.	Diversion, channeling, or other activity that modifies a stream or other water body and affects fish or wildlife.	16 USC 662	Not an ARAR	Response actions are not anticipated to modify a stream or other water body.

Table 3.1 (continued)
Potential Federal Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Wild and Scenic Rivers Act					
Within area affecting national wild, scenic, or recreational river.	Avoid taking or assisting in action that will have direct adverse effect on scenic river.	Activities that affect or may affect any of the rivers specified in Section 1276.	16 USC 1271 et seq. and Section 7(a), 40 CFR 6.302(e)	Not an ARAR	No wild, scenic, or recreational rivers are at or in the vicinity of NAVWPNSTA Seal Beach.
Coastal Zone Management Act					
Within coastal zone.	Conduct activities in a manner consistent with approved state management programs.	Activities affecting the coastal zone, including lands hereunder and adjacent shore land.	Section 307(c) of 16 USC 1456(c); also see 15 CFR 930 and 923.45	TBC	NAVWPNSTA Seal Beach is within the Coastal Barrier Resource System.
National Recommended Water Quality Criteria - Correction 1999					
Habitat including freshwater and saltwater environments.	Establishes water quality standards for freshwater, saltwater, and human-health criteria.	Discharge potentially affecting water quality.	40 CFR 131 Section 304(a)(1) of the Clean Water Act	TBC	Establishes water quality standards for freshwater and saltwater that are based on current toxicity information. Where discharges occur to freshwater and saltwater, these criteria provide guidance.
Historic Sites, Buildings, and Antiquities Act					
Historic sites.	Avoid undesirable impacts on landmarks.	Areas designated as historic sites.	16 USC 461-467, 40 CFR 6.301(a)	Not an ARAR	See comments under National Historic Preservation Act.
Rivers and Harbors Act of 1890					
Navigable waters.	Requires permits for structures or work in or affecting navigable waters.	Activities affecting navigable waters.	33 USC 403	Not an ARAR	NAVWPNSTA Seal Beach is in the vicinity of navigable waters. However, remedial actions should have no adverse effect on navigable waters.
Migratory Bird Treaty Act of 1972					
Migratory bird area.	Protects almost all species of native birds in the U.S. from unregulated "take" that can include poisoning at hazardous waste sites.	Presence of migratory birds.	16 USC Section 703	TBC	IR Site 70 remedial action addresses contaminated groundwater. Migratory birds are not likely to be exposed to VOC-affected groundwater or affected by remedial activities.
Marine Mammal Protection Act					
Marine mammal area.	Protects any marine mammal in the U.S., except as provided by international treaties from unregulated "take."	Presence of marine mammals.	16 USC 13722)	TBC	The project site is in a coastal zone or area that might be habitat for marine mammals.

Table 3.1 (continued)
Potential Federal Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Magnuson Fishery Conservation and Management Act					
Fishery under management.	Provides for conservation and management of specified fisheries within specified fishery conservation zones.	Presence of managed fisheries.	16 USC 1801 et seq.	Not an ARAR	The project site is not near areas of managed fisheries.

Notes:

Statutes and policies and their citations are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate the DON accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading: only substantive requirements of the specific citations are considered potential ARARs.

Acronyms/Abbreviations:

ARAR – applicable or relevant and appropriate requirement
CCR –*California Code of Regulations*
CFR – *Code of Federal Regulations*
DON – U.S. Department of the Navy
EO – Executive Order
ERSE – Extended Removal Site Evaluation
FEMA – Federal Emergency Management Agency
IR – Installation Restoration
NAVWPNSTA Seal Beach – Naval Weapons Station Seal Beach
NWR – National Wildlife Refuge
RCRA – Resource Conservation and Recovery Act
TBC – to be considered
USC – *United States Code*

Table 3.2
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous California Endangered Species Act					
Habitat	No person shall import, export, take, possess, or less any endangered or threatened species or part or product thereof.		Fish and Game Code Sections 2050-2098	TBC	IR Site 70 remedial actions might affect areas that support California-listed endangered species or habitat. The NAVWPNSTA Seal Beach NWR supports endangered species.
California Coastal Act of 1976					
Coastal Zone	Regulates activities associated with development to control direct significant impacts on coastal waters and to protect state and national interests in California coastal resources.		Public Resources Code Sections 30000-30900; 14 CCR 13001-13666.4	TBC	The project site is not in an area governed by this statute.
State Water Resources Control Board and California Regional Water Quality Control Board, Santa Ana Region					
Describes water basins in Santa Ana Region. Establishes beneficial uses of groundwater and surface water. Establishes water quality objectives, including narrative and numerical standards. Establishes implementation plans to meet water quality objectives and protect beneficial uses, and incorporates statewide water quality control plans and policies.	Public Water System.		Water Quality Control Plan for the Santa Ana Basin (Basin Plan).	ARAR	Substantive provisions in Chapters 2 through 4 of the Basin plan are ARARs. The beneficial uses for the Santa Ana Pressure Subbasin are municipal/domestic use (potential drinking water), agricultural supply, industrial service supply, and industrial process supply. These uses also apply to the shallow groundwater system at NAVWPNSTA Seal Beach.
California Ocean Plan of 1997					
Ocean and Coastal Waters.	Provides for the protection of the quality of the ocean waters for use and enjoyment by the people of the State, requiring the control of discharge of waste into the ocean waters.	Discharge potentially affecting water quality.	California Ocean Plan, SWRCB Resolution No. 97-026	ARAR	The remedial actions to be conducted at IR Site 70 may result in discharge of treated groundwater to surface waters terminating in the ocean.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Aquatic Habitat/ Species	Action must be taken if toxic materials are placed where they can enter waters of the State. There can be no release that would have a deleterious effect on species or habitat.		Fish and Game Code 5650(a), (b), and (f)	TBC	These code sections prohibit the deposition into state waters of, *inter alia*, petroleum products (Section 5650(a)), factory refuse (Section 5650(b)), and any substance deleterious to fish, plants or birds (Section 5650(f)). These are substantive, promulgated environmental protection requirements. These requirements impose strict criminal liability on violators. (*People v. Chevron Chemical Company (1983) 143 Cal. App. 3d 50)*. This imposition of strict criminal liability imposes a standard that is more stringent than federal law. The extent to which each subdivision of Section 5650 is relevant and appropriate depends on the site characterization. Section 5650 makes it unlawful "to deposit in, permit to pass into, or place where it can pass into the waters of this state," enumerated substances as petroleum products, sawdust, wood shavings, factory refuse, or any other substances or materials that are deleterious to fish, plant life, or bird life.
Wildlife Species	Action must be taken to prohibit the taking of birds and mammals, including the taking by poison		Fish and Game Code Section 3005 (Stats. 1957, c. 456, p. 1353, Section 3005)	ARAR	This code section prohibits the taking of birds and mammals, including taking by poison. "Take" is defined by Fish and Game Code Section 86 to include killing. "Poison" is not defined in the code. Although there is no state authority on this point, federal law recognizes that poison, such as Strychnine, may effect incidental taking. (*Defenders of Wildlife v. Administrator, Environmental Protection Agency (1989) 882. F. 2d. 1295)*. This code section imposes a substantive, promulgated environmental protection requirement. Because the remediation of this site involves treatment of contaminants, this section appears to be applicable and relevant.
Rare Native Plants	Action must be taken to conserve native plants, there can be no releases and/or actions that would have a deleterious effect on species or habitat		Fish and Game Code Section 1908 (Added by Stats. 1977, c. 1181, p. 3869, Section 8)	TBC	Section 1908 imposes a substantive requirement by forbidding any "person" to take rare or endangered native plants. California Code of Regulations Title 14, Section 670.2 provides a listing of the plants of California that have been declared to be Endangered, Threatened or Rare. Fish and Game Code Section 67 provides the definition of "person" as any natural person or partnership, corporation, limited liability company, trust, or other type of association. Whether the federal government or contractors acting on behalf of the federal government would fall within the definition is a potential issue. To the extent that there are rare or endangered plants on site, Section 1908 would be an ARAR

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Endangered Species	Action must be taken to conserve endangered species, there can be no releases and/or actions that would have a deleterious effect on species or habitat.		Fish and Game Code Section 2080 (Added by Stats. 1984, c. 1240, Section 2).	ARAR	This section prohibits the take, possession, purchase or sell within the state, any species (including rare native plant species), or any product thereof, that the commission determines to be an endangered or threatened species, or the attempt of any of these acts. This section is applicable and relevant to the extent that there are endangered or threatened species in the area which have the potential of being affected if actions are not taken to conserve the species. This section prohibits releases and/or actions that would have a deleterious effect on species or their habitat. This section and applicable Title 14 regulations should be considered applicable, relevant, and appropriate due to the presence of the California least tern, the peregrine falcon, the California brown pelican, and the double-crested cormorant. California Code of Regulations Title 14 Section 670.2 provides a listing of the plants of California declared to be Endangered, Threatened or Rare. California Code of Regulations Title 145 Section 670.5 provides a listing of Animals of California declared to be endangered or threatened. California Code of Regulations Title 14 Section 783 et. seq., provides the implementation regulations for the California Endangered Species Act.
Wildlife / Domestic Species	Action must be taken to prohibit the use of steel-jawed leghold traps		Fish and Game Code Section 3003.1 (Prop. 4, Section 1 approved Nov. 3, 1998, eff. Nov. 4, 1998)	TBC	This section prohibits the use of any body gripping trap and provides that it is unlawful for any person, including an employee of the federal government, to use or authorize the use of such device to capture any game mammal, fur-bearing mammal, non-game mammal, protected mammal, or any dog or cat. This prohibition will not apply in the extraordinary case where the use of such a device is the only method available to protect human health and safety.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Fully Protected Bird Species / Habitat	Action must be taken to prevent the taking of fully protected birds		Fish and Game Code Section 3511 (Added by Stats. 1970, c. 1036, p. 1848 Section 4)	ARAR	This section provides that it is unlawful to take or possess any of the following fully protected birds: a. American peregrine falcon b. Brown pelican c. California black rail d. California clapper rail e. California condor f. California least tern g. Golden eagle h. Greater sandhill crane i. Light footed clapper rail j. Southern bald eagle k. Trumpeter swan l. White-tailed kite m. Yuma clapper rail Although some of the fully protected birds are not typically found in Site 70, this statute will be considered Applicable and Relevant if any of the above mentioned fully protected birds or their habitat are found on or near the site.
Wetlands	Actions must be taken to assure that there is “no net loss” of wetlands acreage or habitat value. Action must be taken to preserve, protect, restore, and enhance California’s wetland acreage and habitat values.		Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	TBC	This policy seeks to provide for the protection, preservation, restoration, enhancement, and expansion of wetland habitat in California. Further, it opposes any development or conversion of wetland that would result in a reduction of wetland acreage or habitat value. It adopts the USFWS definition of a wetland which utilizes hydric soils, saturation or inundation, and vegetable criteria, and requires the presence of at least one of these criteria (rather than all three) in order to classify an area as a wetland. This policy is not a regulatory program and should be included as a TBC.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Fully Protected Mammals	Action must be taken to ensure that no fully protected mammals are taken or possessed at any time		Fish and Game Code section 4700 (Added by Stats. 1970, c. 1036, p. 1848 Section 6)	TBC	This section prohibits the take or possession of any of the fully protected mammals or their parts. The following are fully protected mammals: a. Morro Bay kangaroo rat b. Bighorn sheep except Nelson bighorn sheep c. Northern elephant seal d. Guadalupe fur seal e. Ring-tailed cat f. Pacific right whale g. Salt-marsh harvest mouse h. Southern sea otter i. Wolverine Although some fully protected mammals are not typically found in Site 70, this statute will be considered Applicable and Relevant if any of the above mentioned fully protected mammals or their habitat are found on or near the site.
Fully Protected Reptiles and Amphibians	Actions must be taken to prevent the take or possession of any fully protected reptile or amphibian		Fish and Game Code Section 5050 (Added by Stats. 1970, c. 1036, p. 1849 Section 7)	TBC	This section prohibits the take or possession of fully protected reptiles and amphibians or parts thereof. The following are fully protected reptiles and amphibians: a. Blunt-nosed leopard lizard b. San Francisco garter snake c. Santa Cruz long-toed salamander d. Limestone salamander e. Black toad Although some fully protected reptiles and amphibians are not typically found in Site 70, this statute will be considered Applicable and Relevant if any of the above mentioned fully protected reptiles or amphibians or their habitat are found on or near the site.
Birds	Action must be taken to avoid the take or destruction of the nest or eggs of any bird		Fish and Game Code Section 3503	ARAR	This section prohibits the take, possession, or needless destruction of the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Birds of Prey	Action must be taken to prevent the take, possession, or destruction of any birds-of-prey or their eggs		Fish and Game Code Section 3503.5 (Added by Stats. 1985, c. 1334, Section 6)	TBC	This section prohibits the take, possession, or destruction of any birds in the orders of Falconifromes or Strigifromes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto. This section will be applicable and relevant if such species or their eggs are located on or near the site.
Non-Game Birds	Actions must be taken to prevent the take of non-game birds		Fish and Game Code Section 3800 (Added by Stats. 1971, c. 1470, p. 2906, Section 13)	TBC	This section prohibits the take of non-game birds, except in accordance with regulations of the commission, or when related to mining operations with a mitigation plan approved by the department. This section further provides requirements concerning mitigation plans related to mining. This section is applicable and relevant if non-game birds or their eggs are located on or near the site and such species have not been included in the Fish and Wildlife Conservation Plan filed pursuant to the Federal Fish and Wildlife Conservation Act. Species included in the plan will be protected at the federal standard making this section an ARAR to the extent that it is more stringent than the federal standard of protection.
Fur-Bearing Mammals	Provides manners under which fur-bearing mammals may be taken		Fish and Game Code Section 4000 et. Seq. (Stats. 1957, c. 456, p. 1380, Section 4000)	TBC	This section provides that a fur-bearing mammal may be taken only with a trap, a firearm, bow and arrow, poison under a proper permit, or with the use of dogs
Non-Game Mammals	Action must be taken to avoid the take or possession of non-game animals		Fish and Game Code Section 4150 (Added by Stats. 1971, c. 1470, p. 2907, Section 21)	TBC	Non-game mammals are those occurring naturally in California which are not game mammals, fully protected mammals, or fur-bearing mammals. These mammals, or their parts, may not be taken or possessed except as provided in this code or in accordance with regulations adopted by the commission.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Non-Game Animals	Action must be taken to avoid the take of non-game mammals except as provided in applicable regulations		Title 14 California Code of Regulations (CCR) Section 472, Effective 07/01/74	TBC	This Regulation provides that non-game birds and mammals may not be taken. a. The following non-game birds and mammals may be taken except as provided in Chapter 6: English sparrow, starling, coyote, weasels, skunks, opossum, moles and rodents (excludes tree and flying squirrels, and those listed as furbearers, endangered, or threatened species); b. Fallow, sambar, sika, and axis deer may be taken concurrently with the general deer season; c. Aoudad, mouflon, tahr, and feral goats may be taken all year; and d. American crows may be taken only under provisions of Section 485 and by landowners or tenants, or person authorized by landowners or tenants, when American crows are committing or about to commit depredations upon ornamental shade trees, agricultural crops, livestock, or wildlife, or when concentrated in such numbers and manner as to constitute a health hazard or other nuisance. If required by Federal regulations, landowners or tenants shall obtain a Federal migratory bird depredation permit before taking any American crows or authorizing any other person to take them. Although some of the non-game birds and mammals are not typically found in Site 70, this statute will be Applicable and Relevant if any of the above mentioned non-game birds and mammals or their habitat are found on or near the site.
Tidal Invertebrates	Action must be taken to avoid the take or possession of mollusks, crustaceans, or other invertebrates		Fish and Game Code Section 8500 (Added by Stats. 1972, c. 1248, p. 2436, Section 2, eff. Dec. 13, 1972)	ARAR	It is unlawful to possess or take, unless otherwise expressly permitted in this chapter, mollusks, crustaceans, or other invertebrates, unless a valid tidal invertebrate permit has been issued. The taking, possessing, or landing of such invertebrates pursuant to this section shall be subject to regulations adopted by the commission.
Protected Amphibians	Action must be taken to avoid the take or possession of protected amphibians		Title 14 CCR Sections 40 (Section 40 designated effective 03/01/74)	ARAR	This regulation makes it unlawful to capture, collect, intentionally kill or injure, possess, purchase, propagate, sell, transport, import, or export any native reptile or amphibian, or parts thereof unless under special permit from the department issued pursuant to Title 14 CCR, Sections 650, 670.7, or 783 of these regulations, or as otherwise provided in the Fish and Game Code or these regulations.

Table 3.2 (continued)
Potential State Location-Specific ARARs
IR Site 70, Naval Weapons Station Seal Beach, California

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Furbearing Mammals	Action must be taken to avoid take		Title 14 CCR, Section 460 (effective 07/01/59)	ARAR	Regulation makes it unlawful to take fisher, marten, river otter, desert kit fox, and red fox. Although some of the mammals are not typically found in Site 70, to the extent that the red fox, which is highly possible to occur in the area, or its habitat is found on or near Seal Beach NWS, this section will be an ARAR.
Furbearing Mammals	Provides methods of take for other forbearing mammals not listed in Title 14 CCR, Section 460		Title 14 CCR, Section 465 (effective 07/01/69)	TBC	Furbearing mammals not listed specifically in Title 14 CCR Section 460 and listed in 14 CCR, Section 461, 462, 463, and Section 464 may be taken only with a firearm, bow and arrow, or with the use of dogs, or traps in accordance with the provisions of Section 465.5 of Title 14 and Section 3003.1 of the Fish and Game Code. Although these mammals may not be currently present in Site 70, if one is found on or near Site 70 at some future date, this section will become applicable and relevant.

Notes:

Statutes and policies and their citations are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate the DON accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading: only substantive requirements of the specific citations are considered potential ARARs.

Acronyms/Abbreviations:

ARAR – applicable or relevant and appropriate requirement
CCR – *California Code of Regulations*
DON – U.S. Department of the Navy
IR – Installation Restoration
NAVWPNSTA Seal Beach – Naval Weapons Station Seal Beach
NWR – National Wildlife Refuge
SWRCB – State Water Resources Control Board
TBC – to be considered

Table 3.3
Remedial Action Objectives[1]
IR Site 70
Naval Weapons Station Seal Beach, California

Constituent of Concern	Exposure Route	Receptor(s)	Remediation Goal* (μg/L)
1,1-dichloroethene	Ingestion	Future residential groundwater users	6
Cis-1,2-dichloroethene	Ingestion	Future residential groundwater users	6
Trans-1,2-dichloroethene	Ingestion	Future residential groundwater users	10
Trichloroethene	Ingestion	Future residential groundwater users	5
Vinyl chloride	Ingestion	Future residential groundwater users	0.5
Chloroform	Ingestion	Future residential groundwater users	100

Note:
[1] The EISB performance and MNA monitoring results will be periodically reviewed, including a trend analysis of the remediation performance to evaluate progress towards meeting the remedial action objectives (RAOs). The site numerical model will be periodically updated and recalibrated to evaluate whether RAOs can be met and the time required to achieve the RAOs. Reevaluation of the RAOs may be required at a future date, depending on the trends in remedial performance.
* based on ARARs-based maximum contaminant level

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
EISB – enhanced *in situ* bioremediation
IR – Installation Restoration (Program)
MNA – monitored natural attenuation
RAO – Remedial Action Objective
μg/L-micrograms per liter

Table 4.1
Source Treatment Design Basis
IR Site 70, Naval Weapons Station Seal Beach, California

Treatment Area	Aquifer Unit Targeted	Well Spacing (ft)	Total Porosity [a]	Effective Porosity [b]	Well Screen Length [c] (ft)	Proposed Screen Interval (depth bgs)	Target ROI [d] (ft)	Target Oil Dose[e] (%)
Source Grid Treatment	Upper Fines Unit	20	0.40	0.33	30	25-55	10	0.5%
Source Biobarrier	First Sand Unit	24	0.34	0.28	45	60-105	12	0.5%

Notes

[a] Estimated from soil collected during RDO activities (GeoSyntec 2006).
[b] Effective porosity is assumed to be 83 percent of total porosity, based on grain size evaluation (Technical Memorandum No. 5, Table I 2, BNI, 1999b).
[c] Based on estimated thickness of these units in this region of the aquifer.
[d] Estimated from pilot EVO injections conducted during RDO activities (GeoSyntec 2006).
[e] Based on theoretical stoichiometric demand. Reported as % oil. (*i.e* ., EVO dose is ~twice the oil dose).

Acronyms/Abbreviations

ft - feet
bgs - below ground surface
ROI - radius of influence
RDO - remedial design optimization
EVO - emulsified vegetable oil

Table 4.2
Summary of Biobarrier and Source Area Design Details
IR Site 70, Naval Weapons Station Seal Beach, California

a) Selected Remedial Design

Treatment Zone	Area	Aquifer Unit Targeted	Biobarrier Length (ft)	Total No. of Injection Wells	Estimated Duration of Biobarrier Operation (years)[b]	Well Screen Length (ft)	Proposed Screen Interval (depth bgs)	Target ROI (ft)	Target Oil Dose (%)	Target EVO Volume per Well (gal)[a]	Target Water Volume per Well (gal)	Target Amendment Volume per Well (gal)[a]	Target KB-1™ Dose per Well (L)	Total EVO Volume (gal)	Total Water Volume (gal)	Total KB-1™ Volume (L)	Anticipated Reinjection Frequency (years)
Source	Source Grid Treatment	Upper Fines Unit	--	57	U	30	25-55	10	0.5%	234	23,032	23,266	3	13,338	1,326,162	171	U[c]
	Source Biobarrier	First Sand Unit	325	14	U	45	60-105	12	0.5%	476	46,851	47,327	3	6,664	662,578	42	6
Plume Base Case Scenario	Biobarrier FS-1	First Sand Unit	820	35	14	45	60-105	12	0.5%	476	46,851	47,327	3	16,660	1,656,445	105	6
	Biobarrier FS-2	First Sand Unit	685	29	16	35	65-100	12	0.5%	370	36,440	36,810	3	10,730	1,067,490	87	5
	Biobarrier SH-1	Shell Horizon	725	37	8	25	105-130	10	0.5%	194	19,110	19,304	3	7,178	714,248	111	10
	Biobarrier SH-2	Shell Horizon	630	32	13	25	105-130	10	0.5%	194	19,110	19,304	3	6,208	617,728	96	10
	Biobarrier SS-1	Second Sand Unit	525	22	11	40	125-165	12	0.5%	423	41,645	42,068	3	9,306	925,496	66	15

b) Other Design Alternatives Evaluated

Treatment Zone	Area	Aquifer Unit Targeted	Biobarrier Length (ft)	Total No. of Injection Wells	Estimated Duration of Biobarrier Operation (years)[b]	Well Screen Length (ft)	Proposed Screen Interval (Depth BGS)	Target ROI (ft)	Target Oil Dose (%)	Target EVO Volume per Well (gal)[a]	Target Water Volume per Well (gal)	Target Amendment Volume per Well (gal)[a]	Target KB-1™ Dose per Well (L)	Total EVO Volume (gal)	Total Water Volume (gal)	Total KB-1™ Volume (L)	Anticipated Reinjection Frequency (years)
Plume Design Alternative 1	Biobarrier FS-1	First Sand Unit	625	27	8	45	60-105	12	0.5%	476	46,851	47,327	3	12,852	1,277,829	81	6
	Biobarrier FS-2	First Sand Unit	675	29	8	45	60-105	12	0.5%	476	46,851	47,327	3	13,804	1,372,483	87	6
	Biobarrier FS-3	First Sand Unit	685	29	8	35	65-100	12	0.5%	370	36,440	36,810	3	10,730	1,067,490	87	5
	Biobarrier SH-1	Shell Horizon	725	37	8	25	105-130	10	0.5%	194	19,110	19,304	3	7,178	714,248	111	10
	Biobarrier SH-2	Shell Horizon	690	35	8	25	105-130	10	0.5%	194	19,110	19,304	3	6,790	675,640	105	10
	Biobarrier SH-3	Shell Horizon	630	32	10	25	105-130	10	0.5%	194	19,110	19,304	3	6,208	617,728	96	10
	Biobarrier SS-1	Second Sand Unit	525	22	11	40	125-165	12	0.5%	423	41,645	42,068	3	9,306	925,496	66	15
Plume Design Alternative 2	Biobarrier FS-1	First Sand Unit	625	27	8	45	60-105	12	0.5%	476	46,851	47,327	3	12,852	1,277,829	81	6
	Biobarrier FS-2	First Sand Unit	675	29	8	45	60-105	12	0.5%	476	46,851	47,327	3	13,804	1,372,483	87	6
	Biobarrier FS-3	First Sand Unit	685	29	8	35	65-100	12	0.5%	370	36,440	36,810	3	10,730	1,067,490	87	5
	Biobarrier SH-1	Shell Horizon	725	37	8	25	105-130	10	0.5%	194	19,110	19,304	3	7,178	714,248	111	10
	Biobarrier SH-2	Shell Horizon	630	32	8	25	105-130	10	0.5%	194	19,110	19,304	3	6,208	617,728	96	10
	Biobarrier SS-1	Second Sand Unit	525	22	11	40	125-165	12	0.5%	423	41,645	42,068	3	9,306	925,496	66	15

Notes

[a] Amendment volumes were calculated assuming a cylindrical distribution of fluid around each injection point, and accounting for the effective porosity of the soil, the targeted saturation of the oil, and the oil distribution efficiency around each injection point as quantified during RDO activities (GeoSyntec 2006).

[b] Treatment duration was estimated as the time required to achieve a maximum trichloroethene concentration of 200 µg/L upgradient of each biobarrier as determined from numerical modeling (see Appendix A).

[c] Longevity is dependent upon rate of TCE degradation and TCE DNAPL mass in the subsurface, which is currently unknown.

Acronyms/Abbreviations

ft - feet
% - percent
gal - gallons
L - liters
U- Unknown
bgs - below ground surface
RDO - remedial design optimization
TCE - trichloroethene
µg/L - micrograms per liter

Table 4.3
Summary of Analytes
IR Site 70, Naval Weapons Station Seal Beach, California

ANALYTE	INFORMATION OBTAINED FROM ANALYTE	MONITORING PROGRAM
Volatile Organic Compounds	• Quantify degradation of target chlorinated compounds	PMW, MNA
Dissolved Hydrocarbon Gases (ethene, ethane, methane)	• Ethene and ethane are complete degradation products; secondary indicator of degradation of target compounds • Methane indicator of reducing conditions; also a health and safety issue	PMW, MNA
Iron/Manganese/Arsenic	• Secondary groundwater quality parameters; may be mobilized due to inducement of reducing conditions in groundwater	PMW
Inorganic Anions	• Declining nitrate and sulfate concentrations indicative of reducing conditions • Increasing chloride concentrations is an indicator of reduction of chlorinated VOCs	PMW
Sulfide	• Indicator of sulfate reduction. Also a health and safety issue if forms hydrogen sulfide	PMW
Total Organic Carbon	• Qualitative indicator of presence of electron donor	PMW
Volatile Fatty Acids (acetic, butyric, lactic, propionic)	• VFAs are breakdown products of the electron donor; qualitative indicator of presence of electron donor	PMW
Dehalococcoides (DHC)	• Measures levels of *Dehalococcoides* group of bacteria responsible for degradation of cDCE to VC and ethene • Indicator of bioaugmented culture growth and persistence	PMW, MNA
Depth to Water	• Monitor fluctuations of the water table to track groundwater flow direction	PMW, MNA
Field Parameters (pH, DO, ORP, spc, turbidity, temperature)	• DO and ORP are measures of anaerobic conditions; other parameters are monitored to ensure there is no negative effect on secondary groundwater chemistry	PMW, MNA

Table 4.3
Summary of Analytes
Site 70, Naval Weapons Station Seal Beach, California

Acronyms/Abbreviations
cDCE – cis-1,2-dichloroethene
MNA – monitored natural attenuation
DO – dissolved oxygen
ORP – oxidation reduction potential
PMW – performance monitoring well
spc – specific conductance
VC – vinyl chloride
VFAs – volatile fatty acids
VOCs – volatile organic compounds

TABLE 4.4

SUMMARY OF MONITORING PROGRAM – SOURCE AREA
IR SITE 70, NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

Zone	Targeted Unit	Treatment Area	Monitoring Locations [c]	Screened Intervals [a]	Function of Well in Monitoring Program			Rationale for Well Selection
					PMW [b]	MNA	POC	
Source	Upper Fines	Grid Treatment	PMW-1A	25 to 35 ft bgs	✓			Located in area of elevated [TCE] (4 mg/L), possible DNAPL
			PMW-1B	45 to 55 ft bgs	✓			
			MW-70-27	25 to 35 ft bgs	✓			Located in very high concentration zone, likely DNAPL present
			MW-70-28	50 to 60 ft bgs	✓			
			MNA-1	40 to 50 ft bgs		✓		Monitor MNA of higher [TCE] to assess need for contingency, sentinel well for migration of plume
			MNA-2	35 to 45 ft bgs		✓		Sentinel wells for monitoring plume migration
			MNA-3	35 to 45 ft bgs		✓		
		Point of Compliance	MW-70-02	20 to 30 ft bgs			✓	Upgradient Point of Compliance
			MW-70-10	30 to 40 ft bgs			✓	Crossgradient Point of Compliance
			MW-70-17	30 to 40 ft bgs			✓	
			MW-70-22	20 to 30 ft bgs			✓	Downgradient Point of Compliance
	First Sand	Source Containment Biobarrier	PMW-2A	70 to 80 ft bgs	✓			Upgradient wells for monitoring concentration influx into biobarrier
			PMW-2B	90 to 100 ft bgs	✓			
			PMW-3A	70 to 80 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier
			PMW-3B	90 to 100 ft bgs	✓			
			IW-SC-6	60 to 105 ft bgs	✓			Within biobarrier, provides EISB performance data

Notes

[a] Screen intervals are approximate and may be adjusted in the field according to the local soil lithology. Monitoring well screen intervals should be consistent with injection well screens, and may be modified as necessary in the field.

[b] PMW wells will be used to evaluate the ongoing effectiveness of the EISB program and evaluate the need for biobarrier maintenance, including EVO reinjections, rebioaugmentation, etc.

[c] Monitoring well locations may be found on Figure 4.1. Point of compliance well locations may be found on Figure 4.7.

Acronyms/Abbreviations

ft bgs – feet below ground surface
DNAPL – dense non-aqueous phase liquid
EISB – enhanced *in situ* bioremediation
EVO – emulsified vegetable oil
MNA – monitored natural attenuation
PMW – performance monitoring well
[TCE] – trichloroethene concentration

TABLE 4.5

SUMMARY OF MONITORING PROGRAM – DOWNGRADIENT PLUME
IR SITE 70, NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

Zone	Targeted Unit	Treatment Area	Monitoring Locations [c]	Screened Intervals [a]	Function of Well in Monitoring Program			Rationale for Well Selection
					PMW [b]	MNA	POC	
Plume	First Sand	Biobarrier FS-1	MW-70-38	80 to 100 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			IW-FS1-18	60 to 105 ft bgs	✓			Within biobarrier, provides performance data along plume core
			PMW-6A	70 to 80 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier in plume core
			PMW-6B	90 to 100 ft bgs	✓			
			PMW-4A	70 to 80 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			PMW-4B	90 to 100 ft bgs	✓			
			IW-FS1-8	60 to 105 ft bgs	✓			Within biobarrier, provides performance data in lower [TCE] area (EVO may persist longer in this area than plume core)
			PMW-5A	70 to 80 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier in plume fringe
			PMW-5B	90 to 100 ft bgs	✓			
			RDO-5	65 to 105 ft bgs		✓		Evaluate MNA of plume
			MNA-6	80 to 90 ft bgs		✓		
			MNA-17	80 to 90 ft bgs		✓		
			MNA-15	80 to 90 ft bgs		✓		Sentinel wells for monitoring plume migration
			MNA-16	80 to 90 ft bgs		✓		

TABLE 4.5 (continued)

SUMMARY OF MONITORING PROGRAM – DOWNGRADIENT PLUME
IR SITE 70, NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

Zone	Targeted Unit	Treatment Area	Monitoring Locations [c]	Screened Intervals [a]	Function of Well in Monitoring Program			Rationale for Well Selection
					PMW [b]	MNA	POC	
Plume	First Sand	Biobarrier FS-2	PMW-7A	65 to 75 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			PMW-7B	85 to 95 ft bgs	✓			
			IW-FS2-16	65 to 100 ft bgs	✓			Within biobarrier, provides performance data along plume core
			PMW-8A	65 to 75 ft bgs	✓			Downgradient well for monitoring concentrations leaving biobarrier
			PMW-8B	85 to 95 ft bgs	✓			Downgradient well for monitoring concentrations leaving biobarrier
			MNA-7	75 to 85 ft bgs		✓		Sentinel Well
			MNA-8	75 to 85 ft bgs		✓		Evaluate MNA of plume core
		Point of Compliance	POC Well 1	80 to 90 ft bgs			✓	Upgradient point of compliance
			MW-70-11	80 to 100 ft bgs			✓	Crossgradient point of compliance
			MW-70-35	90 to 100 ft bgs			✓	Crossgradient point of compliance
			MW-70-16	95 to 105 ft bgs			✓	Downgradient point of compliance
	Shell Horizon	Biobarrier SH-1	PMW-9	115 to 125 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			IW-SH1-13	105 to 130 ft bgs	✓			Within biobarrier, provides performance data along plume core
			PMW-10	115 to 125 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier
			RDO-6A	115 to 125 ft bgs	✓			Evaluate MNA of plume core
			MNA-11	115 to 125 ft bgs		✓		Sentinel well for monitoring plume migration

TABLE 4.5 (continued)

SUMMARY OF MONITORING PROGRAM – DOWNGRADIENT PLUME
IR SITE 70, NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

Zone	Targeted Unit	Treatment Area	Monitoring Locations [c]	Screened Intervals [a]	Function of Well in Monitoring Program			Rationale for Well Selection
					PMW [b]	MNA	POC	
Plume	Shell Horizon	Biobarrier SH-2	PMW-11	115 to 125 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			IW-SH2-16	105 to 130 ft bgs	✓			Within biobarrier, provides performance data along plume core
			PMW-12	115 to 125 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier
			MNA-9	115 to 125 ft bgs		✓		Evaluate MNA of plume core
	Second Sand	Biobarrier SS-1	PMW-13A	130 to 140 ft bgs	✓			Upgradient well for monitoring concentration influx into biobarrier
			PMW-13B	150 to 160 ft bgs	✓			
			IW-SSI-9	125 to 165 ft bgs	✓			Within biobarrier, provides performance data along plume core
			PMW-14A	130 to 140 ft bgs	✓			Downgradient from biobarrier, to evaluate concentrations leaving biobarrier
			PMW-14B	150 to 160 ft bgs	✓			
			MNA-14	140 to 150 ft bgs		✓		Evaluate MNA of plume core
			MNA-12	140 to 150 ft bgs		✓		
			MNA-13	140 to 150 ft bgs		✓		Sentinel Well
			MW-70-15	160 to 170 ft bgs		✓		
		Point of Compliance	MW-70-23	110 to 130 ft bgs			✓	Crossgradient point of compliance
			MW-70-36	150 to 160 ft bgs			✓	Crossgradient point of compliance
			MW-70-21	150 to 170 ft bgs			✓	Downgradient point of compliance

TABLE 4.5 (continued)

SUMMARY OF MONITORING PROGRAM – DOWNGRADIENT PLUME
IR SITE 70, NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

Zone	Targeted Unit	Treatment Area	Monitoring Locations [c]	Screened Intervals [a]	Function of Well in Monitoring Program			Rationale for Well Selection
					PMW [b]	MNA	POC	
Plume	Deep Sand	Point of Compliance	POC Well 2	190 to 200 ft bgs			✓	Crossgradient point of compliance
			POC Well 3	190 to 200 ft bgs			✓	Crossgradient point of compliance
			POC Well 4	190 to 200 ft bgs			✓	Downgradient point of compliance

Notes

[a] Screen intervals are approximate and may be adjusted in the field according to the local soil lithology. Monitoring well screen intervals should be consistent with injection well screens, and may be modified as necessary in the field.

[b] PMW wells will be used to evaluate the ongoing effectiveness of the EISB program and evaluate the need for biobarrier maintenance, including EVO reinjections, rebioaugmentation, etc.

[c] Monitoring well locations may be found on Figure 4.2 (First Sand Unit), 4.3 (Shell Horizon), and 4.4 (Second Sand Unit).

Acronyms/Abbreviations

EISB – enhanced *in situ* bioremediation
EVO – emulsified vegetable oil
MNA – monitored natural attenuation
PMW – performance monitoring well
POC – point of compliance
[TCE] – trichloroethene concentrations

Table 5.1
Injection Well Construction Details
IR Site 70, Naval Weapons Station Seal Beach, California

Well Location	Aquifer Unit	Well Total Depth[1]	Total Feet of Screen[1]	Top of Screen (ft bgs)[1]	Bottom of Screen (ft bgs)[1]
Source Area Grid Treatment	Upper Fines	60	30	25	55
Source Area Biobarrier	First Sand Unit	110	45	60	105
Biobarrier FS-1	First Sand Unit	110	45	60	105
Biobarrier FS-2	First Sand Unit	105	35	65	100
Biobarrier SH-1	Shell Horizon	135	25	105	130
Biobarrier SH-2	Shell Horizon	135	25	105	130
Biobarrier SS-1	Second Sand Unit	170	40	125	165

Notes
[1] All construction details are subject to changes in the field due to lithology.

Acronyms/Abbreviations
FS-First Sand
ft bgs-feet below ground surface
IR-Installation Restoration
SH-Shell Horizon
SS-Second Sand

Table 5.2
Monitoring Well Construction Details
IR Site 70, Naval Weapons Station Seal Beach, California

Well Function	Well Location	Well Depth[2]	Aquifer Unit	Well Total Depth[1]	Total Feet of Screen[1]	Top of Screen (ft bgs)[1]	Bottom of Screen (ft bgs)[1]
PMW	Source Grid Treatment Area	A	Upper Fines	40	10	25	35
		B	Upper Fines	60	10	45	55
	Source Containment Biobarrier	A	First Sand Unit	85	10	70	80
		B	First Sand Unit	105	10	90	100
	Biobarrier FS-1	A	First Sand Unit	85	10	70	80
		B	First Sand Unit	105	10	90	100
	Biobarrier FS-2	A	First Sand Unit	80	10	65	75
		B	First Sand Unit	100	10	85	95
	Biobarrier SH-1	--	Shell Horizon	130	10	115	125
	Biobarrier SH-2	--	Shell Horizon	130	10	115	125
	Biobarrier SS-1	A	Second Sand Unit	145	10	130	140
		B	Second Sand Unit	165	10	150	160
MNA	Source Grid Treatment Area	--	Upper Fines	50/55[3]	10	35/40[3]	45/50[3]
	Biobarrier FS-1	--	First Sand Unit	95	10	80	90
	Biobarrier FS-2	--	First Sand Unit	90	10	75	85
	Biobarrier SH-1	--	Shell Horizon	130	10	115	125
	Biobarrier SH-2	--	Shell Horizon	130	10	115	125
	Biobarrier SS-1	--	Second Sand Unit	155	10	140	150
POC	First Sand Crossgradient	--	First Sand	95	10	80	90
	Deep Sand Crossgradient	--	Deep Sand	205	10	190	200
	Deep Sand Downgradient	--	Deep Sand	205	10	190	200

Notes
[1] All construction details are subject to changes in the field due to lithology.
[2] Well depth “A” corresponds to shallower wells denoted as “PMW-#A”, and well depth “B” corresponds to deeper wells denoted as “PMW-#B” installed in the same location (i.e., well nest).
[3] MNA-1 will be screened between 40 and 50 ft bgs. The remainder of the MNA wells within the Source Grid Treatment Area will be screened from 35 to 45 ft bgs.

Acronyms/Abbreviations
FS-First Sand
ft bgs-feet below ground surfac
IR-Installation Restoration
SH-Shell Horizon
SS-Second Sand
PMW-Performance Monitoring Wells
POC-Point of Compliance
MNA-Monitored Natural Attenuation Wells

Table 6.1
Equipment Inventory and Needs For EISB Injection
IR Site 70, Naval Weapons Station Seal Beach, California

	Equipment	Quantity Required	Comments
Groundwater Extraction System	Submersible Pump (0 to 40 gpm)	10	1 inch braided PVC w/ camlock
	Electrical Cable Extension for Submersible Pump	10	long enough to reach power source
	Stainless Steel Cable	10 @ 165 ft	cable connection to stabilize pump in extraction well
	Submersible Pump Hose	10 @ 165 ft	1 inch braided PVC w/ camlock
	Extraction Well Flow Control Valves	10	w/ camlock
	Pump Flow Control System (recirculation line or electronic controller)	10	prevent extraction pump over pressure and control flow rate
	Pressure gauge	10	
	Extraction Lines	130 @ 50 ft	2 inch braided PVC hose w/ camlock
Trailer Mounted EVO Distribution System	Trailer for EVO Distribution System	1	Size = 17 ft
	4 inch PVC pipe with 10 inlet connectors	1	inlet connectors capable of being capped
	Sediment Bag Filter Vessels	2	plumbed in parallel. Size = 200 gpm
	Inline Bag Filters (140 mesh/104µm)	30	prevent sands from entering distribution system
	4 inch Ball Valves	4	
	Compound Pressure Gauge	4	0 to +/- 100 psi
	Pressure Reducing Valves	1	reduce effluent pressure to <100 psi
	4 inch PVC Pipe for Header Assembly	30 ft	Schedule 80 PVC
	2 inch Globe Valves	5	
	Dosmatic Injector	5	A40-2.5% emulsion
	2 inch Ball Valves	22	
	Dosmatic Water Meter/Totalizer	5	1 to 50 GPM
	2 inch PVC Pipe for Dosmatic Assemblies	10 ft	Schedule 40 PVC w/ suitably sized couplings
	4 inch PVC Distribution Header	1	w/ 10-channels but able to modify to include more
	4 inch PVC Pipe for Distribution Manifold Assembly	10 ft	Schedule 40 PVC w/ suitably sized couplings
	Injection Well Water Meters/Totalizers	10	3/4 to 30 GPM
	Flow Control Valves (needle or globe)	10	coordinate with injection well meters. w/camlock
	Injection Delivery Lines[1]	130 @ 50 ft	2 inch braided PVC hose w/ camlock
Well Head Assembly	4 inch Flange and Gasket pairing	20	flanged seal to each injection well
	2 inch Clear PVC Pipe	40 ft	
	2 inch PVC Cross	20	
	2 inch Shut off Ball Valve	20	w/camlock
	2 inch Vent Ball Valve	20	
	Compound Pressure Gauge	1	0 to +/- 100 psi
General	Generators (or Power Supply)	3 (1)	supporting extraction pumps and booster pump
	Closed Top Tank (6,500 gal)	2	rent, storage of anoxic water generation for KB-1™ addition
	Polyethylene Storage Tank (1,000 gal)	3	rent, cleaning fluid for injection equipment
	Water Level Tape	1	rent or purchase
	Fire Hose	~ 500 ft	rent or purchase (to anoxic water tank for KB-1™ addition)
	Hose guard/ ramp or trenching	1	rent if hose or electrical crosses traffic thoroughfare
	Water Meter (City of Seal Beach)	2	rent from City
	Connex Boxes (40 ft x 8 ft)	1	rent, storage of onsite EVO totes
	Spill Kits	3	
	Secondary Containment of Staged EVO	1	
	Argon Gas Cylinders	41	80 ft^3
	Pallet Jack	1	low cost ($100)
	Gradall fork lift	1	rent to unload totes on arrival

Acronyms/Abbreviations
gpm - gallons per minute
ft - feet
ft^3 - cubic feet
PVC - poly vinyl chloride
µm - micrometers
psi - pounds per square inch
gal - gallon
EVO - emulsified vegetable oil

Table 6.2
Summary of Injection Stages, Amendment Volumes, and Estimated Injection Duration - Source Area and Source Biobarrier
IR Site 70, Naval Weapons Station Seal Beach, California

SOURCE AREA

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2	9	0.5%	234	2,106	207,288	209,394	10	90	27	3,600	3.9	7
2	Group 2	Group 3	9	0.5%	234	2,106	207,288	209,394	10	90	27	3,600	3.9	7
3	Group 3	Group4	10	0.5%	234	2,340	230,320	232,660	10	100	30	4,000	3.9	7
4	Group 4	Group 5	10	0.5%	234	2,340	230,320	232,660	10	100	30	4,000	3.9	7
5	Group 5	Group 6/ Group 2	10	0.5%	234	2,340	230,320	232,660	10	100	30	4,000	3.9	7
6	Group 6	Group 5	4	0.5%	234	936	92,128	93,064	5	20	12	1,600	7.8	12
7	Group 7	Group 2	5	0.5%	234	1,170	115,160	116,330	5	25	15	2,000	7.8	12
TOTAL			**57**			**13,338**					**171**			**59**

SOURCE BIOBARRIER

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2	7	0.5%	476	3,332	327,957	331,289	10	70	21	4,480	7.9	12
2	Group 2	Group 2	3	0.5%	476	1,428	140,553	141,981	10	30	9	1,920	7.9	12
3	Group 2	Group 1	4	0.5%	476	1,904	187,404	189,308	5	20	12	2,560	15.8	21
TOTAL			**14**			**6,664**					**42**			**45**

Notes:

[a] EVO injection based on 10 hour days.

[b] Total estimated time for injection includes 3 days for equipment setup, testing, and decommissioning. For injections that will require more than 5 working days, one extra day is included for cleaning of the equipment after every five days for weekend storage.

[c] Anoxic water required for KB-1 injections.

[d] See Figure 6.1 for locations of injection and extraction wells.

[e] See Table 4.2 for a summary of design details and assumptions.

[f] Based on achivable injection rates during RDO activities (GeoSyntec 2006) and accounting for longer screened interval.

Acronyms/Abbreviations

% - percent
gal - gallons
L - liters
gpm - gallons per minute
% - percentage
EVO - emulsified vegetable oil
IW - injection well

Table 6.3
Summary of Injection Stages, Amendment Volumes, and Estimated Injection Duration - Biobarriers FS-1 and FS-2
IR Site 70, Naval Weapons Station Seal Beach, California

BIOBARRIER FS-1

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 4/Group 2	9	0.5%	476	4,284	421,659	425,943	10	90	27	5,760	7.9	12
2	Group 2	Group 3	9	0.5%	476	4,284	421,659	425,943	10	90	27	5,760	7.9	12
3	Group 3	Group 2	9	0.5%	476	4,284	421,659	425,943	5	45	27	5,760	15.8	22
4	Group 4	Group 1	8	0.5%	476	3,808	374,808	378,616	5	40	24	5,120	15.8	22
TOTAL			**35**			**16,660**					**105**			**68**

BIOBARRIER FS-2

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2	10	0.5%	370	3,700	364,400	368,100	10	100	30	5,000	6.1	10
2	Group 2	Group 3	10	0.5%	370	3,700	364,400	368,100	9	90	30	5,000	6.8	11
3	Group 3	Group 2	9	0.5%	370	3,330	327,960	331,290	5	45	27	4,500	12.3	17
TOTAL			**29**			**10,730**					**87**			**38**

Notes:

[a] EVO injection based on 10 hour days.

[b] Total estimated time for injection includes 3 days for equipment setup, testing, and decommissioning. For injections that will require more than 5 working days, one extra day is included for cleaning of the equipment after every five days for weekend storage.

[c] Anoxic water required for KB-1 injections.

[d] See Figure 6.2 for locations of injection and extraction wells.

[e] See Table 4.2 for a summary of design details and assumptions.

[f] Based on achivable injection rates during RDO activities (GeoSyntec 2006) and accounting for longer screened interval.

Acronyms/Abbreviations

% - percent
gal - gallons
L - liters
gpm - gallons per minute
% - percentage
EVO - emulsified vegetable oil
IW - injection well

Table 6.4
Summary of Injection Stages, Amendment Volumes, and Estimated Injection Duration - Biobarriers SH-1, SH-2 and SS-1
IR Site 70, Naval Weapons Station Seal Beach, California

BIOBARRIER SH-1

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2/Group 3	10	0.5%	194	1,940	191,100	193,040	5	50	30	3,500	6.4	10
2	Group 2	Group 3	9	0.5%	194	1,746	171,990	173,736	5	45	27	3,150	6.4	10
3	Group 3	Group 4	9	0.5%	194	1,746	171,990	173,736	5	45	27	3,150	6.4	10
4	Group 4	Group 3	9	0.5%	194	1,746	171,990	173,736	2.5	23	27	3,150	12.9	18
TOTAL			**37**			**7,178**					**111**			**48**

BIOBARRIER SH-2

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2	8	0.5%	194	1,552	152,880	154,432	5	40	24	2,800	6.4	10
2	Group 2	Group 3	8	0.5%	194	1,552	152,880	154,432	5	40	24	2,800	6.4	10
3	Group 3	Group 4	8	0.5%	194	1,552	152,880	154,432	5	40	24	2,800	6.4	10
4	Group 4	Group 3	8	0.5%	194	1,552	152,880	154,432	2.5	20	24	2,800	12.9	18
TOTAL			**32**			**6,208**					**96**			**48**

BIOBARRIER SS-1

Injection Stage	Injection Well Group[d]	Extraction Well Group[d]	Number IW Wells In Each Group	Target Oil Dose (%)[e]	Target EVO Volume Per Well (gal)[e]	Total EVO Volume (gal)[e]	Total Water Volume (gal)[e]	Total Amendment Volume (gal)[e]	Anticipated Injection Rate Per Well (gpm)[f]	Total Anticipated Injection Rate (gpm)	Total Target KB-1™ Dose (L)[e]	Total Volume Anoxic Water (gal)[c]	EVO Injection Duration (days)[a]	Total Estimated Time (days)[b]
1	Group 1	Group 2/Group 3	8	0.5%	423	3,384	333,160	336,544	25	200	24	4,480	2.8	6
2	Group 2	Group 3	7	0.5%	423	2,961	291,515	294,476	25	175	21	3,920	2.8	6
3	Group 3	Group 2	7	0.5%	423	2,961	291,515	294,476	12.5	88	21	3,920	5.6	10
TOTAL			**22**			**9,306**					**66**			**22**

Notes:

[a] EVO injection based on 10 hour days.

[b] Total estimated time for injection includes 3 days for equipment setup, testing, and decommissioning. For injections that will require more than 5 working days, one extra day is included for cleaning of the equipment after every five days for weekend storage.

[c] Anoxic water required for KB-1 injections.

[d] See Figure 6.3 (Biobarrier SH-1 and SH-2) and Figure 6.4 (SS-1) for locations of injection and extraction wells.

[e] See Table 4.2 for a summary of design details and assumptions

[f] Based on achivable injection rates during RDO activities (GeoSyntec 2006) and accounting for longer screened interval.

Acronyms/Abbreviations

% - percent
gal - gallons
L - liters
gpm - gallons per minute
% - percentage
EVO - emulsified vegetable oil
IW - injection well

Table 6.5
Analytical Requirements
IR Site 70, Naval Weapons Station Seal Beach, California

Analyte	Method	Container	Preservation	Volume	Hold Time
Volatile Organic Compounds	8260B	VOA vial	HCL pH<2 Store at 4 ˚C (± 2)	3 x 40 mL	14 days
Dissolved Hydrocarbon Gases (ethene, ethane, methane)	RSK 175	VOA vial	Store at 4 ˚C +/- 2 ˚C	2 x 40 mL	14 days
Dissolved Iron/Manganese/Arsenic	6010B	plastic	HNO_3 to pH<2	1000 mL	6 months
Inorganic Anions Nitrate/Nitrite/Chloride/Sulfate	300.0	plastic	Store at 4 ˚C +/- 2 ˚C	250 mL	NO_3^- 48 hours Cl 14 days SO_4^{2-} 28 days NO_2^- 48 hours
Sulfide	376.2	plastic	Store at 4 ˚C (+/- 2 ˚C), NaOH	500 mL	7 days
Total Organic Carbon	415.1 single burn/9060 quadruple burn	plastic	sulfuric acid	500 mL	14 days
Volatile Fatty Acids (acetic, butyric, lactic, propionic)	300M	plastic	Store at 4 ˚C +/- 2 ˚C	500 mL	28 days
Dehalococcoides (DHC)	PCR 16S rRNA	plastic	Store at 4 ˚C +/- 2 ˚C	1 L	7 days
Depth to Water	water sounding tape	NA	NA	NA	NA
Field Parameters (pH, DO, ORP, spc, turbidity, temperature)	Ion Specific Electrode	NA	NA	NA	NA

Acronyms/Abbreviations

NA – not applicable
PCR – polymerase chain reaction
spc – specific conductance
DO – dissolved oxygen
ORP – oxidation reduction potential
˚C – degrees Celsius
L – liters
VOA – volatile organic analysis
DHC – *Dehalococcoides*

mL – milliliters
HCL – hydrochloric acid
$HN0_3$ – nitric acid
NaOH – sodium hydroxide
NO_3^-- nitrate
NO_2^- - nitrate
Cl - chloride
SO_4^{2-} - sulfate

Table 6.6
Tentative Sampling Schedule For First Five Years of Operation
IR Site 70, Naval Weapons Station Seal Beach, California

Zone	Treatment Area	Monitoring Well	Event	Baseline [10]									Quarterly (Year One Only)						Semi-Annually									Annually			
			Well Function	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	Sulfide [7]	Dissolved Metals [8]	DHC [9]	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	Sulfide [7]	Dissolved Metals [8]	DHC [9]	FP [1]	VOCs [2]	DHGs [3]	DHC [9]
Source	Grid Treatment	PMW -1A	PMW	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X							
		PMW-1B	PMW	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X							
		MW-70-27	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		MW-70-28	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		MNA-1	MNA	X	X	X																						X	X	X	X
		MNA-2	MNA	X	X	X																						X	X	X	
		MNA-3	MNA	X	X	X																						X	X	X	
	Source Biobarrier	PMW-2A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-2B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-SC-6	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-3A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-3B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
Plume	Biobarrier FS-1	MW-70-38	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-FS1-18	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-6A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-6B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-4A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-4B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-FS1-8	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-5A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-5B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		RDO-5	MNA	X	X	X																						X	X	X	X
		MNA-6	MNA	X	X	X																						X	X	X	X
		MNA-15	MNA	X	X	X																						X	X	X	
		MNA-16	MNA	X	X	X																						X	X	X	
		MNA-17	MNA	X	X	X																						X	X	X	X
	Biobarrier FS-2	PMW-7A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-7B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-FS2-16	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-8A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-8B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		MNA-7	MNA	X	X	X																						X	X	X	X
		MNA-8	MNA	X	X	X																						X	X	X	X
	Biobarrier SH-1	PMW-9	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-SH1-13	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-10	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		RDO-6A	MNA	X	X	X																						X	X	X	X
		MNA-11	MNA	X	X	X																						X	X	X	
	Biobarrier SH-2	PMW-11	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-SH2-16	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-12	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		MNA-9	MNA	X	X	X																						X	X	X	X

Table 6.6
Tentative Sampling Schedule For First Five Years of Operation
IR Site 70, Naval Weapons Station Seal Beach, California

Zone	Treatment Area	Monitoring Well	Event	Baseline [10]									Quarterly (Year One Only)						Semi-Annually									Annually			
			Well Function	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	Sulfide [7]	Dissolved Metals [8]	DHC [9]	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	FP [1]	VOCs [2]	DHGs [3]	Anions [4]	VFAs [5]	TOC [6]	Sulfide [7]	Dissolved Metals [8]	DHC [9]	FP [1]	VOCs [2]	DHGs [3]	DHC [9]
Plume	Biobarrier SS-1	PMW-13A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-13B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		IW-SSI-9	PMW	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X			X				
		PMW-14A	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		PMW-14B	PMW	X	X	X	X	X	X	X	X								X	X	X	X	X	X	X	X					
		MNA-12	MNA	X	X	X																						X	X	X	X
		MNA-13	MNA	X	X	X																						X	X	X	
		MNA-14	MNA	X	X	X																						X	X	X	X
		MW-70-15	MNA	X	X	X																						X	X	X	
Point of Compliance Wells	Upper Fines	MW-70-02	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-10	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-17	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-22	POC	X	X	X	X	X	X	X	X																	X	X		
	First Sand	POC Well 1	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-11	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-35	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-16	POC	X	X	X	X	X	X	X	X																	X	X		
	Second Sand	MW-70-23	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-36	POC	X	X	X	X	X	X	X	X																	X	X		
		MW-70-21	POC	X	X	X	X	X	X	X	X																	X	X		
	Deep Sand	POC Well 2	POC	X	X	X	X	X	X	X	X																	X	X		
		POC Well 3	POC	X	X	X	X	X	X	X	X																	X	X		
		POC Well 4	POC	X	X	X	X	X	X	X	X																	X	X		

Notes

[1] Field Parameters (FP) are pH, dissolved oxygen, oxidation-reduction potential, specific conductance, temperature, turbidity and depth to water.

[2] VOCs are Chlorinated Volatile Organic Compounds (EPA Method 8260B).

[3] DHGs are Dissolved Hydrocarbon Gases (i.e. methane, ethene and ethane).

[4] Anions to be analyzed for are chloride, sulfate, nitrate and nitrite.

[5] Volatile Fatty Acids (VFAs).

[6] Total Organic Carbon (TOC).

[7] Total sulfides.

[8] Dissolved Metals include iron, manganese and arsenic.

[9] DNA Assay for *Dehalococcoides* (DHC).

[10] Baseline VOC and field parameter samples will be obtained from every fourth injection well prior to EVO injections to better characterize the VOC distribution across the width of the plume and confirm the need for EVO injections in that area.

X indicates that a sample is to be collected.
PMW - Performance Monitoring Well
POC - Point of Compliance Well
MNA - Monitoring Natural Attenuation Well

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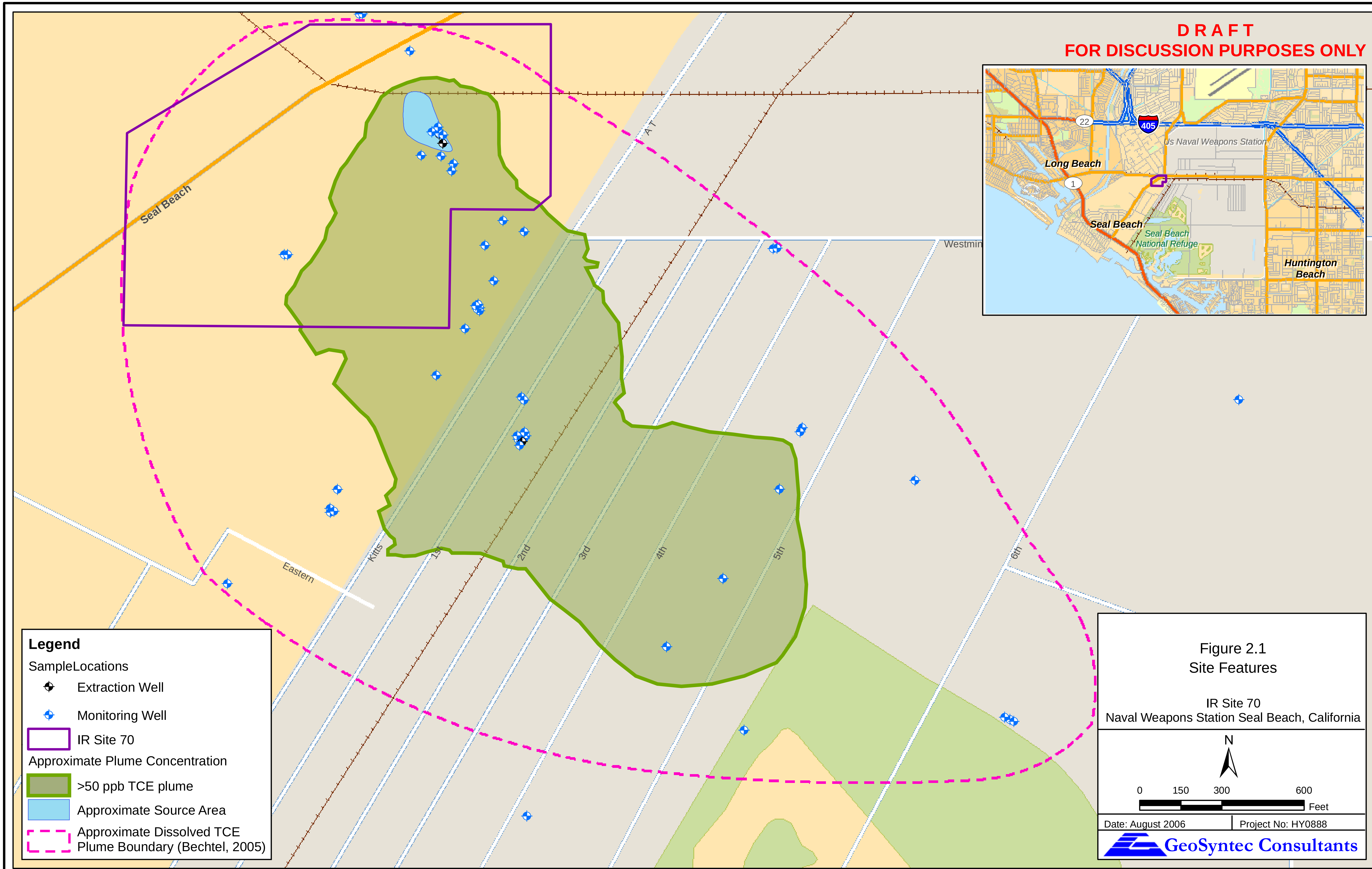

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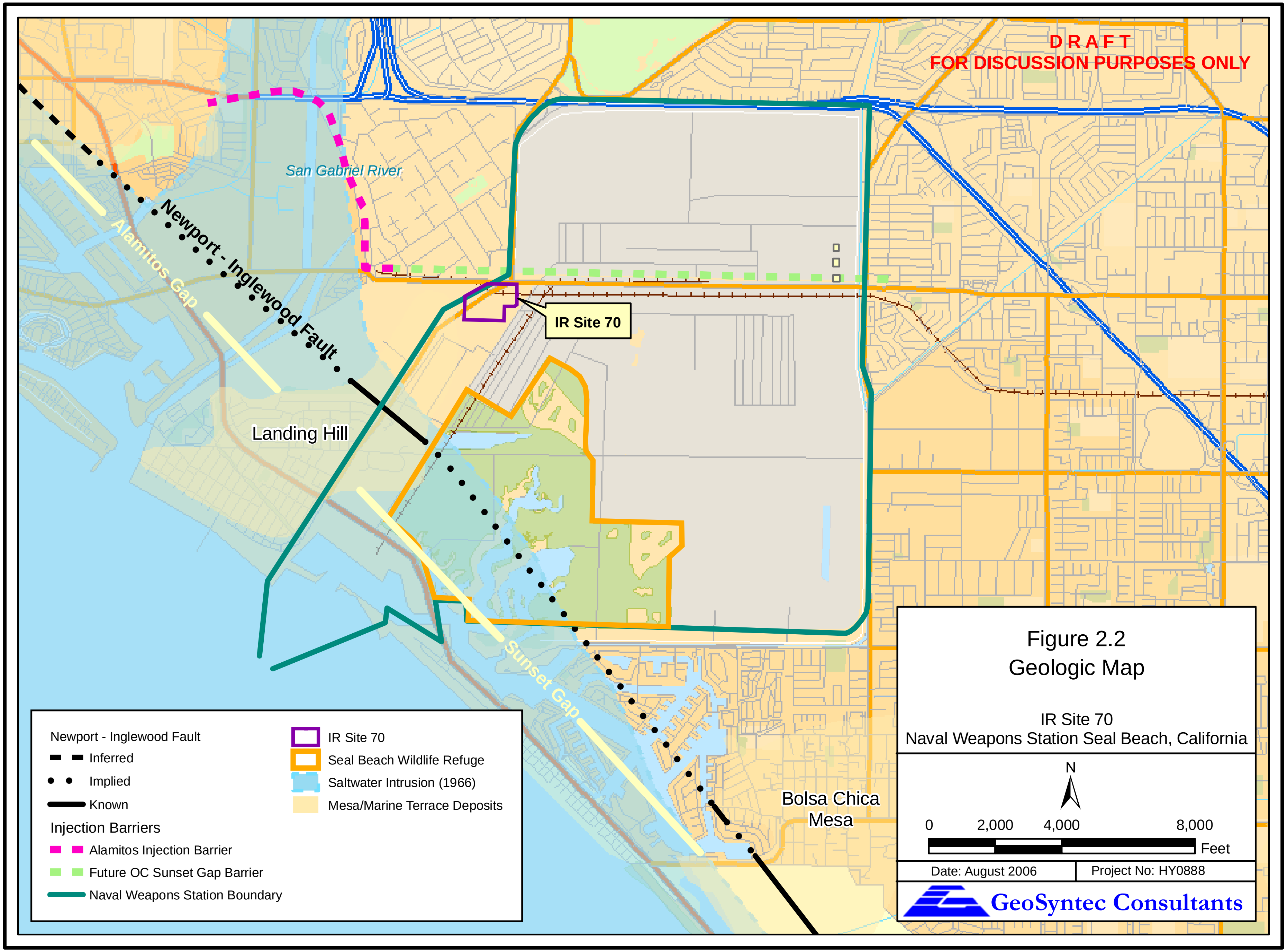

Figure 2.2
Geologic Map

IR Site 70
Naval Weapons Station Seal Beach, California

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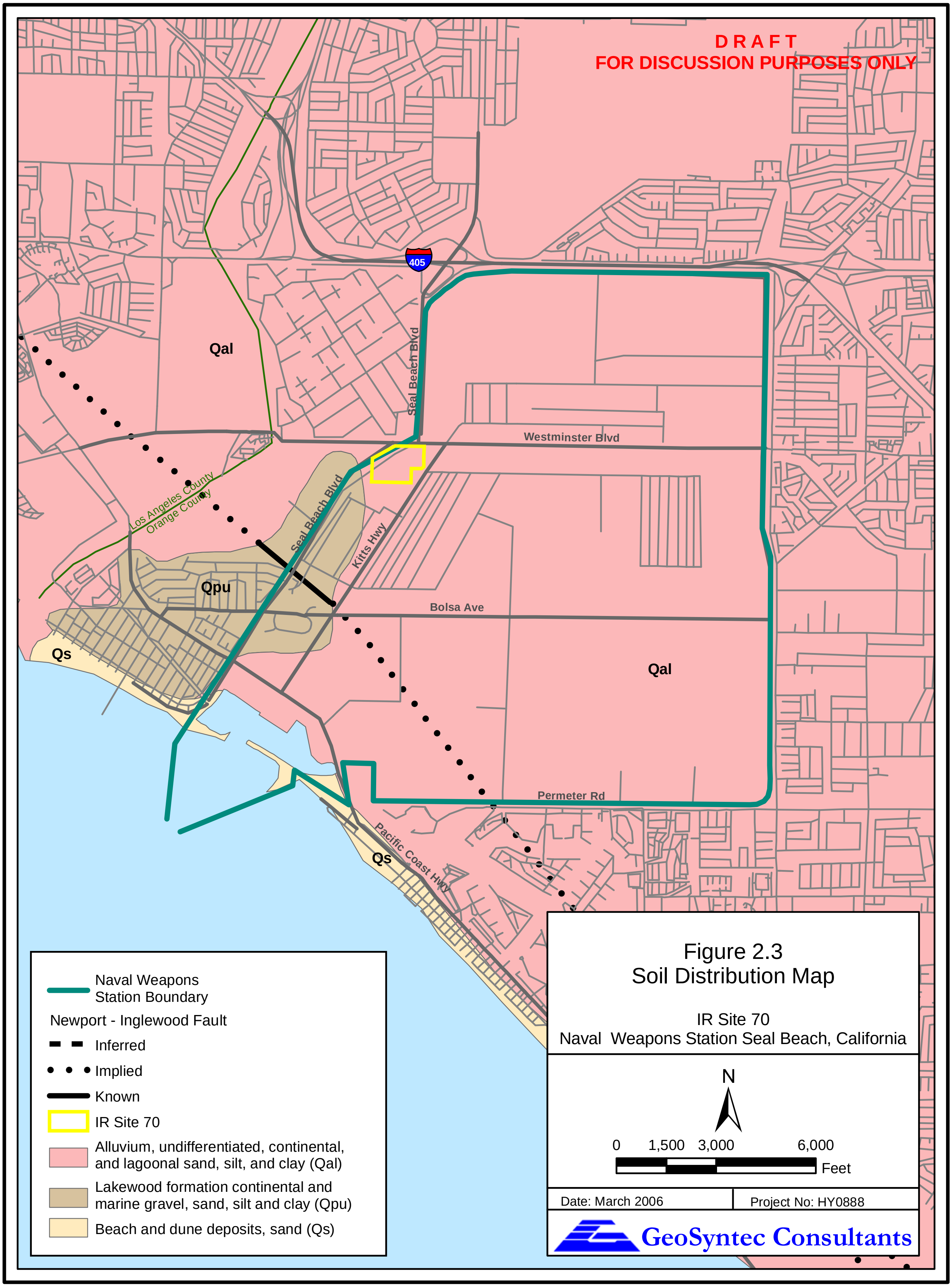

Figure 2.3
Soil Distribution Map

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006

Project No: HY0888

GeoSyntec Consultants

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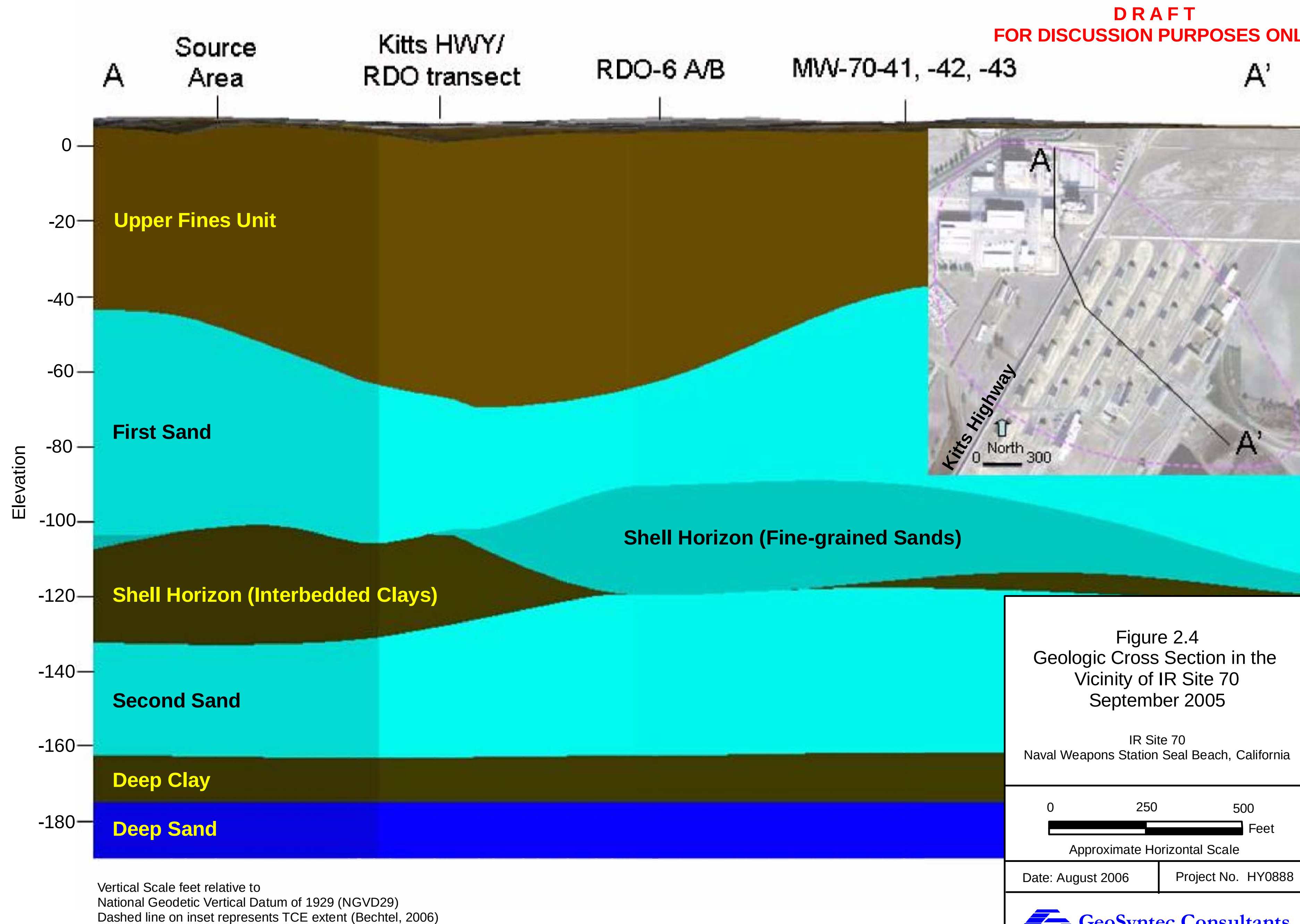

Figure 2.4
Geologic Cross Section in the Vicinity of IR Site 70
September 2005

IR Site 70
Naval Weapons Station Seal Beach, California

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

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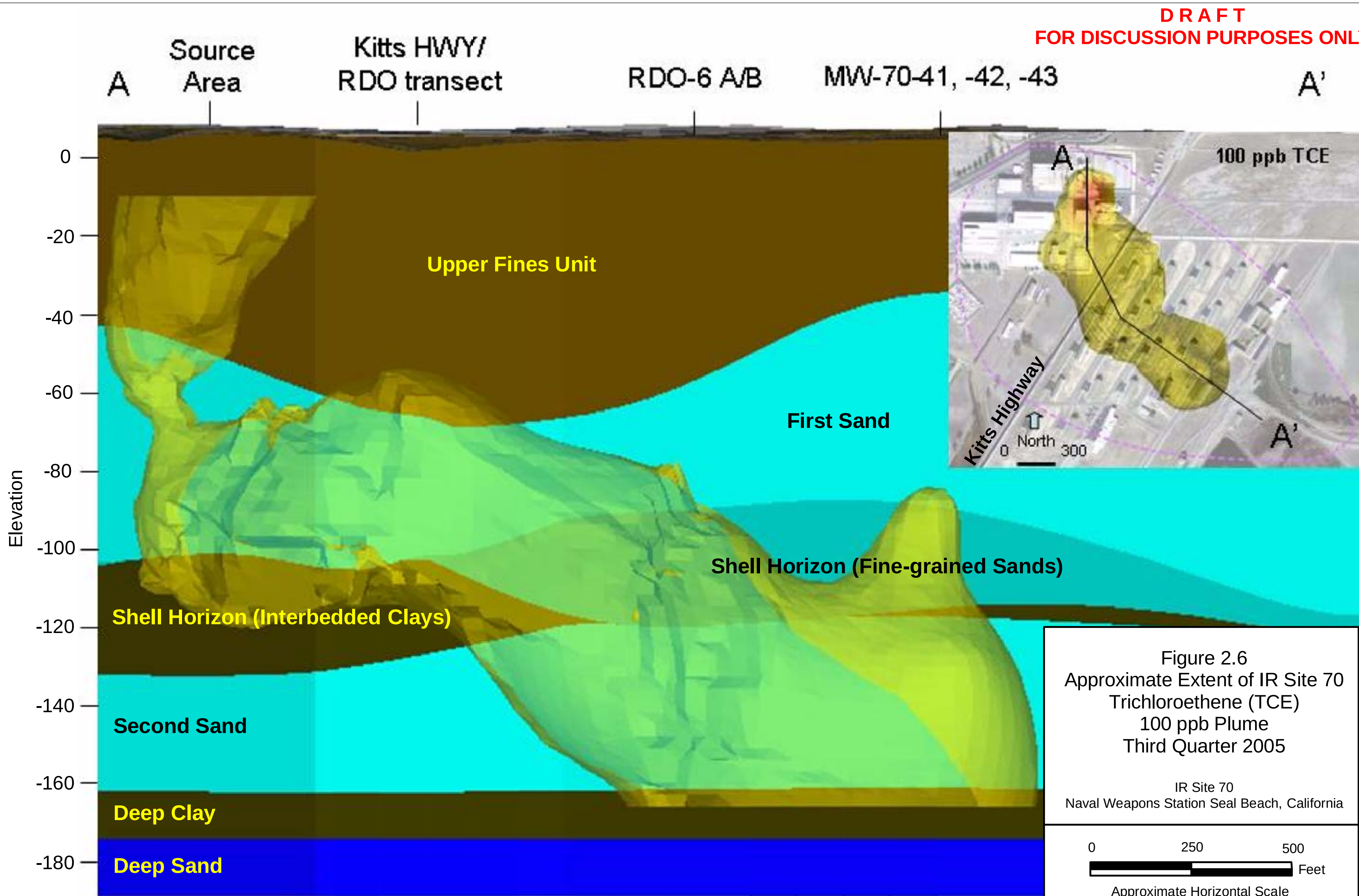
Figure 2.5

This detailed station map has been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.



Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 2.6
Approximate Extent of IR Site 70
Trichloroethene (TCE)
100 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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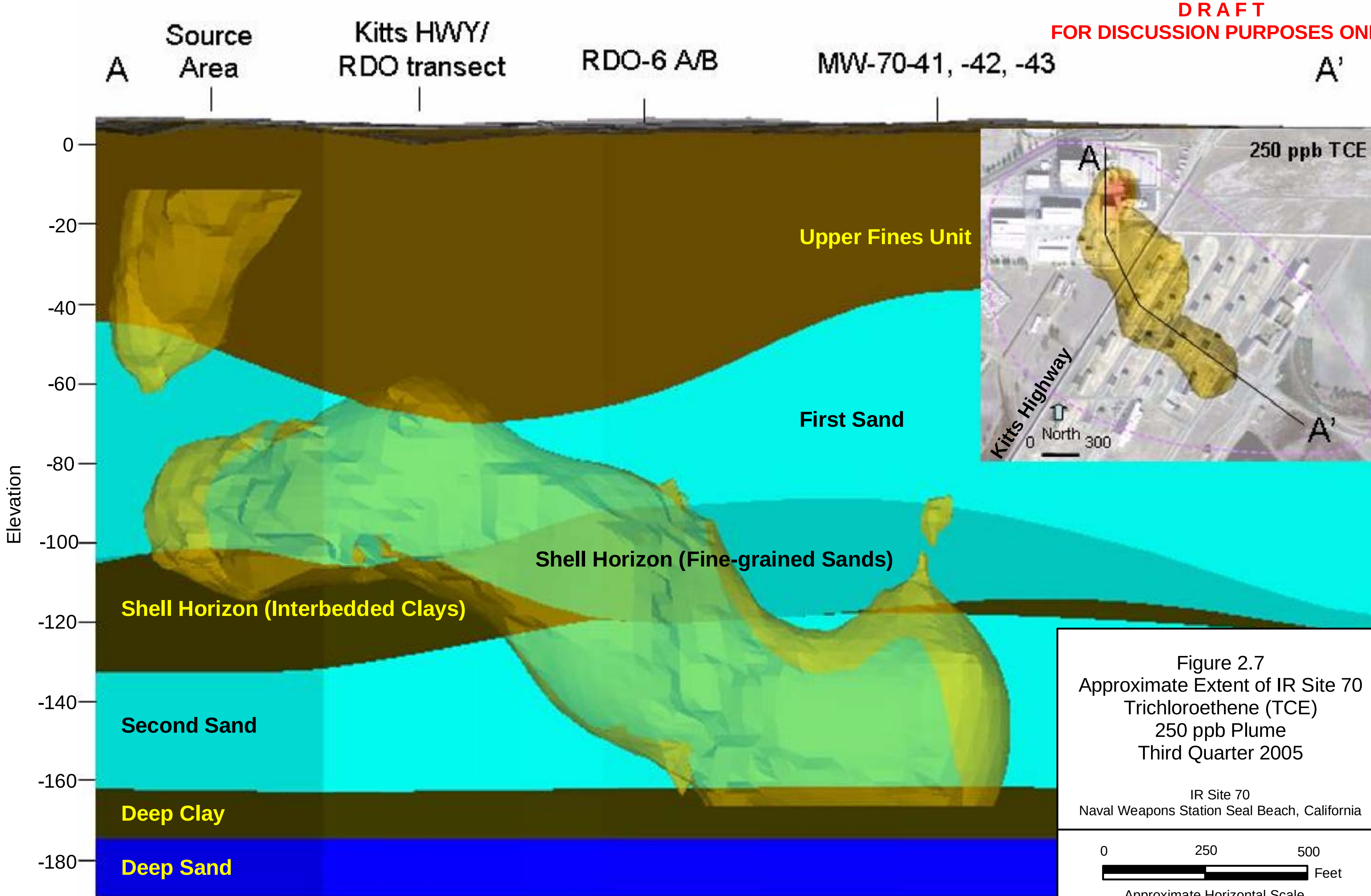

Figure 2.7
Approximate Extent of IR Site 70
Trichloroethene (TCE)
250 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

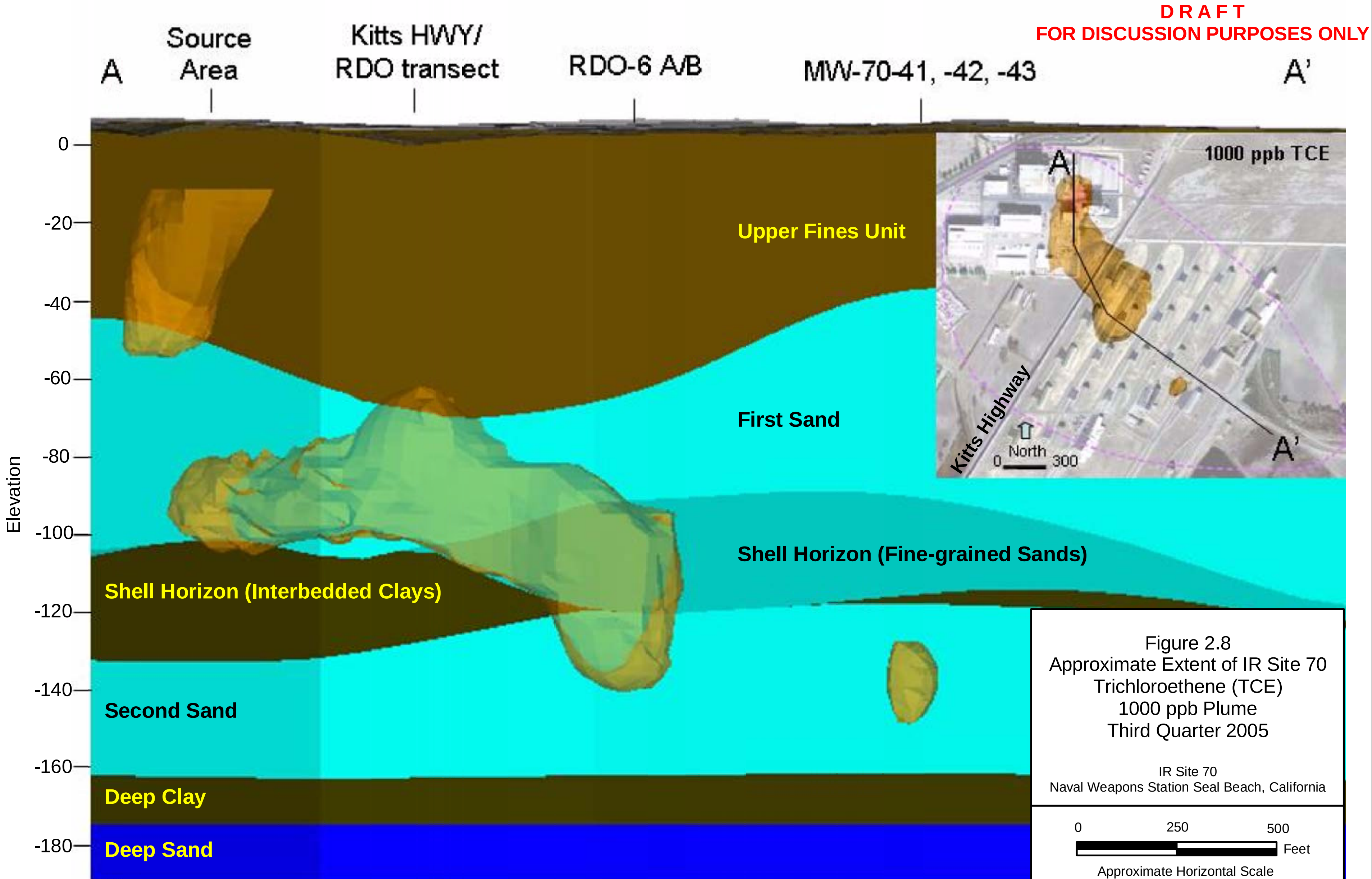

Figure 2.8
Approximate Extent of IR Site 70
Trichloroethene (TCE)
1000 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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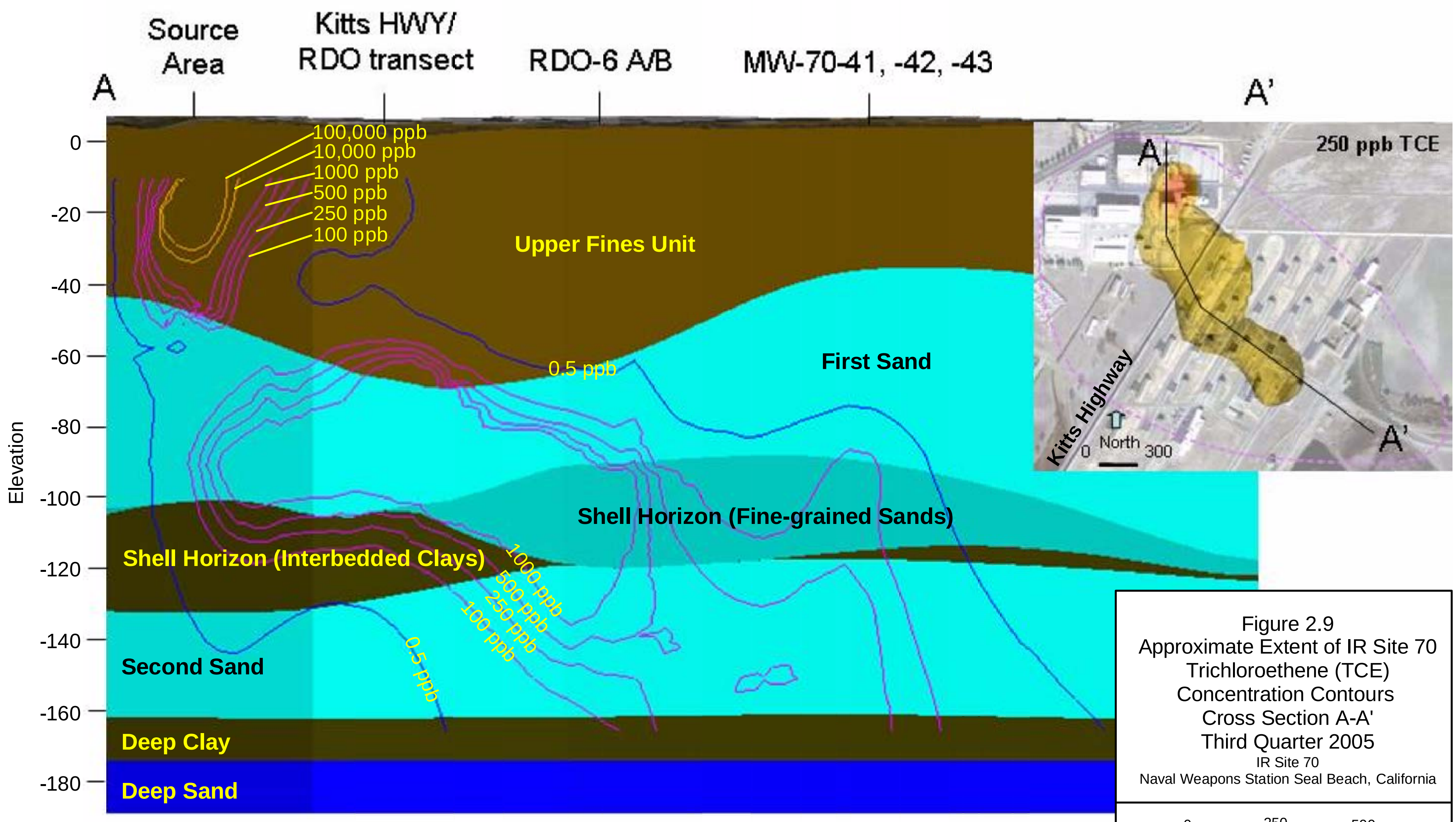

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 2.9
Approximate Extent of IR Site 70
Trichloroethene (TCE)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

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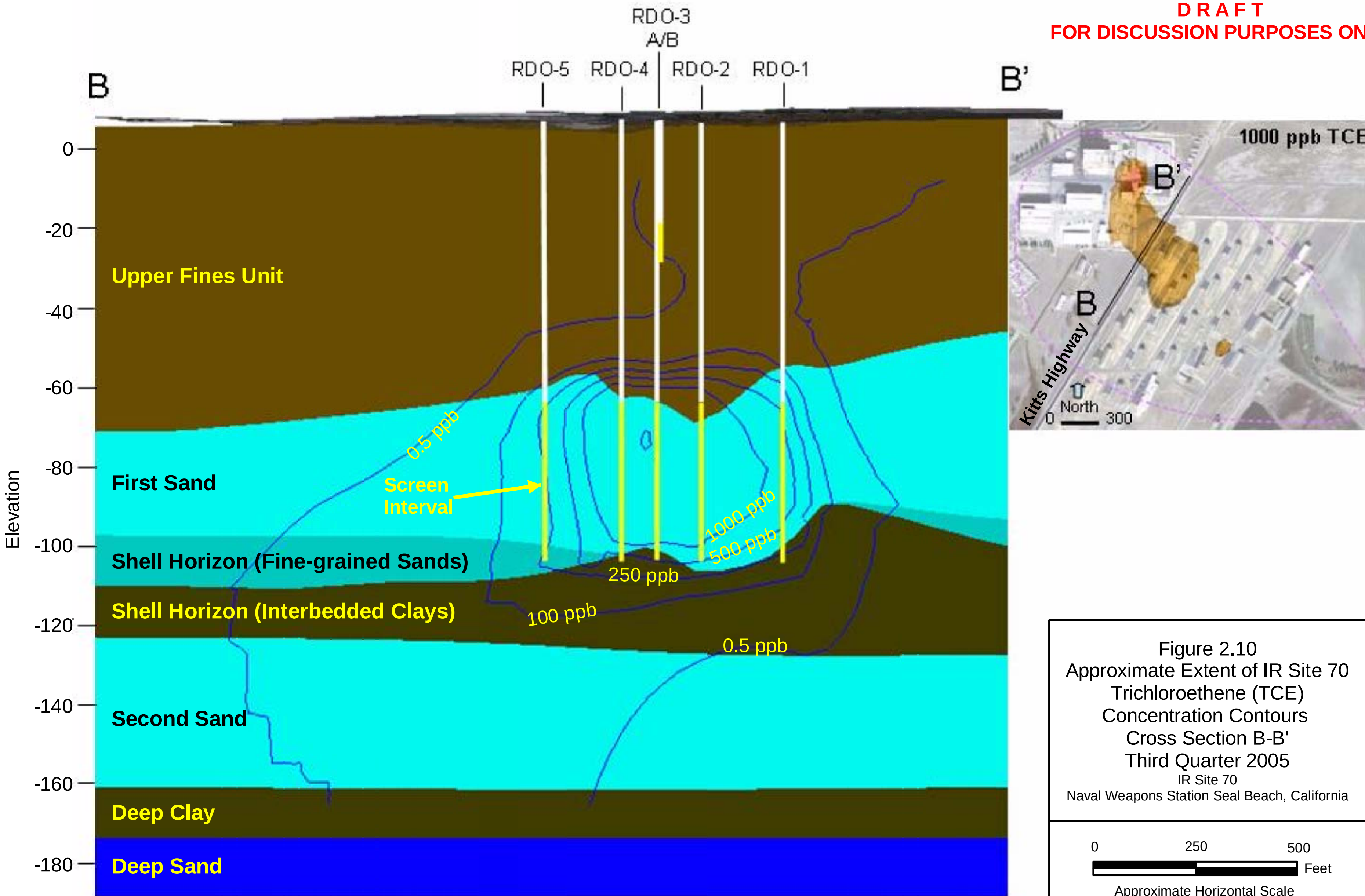

Figure 2.10
Approximate Extent of IR Site 70
Trichloroethene (TCE)
Concentration Contours
Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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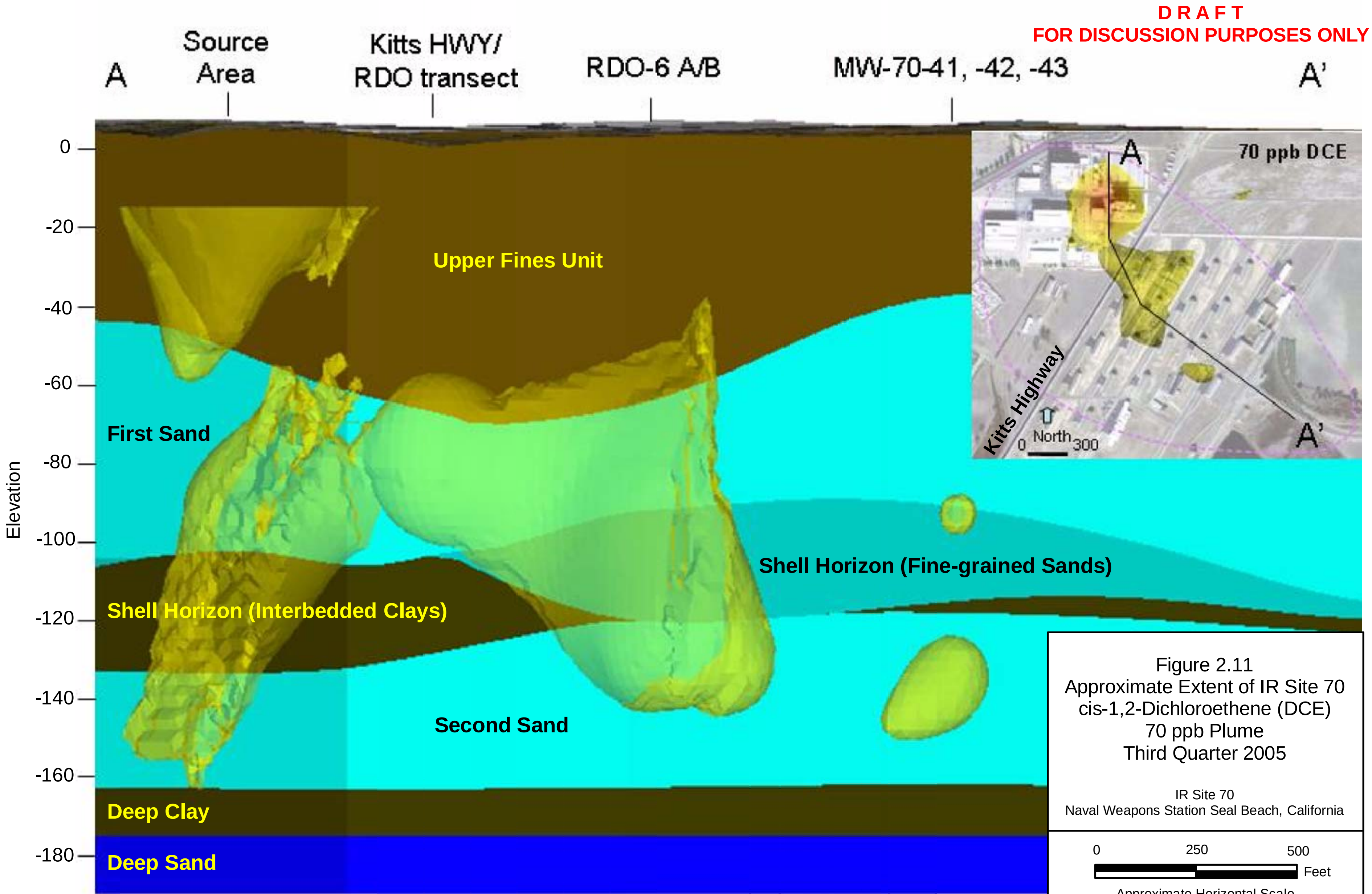

Figure 2.11
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
70 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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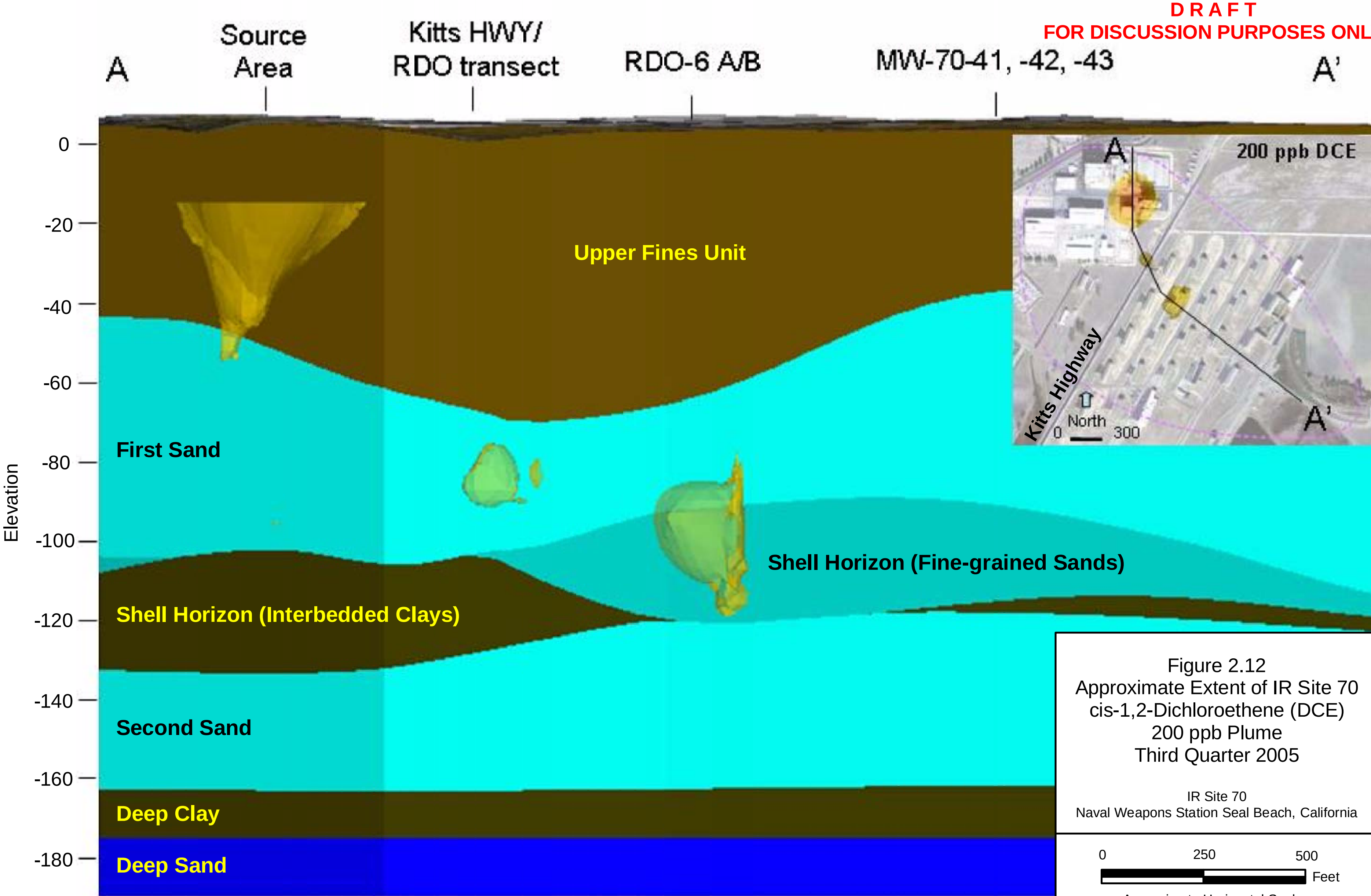

Figure 2.12
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
200 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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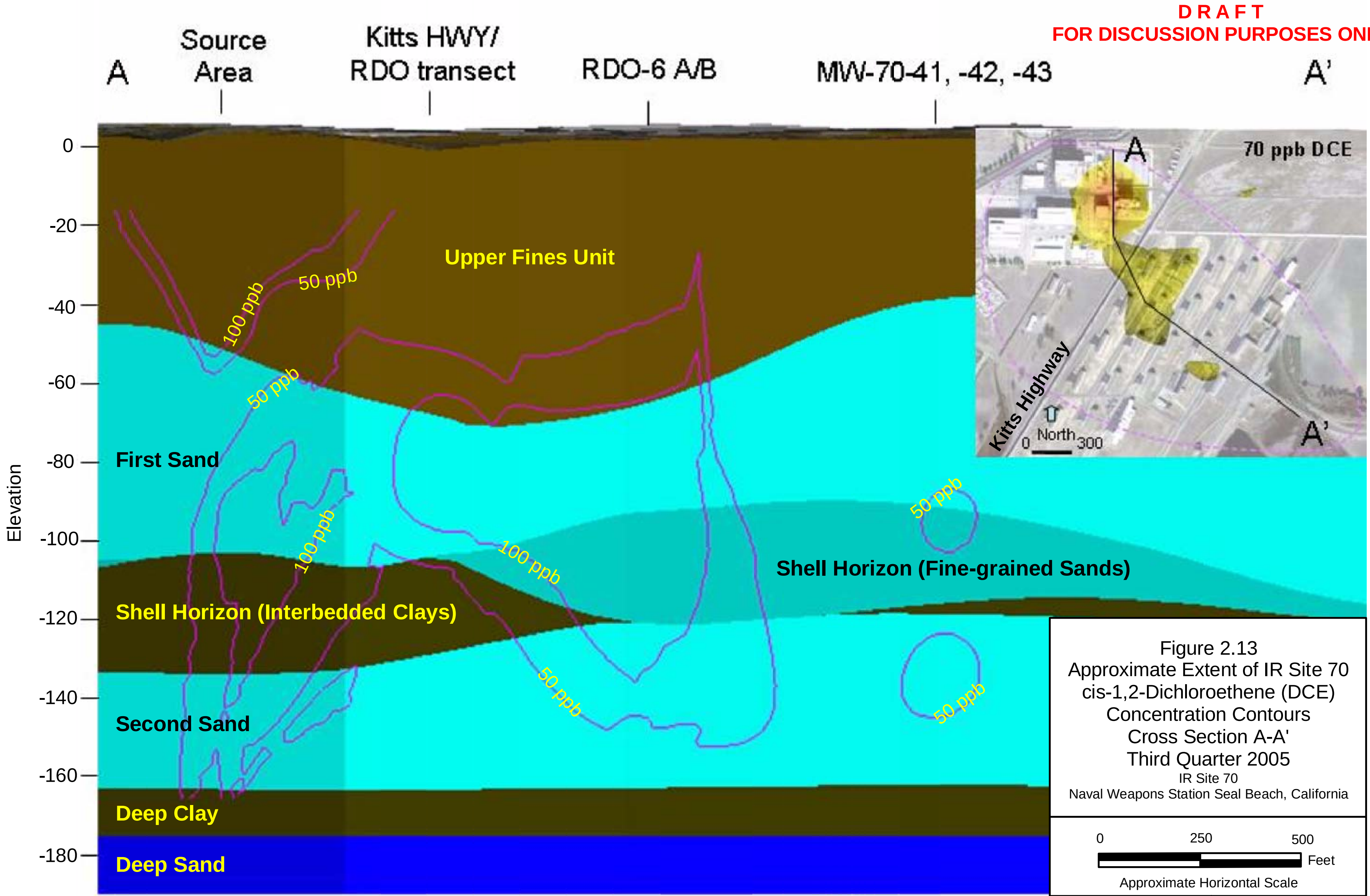

Figure 2.13
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500
Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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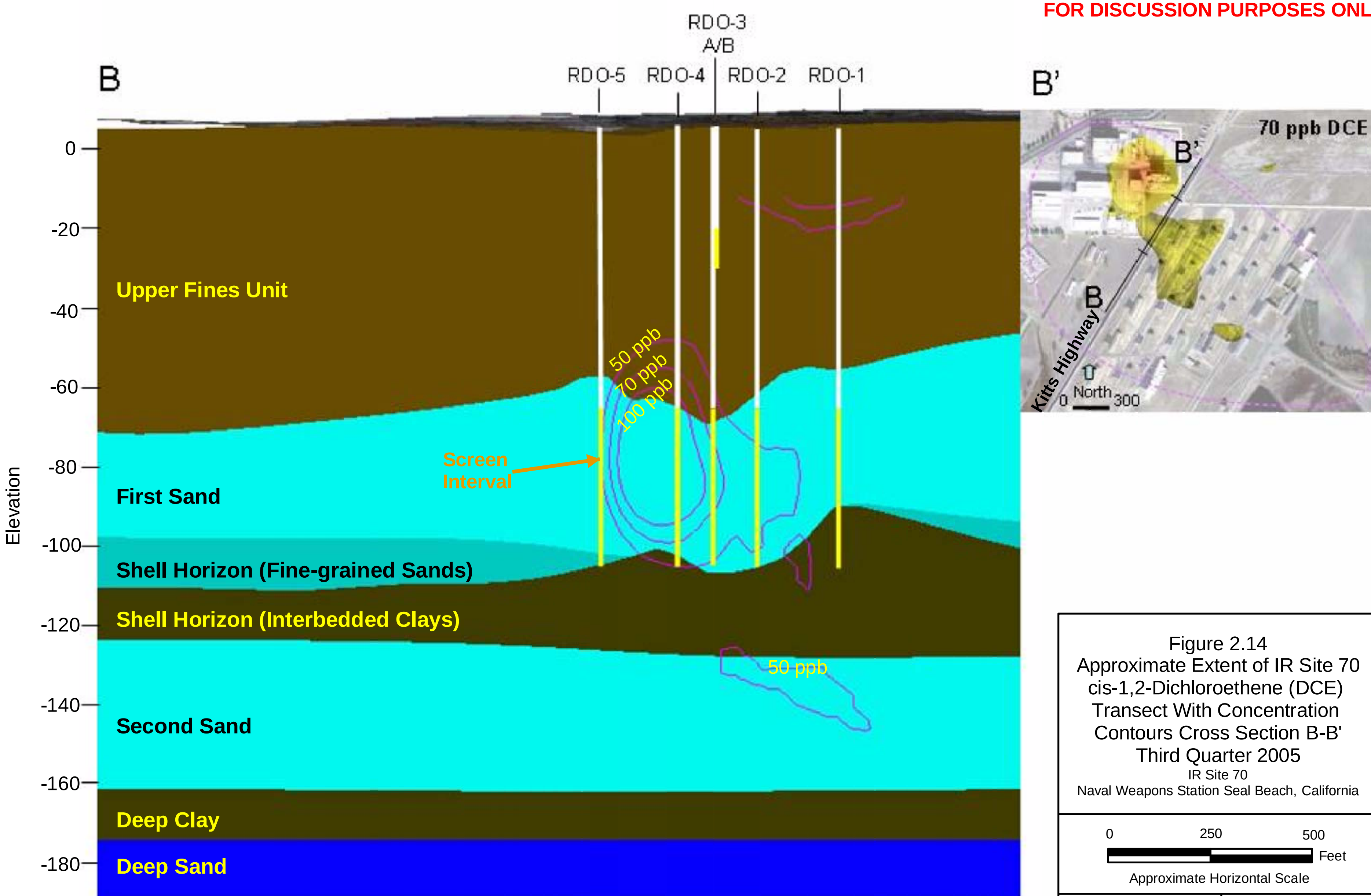

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 2.14
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
Transect With Concentration
Contours Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

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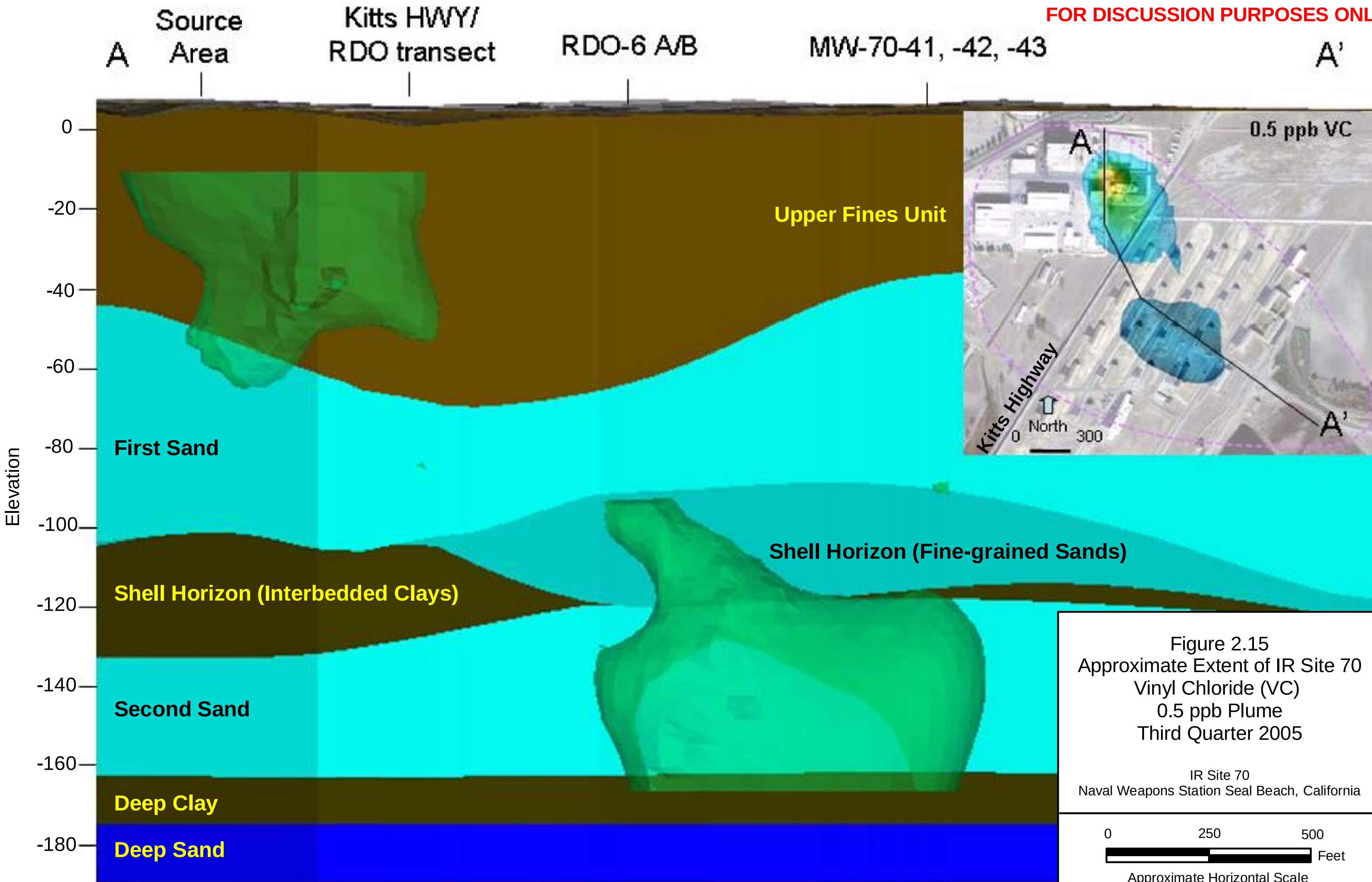

Figure 2.15
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
0.5 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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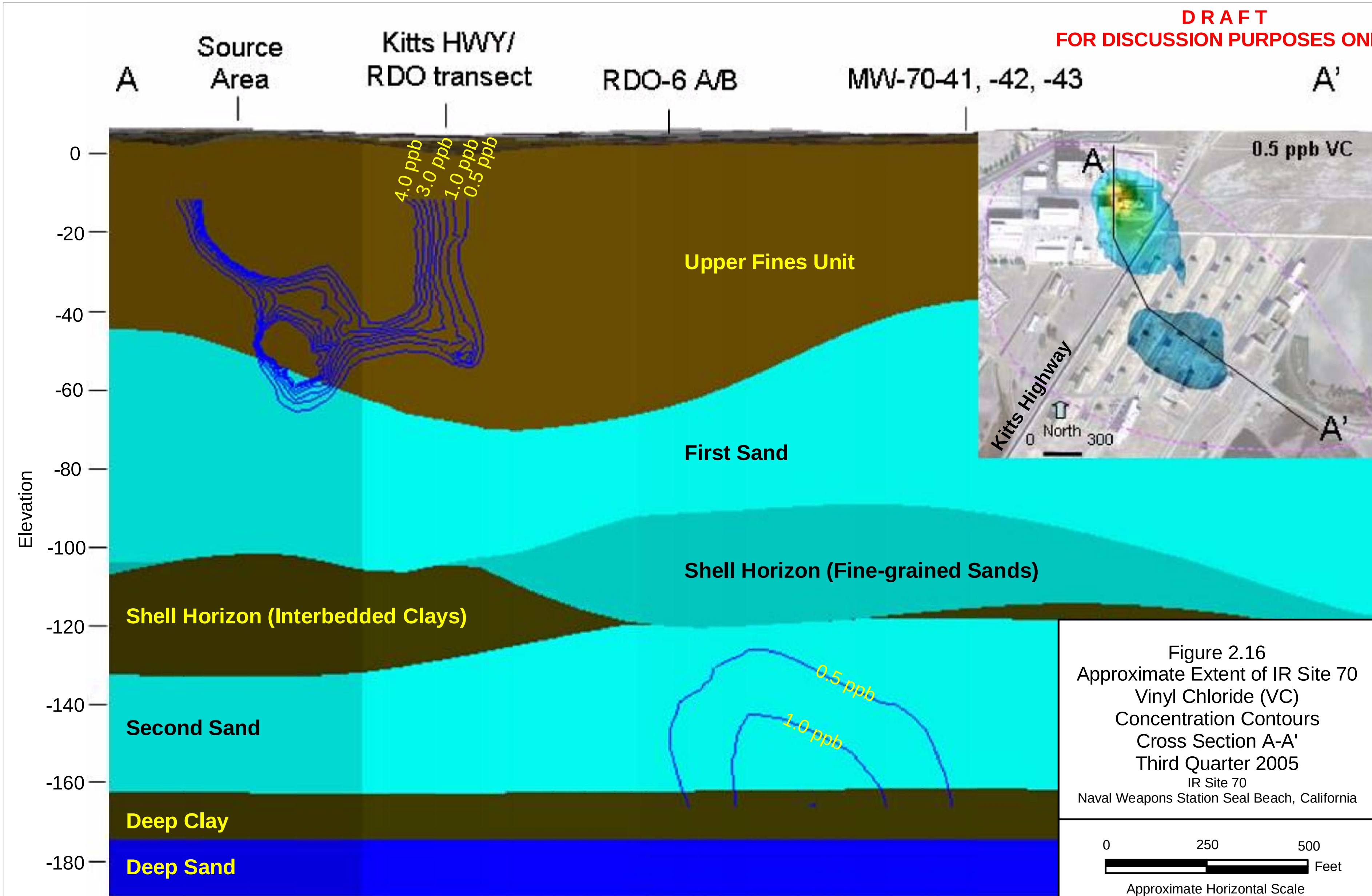

Figure 2.16
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500
Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
Contours in intervals of 0.5 ppb
ppb = parts per billion

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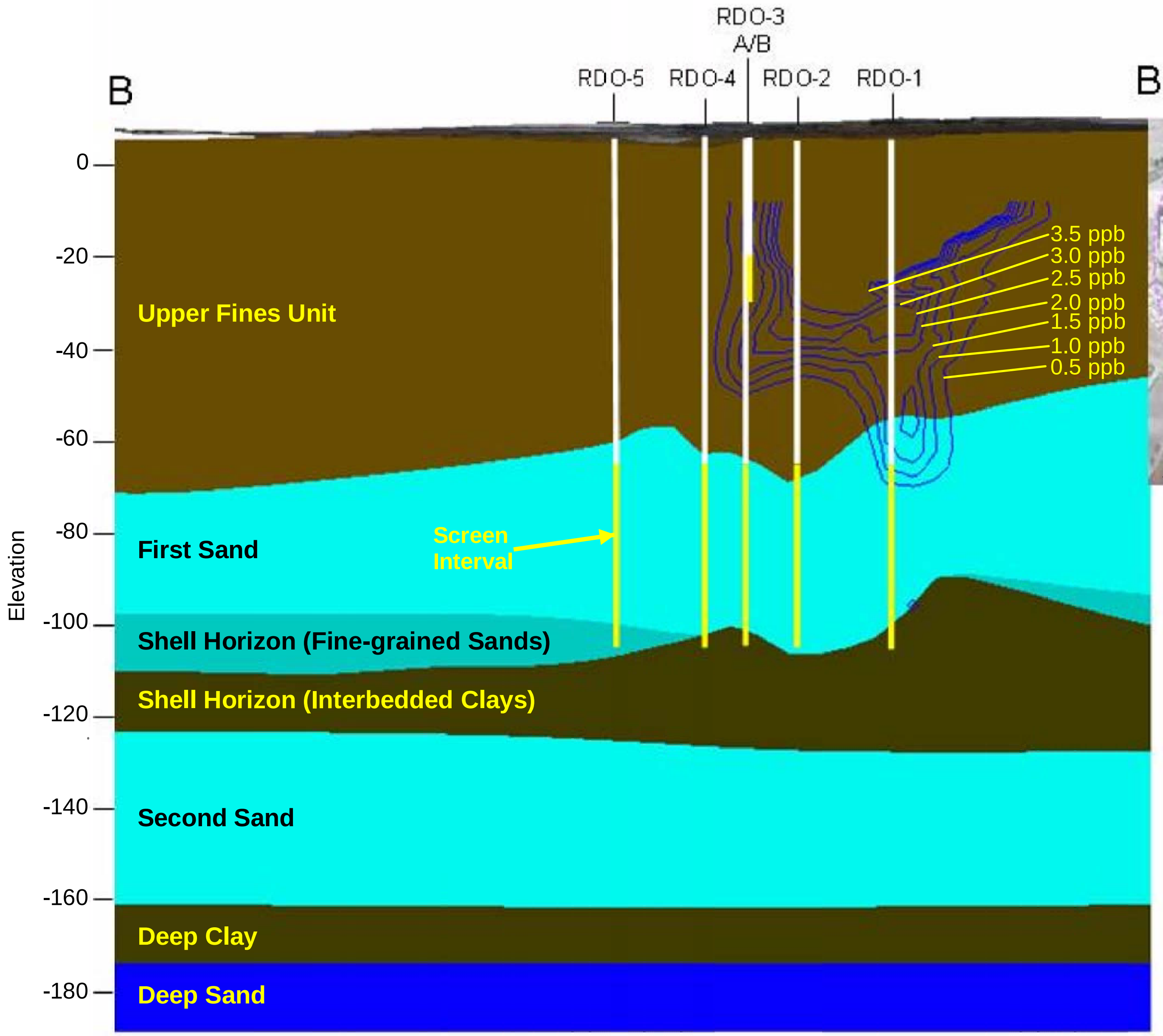

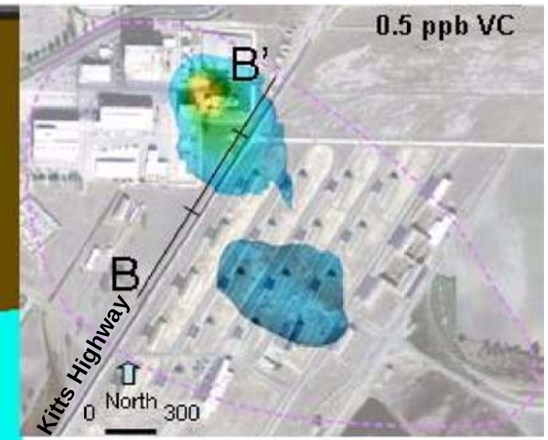

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 2.17
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
Transect With Concentration
Contours Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500
Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

GeoSyntec Consultants

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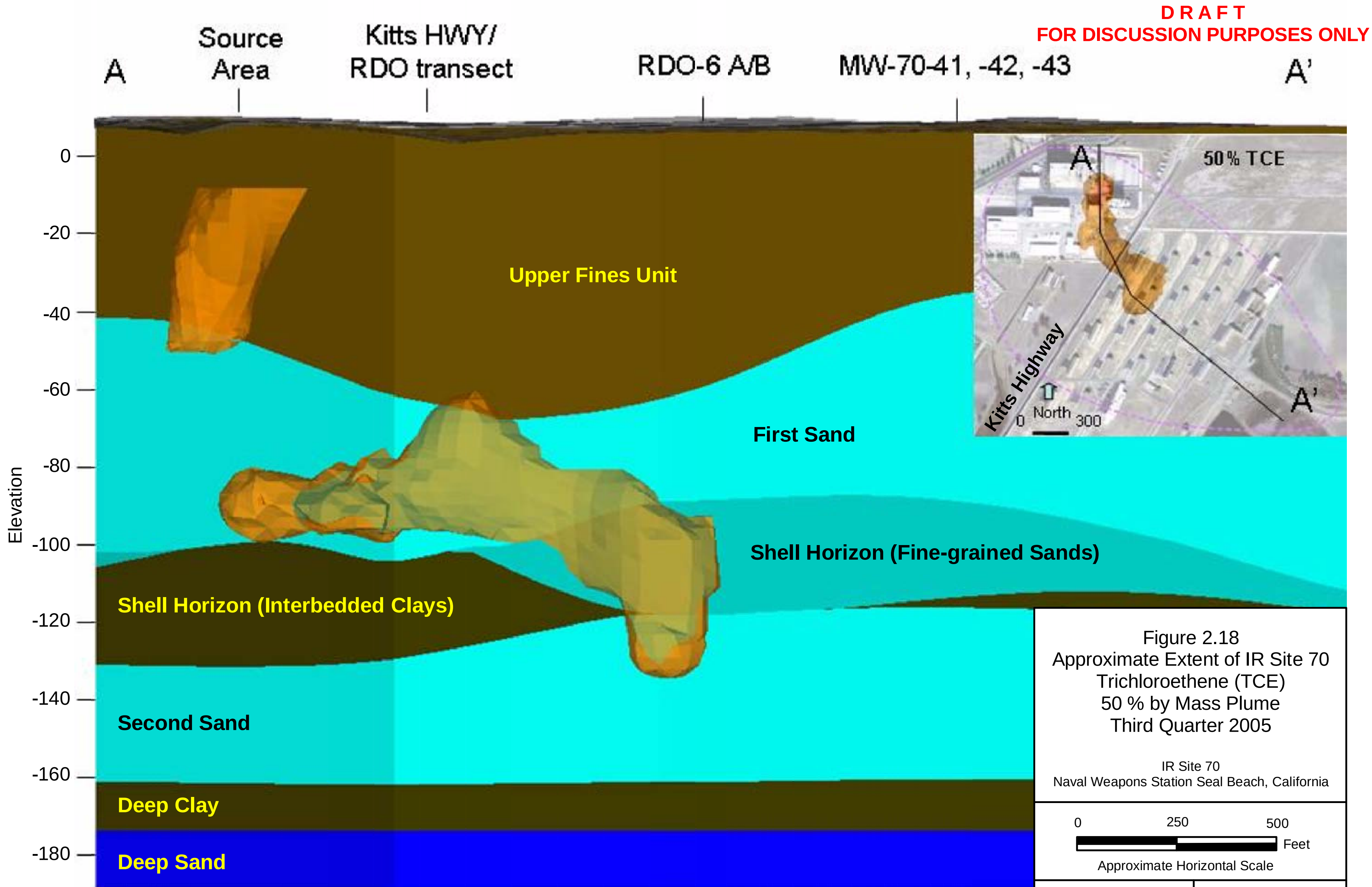

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 2.18
Approximate Extent of IR Site 70
Trichloroethene (TCE)
50 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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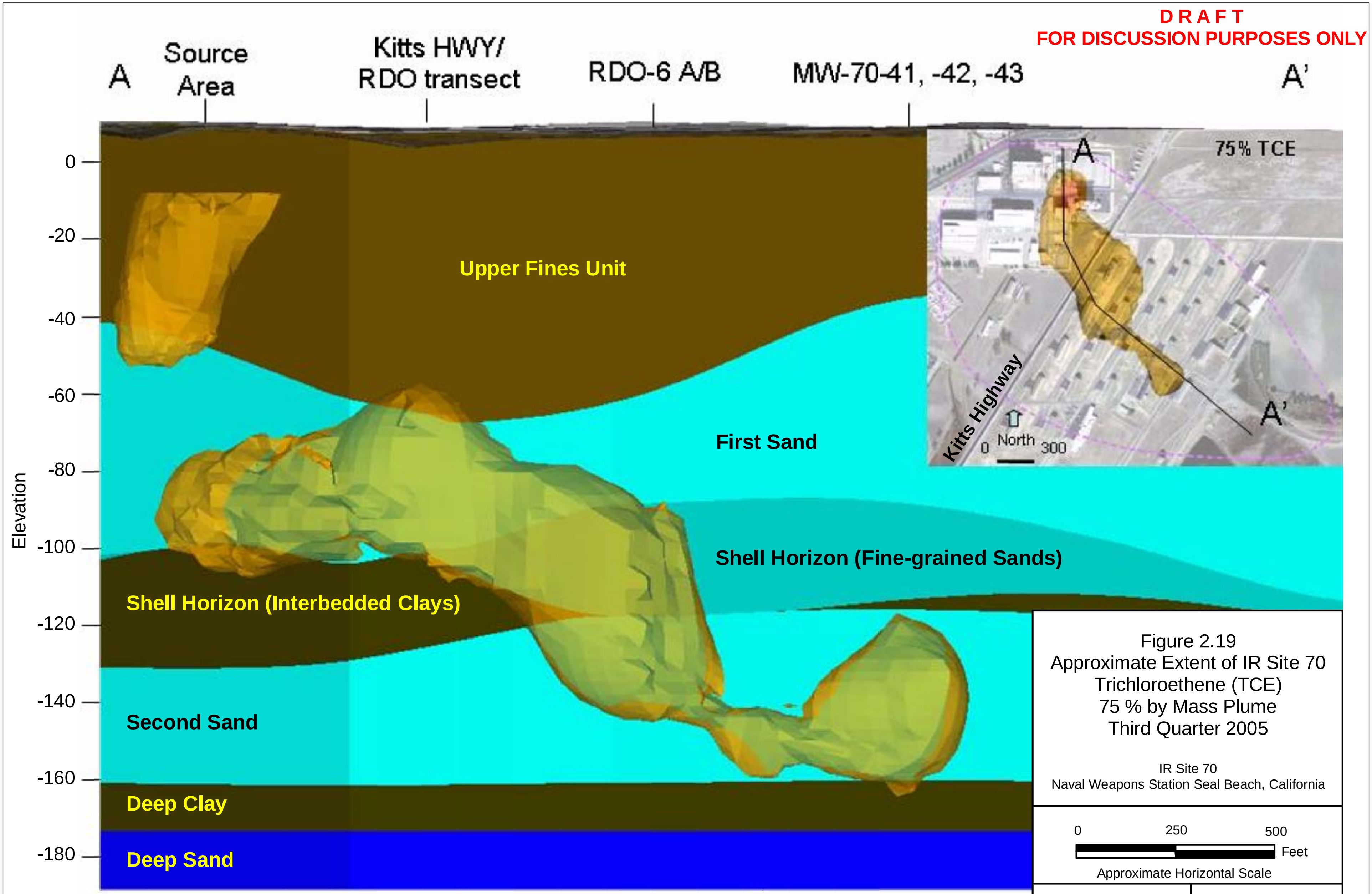

Figure 2.19
Approximate Extent of IR Site 70
Trichloroethene (TCE)
75 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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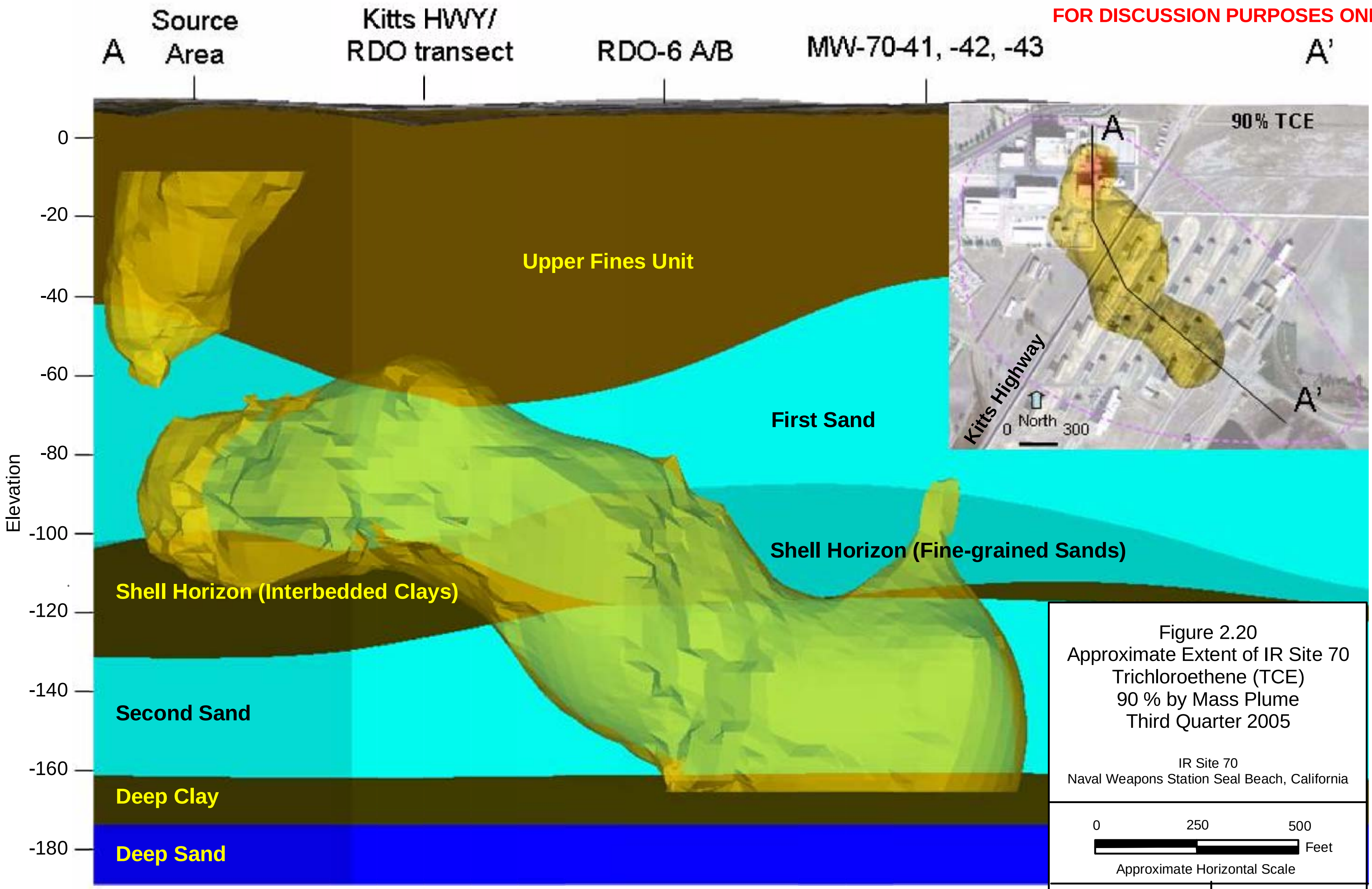

Figure 2.20
Approximate Extent of IR Site 70
Trichloroethene (TCE)
90 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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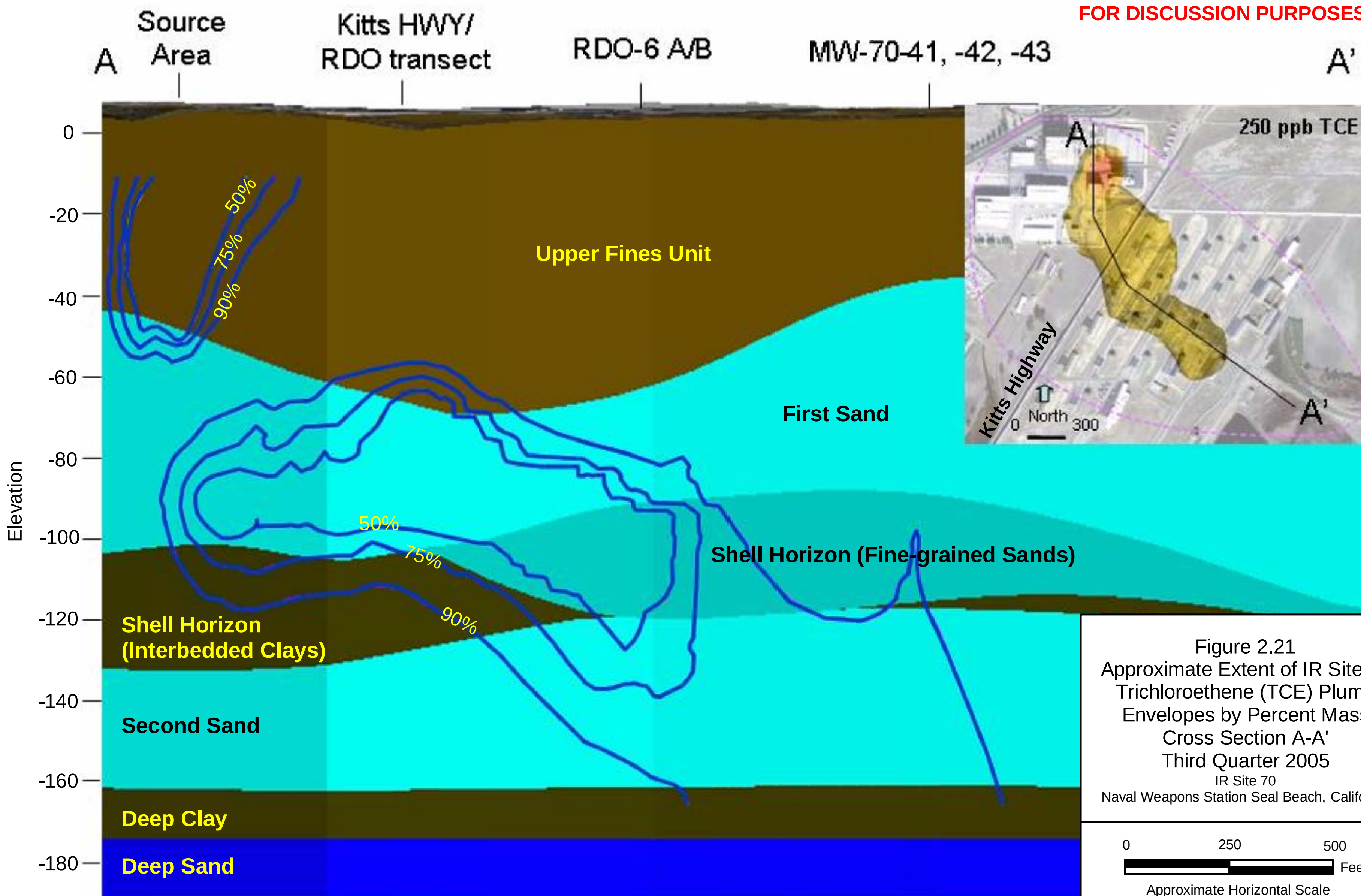

Figure 2.21
Approximate Extent of IR Site 70
Trichloroethene (TCE) Plume
Envelopes by Percent Mass
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)

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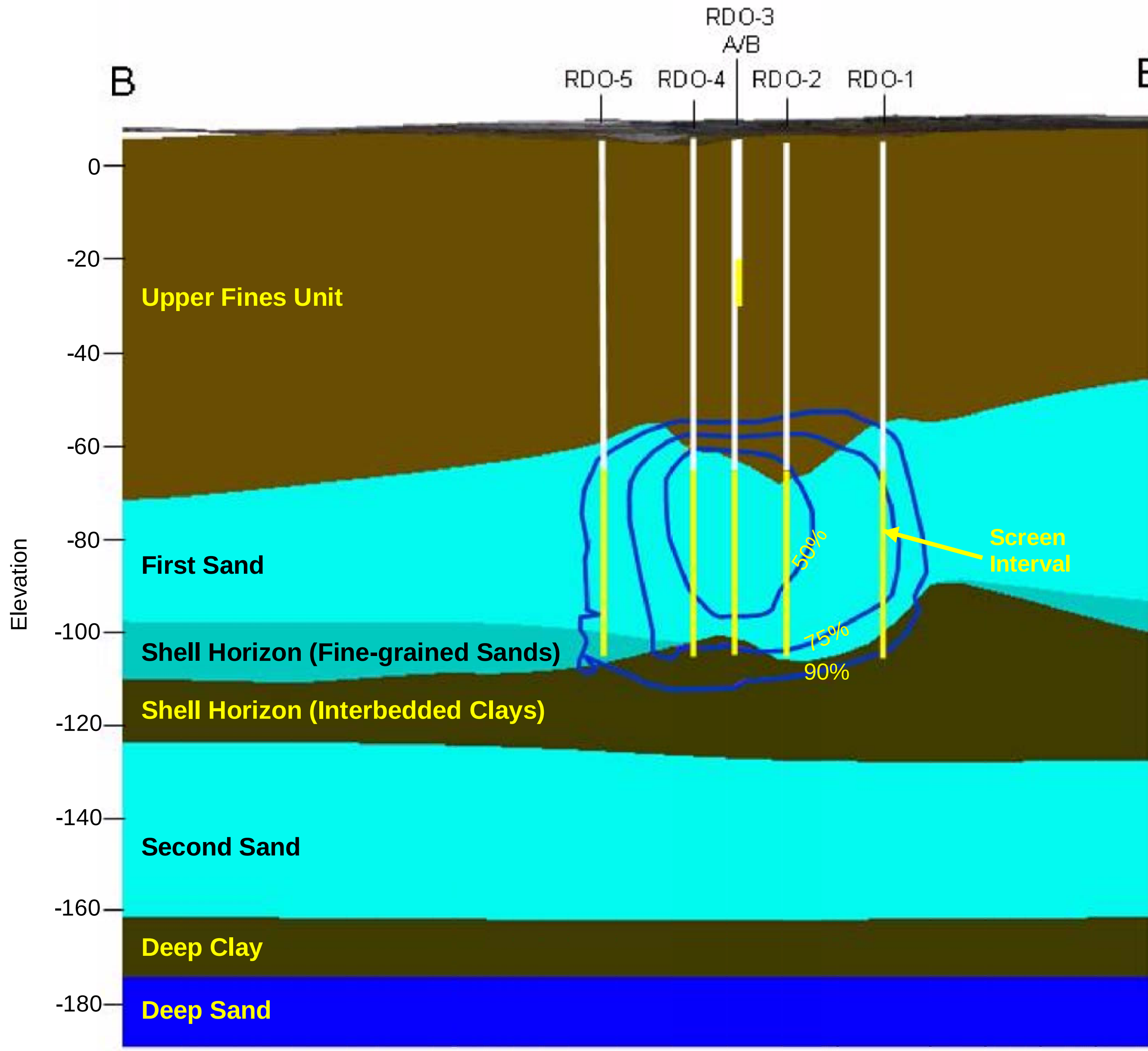

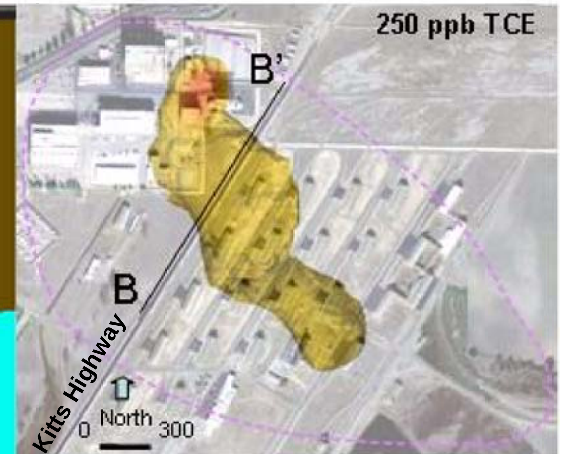

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)

Figure 2.22
Approximate Extent of IR Site 70
Trichloroethene (TCE) Plume
Envelopes by Percent Mass
Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500
Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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Figures 3.1, 4.1 through 4.4

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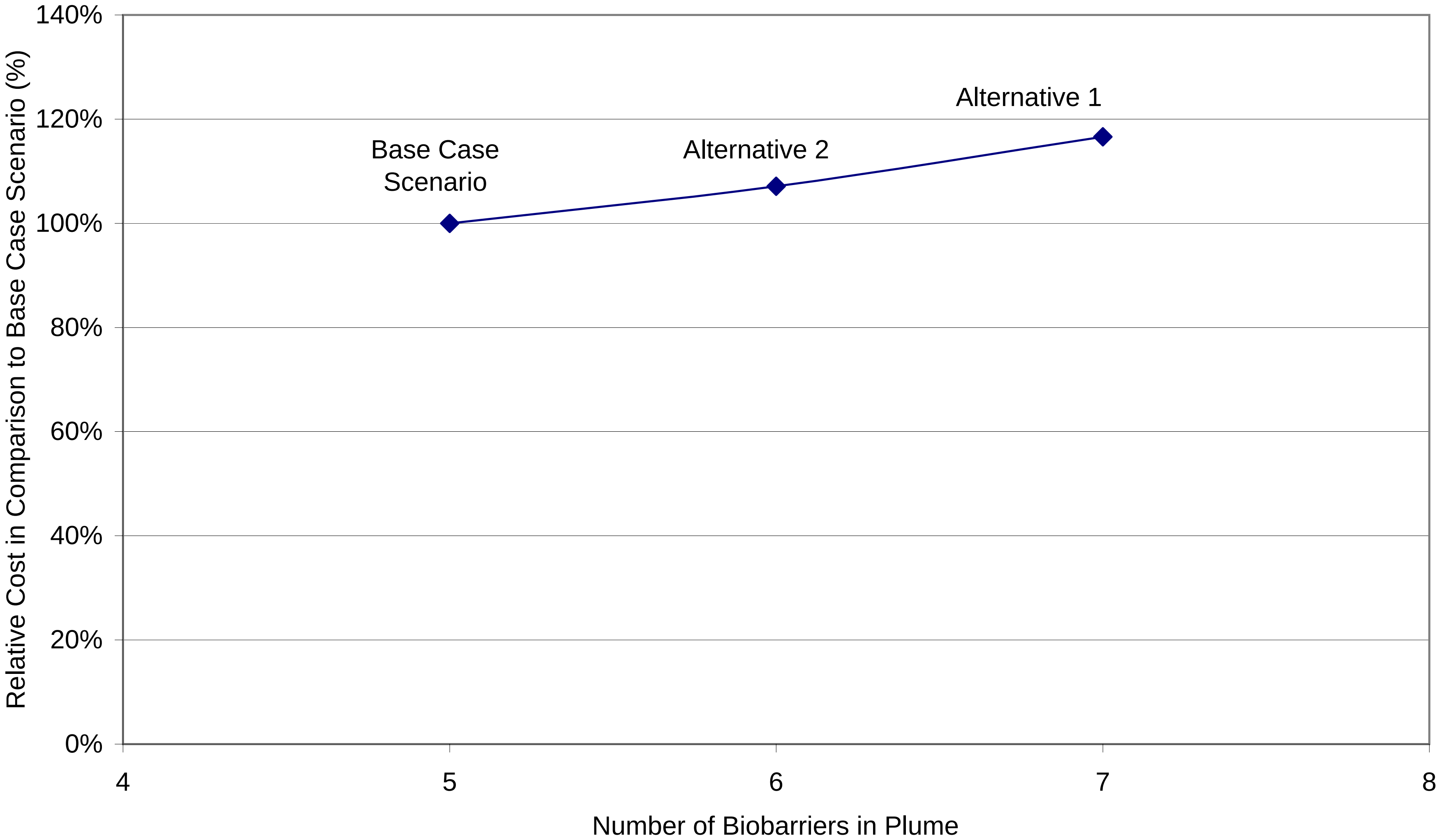

Figure 4.5
Remedial Design Cost Benefit Analysis

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No.: HY0888

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Figure 4.5 - Cost comparison between design options.XLS

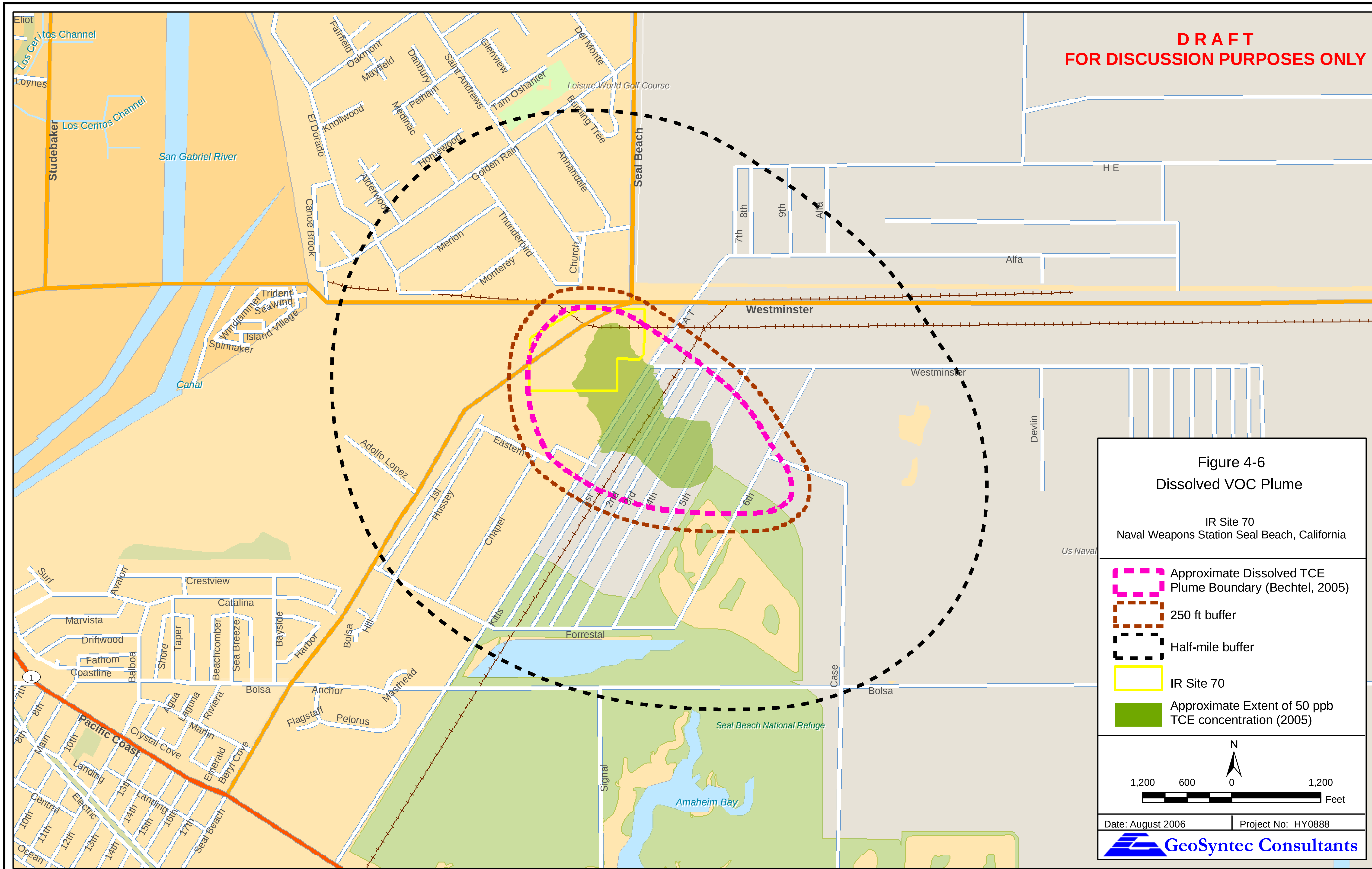

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Figure 4.7

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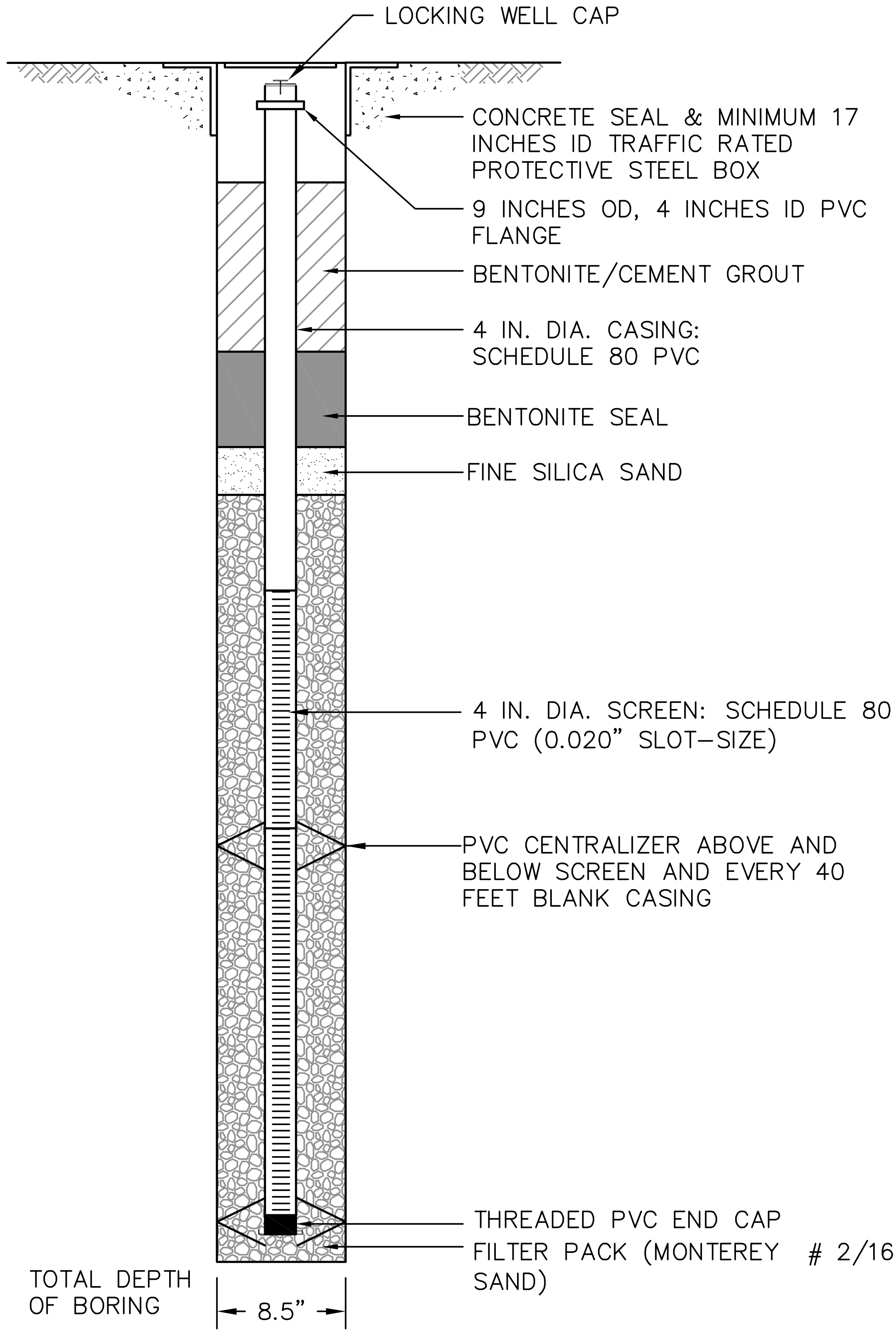

NOTE:

1. FINAL CONSTRUCTION DEPTHS BASED ON FIELD CONDITIONS.

NOT TO SCALE

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WELL CONSTRUCTION DIAGRAM INJECTION WELLS IR SITE 70 NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA	FIGURE NO. 5.1 PROJECT NO. HY0888-06 DOCUMENT NO. DATE: AUGUST 2006

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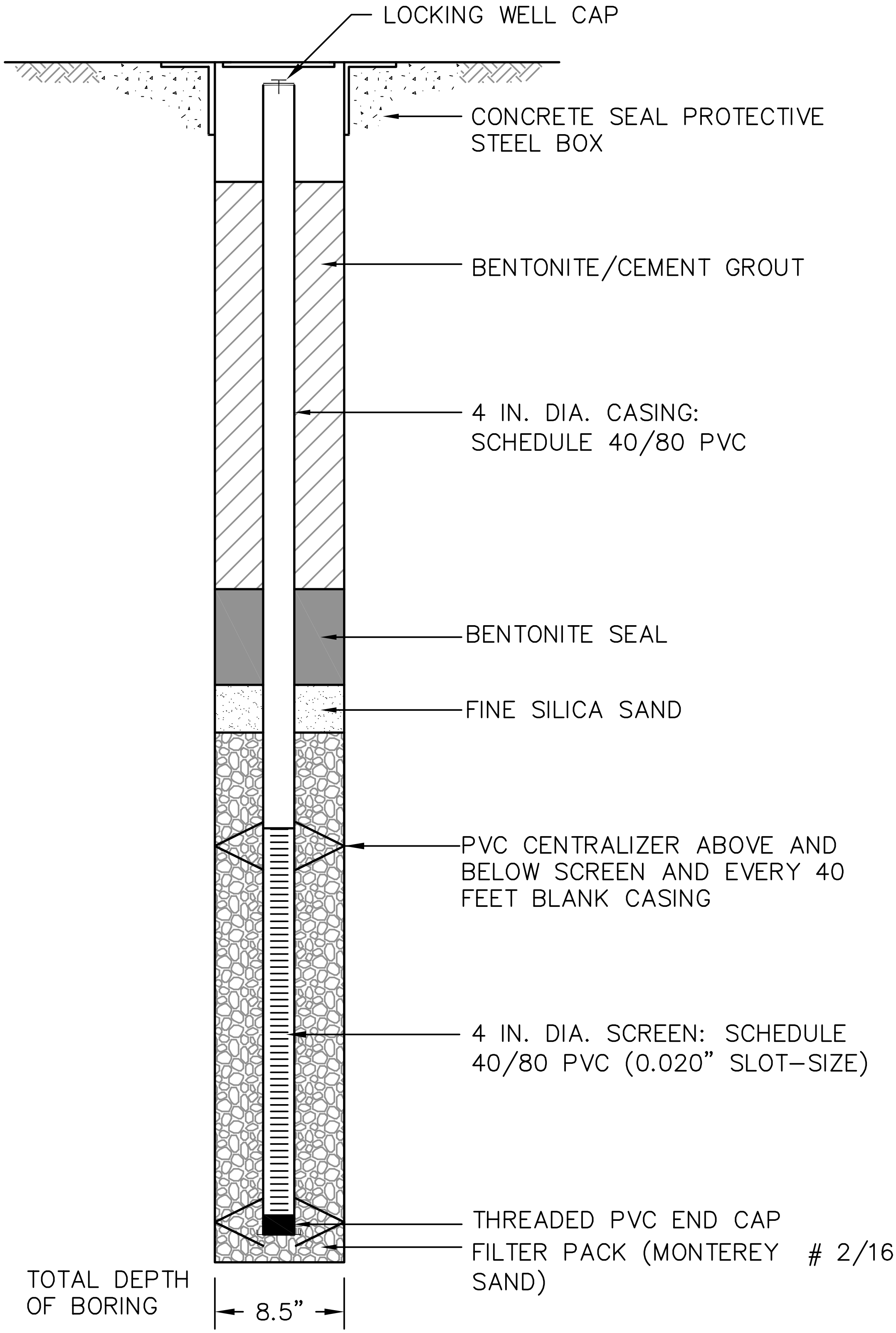

NOTES:

1. FINAL CONSTRUCTION DEPTHS BASED ON FIELD CONDITIONS. ALL DEPTHS IN FEET BELOW GROUND SURFACE.

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WELL CONSTRUCTION DIAGRAM
MONITORING WELLS
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	5.2
PROJECT NO.	HY0888-06
DOCUMENT NO.	
DATE:	AUGUST 2006

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Figures 6.1 through 6.4

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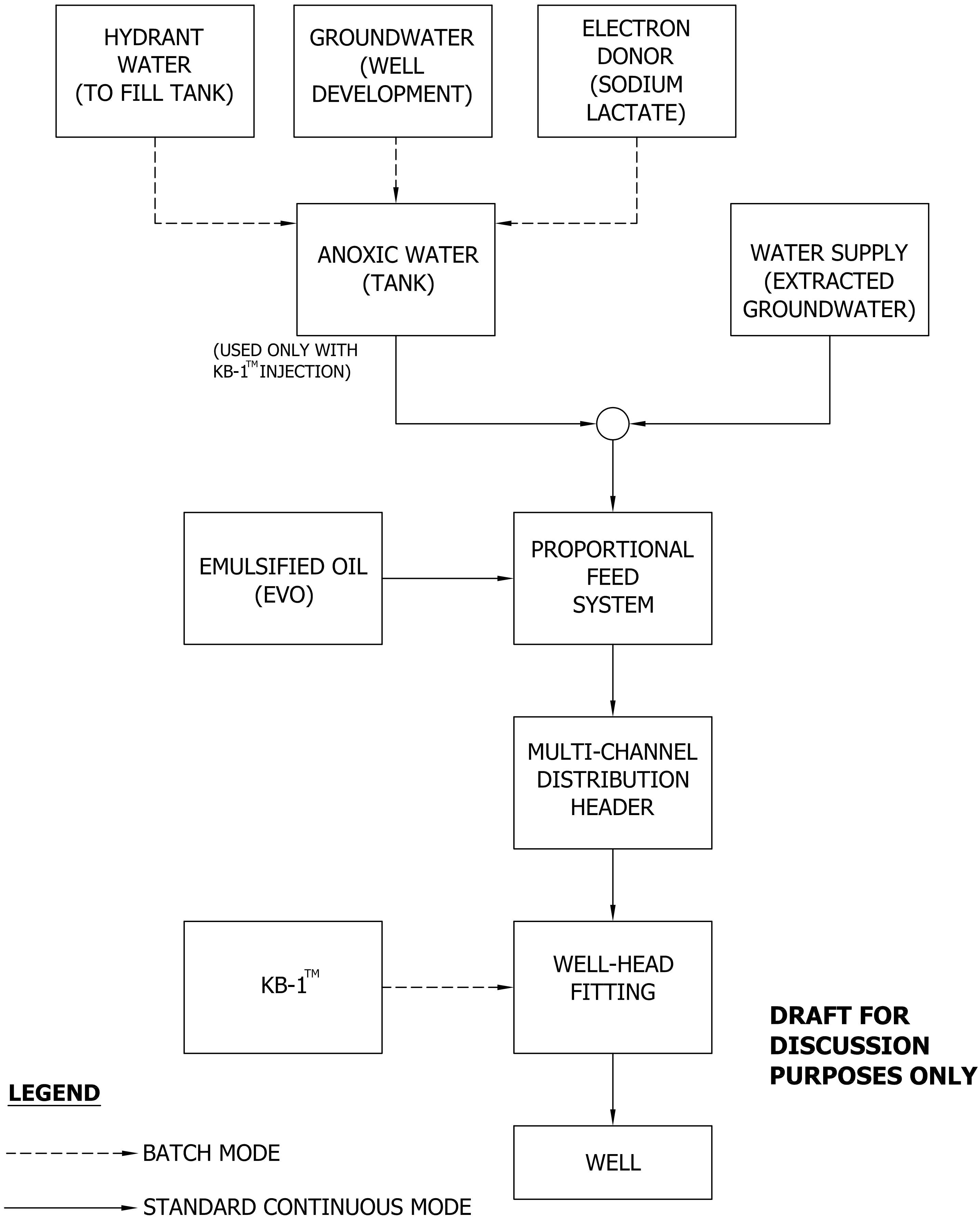

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PROCESS FLOW SCHEMATIC FOR EMULSIFIED OIL INJECTION
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	6.5
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

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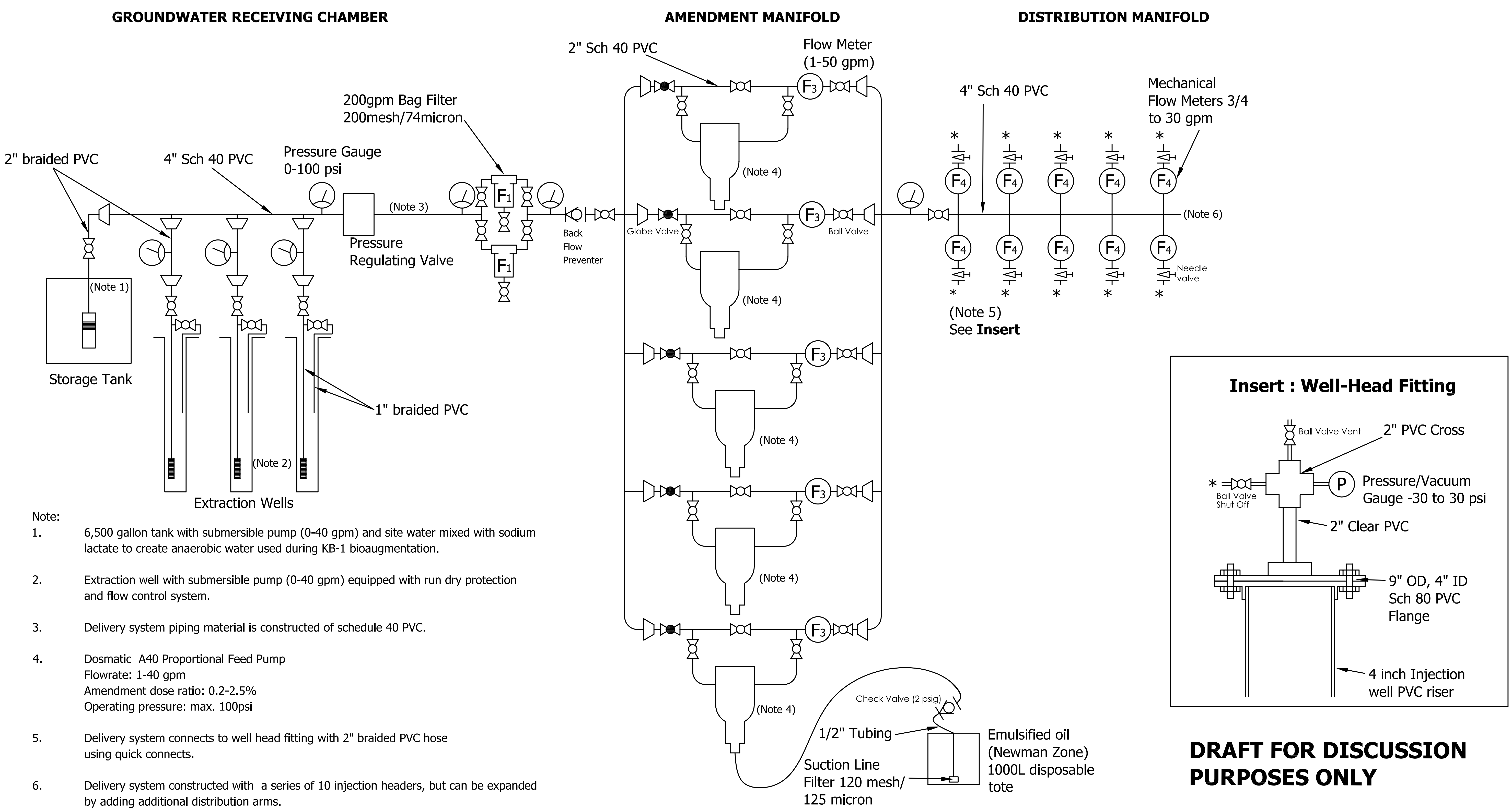

Note:

1. 6,500 gallon tank with submersible pump (0-40 gpm) and site water mixed with sodium lactate to create anaerobic water used during KB-1 bioaugmentation.

2. Extraction well with submersible pump (0-40 gpm) equipped with run dry protection and flow control system.

3. Delivery system piping material is constructed of schedule 40 PVC.

4. Dosmatic A40 Proportional Feed Pump
   Flowrate: 1-40 gpm
   Amendment dose ratio: 0.2-2.5%
   Operating pressure: max. 100psi

5. Delivery system connects to well head fitting with 2" braided PVC hose using quick connects.

6. Delivery system constructed with a series of 10 injection headers, but can be expanded by adding additional distribution arms.

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EMULSIFIED OIL PROPORTIONAL DELIVERY SYSTEM
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	6.6
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

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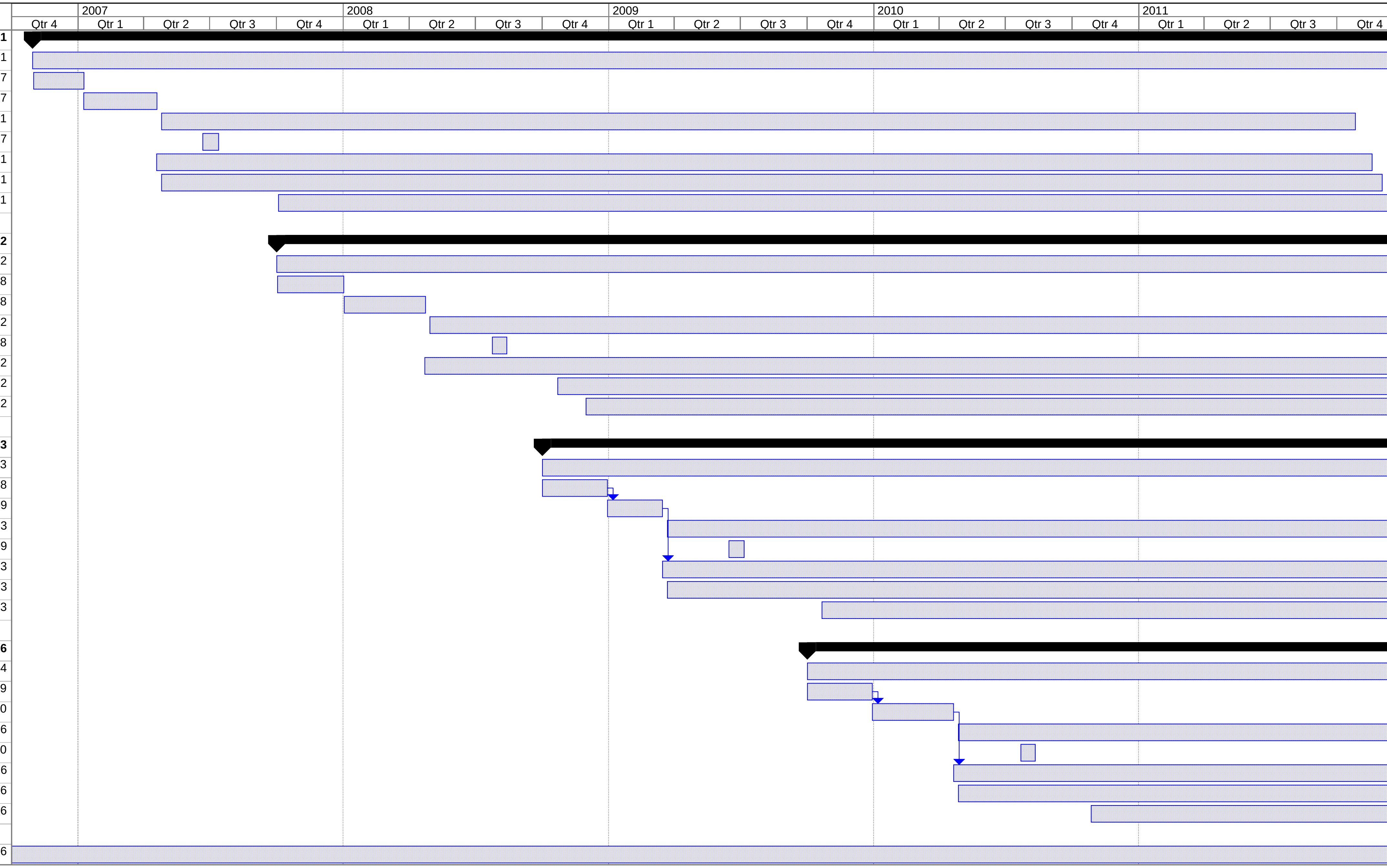
Purposes Only

Figure 8.1
Proposed Project Schedule
IR Site 70
Naval Weapons Station Seal Beach, California

ID	Task Name	Duration	Start	Finish
1	**Phase 1-Source Area**	**1312 days**	**Mon 10/30/06**	**Fri 12/30/11**
2	Task 1-Meetings	1312 days	Mon 10/30/06	Fri 12/30/11
3	Task 2-Pre-Field Activities	45 days	Wed 11/1/06	Tue 1/9/07
4	Task 3-Well Construction	73 days	Mon 1/8/07	Thu 4/19/07
5	Task 4-EVO/KB-1 Injection	1142 days	Thu 4/26/07	Wed 10/26/11
6	Task 5-Demobilization	15 days	Thu 6/21/07	Fri 7/13/07
7	Task 6-Monitoring	1164 days	Thu 4/19/07	Fri 11/18/11
8	Task 7-Data Evaluation	1169 days	Thu 4/26/07	Fri 12/2/11
9	Task 8-Reporting	1065 days	Thu 10/4/07	Wed 12/14/11
10				
11	**Phase 2-First Sand**	**1303.8 days**	**Tue 10/2/07**	**Fri 11/9/12**
12	Task 1-Meetings	1303.1 days	Tue 10/2/07	Thu 11/8/12
13	Task 2-Pre-Field Activities	60 days	Wed 10/3/07	Wed 1/2/08
14	Task 3-Well Construction	80 days	Wed 1/2/08	Wed 4/23/08
15	Task 4-EVO/KB-1 Injection	1152 days	Wed 4/30/08	Thu 11/1/12
16	Task 5-Demobilization	14 days	Fri 7/25/08	Wed 8/13/08
17	Task 6-Monitoring	1162 days	Wed 4/23/08	Thu 11/8/12
18	Task 7-Data Evaluation	1035 days	Thu 10/23/08	Fri 11/9/12
19	Task 8-Reporting	1010 days	Mon 12/1/08	Fri 11/9/12
20				
21	**Phase 3-Second Sand**	**1306.8 days**	**Thu 10/2/08**	**Tue 11/5/13**
22	Task 1-Meetings	1303.3 days	Thu 10/2/08	Wed 10/30/13
23	Task 2-Pre-Field Activities	60 days	Thu 10/2/08	Tue 12/30/08
24	Task 3-Well Construction	52 days	Tue 12/30/08	Mon 3/16/09
25	Task 4-EVO/KB-1 Injection	1189 days	Mon 3/23/09	Mon 11/4/13
26	Task 5-Demobilization	14 days	Tue 6/16/09	Mon 7/6/09
27	Task 6-Monitoring	1113 days	Mon 3/16/09	Fri 7/12/13
28	Task 7-Data Evaluation	1189 days	Mon 3/23/09	Mon 11/4/13
29	Task 8-Reporting	1040 days	Thu 10/22/09	Tue 11/5/13
30				
31	**Phase 4-Shell Horizon**	**1875.8 days**	**Fri 10/2/09**	**Thu 12/29/16**
32	Task 1-Meetings	1314.5 days	Fri 10/2/09	Tue 11/4/14
33	Task 2-Pre-Field Activities	60 days	Fri 10/2/09	Wed 12/30/09
34	Task 3-Well Construction	78 days	Wed 12/30/09	Wed 4/21/10
35	Task 4-EVO/KB-1 Injection	1713 days	Wed 4/28/10	Thu 12/1/16
36	Task 5-Demobilization	14 days	Fri 7/23/10	Wed 8/11/10
37	Task 6-Monitoring	1625 days	Wed 4/21/10	Mon 7/25/16
38	Task 7-Data Evaluation	1713 days	Wed 4/28/10	Thu 12/1/16
39	Task 8-Reporting	1605 days	Thu 10/28/10	Thu 12/29/16
40				
41	Task 9-Project Management	2636 days	Mon 10/2/06	Thu 12/29/16



Project: Figure 8.1.mpp
Date: Wed 3/29/06

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

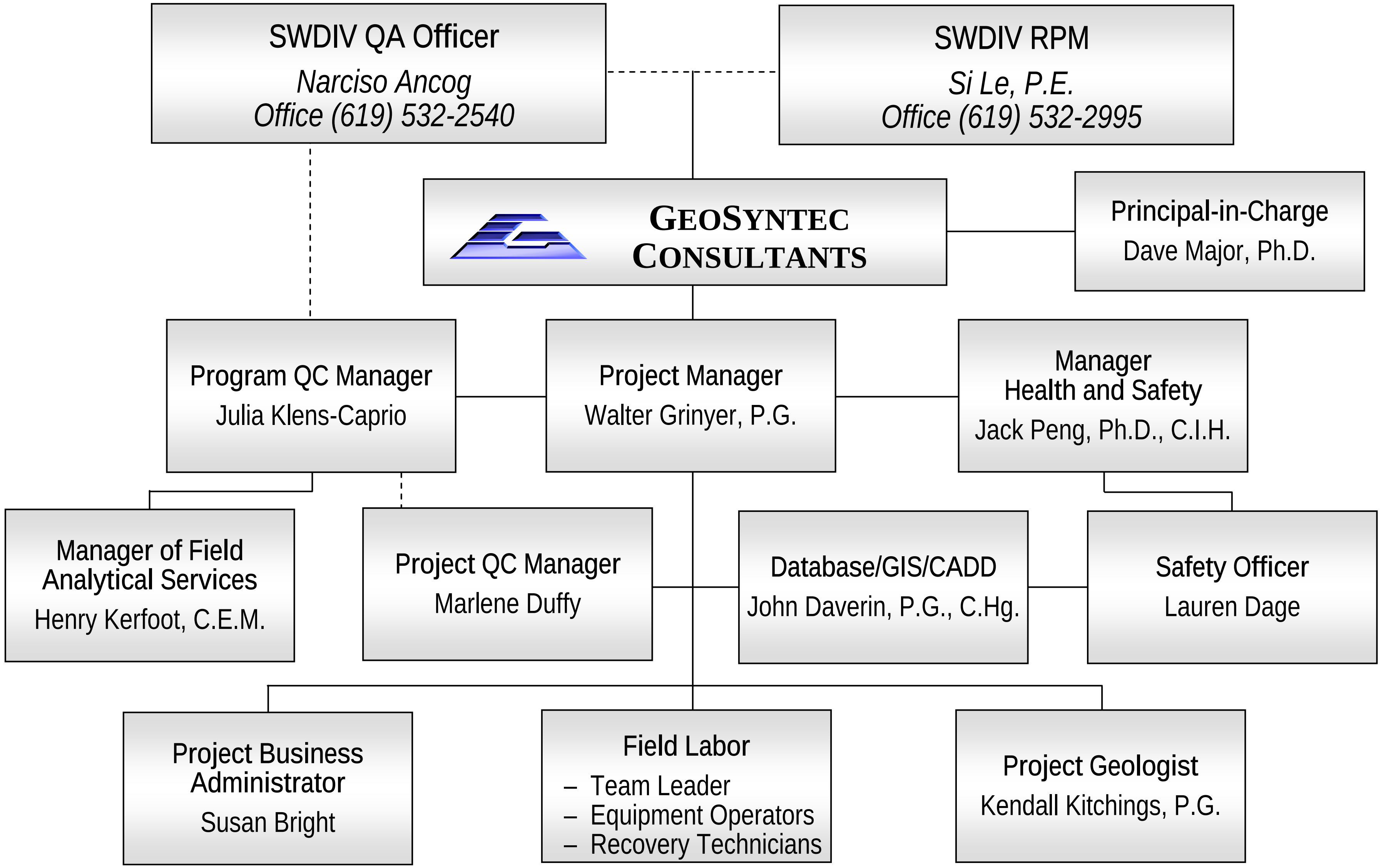


FIGURE 8.2
Project Organization Chart
IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

HY0888\Figure 1-4 Org Chart.ppt

Appendix A

Details of Numerical Modeling

Prepared by:

GEOSYNTEC CONSULTANTS
130 Research Lane, Suite 2
Guelph, Ontario N1G 5G3

GeoSyntec Project Number HY0888.06

2006.02.28

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ACRONYMS

BNI	Bechtel National Inc
cis-1,2-DCE	cis-1,2-dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquid
ERSE	Extended Removal Site Evaluation
EVO	Emulsified Vegitable Oil
EVS	Environmental Visualization Systems
FS	First Sand
IR	Installation Restoration
MCLs	Maximum Contaminant Limits
MNA	Monitored Natural Attenuation
MODFLOW2000	Modular Three-dimensional Groundwater Flow Model 2000
MSL	Mean Seal Level
MT3D99	Multi-species Transport in Three-dimensions
ppb	parts per billion
RDO	Remedial Design Optimization
ROI	Radius of Influence
TCE	trichloroethylene
VC	vinyl chloride
VOCs	Volatile Organic Compounds
WHI	Waterloo Hydrogeologic Inc.
NGVD	National Geodetic Vertical Datum

APPENDIX A: DETAILS OF NUMERICAL MODELING

A.1. INTRODUCTION

This Appendix provides a description of the numerical groundwater flow and transport model that was developed to aid optimization of the design of the bioremediation program for treatment of the dissolved phase plume at Installation Restoration (IR) Program Site 70. Groundwater Flow and Transport models are useful tools to allow scientists and engineers to simulate future conditions at a site. Models are capable of taking into account numerous variables in three dimensions and, through an iterative process utilizing complex algorithms, can produce simulations of future contaminant concentrations. A modeling process was implemented for the design phase of the remediation system due to the complexity of the site conditions at IR Site 70 and the number of possible permutations needing assessment.

The model was utilized to determine the optimum physical dimensions, location, number, and operational longevity of the biobarriers to be placed on Site. The model incorporates the currently known extent of TCE impacted groundwater and is based upon the assumption that source area treatment is completed (i.e., that no DNAPL, sorbed phase or dissolved phase TCE remained in the source area following source area treatment) prior to the start of the optimization simulations without any change in the known extents of TCE impacted groundwater. This assumption is not unreasonable given the presence of the Source Containment Biobarrier (see Section 4.3.1.1 for details), which will mitigate any further mass contribution to the plume from the source area.

The numerical model was based upon the Site conceptual model presented in the Pilot Study Appendix of the Remedial Design (GeoSyntec, 2006). Sections A.2 and A.3 provide overviews of the conceptual and numerical models, respectively. Section A.4 presents the numerical model calibration, and Section A.5 contains a discussion of the results of the design optimization simulations along with the degree and significance of uncertainties in the model. Section A.6 provides a summary of limitations inherent with the modeling process.

A.2. SITE CONCEPTUAL MODEL

Section 2.5 provides details on the current Site conceptual model. A summary of the information relevant to the development of the numerical model is provided below. Results of the Extended Removal Site Evaluation [ERSE; Bechtel National Inc. (BNI), 1998] and subsequent investigations (GeoSyntec, 2006) have shown that volatile organic compounds (VOCs), primarily trichloroethene (TCE), have migrated downward through the shallow stratigraphic units into deeper zones. The highest VOC concentrations in groundwater are located in the Upper Fines Unit in the source area, but VOCs are also present downgradient at lower concentrations in the underlying First Sand, Shell Horizon and Second Sand Units. The deeper portion of the plume, in the First Sand, Shell Horizon and Second Sand Units, has migrated beyond IR Site 70. The conceptual model and the subsequent numerical model focus on the area of the plume within and beyond IR Site 70 and includes stratigraphic units where VOCs have been consistently detected.

A.2.1 Hydrogeology

A.2.1.1 Aquifer System

The site-specific hydrogeologic units are shown in Figure 2.4 (Section 2.5.1). The units include the Upper Fines, the First Sand, the Shell Horizon (Fine-grained Sands), the Shell Horizon (Interbedded Clays), the Second Sand, the Deep Clay, and the Deep Sand Unit. The Upper Fines Unit comprises three zones: a shallow zone of surficial soils and recent clayey sediments; an intermediate zone of interbedded silts, clays, and sandy silts, and clays that includes the semi-perched zone; and a lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands. Coarser-grained soils (sand and silty sand) dominate the First Sand Unit, Shell Horizon (Fine-grained Sands), and Second Sand Unit. The Shell Horizon transitions from interbedded clays, silts, fine-grained sands and shell layers to a predominantly fine-grained sand between RDO-3A/B and RDO-6A/B (GeoSyntec, 2006). The Deep Clay Unit is a locally continuous layer composed of interbedded fine-grained material (clay and silt) (Geosyntec, 2006). The Deep Sand is similar in character to the Second Sand Unit (GeoSyntec, 2006). A more detailed description of Site geology is presented in Section 2.5.1. The water table is located in the Upper Fines Unit (BNI, 2000).

A.2.1.2 Hydraulic Properties and Boundaries

A 5-day pumping test and a 3-month pilot test were performed using well EW-70-01, screened in the Upper Fines Unit (BNI, 1991a,b). A step-discharge pumping test was performed in wells screened within the upper portion of the First Sand Unit, and slug tests were performed in the middle and lower portions of the First Sand Unit, and within the Second Sand Unit (BNI, 1999a). The aquifer parameters measured in these tests that were used in the numerical model are listed in Table A.1.

Natural hydrogeologic boundaries within or adjacent to the Site appear to be absent with the exception of a wetland area to the southeast of the Site. Regional hydrogeologic boundaries beyond the study area (e.g., groundwater divide, river, or ocean) are sufficiently distant from IR Site 70 such that they are unlikely to affect the model development for IR Site 70 (BNI, 2000).

A.2.1.3 Sources and Sinks

Recharge from precipitation infiltrating within IR Site 70 is expected to be small due to land use at the Site. Recharge beyond IR Site 70 is possible in areas of bare soil and unlined stormwater channels, most significantly in areas of agricultural irrigation and domestic lawn watering (BNI, 2000).

Groundwater discharge occurs at water supply wells that were identified in the ERSE Report (BNI, 1998). These supply wells are located beyond IR Site 70, but within the Navy property, and are screened below the Deep Clay Unit identified at IR Site 70 (BNI, 1998).

Water level data collected during the ERSE investigation (BNI, 1998), EW-70-01 pumping test (BNI, 1999a), and EW-70-01 pilot test (BNI, 1998b) indicate seasonal water level fluctuations within a range of approximately 7 feet or more at monitoring wells in the Upper Fines Unit, First Sand Unit, and Second Sand Unit. Potentiometric head differences between the Upper Fines Unit and the First Sand Unit range from an average of 0.2 ft near the source area to an average of 2.0 ft in downgradient areas near the toe of the plume. Head differences between the First and Second Sand Units are much less and typically average around 0.4 ft near the toe of the plume (GeoSyntec, 2006).

The horizontal hydraulic gradient is generally south-southeasterly within the Upper Fines and First Sand Units, and trends to the southeast in the Second Sand Unit (Geosyntec, 2006). A discussion of the magnitude, direction and variability of hydraulic gradients is presented in Section 2.5.3.

A.2.2 Plume Interpretation

The spatial distribution of contaminants at IR Site 70, based on groundwater sampling data collected during the 3rd quarter 2005 groundwater sampling event and the PILOT STUDY activities, was interpolated and visualized by GeoSyntec using the kriging algorithm in C Tech’s Environmental Visualization Systems (EVS) software (GeoSyntec, 2006). Figure 2.5 shows the distribution of sampling locations for the data included in the dataset, including well screen interval depths. The contaminant distribution at IR Site 70, based upon the interpretation of these data, is illustrated in Figures 2.6 to 2.22 and is discussed in Section 2.5.5. These figures show high TCE concentrations (>1,000 µg/L) near the source area and a dissolved phase plume extending to the south-southeast.

A.3. NUMERICAL MODEL DEVELOPMENT

This section describes the modeling codes, grid design, layer discretization, hydraulic properties, and transport properties that comprise the numerical model used for the optimization modeling of the plume full-scale bioremediation design. The flow model properties are summarized in Table A.1, and the transport model properties are summarized in Table A.2.

A.3.1 Modeling Codes

The groundwater flow and transport modeling codes used to simulate the plume bioremediation design options were Modular Three-dimensional Groundwater Flow Model 2000 (MODFLOW2000) (Harbaugh et al., 2000) and Multi-species Transport in Three-dimensions (MT3D99) (Zheng, 1999), respectively. The groundwater transport modeling code MT3D99 simulates advection, dispersion, and decay of contaminants in three dimensional (3-D) flow systems, and also simulates the sequential decay of TCE through cis-1,2-dichloroethene (cis-1,2-DCE), vinyl chloride (VC), ethene and chloride through reductive dechlorination. MT3D99 is designed to be used in conjunction with a block-centered finite difference flow model such as MODFLOW2000. Both codes were operated *via* Waterloo Hydrogeologic's (WHI) graphical user interface Visual MODFLOW, Version 4.1.

A.3.2 Model Domain, Grid, and Boundary Conditions

A.3.2.1 Model Domain

The active modeling domain was centered over the geographic centroid of the plume and extends horizontally 5,600 feet by 5,600 feet and by approximately 200 feet vertically. A much larger domain was originally generated; however, the domain outside this local area of interest was set to 'inactive', so as to focus the simulations on the fate and transport of TCE impacted groundwater in the immediate vicinity of IR Site 70 (see Figure A.1). The domain was rotated approximately 120 degrees from north to align the grid with the major groundwater flow direction in the Second Sand unit.

A.3.2.2 Model Grid

A variable grid size approach was utilized to refine the model in the areas of greatest interest. A horizontal grid cell size of 10 feet by 10 feet was used in the vicinity of biobarriers. A grid cell size of 20 feet by 20 feet was used elsewhere throughout the delineated plume area. Due to model software constraints, incremental grid refinements are necessary so as not to introduce artificial instabilities to the model; therefore, the grid spacing was increased to 80 feet and then to 280 feet approaching the model boundaries. The active model domain and horizontal grid is shown in Figure A.1.

The model horizontal domain was designed to include the current known location of the dissolved phase TCE plume. Water supply wells, surface water bodies, injection wells, etc. in the vicinity of the Site were included implicitly as part of the boundary conditions applied along the edges of the active model domain. Navy Water Wells Nos. 2, 3 and the City of Seal Beach Well SB-7, which are located in the model domain, are inactive and were thus not simulated in the model.

The vertical model domain was discretized to seven layers representing the seven hydrogeologic units from the Upper Fines Unit to the Deep Sand Unit, as shown in Figure A.2. The shallow, intermediate and deep zones of the Upper Fines Unit were combined into a single model layer (Layer 1), representing the Upper Fines. The First Sand, Second Sand, Deep Clay and Deep Sand were each represented by single model layers (Layers 2, 5, 6 and 7). The Shell Horizon was subdivided into the Shell Horizon (Interbedded Clays; Layer 4) and Shell Horizon (Fine-grained Sands; Layer 3). The bottom of the Deep Sand Unit was a no-flow boundary for the model. The layer thicknesses were variable and set according to the Site conceptual model (GeoSyntec, 2006). Figure A.2 illustrates generalized vertical locations and thicknesses of the seven model layers.

A.3.2.3 Boundary conditions

A recharge boundary condition was applied to the upper layer of the model. An average recharge value of 10% of the annual average precipitation rate, equivalent to 1.38 inches per year (35 mm/year), was calculated through the analysis of 15 years of precipitation data collected in Long Beach by the University of California, Agriculture and Natural Resources Department, similar to the model used for the Feasibility Study (FS; BNI, 2000).

Boundary conditions along the four sides of the model were represented by a line of constant head cells in the Upper Fines, First Sand, and Second Sand layers. The value (or values trending linearly, where applicable) of the constant-head boundaries were selected to simulate average gradients across the Upper Fines, First Sand, Shell Horizon (Fine-grained Sands), and Second Sand Units that match the average yearly groundwater flow field, with respect to hydraulic gradient (both horizontal and vertical) direction and magnitude, and the absolute water level elevation value as discussed in more detail in Section 2.5.3. The MODFLOW2000 water budget from the final model calibration simulation indicates that the constant head boundaries chosen lead to reasonable simulated groundwater flow rates across the Site.

A.3.3 Flow Model Properties

The flow model layer properties that most significantly affect most model simulations are the following:

- Horizontal hydraulic conductivity;
- Vertical hydraulic conductivity;
- Specific yield (for the water-table layer 1); and
- Specific storage (for confined layers 2 through 7)

The property values used in the model are summarized in Table A.1. The majority of model parameters utilized in the model were calculated from Site data; however, some were refined to be more representative of Site conditions during the model calibration procedure. The notes section of Table A.1 lists the sources of data for the various model input parameters and this section describes the basis for the property values chosen to be representative of Site conditions in more detail.

Table A.1 presents model layer average elevation and thickness, vertical hydraulic conductivity ratio (i.e., anisotropy), vertical conductance, total porosity, and effective porosity. The thickness of the model layers was based on interpolations of hydrogeologic contact selections kriged in three-dimensions using EVS (GeoSyntec, 2006).

A.3.3.1 Hydraulic Parameters

Layer properties were based on test data, where available, including the constant-discharge pumping test and pilot test at EW-70-01 (BNI, 1999a and b, respectively), the step-discharge test at EW-70-02 (BNI, 1999a), pumping tests at EW-70-03 (BNI, 2003), slug tests in monitoring wells (BNI, 1999a), and a geotechnical laboratory test (GeoSyntec, 2006). Analysis of the 3-month pilot test and 5-day pumping test at EW-70-01 provided an estimate of hydraulic conductivity and storage coefficient for the Upper Fines (BNI, 1999a and b). Slug tests, which provide a measure of hydraulic conductivity, have been performed in monitoring wells in the Upper Fines Unit, First Sand Unit and the Shell Horizon (Fine-grained Sands) Unit (see Table D-3, BNI, 1999a). Remaining properties required for the model were estimated based on literature values, where appropriate, and adjusted through model calibration as necessary.

The horizontal hydraulic conductivity utilized for the Upper Fines Unit (model layer 1) was partly based on the pumping test results for EW-70-01, conducted in the upper portion of the Upper Fines Unit (BNI, 1999a). Based on the reported transmissivity of 1,531 ft^2/day and an average saturated thickness of 15 feet, as indicated by continuously cored EW-70-02, the hydraulic conductivity of the upper portion of the

Upper Fines Unit is 102 ft/day (BNI, 1999a). However, the Upper Fines Unit in the current model also includes a horizon of interbedded finer-grained materials including silt, clay and fine-grained sand. According to the U.S. Bureau of Reclamation (1981), the hydraulic conductivity of these materials is on the order of 0.014 ft/day. Therefore, the hydraulic conductivity of the entire Upper Fines Unit was taken as the weighted average (based on the average relative thickness) of these two portions of the Upper Fines Unit, and was estimated to be 1.20 ft/day.

The horizontal hydraulic conductivity for the First Sand Unit (model layer 2), was taken from slug test results for monitoring wells screened in this unit (BNI, 1999a). Four tests in the lower portion of the First Sand Unit and partially screened in the higher conductivity portion of the shell horizon, at wells MW-70-08, MW-70-12, MW-70-13, and MW70-16, indicate an average hydraulic conductivity of 0.014 cm/s (Table A.1). A mean value, as opposed to a value from a single slug test, was chosen as more representative of the average hydraulic conductivity of the First Sand Unit, due to the variability of reported values (BNI, 1999a).

The Shell Horizon (Fine-grained Sands) Unit (model layer 3) is described in the ERSE Report as consisting of typically fine- to coarse-grained sand, locally fine to medium grained, with shell content ranging from trace to over 50 percent (BNI, 1998). For the model simulations, a horizontal hydraulic conductivity of 0.011 cm/s, as determined through the analysis of pumping test data (BNI, 2003), was assumed for this unit.

The horizontal hydraulic conductivities for the Shell Horizon (Interbedded Clay) Unit (model layer 4) and the Deep Clay Unit (model layer 6) were assumed to be 1×10^{-6} cm/s, based on the following literature values: massive clay typically has a hydraulic conductivity of less than 1×10^{-7} cm/s (U.S. Bureau of Reclamation, 1981); and silt, clay, and mixtures of sand, silt, and clay typically have hydraulic conductivities ranging from 1×10^{-4} cm/s to 1×10^{-7} cm/s (U.S. Bureau of Reclamation, 1981). The Shell Horizon (Interbedded Clay) Unit and the Deep Clay Unit are commonly silty clay with a trace of sand (and shell fragments in the Shell Horizon), and can include clayey silt, sandy silt, and silty sand, although clay appears predominant (Geosyntec, 2006). These units are not considered massive clay, but a value of 1×10^{-6} cm/s reflects the predominance of clay and was chosen as being representative of the units for use in the model.

The horizontal hydraulic conductivity for the Second Sand Unit (model layer 5), was based on the geometric mean of slug test results for monitoring wells screened in this unit. Three tests in the Second Sand Unit, at wells MW-70-09, MW-70-14, and MW-70-15, indicate an average hydraulic conductivity of 0.024 cm/s (BNI, 1999a) (Table A.1). The slug test results indicate a general increase in hydraulic conductivity with depth, which is consistent with the observed increasing proportions of medium- and coarse-grained sand (BNI, 1999a).

The horizontal hydraulic conductivity for the Deep Sand Unit (model layer 7), was assumed to be similar but slightly higher than the hydraulic conductivity of the Second Sand Unit based on the geologic composition. A value of 0.025 cm/s (Table A.1) was chosen as representative, as this unit is considered to be a similar, but slightly coarser sand type.

The anisotropy ratios chosen as representative for the model layers are intended to reflect the observed stratigraphy and the measured head differences between layers. The ratio of horizontal hydraulic conductivity (K_H) to vertical hydraulic conductivity (K_V) in the Upper Fines Unit (model layer 1) was found (through model calibration) to be 400:1. While the K_H:K_V ratio of 400:1 is greater than typical published values (Marsily, 1986), the interbedded character of the Upper Fines Unit make this ratio reasonable. The Upper Fines Unit represents sands with high hydraulic conductivities as well as Clays with low hydraulic conductivities. This wide range of possible hydraulic conductivity values explains the otherwise greater than normal variance between the two representative hydraulic conductivities applied to the Upper Fines Unit.

Vertical hydraulic conductivity values determined through the analysis of constant discharge pumping test data (BNI, 2003), were chosen as representative of Site conditions for the Shell Horizon (Fine-grained sands) Unit (model layer 3) and the Second Sand Unit (model layer 5). As discussed in detail in the Final IR Site 70 Aquifer Test Report (BNI, 2003), when anomalous test results are excluded, the vertical hydraulic conductivity of the Shell Horizon (Fine-grained sands) Unit and the Second Sand Unit are calculated to be 2.5 and 4.2 ft/day, respectively. In conjunction with the K_H values chosen to be representative of Site conditions above, these calculated K_V values give K_H:K_V ratios of 12.5:1 and 16.2:1 for the Shell Horizon (Fine-grained Sands) Unit and Second Sand Unit, respectively. The anisotropy ratio of the First Sand Unit (model layer 2) and the Deep Sand (model layer 7) was assumed to be equivalent to the ratio calculated for the Second Sand (i.e., 16.2:1). The vertical hydraulic conductivity of the Shell Horizon (Interbedded Clays) Unit (model layer 4) and the Deep Clay Unit (model layer 6) was assumed to be one fiftieth of the horizontal hydraulic conductivity (K_H:K_V = 50:1), as vertical to horizontal anisotropy ratios between 1 and 100 are considered typical for soils with a predominance of clay materials (Marsily, 1986). Model calibration indicated that these calculated anisotropy ratios are representative of Site conditions

The total porosity values shown in Table A.1 were based on geotechnical analyses of soil samples collected from the Pilot Study wells (GeoSyntec, 2006). The values chosen to be representative for the model layers were based on the similarity between the layer geology and the soil description of the geotechnical samples. For example, the soil description for the RDO-3B geotechnical sample is “fine SAND (SP), 5-10% shells, clay, clayey sand” (GeoSyntec, 2006) which is similar to the description for the Upper Fines Unit: “surficial soils and recent clayey sediments, interbedded silts and fine to coarse-grained, silty to clayey sands.” (GeoSyntec, 2006) Therefore, the total porosity value of 0.40 for the RDO-3B sample was assigned to model layer 1 (the Upper Fines Unit). Following this method, the assigned total porosities were 0.40 for the finer grained materials of the Upper Fines Unit, the Shell Horizon (Interbedded Clays) Unit, and the Deep Clay Unit (model layers 1, 4, and 6, respectively), 0.34 for the First Sand Unit, Second Sand Unit, and Deep Sand Unit (model layers 2, 5, and 7, respectively) and 0.28 for the Shell Horizon (Fine-grained Sands) Unit (model layer 3). Note that the relatively low porosity value measured for the Shell Horizon (Fine-grained Sands) geotechnical sample is caused by the presence of stringers of coarse gravel and shell fragments (GeoSyntec, 2006). The effective porosity values were assumed to be 83 percent of total porosity, based on the mean grain-diameter relationship for porosity components (Marsily, 1986; and Table I-2, BNI, 1999b).

Representative values chosen for specific yield were based on literature values for various grain sizes. A specific yield of 0.02 to 0.07 is typical for clay and sandy clay, 0.08 is typical for silt, 0.21 is typical for fine sand, and 0.26 is typical for medium sand (Johnson, 1967). A value of 0.08 was chosen as representative for the Upper Fines, as this unit is predominantly clays and silt with some sand. A value of 0.17 was chosen as representative for the First Sand Unit as this value is the average of the values for silt and coarse sand. The Shell Horizon (fine-grained sands), which is composed of sands and silts as well as shell fragments, was assigned a value of 0.14 (the average value for all of these materials). The Second Sand Unit and the Deep Sand Unit are slightly coarser than the First Sand Unit; therefore, a slightly higher value of specific yield, 0.18, was chosen as representative for these units. The Shell Horizon (Interbedded Clay) Unit and the Deep Clay Unit, which are predominantly clay, were assigned a low specific yield value of 0.02.

The Upper Fines Unit is unconfined; therefore the storage coefficient (0.08) was assigned a value equal to the specific yield (Driscoll, 1986). For confined layers, specific storage is generally 0.0001 per foot (ft^{-1}) or less (Fetter, 1994). Therefore, the specific storage value for model layers 2 through 7 were assigned to be 0.00001, a median value within the typical range given by Freeze and Cherry (1979) and Driscoll (1986).

A.3.4 Solute Transport Model Properties

The layer properties required for the transport model simulation include dispersivity, soil/water distribution coefficient, soil bulk density, effective porosity, and degradation rate. Table A.2 summarizes the property values used in the modeling simulations. This section describes the basis for the property values chosen as representative for the Site.

Effective porosity values were those specified in Table A.1 for the flow model. Soil bulk density was derived from geotechnical analysis (GeoSyntec, 2006) in an analogous manner to that described for total porosity above.

Longitudinal dispersivity was calculated according to the method of Xu and Eckstein (1995) which estimates a dispersivity value based on the total plume length. This parameter was estimated to be approximately 30 feet from plume visualizations. The transverse/longitudinal and vertical/longitudinal dispersivity ratios were determined through model calibration to the current spatial orientation of the plume (see Section A.4). A transverse/longitudinal dispersivity ratio of 0.5 and a vertical/longitudinal dispersivity ratio of 0.01 were derived from calibration results.

The distribution coefficient (K_d) was based upon the equation $K_d = K_{oc} \bullet f_{oc}$ (Marsily, 1986), where K_{oc} is the organic carbon distribution coefficient, and f_{oc} is the fraction of organic carbon in soil. K_{oc} values were taken from the literature (Aziz et al., 2000), and the fraction of organic carbon values were derived from laboratory tests on soil samples from IR Site 70 (see Table E2-7, FS report, BNI 2000). The f_{oc} value for the Upper Fines Unit (0.35%) was calculated as the average f_{oc} value for: 1) the shallow zone of surficial soils and recent clayey sediment, 2) the intermediate zone of interbedded silts, clays, and sandy silts and clays, and, 3) the lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands [i.e., the top three layers in the FS transport model, (BNI, 2000)]. The f_{oc} value for the First Sand (0.14%) was determined from laboratory data (Table E2-7 in FS report, BNI, 2000). The f_{oc} value for the Shell Horizon (Fine-grained Sand), Second Sand and Deep Sand Unit were assumed values (0.05), as in the FS model (BNI, 2000). The f_{oc} value for the Deep Clay Unit and the Shell Horizon (Interbedded Clays) was assumed to be equal to the value determined for the Upper Fines Unit. Fate and transport properties for the primary plume contaminant TCE and daughter products cis-1,2-DCE, VC, ethene and chloride required for the transport model include the organic carbon-to-water partitioning coefficient (K_{oc} – see Table A.2 for assumed values for each constituent) and the aqueous diffusion coefficient (D_e), which was 7.72×10^{-4} ft^2/day for TCE (Cohen and Mercer, 1993).

Analysis of the preliminary results of the anaerobic control microcosms presented in GeoSyntec (2006) was inconclusive with regards to a natural attenuation rate, outside of the fact that the degradation rate appears to be fairly slow (>3 years). Therefore, site TCE concentration data along the center line of the plume (monitoring wells MW-70-37, MW-70-38 and MW-70-08) were used to estimate the natural biodegradation half-life using the analytical modeling code BioChlor (Aziz et al., 2000). The estimated natural biodegradation half-life calculated according to Biochlor analysis was five years, as presented in Figure A.3. Throughout model calibration and for the Pilot Study simulations, inter-barrier zones (i.e. areas outside the biobarrier ROI) were assigned TCE degradation half-lives of five years for all units; see Table A.2). In the absence of other data, a five year half-life was assumed for cis-1,2-DCE and VC for all model layers. The degradation rates of TCE, cis-1,2-DCE, VC, and ethene assigned to the bioactive (biobarrier) zones were based on the results of the treatment microcosms presented in GeoSyntec (2006), and are 0.32 day^{-1} (2 day half-life), 0.09 day^{-1} (8 day half-life), and 0.07 day^{-1} (10 day half-life), respectively (see Table A.2).

A.4. NUMERICAL MODEL CALIBRATION

A.4.1 Calibration Targets and Goals

Model calibration is "the process of refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to achieve a desired degree of correspondence between the model simulation and observations of the ground-water flow system" (ASTM 5718). The calibration preformed for the current IR Site 70 model was conducted in a two step process. First, flow model (MODFLOW) predictions of the groundwater flow field were compared to the average (summer and winter) hydraulic gradient (both magnitude and direction) for each of the Upper Fines Unit, First Sand Unit and Second Sand Unit. Secondly, the transport model (MT3D99) prediction of the evolving area of TCE impacted groundwater was compared to isoconcentration contour maps generated using groundwater analytical data. In addition to the matching of hydraulic gradients and isoconcentration contours, the model water budget must also predict reasonable groundwater flow rates through the boundaries constraining the model.

A.4.2 Qualitative Analysis

For the flow field calibration, the constant head boundaries surrounding the model domain were adjusted to achieve a match between model simulations and observed average (summer and winter) gradients and water elevations. Table A.3 shows the observed (identifying the calibration objectives) and simulated gradients and water elevations for the Upper Fines, First Sand, and Second Sand Units. Figure A.4 shows the simulated groundwater elevation equipotentials for each of these units, respectively, following model calibration. As seen in the table, the selected constant head boundary conditions simulated a flow field across the model domain that closely matched the observed average (summer and winter) water elevations and gradients. In addition, the model water budget indicated that the predicted flow rates are reasonable for the gradients and hydrogeologic units simulated, confirming that the model is representative of the groundwater flow field.

For the transport model calibration, a series of initial and constant concentration sources, of appropriate magnitude and reasonable spatial extent, were input as the 'source' of TCE contamination in the model domain. The resulting TCE plume following 40 years of simulation time was compared to concentration contour maps generated using analytical data collected at Site monitoring wells. The simulation time of 40 years was selected for comparison, as the activities leading to TCE contamination at the Site are suspected to have taken place approximately 40 years ago. Figure A.4 overlays the model simulated concentration contours with colored plots of measured concentrations. There is reasonable agreement between the model simulated distribution of contaminants and the currently observed extent of contamination for each of the Upper Fines, First Sand, Shell Horizon (Fine-grained Sands) and Second Sand Units with respect to the magnitude and spatial distribution of TCE.

In total, a series of 15 calibration simulations were conducted, involving slight modifications to the constant head boundary conditions and the physical properties of the simulated hydrogeologic units. Table A.3 and Figure A.4 illustrate that the final calibration was reasonably successful in matching the calibration objectives with respect to hydraulic gradient and contaminant transport, respectively.

A.5. MODEL SIMULATIONS

The following subsections present a summary of the Pilot Study simulations preformed using the calibrated groundwater flow and transport model. Section A.5.1 presents the initial conditions of the simulations, Section A.5.2 presents a discussion of the ‘Base Case’ and ‘Alternative’ layout of the biobarrier remediation system (with respect to number of barriers, dimensions, remedial effectiveness and operational longevity). Section A.5.3 presents the results of a sensitivity analysis and Section A.5.4 presents the results of the long-term natural attenuation simulations.

A.5.1 Initial Conditions

For each of the optimization simulations, the starting water level elevations and boundary groundwater flow conditions were taken from the final calibration simulation. The initial TCE concentrations input to the model, however, were based on the measured concentration data, which were interpolated using three-dimensional (3-D) kriging with EVS. The concentration profiles within each hydrogeological unit were extracted from the interpolated 3-D concentrations, and were used as the initial conditions for the model. Each contour interval was used to delineate areas of initial TCE concentration from 5 μg/L at the periphery of the plume, in log multiples of 10, to 50,000 μg/L around the periphery of the Upper Fines Unit source area. The initial concentrations of the Upper Fines unit excluded the highest values of TCE associated with the source area, as the optimization simulations assumed the complete and immediate removal of TCE from this area due to the proposed source treatment. Therefore, the initial TCE concentrations in the source treatment zone were assumed to be equal to zero at the start of the simulations.

A.5.2 Biobarrier Design

The objective of the biobarrier design optimization was to select the number, dimensions, and location of each biobarrier, and determine the operational longevity of each biobarrier required to actively remediate the TCE plume to concentrations below 200 µg/L. Approximately 25 configurations were evaluated; the two most promising barrier configurations are presented in this section.

The first design option is the ‘Base Case’ biobarrier design, and the second option will be referred to as the ‘Alternative’ biobarrier design. Figure A.5 shows the location and dimensions of the biobarriers utilized in each of these remedial options. Table A.4 summarizes the dimensions of the barriers as well as the operational lifespan of each of the biobarriers to be installed for the two options.

In the Base Case design, a total of six biobarriers would be installed perpendicular to the direction of groundwater flow at each location. Three biobarriers would be required in the First Sand Unit [Source Containment Barrier, Biobarrier First Sand 1 (FS-1), and Biobarrier First Sand 2 (FS-2) in order of increasing distance from the source area], two in the Shell Horizon (Fine-grained Sand) Unit: [Biobarrier Shell Horizon 1 (SH-1) and Biobarrier Shell Horizon 2 (SH-2)], and a single biobarrier in the Second Sand Unit [Biobarrier Second Sand 1 (SS-1)]. Each of these biobarriers would target the core of the TCE plume, as determined from the interpolated 250 µg/L TCE contour, and would be fully screened vertically across the named hydrogeologic unit.

Based on the results of the EVO Injection Pilot Test (GeoSyntec, 2006), the estimated radius of injection of the EVO within the biobarriers is approximately 10-12 feet, resulting in a 20-24 foot travel distance in the direction of groundwater flow. Given the seepage velocities observed on Site, this distance represents travel times that are more than adequate to reduce the dissolved phase TCE concentrations entering the biobarriers (>250 µg/L) to below the 200 µg/L target concentration within the biobarrier itself. Therefore, the majority of mass predicted to remain on Site following biobarrier operation was associated with areas not targeted by the design (e.g., the areas outside the 250 µg/L contour, or downgradient of the biobarrier cut-off point). However, as these areas contain relatively low dissolved phase TCE concentrations (< 250 µg/L) at the outset of biobarrier operation, natural attenuation at the Site (estimated TCE half-life on the order of 5 years) should be capable of remediating these areas to less than 200 µg/L well within the operational lifespan of the biobarrier treatment system. Thus, following biobarrier termination, it was predicted by the model that TCE concentrations above the 200 µg/L remedial goal are unlikely to exist at the Site. Figure A.5 presents the area of remaining TCE contamination (between 5 µg/L and 200 µg/L), outlining the area of impacted groundwater following termination of active treatment on Site.

Biobarrier operation times for the Base Case design vary as a function of hydrogeologic unit, location relative to the nearest upgradient barrier, and upgradient concentration. Thus, not all biobarriers will be operational for the same period of time. Table A.4 presents the predicted operational times for each of the six Base Case biobarriers. The operational times vary from six years for the Source Containment Biobarrier in the First Sand Unit, to 16 years for Biobarrier FS-2. Therefore, active treatment system shut-down is predicted to occur within 16 years of system start-up. The modeling results for this design (as well as for the Alternative design discussed below) assumed that source zone treatment was complete and 100% effective prior to biobarrier system operation. While the majority of the biobarriers will not be affected by the efficacy of the source zone treatment, the Source Containment Biobarrier will only remediate dissolved phase groundwater to concentrations less than 200 µg/L within the predicted time frame of 6 years if the source area is first fully remediated, as assumed in the model. The operational longevity of the source barrier will be extended proportionally should the source remedy be unsuccessful in immediately mitigating all downgradient mass flux.

In the Alternative design, a total of eight biobarriers would be installed perpendicular to the direction of groundwater flow. Four biobarriers would be installed in the First Sand Unit (Source Containment Biobarrier, Biobarrier FS-1, Biobarrier FS-2, and Biobarrier FS-3 in order of increasing distance from the source area), three in the Shell Horizon (Fine-grained Sand) Unit (Biobarrier SH-1, Biobarrier SH-2, and Biobarrier SH-3), and a single biobarrier in the Second Sand Unit (Biobarrier SS-1). The goal of the Alternative design was to increase the number of biobarriers, and thus decrease the time for remediation to the clean-up goal and the costs associated with re-application of EVO. Therefore, Biobarrier FS-1 of the Base Case design was replaced with two biobarriers in the First Sand Unit, and an additional barrier was inserted in the Shell Horizon (Fine-grained Sands) Unit. Each biobarrier targeted the core of the TCE plume, as determined from the interpolated 250 µg/L TCE contour, and would be fully screened across the thickness of the named hydrogeologic unit.

Table A.4 also presents the predicted operational times for each of the eight Alternative barriers. The operational times vary from six years for the Source Containment Biobarrier to 11 years for Biobarrier SS-1. Again, the operation time for the Source Containment Biobarrier is contingent on the immediate and complete treatment of the source area. As in the Base Case design, the model predicted that TCE concentrations were unlikely to exceed the 200 µg/L remedial goal following biobarrier termination at the Site. Figure A.5 also presents the area of TCE contamination (between 5 µg/L and 200 µg/L), outlining the area of impacted groundwater, following total biobarrier termination for the Alternative design.

A.5.3 Sensitivity Analysis

Two sensitivity analyses were performed. They were conducted to evaluate: i) the effect of hydrogeologic unit seepage velocity uncertainty (related to seasonal variations in hydraulic gradient and/or inaccuracies in the estimates of hydraulic conductivities); and ii) the influence of possibly reduced hydraulic conductivity in the biobarrier zone as a result of EVO emplacement.

The effect of seepage velocity uncertainty was examined by considering a case where Site hydraulic conductivity values (as presented in Table A.2) were underestimated by a factor of two across the entire model domain. This will have the effect of increasing the rate of contaminant flushing toward the barriers, and test the performance of the system by reducing the residence time of contaminants within the bioactive zone.

The second sensitivity analysis, the influence of reduced hydraulic conductivity within the biobarrier zone as a result of EVO emplacement, was examined by simulating the Base Case scenario with hydraulic conductivity values reduced by a factor of two within the bioactive zones. This acts to increase the residence time of contaminants within the bioactive zone, but reduce flushing times and force some of the contaminants to flow around the edges of the barrier. This second test was performed due to recent evidence suggesting that EVO emplacement can significantly reduce the permeability of aquifers into which it is injected (Coulibaly and Borden, 2004).

The data on Table A.4 also present the biobarrier performance results for the two sensitivity analysis simulations. The biobarrier operational longevity predictions decrease significantly if the seepage velocity is increased from the Base Case by a factor of two. The operational times for this simulation range from four years at the Source Containment Biobarrier (*versus* six years for the base case simulation), to 10 years at Biobarrier FS-2 (*versus* 16 years for the base case simulation). As mentioned above, the rate of contaminant flushing to the biobarriers was increased as a result of the simulated seepage velocity increase, and the biobarrier operational times were reduced as a result. TCE concentrations predicted to remain on Site following complete termination of the biobarrier operation were less than the 200 µg/L target (as in the Base Case); therefore, the increased seepage velocity had no negative effect on the performance of the barriers. The TCE degradation rates within the bioactive zone (see Table A.4) were adequate to suggest that concentration reductions to below the 200 µg/L target were reached on the downgradient side of the barriers regardless of the decreased contaminant residence times resulting from the seepage velocity increase. In summary, the sensitivity analysis suggests the contaminant flushing time is the dominant factor governing the operational longevity of the barriers.

The data on Table A.4 suggests that there is no observable effect on the operational longevity of the Base Case biobarrier system if bioactive zone hydraulic conductivity reduction results from the emplacement of EVO. The operational longevity times for the various biobarriers of the Base Case design option are identical to the simulated times of this sensitivity run (Table A.4). While some of the impacted groundwater traveled around the biobarriers as opposed to through the treatment zone due to the hydraulic conductivity reduction resulting from the presence of EVO, the concentrations and quantity of dissolved phase TCE circumventing the biobarriers was relatively small. The natural attenuation rate was sufficient to decrease the TCE concentrations of this volume of impacted groundwater to below the 200 µg/L target level within the operational life-span of the biobarriers.

A.5.4 Post Biobarrier Operation: Natural Attenuation for the Base Case Design

Simulation of natural attenuation following termination of biotreatment was conducted for the Base Case scenario to examine the temporal evolution of the TCE plume. Following biobarrier termination, the maximum dissolved phase TCE concentration remaining on Site was projected to be less than 200 µg/L. While natural attenuation processes (e.g. dispersion, biodegradation) will further reduce TCE concentrations over time, the length of time TCE concentrations remain above the target cleanup goals of California State Maximum Contaminant Limits (MCLs; 5 µg/L) and the extent to which the impacted groundwater will migrate, is unknown.

Figure A.6 shows the interpolated maximum extent of TCE (as indicated by the area of TCE impacted groundwater between 5 µg/L and 200 µg/L) for each of the Upper Fines, First Sand, Shell Horizon (Fine-grained Sands), and Second Sand Units at three different times: 20, 35 and 50 years following biobarrier system start-up. The extent of TCE contamination decreases with time as a result of natural attenuation processes. By 50 years, no TCE above MCLs (5 µg/L) was simulated to be within either the Shell Horizon (Fine-grained Sands) or the Second Sand Unit. A 'halo' of concentrations above MCLs surrounding the source area treatment zone may still exist within the Upper Fines Unit. Due to the low seepage velocities of the Upper Fines unit, dispersion is not likely to be a significant attenuation process. As a result of the relatively high concentrations remaining in the Upper Fines Unit following source treatment, natural biodegradation processes alone was not sufficient to remediate this area of the plume within 50 years time; however, the impact to the remaining plume was negligible as the contamination essentially remains confined within the Upper Fines unit. A small area of impacted groundwater was simulated to exist in the First Sand Unit 50 years following the start of biobarrier operation. The area of contamination was approximately 400 by 40 feet, but had traveled no further than approximately 300 feet from the current extent of TCE contamination in this unit. TCE was not generally anticipated to migrate at concentrations above MCLs further southeast than MW-70-15 in the Second Sand Unit, further south than MW-70-36 in either the First Sand or Shell Horizon (Fine-grained Sand) Unit, or beyond the current extents of the plume in the Upper Fines Unit.

The natural attenuation of cis-1,2-DCE and VC was not evaluated due to a lack of both suitable Site and microcosm study data (GeoSyntec, 2006). The extent of cis-1,2-DCE and VC on Site is currently within the bounds of TCE impacted groundwater. It is anticipated that the conclusions drawn above with respect to the time scales and spatial extent of TCE above MCLs following biobarrier termination is expected to hold for cis-1,2-DCE and VC as well.

A.6. LIMITATIONS

The model simulations conducted in Section A.5 included assumptions that current site conditions will not change over the course of active biobarrier operation or during the period of MNA following biobarrier termination. The following summarizes these assumptions:

- Complete and immediate source area remediation prior to plume biobarrier start-up;
- Continued operation of currently active pumping wells in the vicinity of IR Site 70;
- Continued operation of the Alamitos Injection Barrier to the Northwest of IR Site 70;
- No expansion of the currently operating Alamitos Injection Barrier;
- No addition installation and operation of pumping wells in the vicinity of IR Site 70; and,
- No significant change to the precipitation/recharge rate in the vicinity of IR Site 70.

A.7. REFERENCES

Aziz, C.E., Newell, C.J., Gonzales, J.R., Haas, P., Clement, T.P., and Sun, Y., 2000. Biochlor, Natural Attenuation Decision Support System, User's Manual v1.0, EPA/600/R-00/008.

Bechtel National, Inc. 1998. Draft Extended Removal Site Evaluation Report, Installation Restoration Sites 40 and 70, Naval Weapons Station Seal Beach, California. December.

Bechtel National, Inc. 1999a. Final Technical Memorandum No. 4, Groundwater Pumping Test Report, IR Site 70, Naval Weapons Station Seal Beach, Seal Beach, California, April

Bechtel National, Inc. 1999b. Final Technical Memorandum No. 5, Shallow Groundwater Pilot Test Report, IR Site 70, Naval Weapons Station Seal Beach, California. September.

Bechtel National, Inc. 2000. Feasibility Study Report, Installation Restoration Sites 40 and 70, Naval Weapons Station Seal Beach, California.

Bechtel National, Inc. 2003. Final IR Site 70 Aquifer Test Report, IR Site 70, Naval Weapons Station Seal Beach, California, February.

BNI. See Bechtel National, Inc.

Cohen, R. M., and J. W. Mercer. 1993. DNAPL Site Evaluation. United States Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, EPA/600/R-93/022.

Coulibaly, K.M., and R.C. Borden, 2004. Impact of Edible Oil Injection on the Permeability of Aquifer Sands, *J. Contam. Hydrol*., Article in Press.

Driscoll, F.G. 1986. *Groundwater and Wells*. St. Paul, Minnesota: Johnson Filtration Systems, Inc. 1,089p.

Fetter, C. W. 1994. *Applied Hydrogeology*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 604 p.

Freeze, R.A., and J.A. Cherry. 1979. *Groundwater*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 604 p.

GeoSyntec Consultants. 2006. Draft Remedial Design (RD) for In Situ Bioremediation, Installation Restoration Program Site 70, Naval Weapons Station, Seal Beach, Seal Beach, California. CTO 47408-04-C-7526. August.

Geosyntec, 2005. Draft Revised Groundwater Feasibility Study Report, Installation Restoration Program, Site 70, Naval Weapons Station Seal Beach, California. April.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, the U.S. Geological Survey Modular Ground-Water Model -- User Guide to Modularization Concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Johnson, A.I. 1967. Specific Yield – Compilation of Specific Yields for Various Materials. Water-Supply Paper 1662-D, United States Geological Survey.

Marsily, G. de. 1986. *Quantitative Hydrogeology – Groundwater Hydrology for Engineers.* Academic Press, Inc.

United States Bureau of Reclamation, Water and Power Resources Service. 1981. Groundwater Manual.

Xu, M. and Y. Eckstein, 1995, Use of Weighted Least-Squares Method in Evaluation of the Relationship Between Dispersivity and Scale, *J. Ground Water,* 33(6): 905-908.

Zheng, C., 1999: User's Guide. MT3D99 A modular 3D Multi-species transport simulator. S.S. Papadopulos & Associates.

Table A.1
Flow Model Layer Properties
IR Site 70
Naval Weapons Station Seal Beach, California

Model Layer No.	Typical Elevation (ft, MSL) Top to Bottom	Typical Layer Thickness (feet)	Stratigraphic Unit[a]	Hydraulic Conductivity, K[b] Horizontal, K_h (cm/s)	Vertical, K_v (cm/s)	Horizontal, K_h (ft/day)	Vertical, K_v (ft/day)	Vertical Anistropy K_v/K_h (cm/s)	Total Porosity,[c] n	Effective Porosity,[d] n_e	Specific Yield,[e] S_y	Specific Storage,[f] S_s (ft^{-1})
1	Ground Surface to -50	60	Upper Fines	4.24×10^{-4}	1.06×10^{-6}	1.2	0.003	1/400	0.40	0.33	0.08	0.08
2	-50 to -95	45	First Sand	1.40×10^{-2}	8.64×10^{-4}	40	2.5	1/16	0.34	0.28	0.17	1.0×10^{-5}
3	-95 to -125	30	Shell Horizon (Fine-grained Sands)	1.10×10^{-2}	8.82×10^{-4}	31	2.5	1/12	0.28	0.23	0.14	1.0×10^{-5}
4	-95 to -125	30	Shell Horizon (Interbedded Clays)	1.00×10^{-6}	2.00×10^{-8}	0.0028	5.7×10^{-5}	1/50	0.40	0.33	0.02	1.0×10^{-5}
5	-125 to -160	35	Second Sand	2.40×10^{-2}	1.48×10^{-3}	68	4.2	1/16	0.34	0.28	0.18	1.0×10^{-5}
6	-160 to -180	20	Deep Clay	1.00×10^{-6}	2.00×10^{-8}	0.0028	5.7×10^{-5}	1/50	0.40	0.33	0.02	1.0×10^{-5}
7	-180 and deeper	-	Deep Sand	2.50×10^{-2}	1.52×10^{-3}	70	4.3	1/16	0.34	0.28	0.18	1.0×10^{-5}

Notes

[a] Based on modified Site conceptual model developed from RDO activities (Geosyntec, 2006): i) combines the shallow zone of surficial soils and recent clayey sediment, an intermediate zone of interbedded silts, clays, and sandy silts and clays, and a lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands into a single Upper Fines Unit; ii) includes the Deep Sand Unit; and iii) laterally subdivides the Shell Horizon into the Shell Horizon (Fine-grained Sands) and the Shell Horizon (Interbedded Clays) Units.

[b] Horizontal hydraulic conductivities are based upon the following:

Upper Fines: weighted average of the Upper Fines pump test at EW-70-01 hydraulic conductivity value (BNI, 1999a) and the FS model (BNI, 2000) assumed value for the lower portion of the Interbedded Unit [based on the U.S. Bureau of Reclamation (1981) value for the silt and clay content of this material];
First Sand: based on slug test results [BNI, 1999a or Table E2-4, BNI (2003)];
Shell Horizon (Fine-grained Sands): based on interpretation of the Bechtel Pump Test data (BNI, 2003);
Shell Horizon (Interbedded Clays): assumed value to reflect the predominance of clay (U.S. Bureau of Reclamation, 1981), as in FS model (BNI, 2000);
Second Sand: based on slug test results (BNI, 1999a);
Deep Clay: assumed value to reflect the predominance of clay (U.S. Bureau of Reclamation, 1981), as in FS model (BNI, 2000);
Deep Sand: assumed to be similar in character (but slightly more transmissive due to the slightly coarser sands) to the Second Sand Unit.

Vertical hydraulic conductivities are based on the following:

Upper Fines: determined from model calibration to average hydraulic gradient (direction and magnitude);
First Sand: based on the assumption that the ratio of K_v to K_h is the same for the FS and the SS Units;
Shell Horizon (Fine-grained Sands): based on interpretation of the Bechtel Pump Test data (BNI, 2003);
Shell Horizon (Interbedded Clays): assumed K_v/K_h ratio of 1/50 to reflect the predominance of clay (U.S. Bureau of Reclamation, 1981), as in FS model (BNI, 2000);
Second Sand: based on interpretation of the Bechtel Pump Test data (BNI, 2003);
Deep Clay: assumed K_v/K_h ratio of 1/50 to reflect the predominance of clay (U.S. Bureau of Reclamation, 1981), as in FS model (BNI, 2000);
Deep Sand: assumed to be similar in character (but slightly more transmissive due to the slightly coarser sands) to the Second Sand Unit.

[c] Total porosity is based on geotechnical analysis of soil samples collected from the RDO wells (GeoSyntec, 2006); values selected for the model layers are based on the similarity between the layer geology and the soil description of the Geotechnical samples.

[d] Effective porosity is assumed to be 83 percent of total porosity (n_e = 0.83n), based on grain size evaluation (Technical Memorandum No. 5, Table I 2, BNI, 1999b).

[e] Specific yield is based on typical values from literature of 0.02 to 0.07 for clay and sandy clay, 0.08 for silt, 0.21 for fine sand, and 0.26 for medium sand (Johnson, 1967).

[f] Specific storage is based on an assumed value of 0.00001 ft^{-1} typical for confined layers, but model layer 1 is based upon the storage coefficient determined from the pilot test results (Technical Memorandum No. 5, BNI 1999b)

Acronyms/Abbreviations

cm/s – centimeters per second
ft^{-1} – per foot
ft/day – feet per day
ft, MSL – feet (in relation to) mean sea level, NGVD 1929
RDO – Remedial Design Optimization
BNI – Bechtel National Inc.
K – hydraulic conductivity
K_H – horizontal K
K_V – vertical K
n – porosity
n_e – effective porosity
S_y – specific yield
S_s – specific storage

Table A.2
Solute Transport Model Properties
IR Site 70
Naval Weapons Station Seal Beach, California

Model Layer No.	Stratigraphic Unit[a]	Soil Bulk Density[b] p_b (g/cm^3)	Soil Bulk Density[b] p_b (kg/ft^3)	Porosity[c] Total Porosity, n	Porosity[c] Effective Porosity, n_e	Soil Organic Carbon Content,[d] f_{oc} (percent)	Dispersivity[e] Longitudinal, α_L (feet)	Dispersivity[e] Transverse/ Longitudinal, α_T/α_L	Dispersivity[e] Vertical/ Longitudinal, α_V/α_L	Diffusion Coefficient[f] D_e (cm^2/s)	Diffusion Coefficient[f] D_e (ft^2/day)	Distribution Coefficient[g] K_d (mL/g)	Distribution Coefficient[g] K_d (ft^3/kg)	Retardation Factor,[h] R
1	Upper Fines	1.58	44.6	0.40	0.33	0.35	30	0.5	0.01	8.30 E-6	7.72 E-4	0.441	0.0154	3.1
2	First Sand	1.75	49.5	0.34	0.28	0.14	30	0.5	0.01	8.30 E-6	7.72 E-4	0.176	0.0061	2.1
3	Shell Horizon (Fine-grained Sands)	1.89	53.6	0.28	0.23	0.05	30	0.5	0.01	8.30 E-6	7.72 E-4	0.063	0.0022	1.5
4	Shell Horizon (Interbedded Clays)	1.58	44.6	0.40	0.33	0.35	30	0.5	0.01	8.30 E-6	7.72 E-4	0.441	0.0154	3.1
5	Second Sand	1.75	49.5	0.34	0.28	0.05	30	0.5	0.01	8.30 E-6	7.72 E-4	0.063	0.0022	1.4
6	Deep Clay	1.58	44.6	0.40	0.33	0.35	30	0.5	0.01	8.30 E-6	7.72 E-4	0.441	0.0154	3.1
7	Deep Sand	1.75	49.5	0.34	0.28	0.05	30	0.5	0.01	8.30 E-6	7.72 E-4	0.063	0.0022	1.4

		Distribution Coefficient[g]					Degradation Rate[i] (1/day)							
							TCE		cisDCE		VC		Ethene	
Model Layer No.	Stratigraphic Unit[a]	TCE K_d (mL/g)	cisDCE K_d (mL/g)	VC K_d (mL/g)	Ethene K_d (mL/g)	Chloride K_d (mL/g)	Bioactive Zone	Inter-Barrier Zone	Bioactive Zone	Inter-Barrier Zone	Bioactive Zone	Inter-Barrier Zone	Bioactive Zone	Inter-Barrier Zone
1	Upper Fines	0.44	0.44	1.11	1.06	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
2	First Sand	0.18	0.18	0.44	0.42	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
3	Shell Horizon (Fine-grained Sands)	0.06	0.06	0.16	0.15	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
4	Shell Horizon (Interbedded Clays)	0.44	0.44	1.11	1.06	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
5	Second Sand	0.06	0.06	0.16	0.15	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
6	Deep Clay	0.44	0.44	1.11	1.06	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0
7	Deep Sand	0.06	0.06	0.16	0.15	0	0.32	0.00038	0.09	0.00038	0.07	0.00038	0	0

Notes

[a] Based on modified Site conceptual model developed from RDO activities (Geosyntec, 2006): combines the shallow zone of surficial soils and recent clayey sediment,; an intermediate zone of interbedded silts, clays, and sandy silts and clays, and a lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands into a single Upper Fines Unit; includes the Deep Sand Unit; and laterally subdivides the Shell Horizon into the Shell Horizon (Fine-grained Sands) and the Shell Horizon (Interbedded Clays) Units

[b] Soil bulk density is based on Geotechnical analysis of soil samples collected from the RDO wells (GeoSyntec 2006); values selected for the model layers are based on the similarity between the layer geology and the soil description of the Geotechnical samples.

[c] Total and effective porosity from Table A.1.

[d] Soil Organic Carbon content for the UF Unit calculated as the average of f_{oc} values as determined from laboratory data (Table E2-7, BNI, 2000) for: 1) the shallow zone of surficial soils and recent clayey sediment, 2) the intermediate zone of interbedded silts, clays, and sandy silts and clays, and, 3) the lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands (the top three layers in the FS model (BNI, 2000); soil organic carbon content for the First Sand as determined from laboratory data (Table E2-7, BNI, 2000); soil organic carbon content for the Shell Horizon (Fine-grained Sand), SS and Deep Aquifer Unit are assumed values, as in FS model (BNI, 2000); f_{oc} for the Deep Clay Unit and the Shell Horizon (Interbedded Clays) assumed to be equal to the value given for the UF Unit.

[e] Longitudinal dispersivity as calculated according to the method of Xu and Eckstein (1995); transverse and vertical dispersivity ratios are based on the calibrated transport model for the plume as depicted in Figure A.4.

[f] Diffusion coefficient based on literature value as in FS model (BNI, 2000).

[g] Distribution coefficients used correspond to mean K_{oc} values quoted in Aziz et al. (2000), where K_d was calculated from $K_d = f_{oc} \times K_{oc}$ (K_{oc} (PCE) = 398 L/kg, K_{oc} (TCE) = 126 L/kg), K_{oc} (cis-1,2-DCE) = 126 L/kg, K_{oc} (VC) = 316 L/kg, K_{oc} (ethene) = 302 L/kg, and chloride assumed to be conservative (K_{oc} = 0).

[h] Retardation factor, $R = 1 + (P_b/n_e) K_d$ (Freeze and Cherry 1979).

[i] Reaction rate half-lives within bioactive zones as determined from the microcosm study presented in GeoSyntec (2006). Reaction rates outside the bioactive zones as determined through Biochlor analysis of Site data (see Section A.3.4).

Acronyms/Abbreviations

- cm^3/g - cubic centimeters per gram
- cm^2/s - square centimeters per second
- cm/sec - centimeters per second
- R – retardation factor
- ft^2/day - square feet per day
- ft^3/kg - cubic feet per kilogram
- mL/g - milliliters per gram
- BNI – Bechtel National Inc.
- TCE – trichloroethene
- cis-1,2-DCE - cis-1,2-dichloroethene
- VC - vinyl chloride
- p_b – bulk density
- n – porosity
- n_e – effective porosity
- f_{oc} – fraction organic carbon
- α_L – longitudinal dispersivity
- α_T – transverse dispersivity
- α_V – vertical dispersivity
- D_e – diffusion coefficient
- K_d – distribution coefficient

Table A.3
Flow Model Calibration Summary
IR Site 70
Naval Weapons Station Seal Beach, California

Model Layer	Stratigraphic Unit	Average Hydraulic Gradient		Average Direction of Groundwater Flow (degrees from North)		Groundwater Elevation at MW-70-42 (ft. NGVD)	
		Observed[a]	Simulated	Observed[a]	Simulated	Observed[b]	Simulated
1	Upper Fines	0.00055	0.00060	147	145	-9.0	-9.3
2 / 3	First Sand / Shell Horizon (Fine-grained Sand)	0.00175	0.00183	169	170	-12.3	-12.2
5	Second Sand	0.00085	0.00086	120	120	-13.0	-13.1

Notes
[a] taken as the average of summer and winter data (see Table 5.1, GeoSyntec, 2006)
[b] taken as the average of summer and winter water level elevation data as determined from data presented in GeoSyntec (2006)
ft – feet

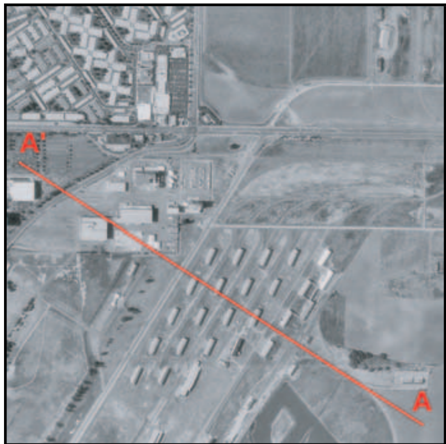
Table A.4
Biobarrier Design Option Performance and Sensitivity Analysis Results
IR Site 70
Naval Weapons Station Seal Beach, California

Unit	Biobarrier	Barrier Length (ft)	Unit Thickness (ft)	Operational Longevity (years)[a]			
				Design Options		Base Case Sensitivity	
				Base Case	Alternative	Increased Seepage Velocity[b]	Decreased Barrier Conductivity[c]
First Sand	Source Containment	325	43	6	6	4	6
	FS-1 (Alternative)	625	50	-	8	-	-
	FS-1 (Base case)	820	43	14	-	8	14
	FS-2 (Alternative)	675	43	-	8	-	-
	FS-2 (Base case)	685	34	16	10	10	16
Shell Horizon (Fine-grained Sands)	SH-1	725	26	8	8	6	8
	SH-2 (Alternative)	690	27	-	8	-	-
	SH-2 (Base) / SH-3 (Alternative)	630	27	13	8	8	13
Second Sand	SS-1	525	42	11	11	8	11
Total Number of Biobarriers				6	8	6	6

Notes
'-' indicates barrier not utilized in the design option.
[a] Operational time of the Source Containment barrier is contingent on the complete removal of all DNAPL in the source area.
[b] An increased seepage velocity (2x greater than observed in the field) was simulated by increasing the hydraulic conductivity of each unit by a factor of 2.
[c] The hydraulic conductivity within each Biobarrier was decreased by a factor of 2 to simulate the possible influence of EVO presence on aquifer permeability.
ft - feet

Figure A.1

This detailed station map has been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.



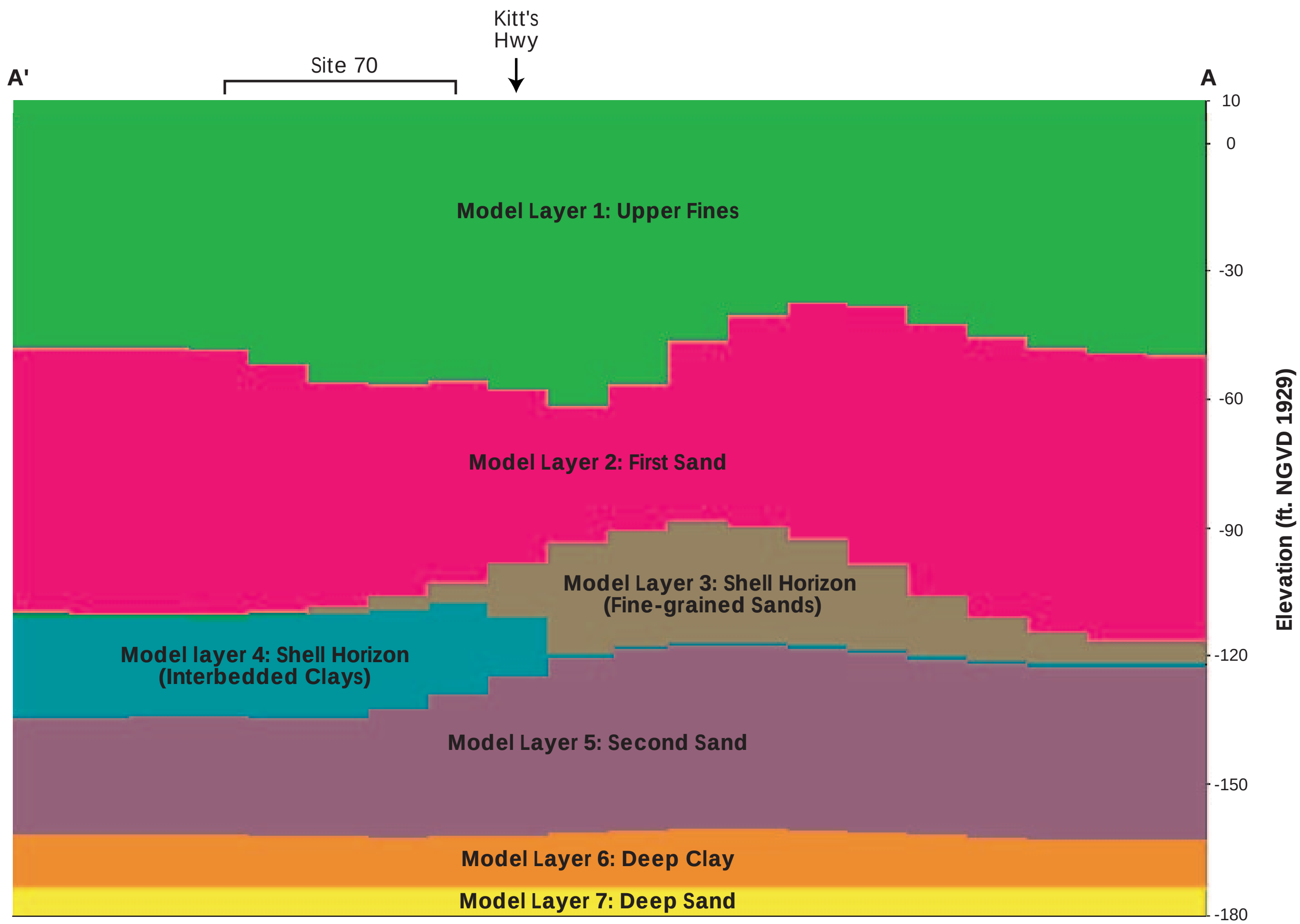


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Figure A.2
Vertical Cross-Section of the Model Domain along the Center Line of the Plume
IR Site 70
Naval Weapons Station Seal Beach, California

0 560 1,120
scale (feet)

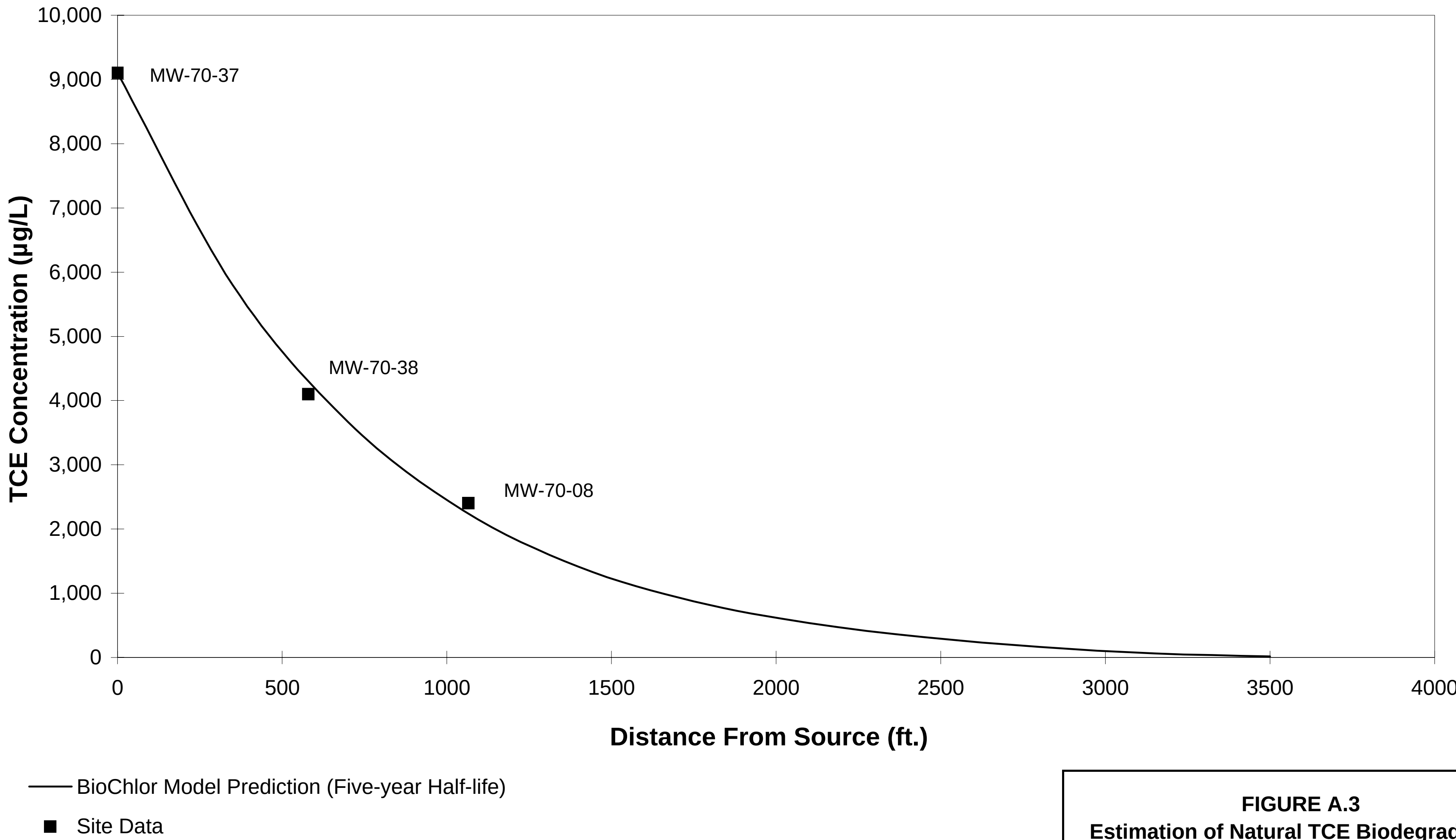
Date: March 2006	Project No. HY0888

GEOSYNTEC CONSULTANTS

Note: *20x vertical exaggeration*

vertical section of domain.ai

Draft for Discussion Purposes Only



µg/L - micrograms per liter
TCE - Trichloroethene
ft - feet

FIGURE A.3
Estimation of Natural TCE Biodegradation Rate
IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No.: HY0888

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Figures A.4 through A.6

These detailed station maps have been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.

Table B.1
Design Parameters and Scoping Calculations for Full Scale Design
IR Site 70, Naval Weapons Station Seal Beach, California

Parameter	Units	Source		Plume Base Case Scenario					Plume Design Alternative 1						
		Source Grid Treatment	Source Biobarrier	Biobarrier FS-1	Biobarrier FS-2	Biobarrier SH-1	Biobarrier SH-2	Biobarrier SS-1	Biobarrier FS-1	Biobarrier FS-2	Biobarrier FS-3	Biobarrier SH-1	Biobarrier SH-2	Biobarrier SH-3	Biobarrier SS-1
Plume Parameters [b]															
Plume Width	ft	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Plume Length	ft	170	325	820	685	725	630	525	625	675	685	725	690	630	525
Plume Thickness	ft	30	45	45	35	25	25	40	45	45	35	25	25	25	40
Electron Acceptor Concentrations [a]															
Tetrachloroethene	mg/L	0.03	0.05	0.02	0.04	0.01	0.01	0.01	0.02	0.02	0.04	0.01	0.01	0.01	0.01
Trichloroethene	mg/L	35.27	9.10	1.97	2.80	3.30	3.30	1.15	1.97	1.97	2.80	3.30	3.30	3.30	1.15
cis-1,2-Dichloroethene	mg/L	7.75	0.20	0.08	0.19	0.14	0.14	0.07	0.08	0.08	0.19	0.14	0.14	0.14	0.07
Vinyl Chloride	mg/L	0.22	0.05	0.02	0.04	0.004	0.00	0.01	0.02	0.02	0.04	0.004	0.00	0.00	0.01
Oxygen	mg/L	6.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrate	mg/L	0.16	0.00	0.20	0.20	0.00	0.00	0.20	0.20	0.20	0.20	0.00	0.00	0.00	0.20
Sulfate	mg/L	663	330	330	370	210	210	210	330	330	370	210	210	210	210
Total Electron Acceptor Concentration	mg/L	712	339	332	373	213	213	211	332	332	373	213	213	213	211
Hydrogeological Parameters															
Average Bulk Horizontal Hydraulic Conductivity	ft/day	1.2	40	40	40	31	31	68	40	40	40	31	31	31	68
Horizontal Hydraulic Gradient	--	0.0006	0.002	0.002	0.002	0.002	0.002	0.0007	0.002	0.002	0.002	0.002	0.002	0.002	0.0007
Soil Effective Porosity	--	0.33	0.28	0.28	0.28	0.23	0.23	0.28	0.28	0.28	0.28	0.23	0.23	0.23	0.28
Seepage Velocity[f]	ft/day	0.002	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Groundwater Discharge Through Biobarrier[g]	ft^3/day	3.7	1,161	2,929	1,903	1,130	982	1,000	2,233	2,411	1,903	1,130	1,076	982	1,000
Design Parameters [d]															
Volume of EVO Injected	gal	13,338	6,664	16,660	10,730	7,178	6,208	9,306	12,852	13,804	10,730	7,178	6,790	6,208	9,306
Volume of EVO Injected	m^3	50.5	25.2	63.1	40.6	27.2	23.5	35.2	48.7	52.3	40.6	27.2	25.7	23.5	35.2
Percentage of Oil in Newman's Zone Emulsified Oil Solution	% (v/v)	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%	47.9%
Volume of Soybean Oil Injected per Biobarrier	m^3	24.2	12.1	30.2	19.5	13.0	11.3	16.9	23.3	25.0	19.5	13.0	12.3	11.3	16.9
Density of Soybean Oil	kg/m^3	920	920	920	920	920	920	920	920	920	920	920	920	920	920
Mass of Soybean Oil per Biobarrer	kg	22,266	11,125	27,812	17,912	11,983	10,363	15,535	21,455	23,044	17,912	11,983	11,335	10,363	15,535
Expected Longevity of EVO per Injection Event [c]															
Electron Acceptor Mass Discharge[h]	kg/yr	U	4,072	10,060	7,342	2,494	2,167	2,186	7,668	8,281	7,342	2,494	2,373	2,167	2,186
Electron Donor Consumption Ratio (ED:EA)[e]	--	0.45	0.45	0.46	0.45	0.45	0.45	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.46
Electron Donor Demand	kg/yr	U	1,836	4,579	3,339	1,130	982	995	3,490	3,769	3,339	1,130	1,075	982	995
Expected Longevity of EVO per Injection Event[i]	yr	U	**6**	**6**	**5**	**11**	**11**	**16**	**6**	**6**	**5**	**11**	**11**	**11**	**16**

Acronyms/Abbreviations:

ft - foot	% (v/v) - percent by volume
mg - milligrams	kg/m^3 - kilograms per cubic meter
L - liters	kg - kilogram
mg/L - milligrams per liter	kg/yr - kilograms per year
ft/day - feet per day	yr - year
ft^3/day - cubic foot per day	-- - not applicable
ft^3 - cubic foot	U - unknown
gal - U.S. gallon	EA - electron acceptor
m^3 - cubic meter	ED - electron donor

Notes:

[a] Electron acceptor concentrations were based on data from select sampling locations within the targeted units having [TCE] > 250 µg/L at select dates, using sampling data from 2005. Non-detect data was assumed to be equal to the detection limit. A concentration of 0 mg/L has been used for oxygen and nitrate when data in the vicinity was not available, as both only have minor impacts on the demand. When sulfate was not available, the next most appropriate data was substituted, as sulfate concentrations have a significant impact on the demand. The source biobarrier sulfate concentration is the average from the Base Case scenario Biobarrier FS-1. All Shell Horizon Biobarrier sulfate data is from RDO-6B.

[b] Plume dimensions correspond to the volume containing >250 µg/L TCE.

[c] Longevity of EVO in source area is dependent upon the mass of TCE DNAPL present (unknown) and the rate of TCE degradation.

[d] See Table 4.2 for details on design parameters.

[e] From Table B.3.

[f] Seepage Velocity = (hydraulic conductivity * horizontal hydraulic gradient) / soil effective porosity.

[g] Groundwater Discharge = seepage velocity * plume length * plume thickness * soil effective porosity.

[h] Electron Acceptor Mass Discharge = [electron acceptor] * groundwater discharge.

[i] Expected Longevity = mass of EVO injected / donor demand.

Table B.2
Stoichiometric Calculations for Determining Molar Consumption Ratios for EVO
IR Site 70, Naval Weapons Station Seal Beach, California

Compound	Chemical Formula	Stoichiometry[a]	Linoleic Acid		Oleic Acid		Palmitic Acid	
			Balanced Redox Reaction[b]	Molar Ratio[c]	Balanced Redox Reaction[b]	Molar Ratio	Balanced Redox Reaction[b]	Molar Ratio
Chorinated Ethenes								
Tetrachloroethene	C_2Cl_4	$C_2Cl_4 + 8e^- + 4H^+ = C_2H_4 + 4Cl^-$	$2C_{18}H_{32}O_2 + 25C_2Cl_4 + 86H_2O = 25C_2H_4 + 18CO_2 + 18HCO_3^- + 118H^+ + 100Cl^-$	2/25	$4C_{18}H_{34}O_2 + 51C_2Cl_4 + 172H_2O = 51C_2H_4 + 36CO_2 + 36HCO_3^- + 240H^+ + 204Cl^-$	4/51	$2C_{16}H_{32}O_2 + 23C_2Cl_4 + 76H_2O = 23C_2H_4 + 16CO_2 + 16HCO_3^- + 108H^+ + 92Cl^-$	1/23
Trichloroethene	C_2HCl_3	$C_2HCl_3 + 6e^- + 3H^+ = C_2H_4 + 3Cl^-$	$3C_{18}H_{32}O_2 + 50C_2HCl_3 + 129H_2O = 50C_2H_4 + 27CO_2 + 27HCO_3^- + 177H^+ + 150Cl^-$	3/50	$C_{18}H_{34}O_2 + 17C_2HCl_3 + 43H_2O = 17C_2H_4 + 9CO_2 + 9HCO_3^- + 60H^+ + 51Cl^-$	1/17	$3C_{16}H_{32}O_2 + 46C_2HCl_3 + 114H_2O = 46C_2H_4 + 24CO_2 + 24HCO_3^- + 162H^+ + 138Cl^-$	3/46
cis-1,2-Dichloroethene	$C_2H_2Cl_2$	$C_2H_2Cl_2 + 4e^- + 2H^+ = C_2H_4 + 2Cl^-$	$C_{18}H_{32}O_2 + 25C_2H_2Cl_2 + 43H_2O = 25C_2H_4 + 9CO_2 + 9HCO_3^- + 59H^+ + 50Cl^-$	1/25	$2C_{18}H_{34}O_2 + 51C_2H_2Cl_2 + 86H_2O = 51C_2H_4 + 18CO_2 + 18HCO_3^- + 120H^+ + 102Cl^-$	2/51	$C_{16}H_{32}O_2 + 23C_2H_2Cl_2 + 38H_2O = 23C_2H_4 + 8CO_2 + 8HCO_3^- + 54H^+ + 46Cl^-$	1/23
Vinyl Chloride	C_2H_3Cl	$C_2H_3Cl + 2e^- + H^+ = C_2H_4 + Cl^-$	$C_{18}H_{32}O_2 + 50C_2H_3Cl + 43H_2O = 50C_2H_4 + 9CO_2 + 9HCO_3^- + 59H^+ + 50Cl^-$	1/50	$C_{18}H_{34}O_2 + 51C_2H_3Cl + 43H_2O = 51C_2H_4 + 9CO_2 + 9HCO_3^- + 60H^+ + 51Cl^-$	1/51	$C_{16}H_{32}O_2 + 46C_2H_3Cl + 38H_2O = 46C_2H_4 + 8CO_2 + 8HCO_3^- + 54H^+ + 46Cl^-$	1/46
Miscellaneous Inorganic Species								
Oxygen	O_2	$O_2 + 4H^+ + 4e^- = 2H_2O$	$C_{18}H_{32}O_2 + 25O_2 = 9CO_2 + 9HCO_3^- + 7H_2O + 9H^+$	1/25	$2C_{18}H_{34}O_2 + 51O_2 = 18CO_2 + 18HCO_3^- + 16H_2O + 18H^+$	2/51	$C_{16}H_{32}O_2 + 23O_2 = 8CO_2 + 8HCO_3^- + 8H_2O + 8H^+$	1/23
Nitrate	NO_3^-	$2NO_3^- + 12H^+ + 10e^- = N_2 + 6H_2O$	$C_{18}H_{32}O_2 + 20NO_3^- + 11H^+ = 10N_2 + 9CO_2 + 9HCO_3^- + 17H_2O$	1/20	$5C_{18}H_{34}O_2 + 102NO_3^- + 57H^+ = 51N_2 + 45CO_2 + 45HCO_3^- + 91H_2O$	3/61	$5C_{16}H_{32}O_2 + 92NO_3^- + 52H^+ = 46N_2 + 40CO_2 + 40HCO_3^- + 86H_2O$	5/92
Sulfate[e]	SO_4^{2-}	$SO_4^{2-} + 10H^+ + 8e^- = H_2S + 4H_2O$	$2C_{18}H_{32}O_2 + 25SO_4^{2-} + 32H^+ = 25H_2S + 18CO_2 + 18HCO_3^- + 14H_2O$	2/25	$4C_{18}H_{34}O_2 + 51SO_4^{2-} + 66H^+ = 51H_2S + 36CO_2 + 36HCO_3^- + 32H_2O$	4/51	$2C_{16}H_{32}O_2 + 23SO_4^{2-} + 30H^+ = 23H_2S + 16CO_2 + 16HCO_3^- + 16H_2O$	2/23

Compound	Chemical Formula	Stoichiometry[a]	Stearic Acid		Gamma-Linoleic	
			Balanced Redox Reaction[b]	Molar Ratio	Balanced Redox Reaction[b]	Molar Ratio
Chlorinated Ethenes						
Tetrachloroethene	C_2Cl_4	$C_2Cl_4 + 8e^- + 4H^+ = C_2H_4 + 4Cl^-$	$C_{18}H_{36}O_2 + 13C_2Cl_4 + 43H_2O = 13C_2H_4 + 9CO_2 + 9HCO_3^- + 61H^+ + 52Cl^-$	1/13	$4C_{18}H_{30}O_2 + 49C_2Cl_4 + 172H_2O = 49C_2H_4 + 36CO_2 + 36HCO_3^- + 232H^+ + 196Cl^-$	4/49
Trichloroethene	C_2HCl_3	$C_2HCl_3 + 6e^- + 3H^+ = C_2H_4 + 3Cl^-$	$3C_{18}H_{36}O_2 + 52C_2HCl_3 + 129H_2O = 52C_2H_4 + 27CO_2 + 27HCO_3^- + 183H^+ + 156Cl^-$	3/52	$3C_{18}H_{30}O_2 + 49C_2HCl_3 + 129H_2O = 49C_2H_4 + 27CO_2 + 27HCO_3^- + 174H^+ + 147Cl^-$	3/49
cis-1,2-Dichloroethene	$C_2H_2Cl_2$	$C_2H_2Cl_2 + 4e^- + 2H^+ = C_2H_4 + 2Cl^-$	$C_{18}H_{36}O_2 + 26C_2H_2Cl_2 + 43H_2O = 26C_2H_4 + 9CO_2 + 9HCO_3^- + 61H^+ + 52Cl^-$	1/26	$2C_{18}H_{30}O_2 + 49C_2H_2Cl_2 + 86H_2O = 49C_2H_4 + 18CO_2 + 18HCO_3^- + 116H^+ + 98Cl^-$	2/49
Vinyl Chloride	C_2H_3Cl	$C_2H_3Cl + 2e^- + H^+ = C_2H_4 + Cl^-$	$C_{18}H_{36}O_2 + 52C_2H_3Cl + 43H_2O = 52C_2H_4 + 9CO_2 + 9HCO_3^- + 61H^+ + 52Cl^-$	1/52	$C_{18}H_{30}O_2 + 49C_2H_3Cl + 43H_2O = 49C_2H_4 + 9CO_2 + 9HCO_3^- + 58H^+ + 49Cl^-$	1/49
Miscellaneous Organics						
Oxygen	O_2	$O_2 + 4H^+ + 4e^- = 2H_2O$	$C_{18}H_{36}O_2 + 26O_2 = 9CO_2 + 9HCO_3^- + 9H_2O + 9H^+$	1/26	$2C_{18}H_{30}O_2 + 49O_2 = 18CO_2 + 18HCO_3^- + 12H_2O + 18H^+$	2/49
Nitrate	NO_3^-	$2NO_3^- + 12H^+ + 10e^- = N_2 + 6H_2O$	$5C_{18}H_{36}O_2 + 104NO_3^- + 59H^+ = 52N_2 + 45CO_2 + 45HCO_3^- + 97H_2O$	4/83	$5C_{18}H_{30}O_2 + 98NO_3^- + 53H^+ = 49N_2 + 45CO_2 + 45HCO_3^- + 79H_2O$	5/98
Sulfate[d]	SO_4^{2-}	$SO_4^{2-} + 10H^+ + 8e^- = H_2S + 4H_2O$	$C_{18}H_{36}O_2 + 13SO_4^{2-} + 17H^+ = 13H_2S + 9CO_2 + 9HCO_3^- + 9H_2O$	1/13	$4C_{18}H_{30}O_2 + 49SO_4^{2-} + 62H^+ = 49H_2S + 36CO_2 + 36HCO_3^- + 24H_2O$	4/49

Notes:

[a]Complete mineralization to the appropriate end products was assumed.

[b]Balanced redox reactions for the components of EVO were developed assuming that the main components are linoleic acid ($C_{18}H_{32}O_2$ - 53.3%), palmitic acid ($C_{16}H_{32}O_2$ - 10.8%), stearic acid ($C_{18}H_{36}O_2$ - 4%), oleic acid ($C_{18}H_{34}O_2$ - 23.8%), and gamma-linolenic acid (C18H30O2 - 7.1%).

[c]Molar ratio is the number of moles of electron donor consumed per mole of constituent.

[d]Sulfate (SO_4^{2-}) reduction to H_2S favored for pH=6. For higher pH (i.e., pH=8), sulfate reduction occurs as $SO_4^{2-} + 8e^- + 9H^+ = HS^- + 4H_2O$ (Weidermeier et al., 1998). Molar consumption ratio will not change for either case.

Acronyms/Abbreviations:

EVO - emulsified vegetable oil
g/mol - grams per mole
H_2S - hydrogen sulfide
SH^- - hydrogen sulfide ion

Electron Donor Molecular Weights (g/mol)

Linoleic acid	280
Oleic acid	282
Palmitic acid	256
Stearic acid	284
Gamma-linolenic	278

Table B.3
EVO Demand Calculations
IR Site 70, Naval Weapons Station Seal Beach, California

			EVO Demand (mg/L)[a]													
Constituent		**Molar Electron Donor Consumption Ratios[b]**	**Source Area**		**Plume Base Case Scenario**					**Plume Design Alternative 1**						
Electron Acceptor	**Molecular Weight (g/mol)**		**Source Area**	**Source Barrier**	**Biobarrier FS-1**	**Biobarrier FS-2**	**Biobarrier SH-1**	**Biobarrier SH-2**	**Biobarrier SS-1**	**Biobarrier FS-1**	**Biobarrier FS-2**	**Biobarrier FS-3**	**Biobarrier SH-1**	**Biobarrier SH-2**	**Biobarrier SH-3**	**Biobarrier SS-1**
Chlorinated Ethenes																
Tetrachloroethene	166	3/40	0.004	0.006	0.003	0.004	0.001	0.001	0.001	0.003	0.003	0.004	0.001	0.001	0.001	0.001
Trichloroethene	131	4/67	4.4	1.1	0.25	0.35	0.41	0.41	0.14	0.25	0.25	0.35	0.41	0.41	0.41	0.14
cis-1,2-Dichloroethene	96.9	1/25	0.88	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01
Vinyl Chloride	62.5	1/50	0.019	0.004	0.002	0.003	0.0004	0.0004	0.001	0.002	0.002	0.003	0.0004	0.0004	0.0004	0.001
Miscellaneous Organic Species																
Oxygen	32.0	1/25	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrate	62.0	1/20	0.04	0.00	0.04	0.04	0.0	0.0	0.04	0.04	0.04	0.04	0.0	0.0	0.0	0.04
Sulfate	96.1	7/88	151	75	75	84	48	48	48	75	75	84	48	48	48	48
Total Electron Donor Demand (mg/L)			**159**	**76**	**76**	**85**	**48**	**48**	**48**	**76**	**76**	**85**	**48**	**48**	**48**	**48**
Safety Factor * Stoichiometric Amount (mg/L)[c]			**317**	**153**	**151**	**170**	**97**	**97**	**96**	**151**	**151**	**170**	**97**	**97**	**97**	**96**
Total Electron Donor Consumption Ratio (by mass)			**41/92**	**32/71**	**5/11**	**5/11**	**29/64**	**29/64**	**5/11**	**5/11**	**5/11**	**5/11**	**29/64**	**29/64**	**29/64**	**5/11**

Notes:

[a]Electron donor demand is based on averages of constituent concentrations measured in the specified area. (see Table B.1 for details)
[b]See Table B.2 for details on consumption ratio calculations. Consumption ratios are reported as the moles of electron donor consumed to the moles of electron acceptor consumed.
[c]A safety factor of 2 is used to increase the calculated electron donor demand above the stoichiometric amount to include any mass consumption pathways not accounted for here.

Acronyms/Abbreviations:

EVO - emulsified vegetable oil
mg/L - milligrams per liter
g/mol - grams per mole

NFESC

Naval Facilities Engineering Service Center
Port Hueneme, California

Contract No. 47408-04-C-7526

Appendix C
Standard Operating Procedures

Design Document
Installation Restoration Program Site 70
Naval Weapons Station Seal Beach
Seal Beach, California

March 2006

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ACRONYMS AND ABBREVIATIONS

DO	Dissolved Oxygen
EVO	Emulsified Vegetable Oil
ft	feet
gal	gallons
gpm	Gallons per Minute
HASP	Health and Safety Plan
i.d.	Inside Diameter
ID	Identification
In.	Inches
KB-1™	Mixed dehalorespiring bacterial culture
µm	micrometers
m	meter
mm	millimeters
MSDS	Material Safety Data Sheet
NASA	National Aeronautics and Space Administration
NTU	National Turbidity Units
o.d.	Outside Diameter
ORP	Oxidation Reduction Potential
PID	Photoionization Detector
psi	Pounds per Square Inch
PVC	Polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
ROI	Radius of Injection
USCS	Unified Soil Classification System
VOCs	Volatile Organic Compounds

APPENDIX C: STANDARD OPERATING PROCEDURES

C.1 DRILLING

Injection and monitoring well boreholes will be drilled by using hollow-stem auger and/or sonic drilling methods for source area treatment and First Sand biobarrier wells. Deeper biobarrier injection wells will be drilled by using sonic, mud rotary, or other appropriate drilling methods. Information specific to each drilling method is provided below.

C.1.1 Hollow-Stem Auger Drilling

A California-licensed driller will be contracted to perform drilling and soil sampling operations with a hollow-stem auger as needed. This type of auger consists of a hollow steel stem or shaft with a continuous, spiraled steel flight welded onto the exterior stem. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring or injection well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils and/or water table. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be fastened onto the bottom of the augers to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Water-tight center plugs are not acceptable because they create suction when extracted from the augers. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by washing out the plug by using a side discharge rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Soil cuttings will be temporarily stored on Site in roll-off bins while drilling and well installation/development activities are being conducted.

C.1.2 Mud Rotary Drilling

Mud rotary borings will be advanced by rapid rotation of the drilling bit, which cuts, chips, and grinds the material at the bottom of the hole into small particles. The cuttings are removed by drilling fluid (potable water and bentonite drilling mud) from an aboveground, leak-resistant container down through the drill rods and bit, and up the annulus between the borehole wall and the drill rods. This fluid flows first into an aboveground trough and ultimately back to the main container for recirculation. Quality Assurance/Quality Control (QA/QC) samples of drilling mud and potable water will be sampled at a point of discharge from the circulation system prior to their disposal or from the drilling mud container.

C.1.3 Sonic drilling

Sonic drilling combines rotation with high frequency vibration to advance a core barrel to a desired depth. Sonic borings will be drilled by using an 8.5-inch outside diameter (o.d) casing and a 3.5-inch (i.d) diameter core barrel to collect soil samples.

C.2 SOIL SAMPLING AND CHARACTERIZATION

Continuous cores will be obtained from one out of every six boreholes in the injection well field. Soil samples will be obtained from continuous cores for purposes of lithologic logging, chemical and geotechnical (grain size distribution, porosity, permeability, etc.) analyses. Drill cuttings will be sampled at locations corresponding to lithologic changes from all other wells for purposes of lithologic logging only. Sections C.2.1, C2.2, and C2.3 below describe the soil sampling methodology, chemical and geotechnical analyses, and the lithologic logging procedures respectively.

C.2.1 Soil Sampling Methodology

The methodologies to be followed for obtaining soil samples by using hollow-stem auger, mud-rotary and sonic drilling techniques are outlined in more detail below.

C.2.1.1 Hollow Stem Auger Soil Sampling

Where continuous cores are desired, a drive sample will be collected every five feet over the continuous core interval. Soil samples will be collected with a Christensen 94-millimeter (mm) Wireline Core Barrel System (or equivalent). The sampler will be fitted with a string of 2-inch diameter, 6-inch long stainless steel (or brass) sample sleeves laid end to end within the sample barrel. This method can collect up to 5 feet of core if the lithology allows. Sample lengths can be reduced if recovery is compromised by coarse-grained material.

In boreholes where drill cuttings are to be logged and sampled, formation samples will be collected at approximately 5-foot intervals from cuttings at the top of the auger flight. Samples will be obtained from a point as near to the borehole as possible. The samples will be contained within a sample box and labeled for the representative depth. The cuttings will be examined and logged. Auger flight time will be accounted for in the logging.

C.2.1.2 Mud Rotary Soil Sampling

Where continuous cores are desired, a drive sample will be collected every five feet over the continuous core interval. Soil samples will be collected with a Christensen 94-mm Wireline Core Barrel System (or equivalent). The sampler will be fitted with a string of 2-inch diameter, 6-inch long stainless steel (or brass) sample sleeves (laid end to end), which can collect up to 5 feet of core if the lithology allows. Sample lengths can be reduced if recovery is compromised by coarse-grained material.

In boreholes where drill cuttings are to be logged and sampled, formation samples will be collected at approximately 5-foot intervals from cuttings within the drilling fluid. Samples will be obtained from a point as near to the borehole as possible, but prior to entering the mechanical separation equipment. Samples of the drilling fluid, including the entrained formation cuttings, will be collected by using an appropriate container and or strainer. The fluid/cutting mixture will be allowed to stand for approximately 1 minute, the drilling fluid will be decanted away, and the remaining cuttings examined and logged. Drilling fluid circulation time will be accounted for in the logging.

C.2.1.3 Sonic Core Recovery

The core barrel will be advanced ahead of the casing for core collection. Continuous core will be collected from the ground surface to the total targeted depth of the borehole. Soil samples will be vibrated out of the core barrel and into a plastic sleeve, knotted at both ends. These will be examined, photographed, and logged while the samples are fresh from the borehole.

C.2.2 Chemical and Geotechnical Analyses of Soil Samples

Soil samples collected from the continuous cores recovered from every sixth boring will be field-screened for total ionizable volatile organic compounds (VOCs) by a hand-held photoionization detector (PID). Approximately one half pint of soil from each sample interval will be sealed in a Ziploc® bag, stored for ten minutes, and then screened for total ionizable VOCs in the headspace of the Ziploc® bag. For each borehole where soil samples are collected within the shallow source area, the sample with the highest recorded total VOC concentration will be submitted to a commercial laboratory for (VOC) analysis. Chemical analyses will be conducted within the shallow source grid treatment area only, to provide more detailed delineation of areas potentially containing DNAPL. This information will help to better delineate the zone that may require extended treatment and/or closer monitoring.

For each borehole from which continuous cores were collected, one or two samples collected from an area selected as representative of the targeted aquifer will be submitted to a commercial laboratory for geotechnical (porosity, permeability, grain size distribution, etc.) or sieve analysis. For all other boreholes, a field sieve analysis or visual screening will be performed on a sample from the screened interval to determine the aquifer grain size.

C.2.3 Lithologic Logging

Detailed soil lithology logs will be developed for one out of every five boreholes within the injection well field by a geologist under supervision of a State of California Professional Geologist. At these boreholes, continuous cores will be obtained and logged from ground surface through the screened interval. At all other wells, lithology logs identifying lithologic changes with depth will be developed from visual screening of drill cuttings.

C.2.4 Record Keeping

Maintaining an organized and complete set of records is an integral part of drilling and well installation and development procedures and is a regulatory requirement. This includes completing field data sheets and maintaining daily field report sheets. Record keeping during drilling and soil sampling procedures will include completing boring logs and maintaining daily field report sheets. During drilling activities, the field boring log will be completed for each location. The boring log sheet shall contain, at minimum, the following information:

- Project (facility) name, boring name, date started and finished, geologist's and driller's names, boring location, rig type, auger size, sampling equipment used, and classification scheme used for soils;

- Lithology-Soils shall be described by using the Unified Soil Classification System (USCS). This will include soil/unconsolidated material/rock type, texture, plasticity, density, and gross petrology;

- Description of stratigraphic and/or lithologic structural features encountered. This will include a description of planar features (e.g. bedding planes, graded bedding), lineations, voids, cementation, nodules, bioturbated zones, organic matter, shell deposits, root holes and other features related to vegetation, and discontinuities. The orientation of these features will be measured when possible. This data will only be available from the drive samples, sonic borings, and continuous core pulled from the borehole.

- Qualitative moisture content (wet, moist, dry), degree of weathering, color (referenced to Munsell color charts), stain (e.g., presence of mottles, iron oxide [Fe_2O_3]), odor and depth to water bearing unit(s), and vertical extent of each water-bearing unit, where possible;

- Observations made during drilling. This includes advance rate, water loss, depth to water table or saturation, drilling difficulties; changes in drilling method or equipment, amounts and types of any drilling fluids used, presence of running sands, cave/hole stability, and depth of borehole and reason for termination of borehole;

- General observations made during sampling (e.g., depth of borehole, blow counts, sample recovery, sample depth/number/type, percent sample recovery);

- PID readings collected from soil samples and in the vicinity of the borehole at the surface. The PID will be used to monitor vapor emissions during drilling. Vapor emissions from the soil samples and from the open borehole casing will be monitored and recorded on the boring log; and

- Other remarks, including deviations from drilling plan, weather conditions, drilling observations, and possible contamination of soil or groundwater.

Daily field sheets will also be maintained during drilling. The daily field sheet will contain other pertinent information that is not on the boring logs, such as observed arrival times and departure times of visitors and subcontractors on the site, drilling problems, and break times, etc.

C.3 WELL INSTALLATION

Following the drilling of each borehole, a monitoring or injection well will be installed. For the EVO injection wells, the screened intervals should target the entire lithologic unit of interest. Monitoring wells will have 10-foot screens across depths that approximately correspond to the center of the injection well screen. Where two monitoring wells are to be constructed at two depths in one location, the screened intervals of the two wells should be selected to correspond to the screened interval of the corresponding injection wells (i.e., distances above, below and between the screened intervals of the monitoring wells in relation to the injection well are equal). Adjustment to the proposed screened intervals may be required to meet these objectives upon approval from the field program manager.

During well construction, the field geologist will keep a complete record of the design and construction of each well and of all materials installed in the borehole (i.e., depth of screen, length of screen and casing, volume of sand and bentonite pellets, bags of cement, etc.). Construction methods will also be verified and recorded in the field by the field geologist. Installation details specific to both EVO injection and monitoring well installation are included in Section C.3.1 and C.3.2 respectively.

C.3.1 Injection Well Installation

PVC centralizers will be installed above and below the screened interval and at 40-foot intervals along the blank casing. The annulus of each well will be filled with filter sand, which will extend from approximately 3 feet above the top of the screen to the bottom of the borehole. The filter sand, a number 2/12 sand or equivalent, will be carefully installed through the annulus between the well screen and the borehole. The sand will be poured slowly and its level will be measured by using a weighted tape measure at approximately one-half bag intervals. A surge block will be applied to the well following placement of the filter pack to induce settlement of the filter pack. Additional filter pack material will be added following surging of the well until the filter pack extends approximately 2 feet above the top of the screen interval. Approximately 1 foot of transition sand (finer grained number 30 or 1C sand or equivalent) will be placed above the filter pack sand to prevent intrusion of annular sealants into the filter pack. The top of the filter pack will be verified by using a weighted tape measure. An approximately 2-foot thick hydrated bentonite pellet/chip seal will be tremied down the annular space of the borehole to ensure a competent seal above the transition sand and hydrated as necessary. The top of the bentonite seal will be verified by using a weighted tape measure. The remaining well annulus will be completed with cement/bentonite grout to provide a surface seal. The cement/bentonite grout will be installed under pressure by using a tremie pipe, leaving approximately 1 foot of exposed polyvinyl chloride (PVC).

Injection wells will be constructed of 4-inch diameter schedule 80 PVC. All injection wells will have 0.020-inch screens. The injection well blank casing will be tightly threaded and sealed to prevent leakage during the injection phase. Sealing can be with a Teflon seal, o-ring, or other method to maintain a seal to a maximum pressure of 50 pounds per square inch (psi). Special care will be taken to seal any connections within the top 10 ft of the well completion. Each well will be completed at surface with either a minimum 17-inch diameter traffic-rated well vault and cover, or an aboveground surface completion with protective posts. Wells constructed in low lying areas will have a minimum of 2 feet of stick up to avoid flooding the well head. A flange fitting (9-inch outside diameter) will be solvent welded to the top of the well casing for attachment of the EVO injection well head fitting and a nominal 4-inch J-plug will seal the annulus of the flange fitting while the injection well is not in operation. The fitting and J-plug will terminate just below the top of the well vault.

C.3.2 Monitoring Well Installation

All monitoring wells shall be installed in general accordance with the Cal-EPA guidance Monitoring Well Design, and Construction for Hydrogeologic *Characterization* (July, 1995). PVC centralizers will be installed above and below the screened interval and at 40-foot intervals along the blank casing. The annulus of each well will be filled with filter sand, which will extend from approximately 3 feet above the top of the screen to the bottom of the borehole. The filter sand, a number 2/12 sand or equivalent, will be carefully installed through the annulus between the well screen and the borehole. The sand will be poured slowly and its level will be measured by using a weighted tape measure at approximately one-half bag intervals. A surge block will be applied to the well following placement of the filter pack to induce settlement of the filter pack. Additional filter pack material will be added following surging of the well until the filter pack extends approximately 2 feet above the top of the screen interval. Approximately 1 foot of transition sand (finer grained, a number 30 or 1C sand or equivalent) will be placed above the filter pack sand to prevent intrusion of annular sealants into the filter pack. The top of the filter pack will be verified by using a weighted tape measure. An approximately 2-foot thick hydrated bentonite pellet/chip seal will be tremied down the annular space of the borehole to ensure a competent seal above the transition sand and hydrated as necessary. The top of the bentonite seal will be verified by using a weighted tape measure. The remaining well annulus will be completed with cement/bentonite grout to provide a surface seal. The cement/bentonite grout will be installed under pressure using a tremie pipe, leaving approximately 1 foot of exposed polyvinyl chloride (PVC).

Monitoring wells will be constructed of 4-inch diameter PVC. Monitoring wells with a total depth less than 100 ft shall be constructed of schedule 40 PVC and monitoring wells with a total depth of greater than 100 ft shall be constructed of schedule 80 PVC. All monitoring wells will have 0.020-inch screens. Each monitoring well will be completed with a locking cap and either a traffic-rated cover or an aboveground surface completion with protective posts.

C.3.3 Record Keeping

During well installation, a well construction record and a well diagram will be completed containing the following information:

- Project (facility) name, well name, date and time of well construction, geologist's and driller's names;
- Well depth (±0.1 ft), casing length and materials, screened interval, material and slot size/design;
- Filter pack material, size, and volume (calculated and actual);
- Annular sealant composition, placement method, and volume (calculated and actual);
- Surface sealant composition, placement method, and volume (calculated and actual); and
- Type and construction of protective casing (well box), well cap and lock.

C.4 WELL DEVELOPMENT

The wells will be allowed to set and recover for at least 48 hours after installation prior to development. This will allow curing of the grout so that development activities do not damage the grout seal. Development of each well will be performed with a Smeal 5T rig, or equivalent, equipped with a steam cleaner, vented surge block, air lift and submersible pumps, bailers capable of removing sediments from the well, and a generator. Prior to development, the rig and development equipment will be steam cleaned to reduce the potential for cross-contamination between wells. Water quality measurement instruments will be calibrated each day, or more often if measurements are suspicious. Calibration will be performed with standards supplied by the instrument manufacturers. Field data collected during the well development procedure will be recorded on a well development log sheet. Initial procedures for well development include:

- Document well identification number, well construction details, bottom of well, screen interval, casing size, and well depth;
- Recording static water depth and total well depth with an electric water level indicator;
- Initially alternate surging and bailing with a surge block and a stainless steel or PVC bailer;
- When sands and silts have diminished in the water coming out of the bailer, pumping should begin in the development process and the following procedures will be implemented.
- Re-record static water depth and total well depth;
- Set the pump at approximately two feet off the bottom of the well;
- Begin pumping;
- Periodically record flow rate, drawdown (water level), and volume of water removed.
- Periodically monitor water quality parameters (pH, temperature, specific conductivity, and turbidity) with a Horiba U-10 meter (or equivalent).

Well development will be considered complete when at least three casing volumes of water have been removed and field readings have stabilized as follows:

- pH, $\pm$0.1;
- temperature, $\pm$10%;
- specific conductivity, $\pm$3%;
- dissolved oxygen, $\pm$0.3 milligrams per liter; and

- turbidity, ±10% (where turbidity is greater than 10 NTU), a turbidity reading of less than 5 National Turbidity Units (NTUs) will be targeted.

During well development, field data sheets will be completed for each well location. The field data sheet will include, at a minimum, a well development log containing the following information:

- Project (facility) name, well name, date and time of development, geologist's and developer's names;

- Depth to static water level, total depth of well, boring and well casing inside diameter (i.d.) and OD, and calculation of well volume; and

- Time, depth to water, volume removed, flow rate, pH, temperature, turbidity, and specific conductance.

C.5 GROUNDWATER SAMPLING

C.5.1 Field Preparation

Prior to the start of each sampling event, the following activities shall be performed to prepare for the sampling event:

- The site-specific Health and Safety Plan (HASP) shall be reviewed and signed by all sampling personnel.

- The sampling personnel shall gather the appropriate containers and forms to have the samples analyzed for the required constituents. Appropriate forms include the chain of custody, labels, and a purge and sampling record.

- The sampling team will collect the Quality Assurance (QA) samples for each day's sampling listed with appropriate QA sample containers, checklist, analyses, and quantity.

- Ensure a water level meter will be present during sampling.

- Obtain a Horiba U-10 meter (or equivalent) to measure pH, specific conductivity, temperature, dissolved oxygen, and turbidity.

- Calibrate Horiba U-10 (or equivalent) at the beginning of every day in accordance with manufacturer's instructions by using provided calibration solution. The Horiba instrument shall also be recalibrated any time during sampling activities if inconsistent readings are suspected.

- Ensure that calibrated containers or drums are available to measure discharge rates, total discharge, and contain purge water.

- Ensure that new tubing will be available for every sample taken.

C.5.2 Groundwater Sampling

C.5.2.1 Pre-Sampling Activities

Groundwater sampling will be conducted no sooner than one week after the completion of development of the sampled wells. Before purging, purging and sampling equipment will be thoroughly cleaned and decontaminated to prevent cross-contamination. Additionally, water levels will be measured by using an electric water level indicator by using the following procedure:

- Measure the depth to water to the nearest ±0.01 feet (ft) (0.003 meter [m]) by using a water level meter consisting of a graduated cable and probe. Calibration of the water level meter will be checked with a measuring tape before use. Decontaminate the water level meter prior to introduction into the well.

- Lower the water level meter probe into the well slowly. The water level indicator will create a sound or turn on a light when the probe comes into contact with water.

- Confirm that the water encountered by the water level indicator probe is the groundwater level by raising and lowering the indicator into and out of the water several times. False indications of water level may be provided by condensation along the well casing or high humidity within the well.

- Document the reading (in feet) indicated by the graduated cable at the reference point (water level depths will be measured from a surveyed elevation, typically, the north edge of the top of casing, or the top of the flange (north side) for the injection wells). Subtract this value from the surveyed reference point elevation (in feet above mean sea level) to calculate the water level elevation (in feet above mean sea level).

- While extracting the water level indicator cable and probe from the well casing, remove water and particles from the cable by passing the cable through a clean paper towel.

C.5.2.2 Purging Activities

Prior to collection of groundwater samples from each well, at least three casing volumes of groundwater will be purged by using electric submersible pumps or air lift pumps, as necessary. Purging of the groundwater will be performed at relatively low flow rates, to ensure minimal drawdown of the surrounding water table. Water purged from the wells will be monitored for temperature, pH, conductivity, dissolved oxygen, oxidation/reduction potential, and turbidity to document changes in water quality. Water quality field parameters will be recorded every three minutes or each time the internal volume of the flow cell is replaced with water during purging. Additionally, color, appearance, and any noticeable odors will be documented.

After the groundwater has reached stabilization and purging is complete, sampling should be conducted immediately. For bulk sampling, laboratory-provided sample containers (with appropriate type and volume of preservative) will be filled directly from the sample pump discharge hose while maintaining the flow rate established during purging to minimize any potential agitation of the groundwater.

C.5.2.3 Sampling Activities

Samples will be collected in accordance with the following guidelines:

- Gloves worn during purging shall be discarded and replaced with clean gloves for sampling;
- Sample containers shall not be opened until immediately prior to filling;
- The insides of sample containers shall not be touched, including with clean gloves;
- Sampling containers shall be filled slowly and with minimal aeration through the hose from the pump (do not touch the tubing to the inside of the sample container);

- Sampling containers shall be filled completely, but not overfilled, as this will result in the loss of preservative;

- QA samples will be collected as specified on the sample collection log, will be properly labeled, and entered on the chain-of-custody.

- Sampling containers shall be filled as expeditiously as possible to minimize the time between filling the first sample container and the last; and

- Filled sample containers shall be labeled, prepared for transport, and stored in an ice chest or cooler as described below.

Immediately following sample collection, each sampling container will be sealed, labeled, and preserved with ice in an ice chest (at a temperature of 4±2^{o}C). Breakable or otherwise fragile sample containers will be stored in travel cases or wrapped in plastic bubble-wrap to reduce potential damage during delivery to the laboratory. Typically, samples will be delivered within 24 hours of sample collection to provide time for sample preparation and testing within EPA holding times.

C.5.2.4 Sample Labeling and Chain of Custody Protocol

Each sample container shall be labeled with a distinct and clearly written label. The field sampling personnel shall complete the information on the sample label at the time of sampling by using indelible ink. The coding to be used to identify each sample shall be standardized.

A note in the field activity report sheet shall be made to correlate the sample identification (ID) number to the well ID number. Labels shall be affixed to a clean and dry surface of the sample bottle and double-checked for completeness. Sampling containers shall be stored properly in an ice chest or cooler to reduce the potential for breakage, spillage, or label deterioration. Proper sample storage consists of “bubble wrap” around glass bottles or vials, sealable Ziploc®-type bags around sample containers, blue ice packs in the cooler, and packing material to occupy remaining voids. Sample containers shall be stored in ice chests immediately following sampling. The samples shall be maintained in the cooler with ice or blue ice packs between the time the samples are collected and the time the samples are analyzed in the laboratory. The presence of solid ice in the ice-cooler will be periodically checked in the field and recorded on daily field sheets. The presence of ice or blue ice packs and the temperature of the samples shall be measured and recorded upon receipt by the laboratory. On hot days, the field samplers shall periodically monitor the cooler to replace melted ice, as needed, to maintain the acceptable volume of ice. The coolers containing the groundwater sample containers shall be delivered to the Laboratory on the same day the samples are collected or the following day by courier. Each set of samples shall be accompanied by a chain-of-custody form, which outlines the contents of the cooler. QA samples will be kept with the respective sample containers to maximize representativeness of the QA samples. Information to be included on the chain-of-custody form is described below.

Chain-of-custody records will be maintained for each sample collected to provide an accurate written record of the possession and holding of samples from the time of collection through laboratory receipt. The following information will be specified for each sample on the chain-of-custody form:

- Site identification;
- Sample identification;
- Sample date;
- Sample time;
- Type of preservative, if appropriate;
- Laboratory analyses/methods;
- Special instructions to the laboratory (e.g., short hold time, quick turn-around time); and
- Signature(s) of the sampler(s).

The sampler and any other intermediate handlers of the samples (i.e., shipping company representative, laboratory courier) will sign the form and record the date and time at which the samples changed possession. The completed chain-of-custody form will be attached to the ice chest. Upon receipt of samples by the laboratory, the laboratory will be responsible for maintaining internal chain of custody of the samples.

C.6 AMENDMENT INJECTION PROCEDURES

C.6.1 General Statement

These standard operating guidelines pertain to the subsurface injection of emulsified vegetable oil (EVO) and bioaugmentation culture KB-1™. These guidelines are intended to provide detailed guidance for conducting oil and KB-1™ injections and are to be used in conjunction with a site-specific implementation plan. Material safety data sheets (MSDS) for EVO and KB-1™ are included in Attachment C-1.

EVO is amended to the subsurface by introducing a volume of water containing the desired concentration of emulsified oil to a well or set of wells installed for this purpose. Injection volumes are designed to achieve a target radius of injection (ROI) around each injection well. Well spacings are selected to achieve reasonable coverage based on well ROI and groundwater flow conditions, creating a continuous passive biobarrier/bioreactive zone. The biobarrier is typically oriented perpendicular to the average horizontal groundwater flow direction to intercept the contaminant plume. Since the objective is to inject a target design volume of amendment, the injection duration will be governed by the rate at which the formation will accept flow.

KB-1™ is amended to each injection well partway through the EVO injection process. During KB-1™ injection, anoxic water is used for EVO dilution and injection to provide the appropriate geochemical environment for growth of the KB-1™ culture. The KB-1™ culture is amended directly to the injection well.

C.6.2 EVO and KB-1™ Injection Objectives

Injection of EVO is intended to emplace a long-lasting source of electron donor (the soybean oil) within a targeted zone of the subsurface to promote biological activity and hence long-term biological degradation of target contaminants. The purpose of the injection is to distribute the EVO over the target interval and throughout a target volume of the formation such that additional injections are required infrequently or perhaps not at all. Injection of KB-1™ is intended to provide the required dechlorinating microorganisms to the subsurface targeted zone to encourage complete dechlorination of TCE to ethene.

C.6.3 Equipment and/or Instrumentation

The overall injection process is illustrated in the process flow schematic in Figure C.1. The injection apparatus is shown in more detail in Figure C.2. The following equipment/supplies are required:

1. **Water supply**. The injections require fairly large volumes of water. Options for water supply are as follows:

    a. **Site groundwater**. Use of site groundwater is preferred, since it can be extracted from the contaminant plume and will therefore emplace the emulsified oil along with the target contaminants and with water chemistry that corresponds to the existing conditions. This is especially important when ground water is already anaerobic and bioaugmentation is going to be implemented. The use of groundwater also mitigates potential spreading of the plume in an adverse manner by maintaining a near neutral water balance. To use site groundwater, there must be extraction wells with sufficient capacity to supply the total injection flow rate; this approach works best when the extraction output can be plumbed directly to the proportional feed system and to the injection well array. This approach requires:

        i. **Extraction wells.** These may subsequently be injection wells.

        ii. **Extraction pumps**. Submersible pumps with flow control, run dry protection and a suitable power source.

        iii. **Piping and manifold**. To connect extraction wells to dosing pump(s).

        iv. **Power supply.** To operate the submersible extraction pump(s). If the site does not have power, one or more generator(s) are required. Each generator will require secondary containment for refueling in the form of 6 mL visqueen underlying and surrounding each generator, and bermed around the edges to provide containment.

    b. **Potable water.** The use of potable water may be necessary for tight formations where sufficient groundwater cannot be supplied. Two options for a supply of potable water exist: (i) direct connection to a source of potable water (e.g., fire hydrant) during injections, or (ii) storage of potable water in a tank. A direct connection with the water supply is preferable, but an alternate method is to use one or more large holding tanks (~20,000 gallon (gal); storage tank) and simply refill it periodically. In locations where it is impractical to maintain a continuous connection to the source, this would allow longer operating times each day, as injections could get underway quicker and run longer if time was not required to set up and take down the fire hose each day. The hose could be rolled out to refill the tank during daily operation, as required. Use of a tank will depend on factors such as length of fire hose required, injection rate (which determines both how quickly a tank will be used up and pump requirements), and site access and utility considerations. The use of potable water will require:

i. **Fire hose**. Ensure that there is sufficient length of hose, including a few spare segments (to allow replacement of leaking connections or worn sections), to run from the selected hydrant to the staging area. A flow meter or hydrant access permit may be required to monitor the volume of hydrant water used. If the fire hose will cross an active transportation corridor, it may be necessary to procure a hose guard to protect it and to post proper traffic warning signs, as appropriate.

ii. **Adaptor with shut off valve.** This component is assembled from standard piping to allow connection of the supply line (i.e. fire hose) to the injection manifold or pump intake lines. It has female fire-hose thread on one end and reduces to a brass 2-inch male cam on the other, with a ball valve in between to allow quick shut-off of the water supply immediately adjacent to the injection equipment. A 2-inch spa hose completes the connection from the cam to the Dosmatic™ assembly (typically the inlet side of the in-line filter).

iii. **Water supply.** If using clean water, and depending on the distance to the water supply, it is generally a good idea to plumb a simple tap off of the adaptor so that there is a ready source of clean water near the work area.

iv. **Pump.** If the water tank is used, a pump is required to transfer water from the water tank to the injection manifold. The transfer pump must have sufficient flow capacity to handle the targeted total injection rate, and must supply sufficient pressure to overcome losses in the manifold, lines and formation. (Note that the vacuum breaker on the 10-channel injection manifold causes significant losses, 15-20 psi)

v. **Power supply.** To operate the transfer pump. If the site does not have power, a generator will be required. Each generator will require secondary containment for refueling in the form of 6 mL visqueen underlying and surrounding each generator, and bermed around the edges to provide containment.

2. **Groundwater Receiving Chamber**. The central header will act to receive groundwater processed from the extraction pumps (or water supply source) and control the water pressure to the EVO amendment manifold (Figure C.2). The chamber consists of a header made of standard 4-inch PVC pipe with multiple inputs connected by cam-lok quick connectors (2-inch polypropylene) to the effluent lines from each extraction pump. A pressure regulating valve is connected to the effluent side of the chamber to reduce down gradient pressure below 100 psi.

3. **In-line filter.** Two bag filters will be plumbed in parallel in-line, downstream of the groundwater receiving chamber to remove fines from the extracted groundwater. The bag filter must have a minimum of 200 gpm capacity, and the filter element must have a nominal filter size of 74 µm at minimum. Pressure gauges with 0 to 100 psi capacity will be plumbed on either side of the bag filters to monitor pressure drop across the filters. Each bag filter will have ball valves installed on either side to allow for isolation of the filter for filter element changes.

4. **EVO Amendment Manifold**. Rather than use a second transfer pump to move the EVO, the injection equipment features proportional feed pumps (Dosmatic™ Advantage Injectors) that are water-driven. The proportional feed pumps are designed to dose the amendment into the water stream in direct proportion to the water flow rate. Five proportional feed pumps are shown in Figure C.2, which illustrates the delivery system, and additional Dosmatic™ Advantage Injectors can be added in parallel to increase the throughput of the system. A ball valve will be installed at the influent to the EVO amendment manifold to allow for isolation of the entire manifold. Individual Dosmatic™ Injectors will be installed in parallel within the manifold. Upstream globe valves on each branch allow control over the flow rate going

through each Dosmatic™ Advantage Injector. Each Dosmatic™ Advantage Injectors will be installed on a bypass with ball valves on either side to allow for isolation of the pump for maintenance, and allow for flow of groundwater without amendment through the manifold for equipment flushing purposes. Flow meters with a minimum capacity of 50 gpm will be installed downstream of each Dosmatic™ Advantage Injector on individual branches to monitor flow rates and ensure that the capacity of each Dosmatic™ Advantage Injector (40 gpm) is not exceeded.

5. **Distribution Manifold**. A multi-channel distribution manifold splits the EVO-amended water stream between multiple lines, for delivery to multiple injection wells simultaneously (refer to Figure C.2). The distribution manifold consists of a ball valve at the influent end for isolation of the entire manifold, a header made of standard 4-inch Schedule 40 PVC pipe and a mechanical totalizing flow meter (brass; minimum capacity up to 30 gpm) on each delivery channel. A needle valve is situated on the effluent side of each flowmeter to adjust the flow rate in each line independent of the other channels. The manifold outputs feature male cam-lok quick connectors (2-inch plastic) threaded into each needle valve.

6. **Amendment Delivery Lines**. The lines that carry the amendment solution from the distribution manifold to the individual injection wells are 2-inch braided PVC hose with female cam-lok quick connect fittings fixed to the hose ends with hose barbs and gear clamps. Most of the lines are 50 ft long, but can be readily connected together to cover longer runs as needed (requires a male/male adaptor to connect hoses).

7. **Injection Wells**. Injection well construction details are based on site specific information and are presented above. Prior to beginning amendment injection, verify that appropriate well construction, development, testing and baseline sampling (if appropriate) have been completed.

8. **Well-Head Fittings**. Each injection well requires a custom-built well-head fitting such as the one depicted in Figure C.2, which is designed for use with a 4-inch well. The fitting consists of a PVC cross to which 2 ball valves (2-inch), a dual vacuum/pressure gauge (-30 to 30 psi) and a clear sight tube are attached. The sight tube is 2-inch clear PVC pipe. The well-head fitting is secured to the well with a Schedule 80 PVC flange fitting (9-inch OD, 4-inch ID). This flange fitting is bolted to the flange fitting installed on the well head with a rubber gasket between

flanges to provide a tight seal for pressurized injections. The clear PVC of the well head is connected to the flange fitting through a 4 in to 2 in reducing coupling solvent welded to the flange and clear PVC pipe. The ball valve on top of the well-head fitting serves as a vent, allowing air to leave the well as it is filled with fluid. The ball valve and vent line on the top of the well must have a 1-inch ID or greater to allow water level measurements through this port. The amendment delivery line attaches, via cam-lok quick connectors, to the 2-inch ball valve on the side. This valve can shut off flow to the well quickly if necessary.

9. **Sampling ports**. Sampling ports, consisting of PVC tees with cam-lok quick connectors and a simple valve, can be added to the lines after the dose pump, or at an injection well-head fitting, if samples are to be collected.

10. **Equipment decontamination supplies**. It is necessary to periodically clean the amendment delivery lines, the proportional feed system and the distribution manifold. This is typically accomplished by recirculating solutions of detergent (Alconox), bleach and water. The following supplies will be needed:
    a. Buckets.
    b. Brush with plastic bristles. To clean filter etc.
    c. Alconox.
    d. Household bleach (~5-6% sodium hypochlorite).
    e. Trash pump and power supply. To recirculate cleaning solutions.
    f. 1,000 gal Tanks. At least 4, to hold cleaning solutions and act as recirculation reservoirs.

11. **Tools**. Various small tools, such as screwdrivers and pipe wrenches, will be useful to tighten fittings on the equipment. Buckets for water, at least one of which has been calibrated for volume, are required. Squirt bottles, filled with Alconox solution and clean water, are useful for cleaning well casings and other pieces of equipment.

12. **Trailer**. The EVO proportional feed delivery system will be mounted to a trailer to allow for ease of transportation of the equipment to various locations within the site, and allow for easy storage of equipment.

13. **Emulsified Oil**. The EVO should be ordered well in advance (6 months notice, 3 months to delivery) of planned field activities to ensure that supplier will have sufficient material available for the job. Ensure that necessary arrangements are made to unload delivery truck and stage the shipping totes (e.g., large tire, off-road fork-lift on hand to move totes).

14. **Secondary containment**. The totes will be stored on site in a Connex storage box or under a shade canopy to minimize exposure to the sun. These areas will be underlain by 6 mL visqueen and bermed around the edges to provide containment.
15. **Spill kit**. The kit should contain absorbent socks and granular absorbent, as well as a storage drum for spent sorbent. It should include a shovel and/or broom for picking up spent sorbent.

C.6.4 Preparation

All the equipment should be assembled and inspected (for cracks, leaks, worn seals, dirty equipment, missing parts, etc.) in advance of field activities. Materials and equipment should be ordered prior to commencing field work. The work plan and the health and safety plan should be reviewed by all personnel involved. If the project requires multiple phases of injection, the injection sequence should be determined in advance and a suitable staging area for the injection equipment and the containers of EVO should be selected.

C.6.5 Procedures

C.6.5.1 Emulsified Oil Injection

C.6.5.1.1 Set-up

The injection equipment should be assembled as depicted in Figure C.2. The well-head fittings should be securely attached to the wells by using the flange fittings. The Dosmatic™ injector must be located no more than 15 ft vertically and 50 ft horizontally from the bottom of the amendment (EVO) container(s). A solution filter (125 µm filter mesh) should be kept on the Dosmatic™ uptake line to protect the injector from damage, and a weighted end is useful to ensure that the uptake line remains submerged in the EVO. The proportional feed system and injection manifold should be situated such that the operator can safely and easily take readings (injection volumes, flow rates) and make flow rate adjustments over the course of the injection process.

Assemble the equipment as follows:

1. Measure water level elevations in all monitoring and injection wells to establish the baseline condition prior to injection.

2. Attach a well-head fitting securely to each injection well by using the flange fitting. Ensure that the two flanges are clean where the rubber gasket must seal against the two flanges.
3. Install groundwater extraction pumps into each of the selected extraction wells.
4. Connect groundwater extraction lines to central header (4-inch PVC) at inlet side of pressure gauges.
5. Connect output channels on the distribution manifold to well-head fittings by using the amendment delivery lines (2-inch braided hose). Close the manifold inlet valve and all output valves. Make certain that any unused channels have closed valves and, if available, end caps.
6. Connect an uptake hose to the suction piston of the Dosmatic™ injector. A check valve attaches to the base of the piston. The suction line should have a solution filter on the inlet end, preferably attached to a weight (for example, a metal bell reducer with a hose barb which connects the solution filter and the suction hose).

C.6.5.1.2 System Testing and Calibration

Upon completion of the system set-up, the system should be tested for leaks and the instrumentation checked prior to beginning the injection of EVO, as follows:

1. Record totalizer readings from all mechanical flow meters. Note which meters connect to which injection wells, and put temporary labels at all meters that correspond to the injection well identifiers.
2. Fill a couple of buckets with water. Place Dosmatic™ injector uptake hose in a bucket of water. Adjust the turndown ratio of the injector(s) to maximum (2.5% on the A40 model). Monitor the water level in the bucket so that the suction side of the injector does not run dry.
3. Close all valves except for valves at the extraction well head to prevent flow through the system. One by one, turn on each groundwater extraction pump long enough to pressurize the hose, and then turn the pump off. Inspect all hose connections to the extraction well for leaks and address as needed.
4. Open the ball valve at the inlet end of the amendment injection manifold, allowing flow to the system and initiate groundwater extraction from one well long enough to pressurize the system, and then terminate pumping. Inspect system for leaks and address as needed.

5. Following a similar process, partially open one globe valve within the amendment injection manifold and all other ball valves on the branch for the corresponding Dosmatic™ injector, keeping the ball valve at the inlet to the distribution manifold closed. Inspect for leaks and address as needed. Do not build pressure beyond 100 psi at the Dosmatic™.

6. Open the ball valve at the inlet to the distribution manifold and a needle valve on one output channel. Open the ball valve at the corresponding well head, allowing water to flow into the well. Keep the vent valve closed. Inspect delivery line and connections for leaks and address as needed.

7. Once continuous flow is established, check the Dosmatic™ injector. It should make a noticeable click; the frequency of the clicks increases as the flow rate through the pump increases. Check that the suction hose is in fact taking up water from the bucket.

8. Monitor flow rate with the sweep hand on the water meter. Monitor pressure at the well-head. Increase flow (open needle valve further) gradually, monitoring the pressure in the well (may need to open globe valve further at this point). Continue to increase the flow rate until the pressure in the well reaches 20 psi and note the flow rate. If the flow rate reaches 10 gallons per minute (gpm) (25 gpm for the Second Sand Biobarrier), note the maximum pressure reached.

9. Once one well has been leak and pressure tested and the injector has been inspected, the Dosmatic™ injector should be calibrated. While there is no flow through the system, place the injector suction hose into a bucket of water that has volume calibration markings. Adjust the turndown ratio to the desired setting. The turndown ratio is the ratio of emulsion being injected to water passing through the injector. For example, an injector setting of 2.1% will yield 1% oil (1.1% injector setting will yield 0.5% oil) in the amendment fluid when using Newman Zone, which is 48% oil by volume. Upon completion of calibration, close the ball valve at the well head, close the needle valve at the distribution manifold, the ball valve at the inlet to the distribution manifold, and close all valves within the manifold to prevent flow through the calibrated Dosmatic™ injector (keeping the ball valve at the inlet to the amendment injection manifold open). If the well is pressurized, slowly open the vent valve to release the pressure.

10. Repeat steps 5 to 9 for each injection well and Dosmatic™ injector, until all lines, injectors, and well-head fittings have been tested.

11. As each well is tested, take note of the volume taken up by the injector and compare this to the volume applied to the well. Adjust the turndown ratio to achieve the desired feed ratio and note the actual setting (scale reading) required to deliver this ratio on the log sheet.
12. Inspect the in-line filters. With the water supply shut off, drain the cartridge into an empty bucket if solids have accumulated. Clean filter element if necessary.

C.6.5.1.3 Amendment Addition

The EVO will be amended over a period of several days to weeks, with daily operating periods of 8 to 10 hours. Since the EVO injection is governed by the total volume injected, the duration will be dependent on the specific capacity of the injection and/or extraction wells, which in turn depends on the hydraulic conductivity of the target formation. The procedure to be followed for each EVO injection day is:

1. Water levels in the injection wells will be measured prior to start of injection in the morning and after the well has been depressurized at the end of the day (through the vent ball valve - after the well has been depressurized), to evaluate the rate at which the injection mound dissipates. Water level measurements will be recorded in the comments section of the log sheet Emulsified Oil Injection - Injection Flow Measurements, a sample of which is included in Attachment C-1.
2. Connect all equipment as outlined in Section C.6.5.1.1. Make sure that the correct channels are connected to the correct wells and that the log sheet, Emulsified Oil Injection – Injection Flow Measurements (in Attachment C-1), for each injection well indicates which flow totalizer is in use for that well. Each well should have its own injection log sheet.
3. Ensure that the Dosmatic™ uptake hose is submerged in the EVO. Secure the hose in place if necessary (due to pulsing of the pump). Check that the injector is set to the proper turndown ratio.
4. Record totalizer readings from all water meters that will be used. Record start time, and quantity of amendment in source (tote).
5. With all valves closed, turn on the extraction pumps.
6. Open the valves on the bypasses to each bag filter. Open valves on the amendment injection manifold, beginning with the ball valve at the inlet end, then upstream globe valves and moving towards downstream valves. On each branch of the manifold, the bypass valves to the Dosmatic™ injectors will be opened, and the main branch valves will

remain closed to ensure that all groundwater is fed through the Dosmatic™ injectors. Open the ball valve at the inlet to the distribution manifold.

7. Open the appropriate needle valves. Open the well-head ball valves, one at a time, ensuring that the flow rate into each well is acceptable. Adjust the flow rate in individual channels by using the needle valves.

   Note: What flow rate is 'acceptable' will depend on the site. If this is the first time injecting into the well, a flow rate of 1-2 gpm should be used initially, to evaluate the pressure development. Otherwise, the flow should be about what was achieved the previous day. The pressure at the well head should be maintained below the site target, and certainly below the maximum pressure achieved during leak testing (Section C.6.5.1.2).

8. As flow proceeds into the well, pressure may build up. Pressure in the well can be relieved by carefully opening the vent valve. Be sure that the operator's face is not directly above the vent valve. When venting, stay by the well. Watch the site tube to see how amendment is flowing. Under certain conditions the fluid level in the well can be brought up to just above the base of the site tube.

9. Once flow appears to be relatively stable, note the pressure at each well.

10. The sweep hands on the water meters can be timed to estimate the flow rate. Use the needle valves to balance the flow rates on individual channels as much as possible.

    Note: At some sites the decision can be made to simply operate each well as fast as possible without exceeding the maximum pressure.

11. Periodically (every 1 to 2 hours), time and date, flow totalizer readings, well-head pressure gauge readings and the volume of EVO remaining in the tote should be recorded on the log sheets (Injection Flow Measurements).

    Note: The disposable shipping totes are not graduated, so volume must be estimated by visual inspection. A graduated stick (suggest narrow diameter PVC with round end cap as it must not puncture the tote liner) can be used as an aid, since the shipping tote has a square cross-section.

12. Periodically monitor water levels in the designated wells, per 1 above.

13. Monitor the volume of EVO remaining. Ensure that a replacement tote is on hand, unless it is the final quantity of EVO to be injected, .

    a. If necessary, flow can be stopped to the wells to facilitate the change-over between EVO containers. To do this, shut off the ball valve at the inlet to the distribution manifold, then the ball valve at the inlet to the amendment injection manifold. Move the injector uptake hose to the new container. Re-open the upstream ball valve at the inlet to the amendment injection manifold and then the downstream ball valve at the inlet to the distribution manifold to re-initiate injection.

b. Record time of stop and re-start, along with flow totalizer readings. This data is important for checking the bulk oil dose ratio.

14. Check the calibration of the Dosmatic™ injector periodically. The actual frequency will depend on how long each tote is lasting, but a reasonable guideline is once per tote (250 gal).

a. Fill a calibrated vessel with EVO.

b. Stop flow through the apparatus by closing the ball valves at the inlet to the amendment injection and distribution manifolds as outlined in 13a above. Record time and flow totalizer readings. Place the injector uptake hose in the calibrated vessel. Re-start flow by opening the valves. Record time of re-start.

c. Before the injector runs out of EVO to draw up, stop injection again. Record time and flow totalizer readings.

d. Use the ratio of EVO used to volume injected to check the calibration of the injector. Adjust turndown ratio if necessary. Document change on log sheets (Injection Flow Measurements) if an adjustment is made.

e. Repeat steps a to d until desired setting is reached.

f. Place the injector uptake hose back in the EVO tote. Re-start flow by opening the valves. Record time of re-start. Record volume of EVO taken up during calibration test.

15. At the end of day, collect the final set of water level data prior to shutting down injection.

16. Before stopping for the day, run some clean, non-EVO-amended water through the equipment and the delivery lines.

a. First, record the well-head pressures.

b. Stop flow by closing the downstream ball valve at the inlet to the distribution manifold, then the upstream ball valve at the inlet to the amendment injection manifold. Record time and flow totalizer readings.

c. Place injector uptake hose in a bucket of clean water. Seal EVO tote. Restart flow through the system by opening the valves.

d. Allow about 25 to 50 gal to flow into each well to flush EVO out of the equipment. Once a line has received sufficient flush volume, stop flow in that channel by closing the needle valve. Close the ball valve at the well-head to ensure no flow in the delivery line. Shut down extraction pumps as required to limit pump stress while maintaining adequate flow through to the injection wells still in operation. If all wells are complete, shut off flow with the ball valves at the inlet to the amendment injection manifold and at the inlet to the distribution manifold. Close all other valves within the amendment injection manifold.

e. Record flow totalizer readings.

f. Shut off the groundwater extraction pumps.

g. As the water level in the injection well recedes, it will put negative pressure on the well. Allow pressure in the well to return to nearly zero and then slowly open the vent valve.

h. Check that there is no pressure remaining in the injection equipment, and release it if there is. This might require reopening one delivery line and well-head vent.

17. On subsequent operating days for the same wells, inspect the equipment and connections before proceeding from step 2 above.

18. If EVO addition is complete or at the end of each work week, the final water flush should be approximately 250 gal into each injection well. This will push the amendment out of the well and filter pack and avoid biofouling of the well screen.

C.6.5.1.4 Contingency Plan

The injection design will designate target injection volumes for each well, and the estimated duration of the injection process will be based on average injection well flow capacities. Two site-specific factors have been identified that may result in deviations from the plan:

1. Average achievable injection flow rate in target area is lower-than-expected, resulting in longer-than-expected durations to achieve target volumes. In this case, it is likely that the work period will be extended. .

2. Achievable injection flow rate varies considerably between wells, resulting in certain wells reaching their targets before others. In this

case, injection into the wells that have reached their targets should be terminated, and extraction rates decreased proportionally. Injection into the remaining wells will continue until their target volumes are achieved.

3. Achievable extraction flow rates for a given drawdown and interception of injected EVO at the operating extraction wells are two important considerations. Extracting groundwater at a rate that exceeds the capacity of the well to recover should be avoided and the extraction rate decreased to a sustainable rate in this well. The total injection rate will then decrease correspondingly, which will result in longer injection times. Interception of the EVO at the extraction wells will increase the likelihood of biofouling within the distribution manifold, extraction pumps, process lines and extraction and injection wells as they sit idle during off hours. Should this occur, a more frequent and detailed decontamination effort will be required at the end of each operating day. This will have a direct impact on achievable daily injection times.
4. If extracted water has a lot of sediment in it, frequent filter changes/cleaning will be required.

C.6.5.2 Bioaugmentation

The addition of KB-1™ (a mixed dehalorespiring bacteria culture) to promote complete dechlorination of the target chlorinated ethenes (trichloroethene, cis-1,2-dichloroethene, and vinyl chloride) to ethene should be completed in the early stages of amendment addition (i.e., after approximately one-quarter of the total amendment fluid has been injected) so that the microorganisms can be distributed over a large area. Most dechlorinating cultures, including KB-1™, are sensitive to oxygen and should be applied under anaerobic conditions. It is recommended that some anoxic water be generated as described below.

The target quantities of KB-1™ culture that are to be amended to each well are determined as part of the implementation plan, in consultation with the vendor (SiREM). KB-1™ will be shipped to the site in stainless-steel pressure vessels. Storage facilities for these vessels should be available. A MSDS for KB-1™ is provided in Attachment C-1.

Residual chlorine and/or chloramines might pose a threat to the viability of the KB-1™ culture. If using water that has been treated with chlorine, it may be prudent to have a sample of the water analyzed. If concentrations appear to be a concern, steps can be taken to remove these residuals (e.g., carbon treatment).

Amendment of KB-1™ culture should be performed by personnel trained to do so. KB-1™ will be amended directly to each well through the well-head fitting. It will not be injected via the manifold and delivery lines. The process involves the following steps:

1. At least 8 to 12 days prior to introducing KB-1™, prepare a tank of a suitable size (6,500 gal) to contain 400 gallons of anoxic water per bioaugmentation location (injection well). This is prepared by mixing sodium lactate and water and allowing the naturally occurring bacteria to consume the oxygen. If hydrant water is used to fill the tank, it is best to add several hundred gallons of groundwater to the tank as well. This will increase the initial bacterial population within the tank, decreasing the length of time for the tank of water to reach anoxic conditions.

2. Use a water parameter meter to monitor the dissolved oxygen (DO) and oxidation reduction potential (ORP) once the tank has been sitting for at least 8 days on a daily basis until the DO has decreased to at least 0.75 mg/L and the ORP to -100 mV. When this has occurred, the tank of water is considered to be anoxic and ready for use during KB-1™ bioaugmentation.

3. Prior to introducing KB-1™, prepare the well by injecting some anoxic water from the tank (approximately 200 to 300 gal) amended with EVO. This will create reducing conditions in the vicinity of the injection well.

4. By using a drop line, flush the well with an oxygen-free gas, such as argon (supply of argon should be available onsite), to purge any residual oxygen from the water in the well and from the air standing in the well bore.

5. Transfer the desired volume of culture from the KB-1™ shipping vessel to the volumetric delivery vessel. This is done by using the pressure from the argon gas to push the KB-1™ solution from one vessel to the other.

6. Deliver the specified volume of KB-1™ to the middle of the screened interval through a drop line, again using argon gas to push KB-1™ from the delivery vessel into the well.

7. Add another 200 to 300 gal of anoxic water, with EVO amendment, to the well immediately after KB-1™ addition to push the culture out of the well and into the formation.

8. Resume regular EVO injection.

C.6.6 Equipment Decontamination and Disposal

C.6.6.1 Supplies and Equipment

The decontamination procedures will require the following equipment:

1) Four 1,000 gal tanks, initially clean, to hold decon water.
2) Alconox. Prepare solution according to manufacturer's instructions.
3) Household bleach (up to 6% sodium hypochlorite). Prepare a 10% solution of bleach, adding one volume of bleach to 9 volumes of water.
4) A pump to circulate water through the lines to be cleaned. The pump should be capable of relatively high flow rates. Pump output fitting should have a male cam-lok quick connect for easy attachment to distribution manifold and the amendment lines. Pump intake should be protected by a filter if possible.

C.6.6.2 Decontamination Procedure

C.6.6.2.1 Amendment Delivery and Groundwater Extraction Lines

The injection equipment (and extraction lines if EVO is present in those lines), in particular the amendment delivery lines, may gradually start to develop some biological growth as a result of lying in the sun filled with the EVO electron donor. It is best to limit this to the extent possible by periodically (at minimum once per week) cleaning the delivery lines. The decontamination procedure is as follows:

1) If possible, have spare, clean amendment delivery line available. This can be substituted for the segments to be cleaned, with little disruption to the injection process.
2) Prepare four 1,000-gal tanks for decontamination liquids. One containing Alconox solution, one containing bleach (10% solution,), and two containing water.
3) Shut down flow in affected line to be decontaminated. Record time and flow totalizer reading. Once the well-head indicates negative pressure, drain the line into the well by disconnecting at the manifold (needle valve).
4) Remove amendment line(s). Replace with clean amendment lines.
5) Re-start flow to the well. Record time of re-start.

6) Connect affected amendment delivery lines, in series, to the recirculation pump.

7) First circulate water (container A) to rinse residual injection fluid from the hose. This should be a separate container because the rinsate will be quite milky. A quick rinse is sufficient. Drain tubing back to container A.

8) Recirculate the Alconox solution (container B) through the tubing for ~20 minutes. Flex the tubing if necessary to dislodge biofilm. Drain tubing back to container B.

9) Recirculate the bleach solution (container C) through the tubing for ~20 minutes. Drain tubing back to container C.

10) Recirculate water (container D) through the tubing for ~20 minutes. Drain tubing back to container D.

11) Tubing should be ready to be used again (store in cool dark place until reuse).

12) Note that if multiple sections are affected, it is possible to treat several sections together by simply connecting the tubing in series to form a large coil. While this saves time on the recirculation, it may make it difficult to drain back to each drum. Total volume of the coil must also be less than the volume of solution available.

C.6.6.2.2 Injection Manifold

The entire distribution apparatus should be decontaminated after each week of use. This can best be done toward the end of the day, since the first step is to rinse as much EVO from the equipment as possible. Proceed as follows:

1) With the injector uptake hose in a pail of clean water, run several gallons through the entire injection apparatus.

2) With flow stopped, drain the filter cartridge and remove the housing. Clean the filter element and replace.

3) Switch the water supply for the manifold to that delivered from a pump, so that decon solutions can be recirculated.

4) Make sure all injection lines return to the appropriate source tank. Note that depending on the flow rate achievable by the pump, it might be necessary to clean only a few channels at a time, to make sure that the recirculation rate is sufficiently high to dislodge material from the

hoses. All channels should be operated eventually, to ensure there are no dead end spaces within the manifold.

5) Recirculate the Alconox solution (container B) through the apparatus for ~30 minutes. Flex the tubing if necessary to dislodge biofilm. Drain the tubing back to the container B, if possible. A bucket of Alconox solution for the injector uptake should also be used.

6) Recirculate the bleach solution (container C) through the apparatus for ~30 minutes. Drain tubing back to container C, if possible. A bucket of bleach solution for the injector uptake can also be used.

7) Recirculate water through the apparatus for ~30 minutes. Drain tubing back to container D, if possible. Use a bucket of clean water for the injector uptake.

8) When finished, drain the filter cartridge and remove the housing. Clean the filter element and replace.

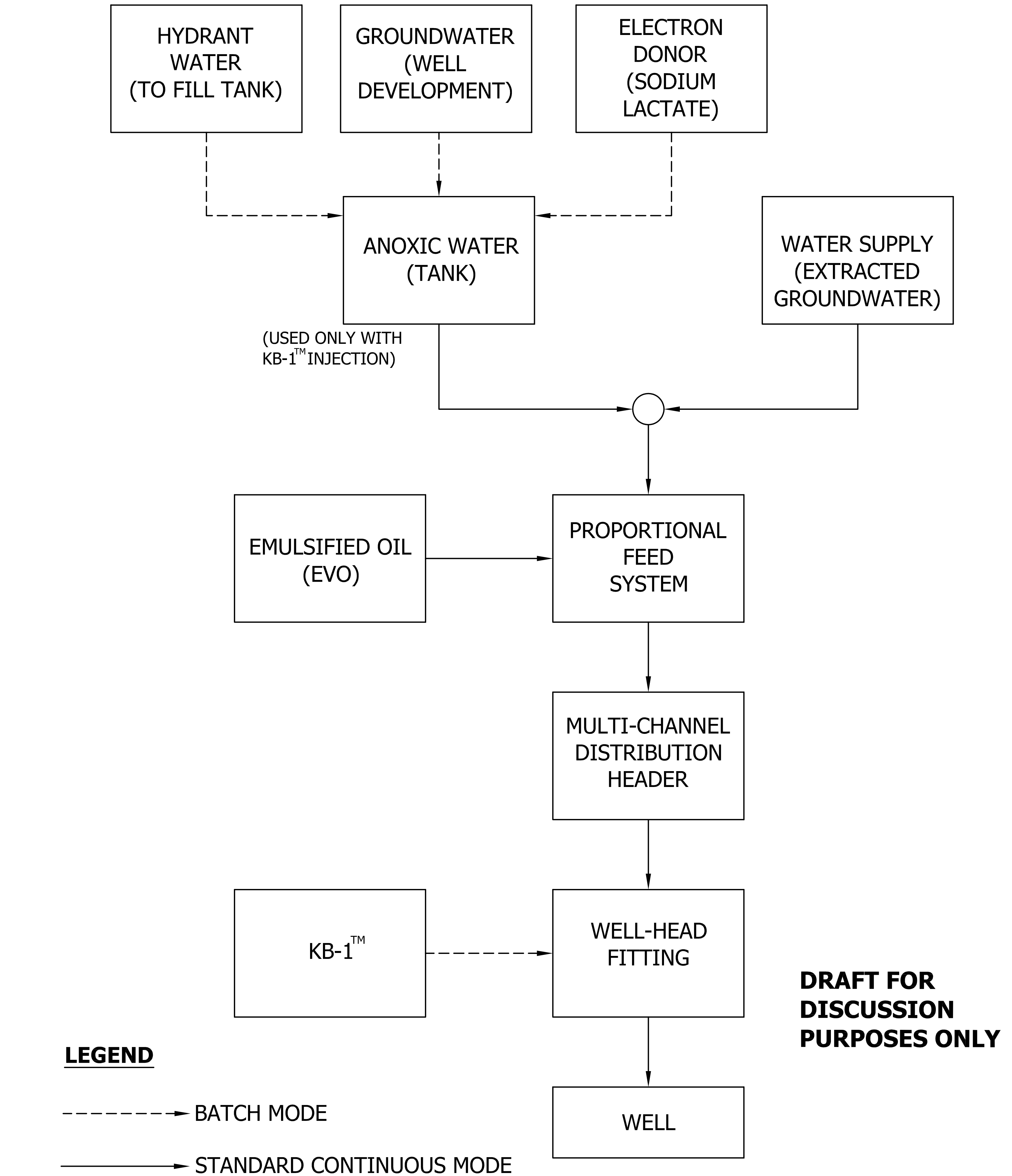
9) If possible, run clean water though the manifold and amendment delivery lines and direct this water to waste.

C.6.7 Documentation

Sample log sheets are provided in Attachment C-1. These sheets will be completed in conjunction with a routine daily field log of all pertinent site activities. Copies of the log sheets and field QC will be provided/communicated to the project manager on a daily basis.

C.6.8 Quality Assurance

QA during EVO injection will be accomplished by following these standard operating procedures. In addition, the project manager or designated field QA person will review all field notes, daily field logs, water level measurement logs and injection flow logs to ensure that the field operations conform with these guidelines. Daily tracking of injection flow rates and total volumes will allow the progress to be monitored as the work proceeds.



GeoSyntec Consultants

PROCESS FLOW SCHEMATIC FOR EMULSIFIED OIL INJECTION
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	C.1
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

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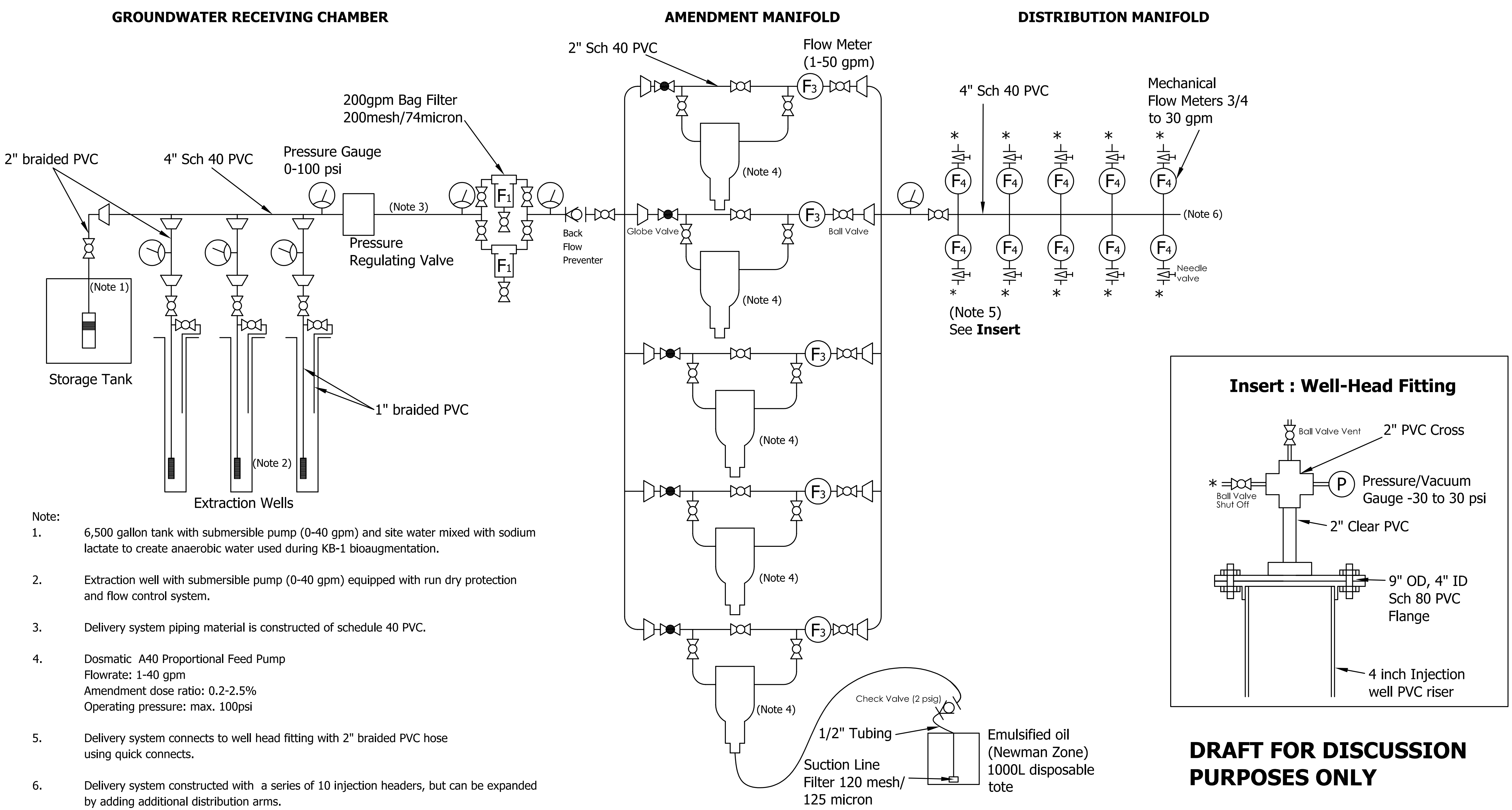

Note:

1. 6,500 gallon tank with submersible pump (0-40 gpm) and site water mixed with sodium lactate to create anaerobic water used during KB-1 bioaugmentation.
2. Extraction well with submersible pump (0-40 gpm) equipped with run dry protection and flow control system.
3. Delivery system piping material is constructed of schedule 40 PVC.
4. Dosmatic A40 Proportional Feed Pump
   Flowrate: 1-40 gpm
   Amendment dose ratio: 0.2-2.5%
   Operating pressure: max. 100psi
5. Delivery system connects to well head fitting with 2" braided PVC hose using quick connects.
6. Delivery system constructed with a series of 10 injection headers, but can be expanded by adding additional distribution arms.

DRAFT FOR DISCUSSION PURPOSES ONLY

GeoSyntec Consultants

EMULSIFIED OIL PROPORTIONAL DELIVERY SYSTEM
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	C.2
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

ATTACHMENT C-1

MSDS FOR NEWMAN ZONE AND KB-1™

Remediation and Natural Attenuation Services Incorporated
6712 West River Road
Brooklyn Center, MN 55430

Product Information: 763-585-6191 Issue Date: March 28, 2002

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Section 1: IDENTIFICATION

1.1 Product Name: Newman Zone
1.2 Product Type: Inedible Industrial Nutrient for Microbial Organisms
1.3 Hazard Rating: Health: 1 Fire: 1 Reactivity: 1
1.4 Formula: Proprietary

Substances Subject to SARA 313 Reporting Are Indicated by "#"

It is our opinion that the above named product does not meet the definition of "hazardous Chemical" as defined in the OSHA "Hazard Communication Standard" regulation 29 CFR 1910.1200. This material Safety Data Sheet is provided as general information for health and safety guidelines.

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Section 2: INGREDIENTS/COMPOSITION

	CAS No.	%	PEL (mg/m^3)	TWA (mg/m^3)
Soybean Oil (food grade)	8001-22-7	45	15(Mist)	10(Mist)
Sodium-L-Lactate	867-56-1	4		
Food Additives/Emulsifiers/Preservatives	(Proprietary)	<10		
Water		<45		

EMERGENCY ONLY, 24-HOUR SERVICE: CHEMTREC: 1-800-424-9300

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Section 3: PHYSICAL AND CHEMICAL CHARACTERISTICS

This section completed per formulation ingredient data unless stated.

- Solubility: Dispersible in water (product)
- PH: 6 (product)
- Specific Gravity: 0.98 (product)
- Boiling Point: NA
- Vapor Pressure: NA
- Vapor Density: NA
- Percent Volatile By Volume (%): NA
- Evaporation Rate: NA
- Viscosity: 23.6 cps @ 68°F (Brookfield)(product)
- Product Appearance and Odor: Light yellow-cream colored liquid, vegetable oil odor.

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Section 4: FIRE AND EXPLOSION HAZARDS

This section completed per formulation ingredient data unless stated.

4.1 Special Fire Hazards: Product - none, does not support combustion.

Flash Point: >540 degrees F (Pure Soybean Oil Closed Cup).
Flammable Limits
LEL ND
UEL ND

4.2 Fire Fighting Methods: Use method appropriate for surrounding fire.
4.3 Extinguishing Media: Dry Chemical or CO_2 Preferable; water may cause spattering or spreading.

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Section 5: HEALTH HAZARD DATA

5.1 THIS PRODUCT IS NEITHER INTENDED NOR MANUFACTURED FOR HUMAN OR ANIMAL CONSUMPTION AND SHOULD NOT BE USED FOR FOOD OR FEEDSTUFFS.
5.2 Effects of Overexposure: NA
5.3 Emergency and First Aid Procedures: If inhaled, remove from contaminated atmosphere. For eye contact immediately flush eyes with large amounts of water. Ensure rinsing entire surface of eye & under lid. For skin contact wash affected areas thoroughly with soap and water. Seek medical help for persistent irritation.
5.4 Hydrolyzed soy protein has been identified by the United States Food and Drug Administration as a food allergen. Symptoms include swelling of the lips, stomach cramps, vomiting, diarrhea, skin hives, rashes, eczema and breathing problems.
5.5 Occupational Exposure Limits [8-hour time weighted averages (TWA)]:

	CAS No.	mg/m^3 OSHA PEL/ACGIH TLV
Soybean Oil (food grade)	8001-22-7	15(Mist)/10(Mist)

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Section 6: REACTIVITY DATA

This section completed per formulation ingredient data unless stated.

6.1 Stability: Stable under normal conditions.
6.2 Conditions to Avoid: NA
6.3 Incompatibilities: None known
6.4 Hazardous Decomposition Products: Product - None identified. Ingredients – Carbon oxides. Biological decomposition (spoilage) may result in offensive odors.
6.5 Hazardous Polymerization; None known

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Section 7: SPILL OR LEAK PROCEDURES

This section completed per formulation ingredient data unless stated.

7.1 Spill Response: Water dispersible. Same as for vegetable oil spills: isolate spill, prevent from entering waterways, and sewer systems. Sorb or remove spilled materials as soon as possible. Oils and specific quantities of oils may be reportable under federal, state, or local regulations.
7.2 Waste Disposal Method: This product is not hazardous, however, wastes must be disposed in accordance with local, state or federal regulations. Consult with local sewer authority, or solid waste facility prior to disposition.

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Section 8: SPECIAL PRECAUTIONS

No protective equipment is necessary under normal use conditions.

8.1 Eyes: If splashing may occur, eye protection recommended.
8.3 Skin: Wear impervious gloves for prolonged or repeated exposure.
8.4 Respiratory: Avoid breathing mists of this product

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Section 9: TRANSPORTATION PRECAUTIONS

This section completed per formulation ingredient data unless stated.

9.1 Transportation Considerations: This product is not classified as dangerous in the meaning of transport regulations. Shippers and transporters may need to meet packaging and transportation requirements for certain oils and respective quantities under CFR 49 Part 130.

The above information is believed to be correct with respect to the formula used to manufacture the product in the country of origin. As data, standards, and regulations change, and conditions of use and handling are beyond our control, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE AS TO THE COMPLETENESS OR CONTINUING ACCURACY OF THIS INFORMATION.

*******Material Safety Data Sheet*******

Identification

Name: KB-1™ Dechlorinator

Synonyms: KB-1; Dechlorinating Microbial Consortium KB-1

Company / Manufacturer Identification:
SiREM (a division of GeoSyntec Consultants Inc.) 130 Research Lane, Suite 2, Guelph, Ontario, Canada N1G 5G3

For Information call: 519-822-2265 / 1-866-251-1747
Emergency Number: 519-822-2265

Product Introduction

KB-1™ Dechlorinator is a mixed naturally derived microbial enrichment culture, used in the bioremediation of chlorinated ethene contaminated sites via injection into site groundwater. KB-1™ Dechlorinator culture was originally derived from soil and groundwater and is grown in, and delivered, in a microbial media that is shipped in 25 L stainless steel culture vessels.

Physical and Chemical Properties:

Physical State: liquid

Appearance: black or grey, slightly turbid liquid if anaerobic, pink if exposed to air.

pH: 6.5-7.5

First Aid Measures

Eyes: Flush Eyes with water for at least 15 minutes, occasionally lift upper and lower eyelids, if undue irritation or redness occurs seek medical attention

Skin: Remove contaminated clothing and wash skin thoroughly with hot water and antibacterial soap

Ingestion: Do not induce vomiting, drink several cups of water, seek medical aid

Exposure Controls

Personal protective equipment:

Wear appropriate protective eyeglasses or goggles when opening KB-1 vessels valves or pressurizing vessels when injecting contents in to groundwater. Disposable latex or nitrile gloves should worn when handling and disposed of after use.

Accidental Release Measures

Spilled liquid should be soaked up with sorbant, saturated with 10% bleach. Sorbant should be double bagged and disposed of in garbage. After removal of sorbant, area should be washed with 10% bleach solution (1/10 diluted standard bleach) to disinfect. If liquid from the culture vessel is present on the fittings, non-designated tubing or exterior of the culture vessel liquid should be wiped off and area washed with 10% bleach solution.

Storage:

Avoid exposing KB-1 Stainless Steel storage vessels to undue temperature extremes which might result in harm to the microbial cultures and damage to the vessel. All valves should be in the closed position when the vessel is not pressurized to prevent the escape of gases and to maintain anaerobic conditions in the culture vessel. Avoid exposure of culture to air as this will kill dechlorinating microorganisms.

Composition, Information on Ingredients

KB-1™ Dechlorinator consists of a microbial culture grown in a media containing the ingredients listed in Table 1. In addition compounds not added but produced by bacterial conversion of the initial ingredients may be present, for example hydrogen sulfide.

Table 1, Chemical Ingredients of KB-1 Dechlorinator

Chemical Name	Formula	CAS#	Comments
Potassium Phosphate Dibasic	KH_2PO_4	7758-11-4	Major Component
Potassium Phosphate Monobasic	K_2HPO_4	7778-77-0	Major Component
Ammonium Chloride	NH_4Cl	12125-02-9	Major Component
Calcium Chloride	$CaCl_2$	10035-04-8	Major Component
Magnesium Sulfate	$MgSO_4$	10034-99-8	Major Component
Ferrous Chloride	$FeCl_2$	13478	Major Component
Resazurin	$C_{12}H_6NNaO_4$	62758-13-8	Major Component

Chemical Name	Formula	CAS#	Comments
Sodium bicarbonate	$NaHCO_3$	144-55-8	Major Component
Ferrous Ammonium Sulfate	$(NH_4)_2Fe(SO_4)_2$	7783-85-9	Major Component
sodium sulfide	Na_2S	1313-84-4	Major Component
Sulfuric acid	H_2SO_4	7664-93-9	pH of KB-1, 6.5-7.0
Boric Acid	H_3BO_3	10043-35-3	Minor
Zinc Chloride	ZnCl	7646-85-7	Minor
Sodium Molybdate	Na_2MoO_4	10102-40-6	Minor
Nickel II Chloride	$NiCl_2$	7791-20-0	Minor
Manganese Chloride	$MnCl_2$	13446-34-9	Minor
Copper II Chloride	$CuCl_2$	10125-13-0	Minor
Cobaltous Chloride	$CoCl_2$	7791-13-1	Minor
Disodium Selenite	Na_2SeO_3	10102-18-8	Minor
Aluminum Trisulfate	$Al_2(SO_4)_3$	10043-01-3	Minor
Vitamins	various	various	Minor

The microbial composition of KB-1™ Dechlorinator (as determined by phylogenetic analysis) is listed in Table 2. Identification of organisms was obtained by matching 16S rRNA gene sequence of organisms in KB-1™ to other known organisms. The characteristics of related organisms can be used to identify potential or likely characteristics of organisms in KB-1™.

Table 2. Genus' identified in KB-1™ Dechlorinator Microbial Inoculum

Genus
Dehalococcoides sp. (2)
Acetobacterium sp.
Geobacter sp.
Methanospirillum sp.
Methanosaeta sp.

Hazard Identification

Potential for Pathogenicity:
KB-1™ Dechlorinator has tested negative (i.e. these organisms are not present) for a variety of pathogenic organisms as outlined below in Table 3. While there is no evidence that virulent pathogenic organisms are present in KB-1, there is potential that certain organisms in KB-1™ might have the potential to act as opportunistic (mild) pathogens,

particularly in individuals with compromised immune systems. For this reason standard hygenic procedures such as hand washing after use should be observed.

Table 3, Results of Human Pathogen Screening of KB-1

Organism	**Disease(s) Caused**	**Test result**
Salmonella sp.	Typhoid fever, gastroenteritis	Not Detected
Listeria monocytogenes	Listerioses	Not Detected
Vibrio sp.,	Cholera, gastroenteritis	Not Detected
Campylobacter sp.,	Bacterial diarrhea	Not Detected
Clostridia sp.,	Food poisoning, Botulism, tetanus, gas gangrene	Not Detected
Bacillus anthracis	Anthrax	Not Detected
Pseudomonas aeruginosa,	Wound infection	Not Detected
Yersinia sp.,	Bubonic Plague, intestinal infection	Not Detected
Yeast and Mold	Candidiasis, Yeast infection etc.	Not Detected
Fecal coliforms	Indicator organisms for many human pathogens diarrhea, urinary tract infections	Not Detected
Enterococci	Various opportunistic infections	Not Detected

NFESC

Naval Facilities Engineering Service Center
Port Hueneme, California

Contract No. 47408-04-C-7526

Appendix D

Pilot Study for Enhanced In Situ Bioremediation

Installation Restoration Program Site 70
Naval Weapons Station Seal Beach
Seal Beach, California

Volume I of I

Revision: 0

Prepared by:

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22 August 2006

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__________________________	__________________________
Dave Major, Ph.D. Principal-in-Charge	Walt Grinyer, P.G. Project Manager

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ACRONYMS AND ABBREVIATIONS

AMSL	above mean sea level
AOCs	areas of concern
BNI	Bechtel National, Inc.
Cal-EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
cm/sec	centimeter per second
COPCs	chemicals of potential concern
CPT	cone penetrometer test
cVOC	chlorinated volatile organic compounds
DERP	Defense Environmental Restoration Program
DNAPL	dense non-aqueous phase liquid
DOC	dissolved organic carbon
DON	Department of the Navy
D.O.T	Department of Transportation
DQO	data quality objective
DTSC	Department of Toxic Substances Control
EBF	electromagnetic borehole flowmeter
EOS	EOS Remediation Inc.
ERSE	Extended Removal Site Evaluation
EVO	emulsified vegetable oil
EVS	Environmental Visualization Systems
FS	Feasibility Study
ft	feet
ft bgs	feet below ground surface
g	grams
IDW	investigation derived waste
IR	Installation Restoration (Program)
K	hydraulic conductivity
KB-1™	mixed dehalorespiring bacterial culture
L	liters
LUC	land use controls
µg/kg	micrograms per kilogram
µg/L	micrograms per liter (equivalent to parts per billion)
MCL	Maximum Contaminant Levels
mg/L	milligrams per liter (equivalent to parts per million)

ACRONYMS AND ABBREVIATIONS (cont.)

mL	milliliter
mmol	millimoles
MNA	monitored natural attenuation
MS/MSD	matrix spike/matrix spike duplicate
MW	monitoring well
NAD	North America Datum
NASA	National Aeronautics and Space Administration
NFESC	Naval Facilities Engineering Service Center
NAVWPNSTA	Naval Weapons Station
NAVD	North American Vertical Datum
Navy	U.S. Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGVD	North Geodetic Vertical Datum
o.d.	outside diameter
OCEHS	Orange County Environmental Health Services
PA	Preliminary Assessment
PID	photoionization detector
PP	Proposed Plan
ppm	parts per million
PS	Pilot Study
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QEC	Quantum Engineering Corporation
RDO	Remedial Design Optimization
RFS	Revised Feasability Study
RI	Remedial Investigation
RNAS	Remediation and Natural Attenuation Services Inc.
ROD	Record of Decision
ROI	radius of injection
RRSEM	Relative Risk Site Evaluation Model
RSE	Removal Site Evaluation
RT&E	Research, Testing, and Evaluation Area
RWQCB	Regional Water Quality Control Board
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SOP	standard operating procedures
SWDIV	Southwest Division of the Naval Facilities Engineering Command
TCE	trichloroethene

ACRONYMS AND ABBREVIATIONS (cont.)

TDS	total dissolved solids
TOC	total organic carbon
USCS	Unified Soil Classification System
U.S. EPA	United States Environmental Protection Agency
USTs	underground storage tanks
VC	vinyl chloride
VOC	volatile organic compound
WRD	Water Replenishment District of Southern California
XRD	X-ray diffraction

1. INTRODUCTION

This *Pilot Study (PS*), former Remedial Design Optimization (RDO) Invesetigation and Report, describes the PS activities at Installation Restoration (IR) Program Site 70 (the Site) at Naval Weapons Station (NAVWPNSTA) Seal Beach, California. GeoSyntec Consultants, Inc. (GeoSyntec) prepared this PS Report for Southwest Division Naval Facilities Engineering Command (SWDIV) through the Naval Facilities Engineering Service Center (NFESC), Port Hueneme, California under Contract No. 47408-04-C-7526. This work was performed in accordance with the Remedial Design Optimization Work Plan for Installation Restoration Program Site 70 [GeoSyntec, 2005a].

In 2004, the Department of the Navy (DON) contracted GeoSyntec to evaluate non-pump and treat remediation scenarios for IR Site 70. GeoSyntec was contracted by the Navy to develop a Revised Feasibility Study (RFS) that evaluated the potential for enhanced bioremediation at IR Site 70. The RFS evaluated *in situ* enhanced bioremediation for the Site 70 source area and dissolved phase plume. This technology provides the capability to address both the source area and dissolved phase plumes with slightly different approaches that have the possibility of accelerating the overall cleanup time frame. This report presents the results to date of the PS that was implemented to address data gaps identified during the conceptual design of a full-scale bioremediation program.

GeoSyntec staff prepared this PS under the direction and supervision of Mr. Walt Grinyer, P.G., Project Manager, and Dr. David Major, Ph.D., Principal-in-Charge. This PS was reviewed by Mr. Grinyer and by Dr. Major in accordance with the peer review policy of the firm.

1.1 <u>Purpose</u>

The purpose of this PS is to present additional site characterization data to support optimization of the design and implementation of a full-scale bioremediation program at Site 70. The PS activities documented in this report were implemented in August 2005 and completed in November 2005.

1.2 Scope

The PS scope of work was designed to address uncertainties identified in the conceptual design of the full-scale bioremediation program. This was done by conducting additional characterization of the source area and dissolved phase plumes being considered for implementation of the bioremediation program. The work included performing treatability testing [microcosm study] to gauge the efficacy of the proposed remediation strategy.

The full scope of the PS includes the following elements:

- Direct Push Sampling of Soil and Groundwater;
- Mud Rotary Drilling and Soil Sampling;
- Monitoring Well (MW) Installation and Development;
- Monitoring Well Groundwater Sampling;
- Electromagnetic Borehole Flowmeter (EBF) Surveys;
- EVO Field Injection Study;
- Microcosm Study; and
- Refinement of the Site Conceptual Model.

1.3 Regulatory Overview

Cleanup at IR Site 70 is being conducted as part of the IR Program at NAVWPNSTA Seal Beach. The program identifies, assesses, characterizes, and cleans up or controls pollution from past hazardous waste operations and spills. The program was established to comply with Federal requirements regarding cleanup of hazardous waste sites. These Federal requirements are outlined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

The DON, under the Defense Environmental Restoration Program (DERP), follows the United States Environmental Protection Agency (U.S. EPA) remedial investigation (RI) and feasibility study (FS) protocols. An RI/FS involves characterizing the nature and extent of risk posed by hazardous waste sites and evaluating options for cleanup. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 *Code of Federal Regulations* [CFR] 300) provides the RI/FS protocols.

An FS Report for groundwater cleanup at IR Sites 40 and 70 (Research, Testing, and Evaluation Area [RT&E Area]) was developed [BNI, 2002]. The original FS document [BNI, 2002] was amended by the RFS Report for IR Site 70 [GeoSyntec, 2005b]. The FS and RFS reports did not identify or recommend a preferred remedial alternative for IR Site 70. Comments made during the public and regulatory agency review of the RFS Report will be evaluated and considered during the remedy selection process. As required by the NCP and U.S. EPA guidance [U.S. EPA 1988], these comments will also be addressed in the proposed plan (PP) and record of decision (ROD). The ROD will provide the administrative record decision document for the Site 70 remedial action.

The RFS evaluated *in situ* enhanced bioremediation for Site 70 source area and dissolved phase plume. This technology provides the capability to address both the source area and dissolved phase plumes with slightly different approaches that have the possibility of accelerating the overall cleanup time frame. The enhanced bioremediation approach considers the potential impact from intermediate by-products during the remediation phase. The enhanced bioremediation alternative must complete the dechlorination sequence within the anaerobic conditions of the treatment zones.

The enhanced bioremediation approach also minimizes secondary impacts to the aquifer. There is limited disruption of the groundwater, primarily during the injection phase for electron donor and microbial consortia. The mechanism for the treatment is ambient groundwater flow through the treatment zones.

The technical approach for this pilot study conforms to the "Remedial Design Optimization Work Plan – IR Site 70" [GeoSyntec, 2005a]. Treatability studies are a main component of the RI/FS process and are performed to address data gaps that arise during the evaluation of remedial alternatives under the FS process [U.S. EPA, 1992]. The treatability studies of enhanced bioremediation at nearby IR Site 40 [BNI, 2004] provide a pilot-scale demonstration of the technical approach. For Site 70, the microcosm study conforms to a remedy screening (bench scale), the IR Site 70 pilot study provides the pilot test, and the remedial design/remedial action will implement the full scale system. System optimization data were provided through the field injection tests at Site 70.

This PS falls into the remedy-selection and/or the treatability study category. Components of the PS will be used to optimize the system design. According to the U.S. EPA [1992], remedy selection treatability studies are designed to verify if a process option can meet the site's cleanup criteria and at what cost. The results from the PS, microcosm study, and previous Site 40 pilot tests will be used to generate the critical performance and cost data necessary for remedy evaluation and selection.

The PS does not constitute a decision document within the CERCLA framework. The PS provides the information necessary for informed decisions by the decision-makers. Decision documents will be provided within the CERCLA framework.

1.4 Report Organization

The remainder of this report is organized as follows:

- Section 2.0 - Site Background;
- Section 3.0 - Technical Approach;
- Section 4.0 - Data Collection Methods and Results;
- Section 5.0 - Conceptual Model; and
- Section 6.0 - Conclusions.

2. SITE BACKGROUND

This section presents background information for the PS at IR Site 70, NAVWPNSTA Seal Beach.

2.1 Facility and Site Descriptions

2.1.1 Facility

IR Site 70, also known as the RT&E area, consists of multistory office and production buildings, asphalt-paved parking areas, an assortment of aboveground tanks and attendant above- and below-ground piping distribution systems, several concrete-lined sumps, and underground storage tanks (USTs). From 1962 to 1973, the National Aeronautics and Space Administration (NASA) utilized the area for the design and manufacture of the Saturn II launch vehicle for the Apollo Program. Subsequent to NASA leaving the area, the United States Department of Energy and Garrett Engineering (Allied Signal) conducted pilot test assembly operations for a classified uranium enrichment process in portions of Building 112 (S-03). These tests were conducted from 1980 to 1985, but did not include either the manufacture or enrichment of uranium. Currently, the building is used for storage, communications, research, and office space.

The Removal Site Evaluation (RSE) Report from Bechtel National, Inc. [BNI 1996a] for the IR Site 70 area addressed potential waste sources from:

- Bulkhead Fabrication Building 128 (S-02);
- Vertical Assembly and Hydrotest Building 112 (S-03);
- Pneumatic Test, Paint, and Packaging Building 122 (S-04);
- Tool and Maintenance Building 130 (S-05);
- Structural Test Tower (S-06); and
- Water Conditioning Plant (S-07).

Operations at these facilities included the use of diluted acids, volatile organic compounds (VOCs), including chlorinated solvents such as trichloroethene (TCE), phenolic compounds, petroleum oils, sodium dichromate containing hexavalent chromium, detergents, metals containing paint wastes, and machine lubricating oil. Discharged wastewater contained high total dissolved solids (TDS), sodium, chloride, and had high or low pH.

2.1.2 Site 70

Soils and groundwater beneath Site 70 are impacted by the past use of chlorinated solvents (primarily TCE), with possible dense non-aqueous phase liquid (DNAPL) and dissolved-phase chlorinated solvents reported [BNI, 2002]. Site 70 encompasses approximately 40 acres, but the groundwater plume extends beyond the site boundaries (Figures 2-1 and 2-2). Groundwater contamination extends from the water table near the source area to approximately 195 feet below ground surface (ft bgs) near the leading edge of the plume. Sources and releases contributing to the TCE plume were investigated by the Navy in the RSE Report [BNI, 1996a] and the *Extended Removal Site Evaluation of IR Sites 40 and 70* (ERSE) [BNI, 1999] and are discussed in those documents. A site conceptual model was generated from the remedial investigation data and presented in the FS [BNI, 2002].

2.2 <u>Previous Investigations</u>

In 1993, Jacobs Engineering Group (JEG) conducted a Preliminary Assessment (PA) of IR Site 70 [JEG 1994]. Ten Areas of Concern (AOCs) were identified for further evaluation to assess the presence or absence of chemicals of potential concern (COPCs). These ten AOCs were identified based on historical activities, use of chemicals, and the likelihood of a potential threat to human health and the environment. The PA identified major COPCs as hexavalent chromium, TCE, phenolic compounds, trichlorotrifluoroethane (Freon TF), and heavy metals.

BNI conducted an RSE for the RT&E area [BNI 1996a] to address potential waste sources from IR Site 70. The RSE report recommended that process piping systems and facilities be decommissioned and that soil and groundwater in the area be investigated further [BNI 1996a]. The report also recommended soil investigations for the presence of hexavalent chromium, vinyl chloride (VC), and heavy metals. Groundwater investigations were recommended to delineate the TCE plume and to determine a potential vadose zone source, as well as the nature and extent of hexavalent chromium, phenolic compounds, and heavy metals.

In 1996, soil and groundwater samples were collected at IR Site 70 to obtain analytical data necessary to populate a Relative Risk Site Evaluation Model [RRSEM, BNI 1996b]. By using data collected at NAVWPNSTA Seal Beach and 14 other bases, the RRSEM was used to assist in prioritizing funding for sites in the IR Program. The samples indicated the presence of VOCs, semivolatile organic compounds, polychlorinated biphenyls, pesticides, and metals. Based on this and subsequent studies, including the ERSE of IR Sites 40 and 70 (BNI, 1999), the Navy determined that there was no immediate threat to the environment from groundwater at Site 70. The RI/FS [BNI, 2002] determined that groundwater at IR Site 70 was impacted and a remedial action was required to address the source area and dissolved phase plume, based on a human health risk evaluation.

2.3 Current Investigation

The PS is the initial phase in the design of the full-scale bioremediation program in that it provides supplemental data needed to move beyond the conceptual design. Groundwater data points used to characterize the source area and dissolved plumes are found on Figure 2.3, and the soil data points are presented in Figures 4.1 and 4.3. The proposed conceptual design for the bioremediation program within the source area consists of biostimulation, combined with bioaugmentation using a dehalorespiring culture (KB-1™) to stimulate full dechlorination of TCE to ethene. Stimulation of bioactivity throughout the source area will enhance biodegradation of the chlorinated ethenes, resulting in a substantial decrease in the required duration and costs of remediation activities. A long-term, low-solubility electron donor is proposed (emulsified vegetable oil [EVO]), which requires infrequent re-injections (typically, on the order of one to three years) and can be injected by using temporary equipment, resulting in limited impacts to site activities. To allow for repeated injections of the electron donor, permanent flush-mounted wells will be installed on a regular grid throughout the source area at a spacing equal to the achievable radius of injection of the EVO. It is anticipated that only a one-time injection of KB-1™ into these same wells will be required over the duration of remedial activities.

Within the dissolved-phase plume (First and Second Sand aquifers), the proposed bioremediation alternative is a passive approach using the same long-term electron donor (EVO), a one-time injection of KB-1™ to ensure complete dechlorination of the TCE to ethene, and ambient groundwater flow and natural attenuation to supplement the enhanced bioremediation. Biostimulation throughout the entire plume area would be cost prohibitive; thus, to minimize installation and operation costs, one or more transects of electron donor (EVO) and KB-1™ injection zones will be created perpendicular to the groundwater flow direction to form permeable biobarriers with enhanced bioactivity. This passive approach relies on ambient groundwater flow to flush contamination into the biobarriers, where the enhanced bioactivity will cause complete biodegradation of the TCE and daughter products, resulting in the outflow of dechlorinated groundwater from the downgradient side of the biobarrier. Plume remediation will be enhanced by natural attenuation between the biobarriers. To allow repeated injections of the electron donor, permanent flush-mounted wells will be established, but no other permanent infrastructure will be required, which minimizes impacts to site activities. The length, spacing, and number of biobarriers will be optimized to balance costs and treatment duration, based on natural attenuation rates, the contaminant distribution, and the achievable radius of oil injection within each aquifer. The number of wells per biobarrier and the well spacing will also be optimized to balance operational costs (*i.e.,* mass of oil required per injection) with capital costs (*i.e*., number of wells).

The addition (also known as bioaugmentation) of a dechlorinating culture (such as KB-1™), which has been demonstrated to effectively biodegrade TCE to innocuous end products such as ethene and ethane, will simulate biodegradation of daughter products such as VC and cis-1,2-dichloroethene (cis-1,2-DCE).

The IR Site 70 *in situ* bioaugmentation process for both the source area and the dissolved phase plume will be followed by a monitored natural attenuation phase where final degradation, dispersion, and adsorption will reduce the chlorinated compounds to below the target concentrations. This process will occur at different times within the plume as the *in situ* bioremediation processes achieves the target cleanup levels. During the total duration of the *in situ* remediation sequence (biostimulation/bioaugmentation and monitored (enhanced) natural attenuation), land use controls (LUC) will be maintained over the site. The LUC will restrict access and use of groundwater within the treatment areas and provide for ongoing access to the wells for subsequent reinjection of EVO and monitoring purposes.

3. TECHNICAL APPROACH

The technical approach and methods applied in the PS were developed in the context of the data quality objective (DQO) process as part of the RDO Work Plan [GeoSyntec 2005a]. The DQQs were developed in accordance with the seven-step process described in U.S. EPA guidance [U.S. EPA, 1994].

3.1 Data Quality Objectives

The DQO process is a series of planning steps based on scientific methods that are designed to ensure that the type, quantity, and quality of environmental data used for decision making are appropriate for the intended application. The DQO process, as defined by U.S. EPA, consists of seven steps that are designed to provide a systematic approach to resolving issues that pertain to the RDO study [EPA, 2000], as follows:

- Statement of Problem;
- Decision Questions;
- Inputs to the Decisions;
- Boundaries of the Study;
- Decision Rules;
- Limits on Decision Errors; and
- Optimization of Sampling Design.

3.1.1 Statement of Problem

3.1.1.1 Source Area

Successful implementation of the source area remedy is dependent upon effective distribution of the electron donor throughout the source area and, in particular, delivery of the electron donor to high concentration areas. Uncertainties in the remedial design for the source area include the following:

- **Lateral and vertical distribution of the dissolved contamination and high concentration areas.** Remedial costs will be minimized by limiting remediation activities to areas with known contamination; therefore, an accurate conceptual model of the contaminant distribution is necessary. High concentration areas will require longer treatment than areas with lower concentration contamination; thus, long term costs may be minimized by extending the treatment duration within these high concentration areas only.

- **Impact of soil heterogeneity on contaminant distribution and the radius of influence (ROI) of injected EVO.** The heterogeneity of soils within the source area may impact contaminant distribution (particularly the high concentration areas) and the effectiveness of EVO injection.

- **The achievable ROI of EVO injection.** In order to minimize capital costs and achieve distribution of electron donor throughout the source area, the injection wells should be spaced at a distance slightly less than the maximum achievable ROI of the EVO.

3.1.1.2 Dissolved-Phase Plume

Successful, cost-effective implementation of the plume treatment remedy is dependent upon creation of biobarrier(s) that continuously extend across the width of the plume and provide an optimal balance of naturally attenuating and biostimulated treatment zones. Because of the reliance upon ambient groundwater flow to flush the contaminants to the biobarrier, an understanding of the factors controlling the local hydrogeology is necessary (*e.g.,* groundwater flow direction and velocity, preferential contaminant flow paths, and fluctuations in groundwater flow direction and velocity over time). Another critical factor impacting biobarrier design is the contaminant attenuation behavior under both natural and biostimulated conditions. Uncertainties in the remedial design include the following:

- **Lateral and vertical distribution of the dissolved contamination.** Biobarrier installation and operational costs may be minimized by delineating the lateral and vertical extents of the contaminant distribution.

- **Impact of soil heterogeneity on contaminant distribution, migration, and the ROI of EVO injection.** Heterogeneity of the soil may be significant enough to cause preferential pathways within the plume (*e.g.,* the shell horizon and/or gravel layers), which may impact contaminant distribution and the effectiveness of EVO injection.

- **Groundwater flow direction and velocity.** In order to be most effective and minimize costs, the biobarriers should be oriented perpendicular to the groundwater flow direction. Seasonal fluctuations in the flow direction and/or velocity will need to be considered for the spacing and orientation of the biobarriers.

- **Contaminant biodegradation and attenuation rates.** TCE and daughter product biodegradation rates under biostimulated conditions impact the required width of the biobarrier. The natural attenuation rates of these compounds also will impact the spacing and number of biobarriers, as a faster natural attenuation rate will shorten the required treatment time and thus allow for larger spacings between biobarriers.

- **The achievable ROI of EVO injection.** *i.)* For a biobarrier design, the thickness of the biobarrier should be, at minimum, equal to the distance required for complete dechlorination of inflowing contaminants to occur [*i.e.,* equal to the groundwater velocity through the biobarrier multiplied by the time required to achieve sufficient biodegradation rates of TCE and its daughter products cis-1,2-DCE and VC to meet maximum contaminant levels (MCLs) of all compounds]. If the minimum distance is greater than the achievable ROI of the EVO, then a biobarrier consisting of more than one line of injection wells may be necessary. *ii.)* If the minimum distance is less than the achievable ROI, then the well spacing may be optimized with the EVO volume requirements to find the optimum balance between capital and operating costs.

- **Impact of the EVO on soil permeability.** The biobarriers are intended to be permeable to groundwater flow. Reductions in soil permeability related to gas formation or pore blockage by oil droplets may cause a change in the groundwater flow direction and reduced treatment efficiency. The magnitude of permeability reductions is site specific and is related to EVO concentration and soil types.

3.1.2 Decision Questions

The scope of work and specific objectives of the PS were developed on the basis of the uncertainties described in Section 3.1.1 and stated in the form of the following questions to be answered by implementation of the PS.

a. What is the lateral and vertical extent of contamination within the source area and within the area impacted by dissolved-phase contaminants?

b. What geologic units are governing the contaminant migration behavior?

c. What degree of temporal and spatial variability is there in hydraulic conductivity and water elevation (i.e., hydraulic gradient) with depth?

d. What is the rate of natural attenuation in the shallow zone and deeper units at the site?

e. What is the achievable ROI for EVO injection into the subsurface geologic units identified at Site 70?

f. What is the achievable EVO rate of injection within the shallow and deeper units at the site?

g. What impact does injection of EVO have on the hydraulic conductivity of the aquifer?

h. Will the combination of biostimulation and bioaugmentation effectively dechlorinate site soil and groundwater based on the microcosm study and what is the biodegradation rate under these conditions in the plume and source?

3.1.3 Inputs to the Decisions

The following are inputs to the decisions:

- Soil and groundwater data derived from field measurements and laboratory analysis;
- Results of electromagnetic borehole flowmeter (EBF) tests;

- Results of EVO injection tests; and

- Biotreatability test data obtained from the laboratory analysis of samples collected from microcosms (batch reactors) constructed from the Site aquifer materials.

3.1.4 Boundaries of the Study

The physical and temporal boundaries of the site are summarized below:

- IR Site 70 is located south of the intersection of Westminster Blvd and Seal Beach Blvd in Seal Beach , CA. (Figure 2-1);

- The site is bounded by agricultural and light industrial usage space (Figure 2-1); and

- The site is approximately 40 acres.

The anticipated duration of these activities under the RDO Work Plan was 12 months.

3.1.5 Decision Rules

To determine the answers to the questions identified in Section 3.1.2 the following rules were established:

a. The limits of the 1,000 µg/l TCE concentration will define the lateral and vertical extent of the source area treatment zone. Direct push sampling results will determine whether or not these limits have been defined. Sampling results from the drilling and installation of the transect wells will be used to verify the lateral and vertical extent of the dissolved-phase plume in an area being considered for installation of a biobarrier. Data available from the new wells installed by Bechtel at the leading edge of the plume will be used to infer the downgradient extent of the plume. If contaminant concentrations in the Bechtel wells are less than 10 µg/l we can infer that the plume has not expanded significantly from the conceptual model in the FS (BNI, 2002) and

RFS (GeoSyntec, 2005b). Data from the transect wells, the new Bechtel wells and the most recent quarterly groundwater monitoring report (July 2005) will be evaluated and the conceptual model updated as needed [BEI, 2005].

b. Visual descriptions of soils encountered during direct push sampling in the source area and mud rotary drilling in the dissolved-phase plume will be used to characterize geologic units in both areas. Laboratory results for selected soil samples will allow correlation of contaminant concentrations with geologic units for the assessment of contaminant migration pathways. EBF survey results in the new RDO well installations will be used to discretize the variability in hydraulic conductivity (K) with depth. Historical water elevation data will be collected and analyzed to evaluate trends with depth and spatial location. Depth-discrete groundwater sampling conducted at depths corresponding to significant changes in hydraulic conductivity (as determined by the EBF surveys) will provide data to determine vertical variability of VOC concentrations. Correlations between K, hydraulic gradient, VOC concentrations, and soil types with depth and spatial location will be considered evidence of preferential contaminant flow paths.

c. The temporal and spatial variability in hydraulic conductivity will be evaluated using the results of the EBF surveys and historical water level data. An understanding of the distribution of hydraulic conductivity across the site will aid in the design of biobarrier dimensions and spacing. It will also impact the distribution of EVO and the effectiveness and duration of remediation. The Remedial Design Optimization Sampling and Analysis Plan [GeoSyntec, 2005a] states that if the EBF survey data indicate spatially similar K values (within 20% of adjacent points), then the EVO injection can be designed to target the whole interval during injection. It also states that if EBF data indicate significant (greater than one order of magnitude) spatial variability in K values and/or significant vertical gradients within the target treatment areas, then the remedial design may require focused injection zones. However, the EBF data set was unable to provide reliable measurements of absolute K: the survey was only able to delineate zones of higher or lower K within a given screen interval (see Section 4.2.5). Therefore, the target treatment interval will be determined through examination of the pre- / post-EVO injection EBF survey data.

d. The microcosm study will be used to determine if natural attenuation is occurring and provide biodegradation rates for the sampled zones. The biodegradation rates within the plume govern the number of required biobarriers and their spacing within the plume. If the microcosm study indicates that natural attenuation is occurring, then the natural attenuation rates will be determined and used in a numerical model to determine the number of biobarriers and the spacing between them. Otherwise, if natural attenuation does not appear to be occurring, the numerical model will include biodegradation of the plume contaminants within the biobarriers alone. A lack of natural attenuation will require additional biobarriers to achieve the final cleanup goals.

e. The ROI for EVO injection will be determined from the results of EVO injection tests in wells RDO-3A (Upper Fines Unit), RDO-6A (Shell Horizon), and RDO-6B (Second Sand Unit). Downgradient wells MW-70-01, MW-70-08, and MW-70-31, respectively, will be monitored for breakthrough of EVO using three criteria: laboratory analysis of total organic carbon (TOC), field measurements of bromide tracer, and visual changes in groundwater appearance (the EVO fluid makes the groundwater appear milky). The detection of bromide tracer without visual evidence of EVO or an increase in TOC will indicate the ROI for EVO is less than the distance between the injection well and the monitoring well. If no bromide tracer is observed, we will infer that the flow rate may be slower for this interval or that the well screens do not intercept the same aquifer zone.

f. The Remedial Design Optimization Sampling and Analysis Plan (Geosyntec, 2005a) states that the EVO injection rate in the screened zone of each well will be determined from the changes in water levels recorded in each well while sequentially increasing the injection rate. It states that if the water level within the well exceeds 5 ft (feet) below the top of casing, then the maximum achievable injection rate will be determined, and that if the maximum rate of EVO injection is reached and EVO breakthrough is detected in the downgradient monitoring well, then the last injection rate will be used for the design parameters. However, during the EVO injection test, the maximum injection rate was limited by the integrity of the injection equipment under pressure. This change in methodology will be reflected in new Data Quality Objectives during full scale implementation of the Remedial Design.

g. If a comparison of pre- and post-EVO injection EBF surveys conducted on the EVO injection wells indicates minor or non-detectable hydraulic changes (no change in K value for discrete zones), then EVO impacts are not a significant impediment to groundwater flow. If pre- and post EVO injection EBF surveys detect significant (greater than 50%) changes in the observed K, then the EVO injection may impact groundwater flow and the barrier length, well spacing, and orientation may be modified in the design. If pre- and post-EVO injection EBF surveys detect order of magnitude changes in K for any of the discrete intervals, then the treatment system design will need to be modified to provide for this variability.

h. The microcosm study will evaluate the effectiveness of biostimulation/bioaugmentation in dechlorinating the soil and groundwater from the source area and dissolved-phase plume, as well as provide biodegradation rates. The biodegradation rates within the plume govern the required biobarrier thickness. If the microcosm study indicates that neither biostimulation nor bioaugmentation are an effective dechlorination treatment for the source area, then EVO should not be considered as a viable remedy for the Site. If the microcosm study indicates that biostimulation/bioaugmentation are effective in dechlorination of the soil and groundwater, then biodegradation rates will be used to determine the thickness of the biobarriers within the plume.

Professional judgment and data collected during this study will be utilized to develop the remedial design at Seal Beach IR Site 70.

3.1.6 Limits on Decision Errors

Statistically derived limits on sampling design errors were not quantifiable because a judgmental sampling design was employed. The number and location of samples to be located are based on professional experience and previously identified contaminant plumes.

3.1.7 Optimization of the Sampling Design

Professional judgment and data collected from the previous studies were used to select the sample locations and testing methodologies for this project. Maximum utilization of existing monitoring wells was incorporated into the RDO Work Plan.

4. DATA CORRECTION METHODS AND RESULTS

4.1 Pre-Field Investigation Activities

4.1.1 Notifications

Prior to the start of field activities at the site, the following interested parties were notified:

- The Navy (SWDIV) Project Manager;
- Naval Weapons Station Seal Beach;
- California Environmental Protection Agency (Cal-EPA);
- Department of Toxic Substances Control (DTSC);
- Regional Water Quality Control Board (RWQCB); and
- Orange County Environmental Health Services (OCEHS).

Signed dig permits were obtained from the Facilities Department on base before any excavation or drilling work began. In lieu of a kick-off meeting, GeoSyntec met individually with the NAVWPNSTA Seal Beach Facilities Department, Ordnance Department, Fire Department, Security Department, and Environmental Department.

4.1.2 Utility Clearances

Potential underground utilities were investigated at each location proposed for direct push and rotary drilling prior to commencement of the drilling program. The following steps were taken to clear these locations:

- GeoSyntec compiled and plotted on base maps all known utilities depicted in NAVWPNSTA Seal Beach engineer’s drawings provided by the Facilities Department.

- Spectrum Geophysics conducted geophysical utility clearance surveys in the vicinity of each proposed cone penetrometer test (CPT) and soil boring location.

- Underground Service Alert was notified of the proposed drilling locations and verified the location of utilities in the field.

- All boring locations were physically cleared by using an air-knife rig or hand auger prior to positioning the drill rig or CPT rig over each boring location.

No underground utilities or other impediments were encountered during installation of any boring.

4.2 Field Investigation

Activities for this project included:

- Direct Push Soil and Groundwater Sampling (Figures 4.1 and 4.2);
- Mud Rotary Drilling and Soil Sampling (Figure 4.3);
- Monitoring Well (MW) Installation and Development;
- Monitoring Well Groundwater Sampling (Figure 4.4);
- EBF Survey (Figures 4.5-4.8);
- EVO Field Injection Study (Figures 4.9-4.14);
- Microcosm Study (Figures 4.15 and 4.16); and
- Investigation Derived Waste (IDW) Disposal.

4.2.1 Direct Push Soil and Groundwater Sampling

4.2.1.1 Objectives

Additional characterization of the source area was conducted with the intent of refining and updating the current conceptual model of the contaminant distribution and aquifer characteristics by evaluating the vertical and lateral extent of the high concentration areas within the source area and collecting additional information on the lithology and heterogeneity of the shallow aquifer.

4.2.1.2 Activities Carried Out

Twenty (20) direct push borings to 60 ft bgs were advanced in the source zone from August 29, 2005 to September 8, 2005. Boring locations are shown in Figure 4.1. Approximately the first 6 feet of each boring was hand augered prior to the use of the direct push rig. Beginning at 20 ft bgs, soil samples were collected by using a core barrel device pushed by the rig at approximately 5- to 10-foot intervals. Each sample collected was immediately placed in a Ziploc® bag and allowed to sit for at least ten minutes. A photo ionization detector (PID) reading was taken in the headspace of each bag, and the two samples in each borehole with the highest readings were selected for chemical analyses. A small portion of each sample was set aside for logging purposes. An additional soil sample was collected from Boring S1 for use in microcosm studies.

Upon completion of soil sampling, groundwater samples were collected by using a hydropunch groundwater sampler. The groundwater sampler is equipped with a retrievable stainless steel or disposable polyvinyl chloride (PVC) screen and an expendable steel tip. The sampler operates by advancing small diameter hollow-push rods with the filter tip in a closed configuration to the base of the desired sampling interval. Once at the desired sample depth, the push rods are retracted; exposing the encased filter screen allowing groundwater to infiltrate from the formation into the inlet screen. A small diameter, disposable bailer (lowered through the pushrods into the screen section) was used to retrieve the groundwater samples. The bottom of the PVC screen was placed at either 60 ft bgs or 50 ft bgs depending upon the permeability of the formation material. Samples that were analyzed for dissolved metals were pumped into sample containers through a filter.

One groundwater sample and two soil samples were analyzed for each borehole completed within the source area. Sample names and locations are provided in Tables 4.1 and 4.2.

4.2.1.3 Results

Detections of TCE and degradation products in soil are shown in Table 4.3. Detected concentrations of TCE in source area soil samples range from 1.8 to 12000 micrograms per kilogram (µg/kg). Detections of TCE in soil samples are shown on Figure 4.1 along with the location of source area borings. Cis-1,2-DCE was detected in source area soil samples in concentrations from 1.9 to 750 µg/kg. Detections of VC in source area soil samples ranged from 2.3 to 4.2 µg/kg.

Detections of TCE and degradation products in groundwater are shown in Table 4.4. TCE was detected in source area groundwater samples in concentrations from 1.6 to 4000 micrograms per liter (µg/L). Figure 4.2 shows the concentrations of TCE detected in groundwater samples pulled from source area borings completed during this work. Detected concentrations of cis-1,2-DCE were from 0.97 to 420 µg/L. VC was detected in source area groundwater samples in concentration of 0.43 to

5.1 µg/L and ethane was detected at concentrations of 1.1 µg/L and 1.3 µg/L. Appendix D-A is a complete listing of analytes detected in the samples collected. Section 5.0, which describes the revised site conceptual model, provides more details on the spatial distribution of VOCs and correlations with site geology/hydrogeology.

4.2.2 Mud Rotary Drilling and Soil Sampling

4.2.2.1 Objectives

Within the dissolved-phase plume, data were collected to define the vertical and lateral extent of contaminants downgradient of the source area and characterize the geologic units within the dissolved-phase plume.

4.2.2.2 Activities Carried Out

Eight boreholes were drilled by using mud rotary drilling techniques and a Versa-Drill V100 drill rig. Drilling services were provided by Gregg Drilling of Signal Hill, California. Formation samples were collected at approximately 5-ft intervals from cuttings within the drilling fluid. Samples were obtained from a point as near to the borehole as possible and before the drill cuttings entered the mechanical separation equipment. Cuttings were collected by using a strainer and gently washing the returns to remove drilling fluid. The remaining cuttings were examined and logged. A boring log was prepared for each mud rotary boring location (Appendix D-B). At a minimum, boring logs contain the following information:

- Lithology-Soils were described by using the Unified Soil Classification System (USCS). This includes soil and other unconsolidated material, grain size, plasticity, and density/consistency; and

- Qualitative moisture content (wet, moist, dry), degree of weathering, color (referenced to Munsell color charts), stain (e.g., presence of mottles, iron oxide [Fe_2O_3]), odor, and depth.

A drive sample was collected every five ft for the last 25 ft of the boring (approximately 85 to 105 ft for the five transect wells) or at depths specified by GeoSyntec's supervising geologist. The sampler was fitted with a string of three 2-inch diameter, 6-inch long brass sample sleeves. Soil samples were collected for the purposes of chemical and geotechnical (grain size distribution, porosity, permeability, etc.) analyses. A portion (at least a half pint) of each sample was set aside in a Ziploc® bag and allowed to sit closed for at least ten minutes. A PID reading was then taken in the bag headspace and recorded. Based on these readings and field observations, two of these samples were sent to a commercial laboratory (Columbia Analytical Services) for chemical analysis from each of the borings deeper than 40 ft. For each of these deeper borings, an additional sample was collected from an area selected as representative of the aquifer and sent in for geotechnical analysis. Representative samples also were collected from the various horizons for x-ray diffraction (XRD) analysis. Both the geotechnical analysis and XRD analysis were performed to provide input for decision rule b.

4.2.2.3 Results

A total of 14 soil samples from eight boreholes were sent in for chemical analysis. Results of VOC testing are shown in Table 4.5. Seven volatile organic chemicals were detected in the 14 samples. Acetone was detected in all samples, at concentrations ranging from 4.9 to 9.8 µg/kg. Nine samples contained detectable concentrations of cis-1,2-DCE (1.7 to 46 µg/kg). Carbon disulfide, methylene chloride, 1, 1-dichloroethene, and trans-1,2-DCE were detected in one sample each. TCE was detected in 11 samples with concentrations ranging from 1.9 to 480 µg/kg (see Figure 4.3). Section 5.0 provides more details on how the VOCs in soil are spatially distributed and correlations with site geology/hydrogeology.

A total of 8 soil samples from five boreholes were sent in for XRD analysis. One sample was collected from 28 ft bgs from RDO-3A, two from RDO-3B at 95 and 100 ft bgs, one from RDO-5 from 90 ft bgs, two from RDO-6A from 35 and 99.5 ft bgs, and two from RDO-6B from 75 and 105 ft bgs. The XRD analyses run on these samples indicated the presence of Quartz, Calcite, Dolomite, Albite, and Microcline in each of the samples tested. The samples collected at 100 ft bgs from RDO-3B and 105 ft bgs from RDO-6B had detections of Muscovite, which the other samples did not. The full results are included in Attachment A.

4.2.3 Monitoring Well Installation and Development

4.2.3.1 Monitoring Well Installation

A transect of six wells was installed downgradient of the suspected source area. These wells are located such that they span the high-concentration core of the dissolved-phase plume, with the center wells within this transect (RDO-3A and RDO-3B) installed approximately 12 ft upgradient of existing monitoring wells MW-70-01 and MW-70-07, respectively. These wells, with the exception of RDO-3A, are constructed of nominal 4-inch diameter schedule 40 PVC riser and 40 ft of 0.020-inch horizontally slotted screen, extending from approximately 65 to 105 ft bgs. Well RDO-3A was constructed by using 4-inch diameter schedule 40 PVC riser and 10 ft of a 0.020-inch screen extending from approximately 20 to 30 ft bgs. RDO-6A and RDO-6B were installed approximately 12 feet upgradient of existing wells MW-70-08 and MW-70-31 to approximate depths of 105 and 145 ft bgs, respectively. These wells are located within the dissolved-phase plume and are constructed of 4-inch diameter Schedule 40 PVC riser, with 10 feet of 0.020-inch screen. Well construction details are shown in Table 4.6.

Stainless steel centralizers were installed above and below the screened intervals and at 40-foot intervals along the blank casing in each well. The annulus of each well was filled with filter sand (Lone Star Monterey # 2/12), which extends from approximately 3 feet above the top of the screen to the bottom of the borehole. The filter sand was carefully poured through a tremie pipe and washed into the annulus between the well screen and the borehole with potable water. The sand was poured slowly and the top of sand was monitored regularly for signs of bridging by using a weighted tape. The screened interval in each well was surged with a vented surge block to settle the sand pack. Additional filter pack material was added, as needed, following surging of the well until the filter pack extended approximately 3 feet above the top of the screen interval. Approximately 1 ft of transition sand (Lone Star Monterey #1C) was placed above the filter pack sand to prevent intrusion of annular sealants into the filter pack. The top of the filter pack was verified using a weighted tape measure. An approximately 3-ft thick hydrated bentonite pellet/chip seal was placed by free fall from the surface into the annular space and washed down with potable water. The top of the bentonite seal was verified by using a weighted tape measure. The remaining well annulus was completed with cement/bentonite (5% by weight mix) grout to provide a surface seal. The cement/bentonite grout was installed under pressure by using a tremie pipe, leaving approximately 1 foot of exposed PVC. Each well was completed with a locking cap and an aboveground surface completion with protective posts. Well construction logs are in Appendix D-C.

4.2.3.2 Development

The wells were allowed to recover and stabilize for at least 48 hours after installation prior to development. This allowed curing of the grout so that development activities did not damage the grout seal. Development of each well was performed with a Smeal 5T rig, equipped with a steam cleaner, vented surge block, air lift and submersible pumps, bailers capable of removing sediments from the well, and a generator. Prior to development, the rig and development equipment were steam cleaned to reduce the potential for cross-contamination between wells. Water quality measurement instruments were calibrated each day, or more often when instrument drift was suspected. Calibration was performed with standards supplied by the instrument manufacturers. Field data collected during the well development procedure was recorded on a well development log sheet. These development logs are included in Appendix D-D.

4.2.4 Groundwater Sampling

4.2.4.1 Objectives

Groundwater data were collected within the dissolved-phase plume to define the lateral and vertical extent of impacted groundwater both downgradient of the source area and near the leading edge of the plume (courtesy of Bechtel). An estimate of the total mass flux from the source area and the variation in mass flux across the lateral cross-section of the plume will be modeled from this data during the design phase, which will allow for refinement of the length of the biobarrier(s) to target the higher concentration areas that will not sufficiently attenuate naturally within the targeted treatment duration. The vertical distribution of the contaminants in the plume along the transect of wells was also better characterized. This will allow for refinement of the vertical interval over which the biobarrier(s) are constructed.

4.2.4.1.1 Bulk Sampling Methods

Groundwater sampling was conducted approximately two weeks after the completion of development in the monitoring wells. Before purging, purging and sampling equipment was thoroughly cleaned and decontaminated to prevent cross-contamination and water levels were measured by using an electric water level indicator.

Prior to collection of groundwater samples from each well, at least three casing volumes of groundwater were purged using electric submersible pumps. Purging of the groundwater was performed at relatively low flow rates to ensure minimal drawdown in the well. Water purged from the wells was monitored for temperature, pH, conductivity, and turbidity to document changes in water quality. Water quality field parameters were recorded after each well volume purged (Appendix D-D).

After the groundwater stabilized and purging was complete, sampling was conducted immediately. Laboratory-provided sample containers (with appropriate type and volume of preservative) were filled directly from the sample pump discharge hose while maintaining the flow rate established during purging to minimize any potential agitation of the groundwater. Samples that were analyzed for dissolved metals were pumped into sample containers through a filter. New tubing was used for each new well sampled in order to prevent cross-contamination.

4.2.4.1.2 Depth Discrete Methods

Prior to collection of depth discrete groundwater samples from RDO-1, 2, 3B, 4, and 5, each well was purged by using an extraction pump. Water purged from the wells was monitored for temperature, pH, conductivity, and turbidity to document changes in water quality. Water quality field parameters were recorded every three minutes. For the depth discrete sampling, an extraction pump was located either at the top or bottom of the well depending on the direction of vertical flow and was used to compensate for high flow from zones not being sampled. The second pump, used for depth-discrete sampling, was a peristaltic pump operated at low flow rates. The pumping rate on the extraction pump during purging was maintained throughout sampling. The sampling pump intake was located at depths corresponding to significant changes in hydraulic conductivity observed during the electromagnetic borehole flowmeter [EBF] surveys. Laboratory-provided sample containers (with appropriate type and volume of preservative) were filled directly from the discharge hose of the sampling pump at each targeted depth and sample labels specified the sampling depth. New tubing was used on the peristaltic pump for each new sampling depth. New tubing was used on the extraction pump for each well.

4.2.4.2 Results

4.2.4.2.1 Bulk Sample Results

With the exception of RDO-3A, the only volatile organic compounds detected in bulk groundwater samples collected from the RDO wells were cis-1,2-DCE and TCE (Table 4.7). An additional six VOCs, including vinyl chloride, were detected in the bulk groundwater sample collected from RDO-3A. Detected concentrations of cis-1,2-DCE range from 9.8 to 190 µg/L in the RDO wells and detected concentrations of TCE range from 21 to 5200 µg/L in the RDO wells. Although RDO-3A (the lowest detected concentration of TCE) is adjacent to RDO-3B (the highest detected concentration of TCE), the depths of the screened intervals are different in the two wells. RDO-3A is screened from 20 to 30 ft bgs while RDO-3B is screened from 65 to 105 ft bgs. Figure 4.4 shows the detected concentrations of TCE for each RDO well sampled. Section 5.2.5 provides a more detailed interpretation of the contaminant distribution both laterally and vertically within the plume and a discussion on the correlation between soil lithology and contaminant migration pathways.

4.2.4.2.2 Depth Discrete Sample Results

Three VOCs were detected in depth discrete groundwater samples collected in the RDO transect wells (Table 4.8). Vinyl chloride was detected at concentrations ranging from 3.6 to 4.2 µg/L in three of the four depth discrete samples with VOC detections collected from RDO-1. Both cis-1,2-DCE and TCE were detected in all depth discrete samples with VOC detections (Table 4.8). Detections of cis-1,2-DCE ranged from 7.5 to 180 µg/L and detections of TCE ranged from 180 to 4700 µg/L. Section 5.2.5 provides a more detailed interpretation of the contaminant distribution both laterally and vertically across the cross-section of the plume and a discussion on the correlation between soil lithology and contaminant migration pathways.

4.2.5 Electromagnetic Borehole Flowmeter Survey

4.2.5.1 Objectives

EBF surveys were conducted in wells RDO-1 through RDO-6(A and B) by Quantum Engineering Corporation (QEC) to delineate the vertical profile of relative *K* across the open (screened) interval of the wells. The surveys were done under both pumping and non-pumping conditions to determine preferential pathways for contaminant migration under ambient groundwater flow and preferential pathways for EVO during injection activities. In the EVO injection test wells (RDO-3A, RDO-6A, and RDO-6B), pre- and post-injection surveys were completed to evaluate the impact of the EVO injection on soil permeability and to illustrate any changes in the locations of these preferential pathways.

4.2.5.2 Methods

The EBF surveys were carried out following the standard operating procedures (SOPs) outlined in Section A.6 of the SOP. The following sections summarize the equipment, pre-logging activities, flow measurement protocol, and record keeping procedures utilized throughout the EBF surveys.

4.2.5.2.1 Equipment and/or Instrumentation

The following equipment was utilized to conduct the EBF surveys:

- 1-inch I.D. (2-inch outside diameter (O.D.)) EBF downhole probe, equipped with a collar for use in 4-inch O.D. wells;

- Hand-operated winch equipped with a depth indicator;

- Peristaltic 1 1/2-inch diameter pump capable of extraction rates of up to 10 gallons per minute (gpm); and

- Datalogger.

The 2-inch O.D. downhole probe was fitted with a collar and rubber gasket sized to the 4-inch diameter well to prevent vertical flow bypassing the recording interior of the probes. For the post-EVO injection EBF survey of well RDO-6A, the installed riser prevented the use of this collar, which impacted the quality of the data and thus this data set will not be included in the following discussion. The performance specifications of the probe are presented in Table 4.9. The probe utilized in the RDO well tests was new and was calibrated shortly before use. The EBF system calibration test produced a linear signal throughout the range of flow rates tested.

4.2.5.2.2 EBF Flow Measurements

The flowmeter survey for each well was initiated by measuring ambient flow throughout the screened section of the well. The ambient flows reveal the presence of vertical pressure gradients, positive or negative, between strata, delineate preferential flow paths, and provide a baseline for analyzing induced flow into the well during pumping. Once the ambient flow pattern was recorded, the induced flow test was initiated by pumping into or from the well at a constant rate.

The flow surveys were conducted according to the procedure outlined in Section A.6.3 in the SOP. Upon completion of the surveys, the lateral inflow from each stratum was calculated by successively subtracting the cumulative flow measured at those strata from the cumulative flow recorded at the level immediately below. Hydraulic conductivity was calculated for those strata by using the Cooper-Jacob formula for horizontal flow to a well (Cooper and Jacob, 1946). The ratio of local hydraulic conductivity, K_i to average hydraulic conductivity, K_{bulk}, for each well was computed according to (Molz and Young, 1993):

$$\frac{K_i}{K_{bulk}} = \left[\frac{\left(\frac{\Delta Q_i - \Delta q_i}{\Delta z} \right)}{\frac{Q_{pump}}{b}} \right]; \qquad i=1,2,\ldots,n$$

where ΔQ_i is the flow from the i^{th} layer in the well, Δq_i is the ambient flow from the i^{th} layer of the well, Δz is the thickness of the i^{th} layer, Q_{pump} is the flow rate pumped from the well during the induced flow test, and b is the aquifer thickness.

4.2.5.3 Results

Figure 4.5 shows the flow rate profiles for each of the eight RDO wells. These profiles illustrate the magnitude and direction of vertical flow under both ambient and pumping conditions. Figure 4.6 shows the normalized hydraulic conductivity values for each test elevation of the eight RDO wells. Normalized hydraulic conductivity is defined as the proportion of hydraulic conductivity contributed by a stratum to the overall bulk hydraulic conductivity of the interval over which the well is screened. These profiles are useful for delineating areas of relatively high hydraulic conductivity that may act as preferential flow pathways for contaminated groundwater at the Site. These profiles were generated by using the net results of the measured response from the EBF pumping test corrected for the ambient flow, which had to be overcome during pumping. Table 4.10 provides a comparison between the aquifer matrix lithologic description and the relative and normalized values of hydraulic conductivity calculated for each interval tested in the EBF survey.

From the data shown in Figures 4.5 and 4.6 and Table 4.10, it is evident that there is generally a correlation between the soil lithology and transmissivity (capacity for flow) of the layer, with layers having a coarser lithology (e.g., medium sands, sands with gravel, etc.) having a higher transmissivitiy as expected. Local variability in K ranges up to and exceeds an order of magnitude in some locations. This variability is seen in all units and all depths.

For RDO-1, ambient flow appears to be entering the well between -60 and -70 ft above mean sea level (AMSL), which coincides with a medium sand layer. Water entering below -67 ft AMSL (gravel layer at -74.6 AMSL) is moving downward under ambient flow conditions and that entering above -67 feet is moving upward. There appears to be a slight anomaly near the top of the screen, as the recorded flow rate did not return to zero as recorded at the bottom of the screen. This could be a result of residual flow in the solid casing caused by vertical movement of the probe to this depth. Such residual flows are sometimes noted in zones of extremely low flow rates. Figure 4.6 and Table 4.10 show that RDO-1 is screened across a relatively high hydraulic conductivity zone from -75 to -80 ft AMSL (gravel layer) and that another higher *K* zone exists near the top of the screen.

For RDO-2, flow is entering the screen over the bottom ten feet (a sand layer containing minor shell content), flowing upward in the well, and exiting at elevations above -70 ft AMSL (a silt layer containing coarse sand). This is consistent with the flow profile measured during pumping. The normalized *K* profile for RDO-2 (Figure 4.6 and Table 4.10) indicates zones of higher *K* near the top (silt with coarse sand) and bottom (sand with shells) of the screen, separated by a zone of lower *K* (sequences of clayey silt, silty sand and sand with clay stringers) between -70 and -90 ft AMSL.

For RDO-3A, ambient flow is entering the well between -18 and -22 ft AMSL (medium to coarse sand), is flowing in a downward direction, and is exiting very near the bottom of the screen. The normalized *K* profile for RDO-3A (Figure 4.6 and Table 4.10) indicates that the *K* is significantly higher between -18 ft AMSL (medium to coarse sand) and the bottom of the well.

In RDO-3B, ambient flow is again downward, entering the well between the top of the screen (medium to coarse sand) and approximately -70 ft AMSL, and exiting the well between -70 ft AMSL and the bottom of the screen (fine sand with shells). The greatest ambient flow measured in any of the eight RDO wells tested was recorded in this well. In RDO-3B, the normalized *K* profile (Figure 4.6 and Table 4.10) indicates a zone of lower *K* between -65 and -75 ft AMSL (clayey sand), separating zones of higher *K* above (medium to coarse sand) and below (fine sand with shells).

The flow profiles for RDO-4 and RDO-5 exhibit similar behavior, and reveal that groundwater is entering the well screen between -65 and -70 ft AMSL (fine to medium sand with gravel), flowing downward, and gradually exiting between -70 (RDO-4) to -85 (RDO-5) and -95 ft AMSL (fine sand with variable shells, gravel and silt/clay content). The normalized *K* profiles for RDO-4 and RDO-5 (Figure 4.6 and Table 4.10) are also similar and reveal distinctly different conditions above -70 ft AMSL (fine to medium sand with gravel) from that below (fine sand, silt/clay layers), with the hydraulic conductivities of the upper region being much greater than one order of magnitude than those below.

RDO-6A reveals a pattern of upward ambient flow, with water entering the well in the lowest foot of the screen (-96 ft AMSL; sand) and exiting in the top two feet (-84 to -86 ft AMSL; coarse sand and gravel). In RDO-6A, the greatest values of *K* (Figure 4.6 and Table 4.10) were found to be in the lowest portion of the screen where ambient flow was seen to be entering (sand layer), as well as in the uppermost portion of the screen (coarse sand with gravel) where ambient flow was seen to be exiting. Other zones with smaller gradients are also identified in the normalized *K* profile for RDO-6A.

The ambient flow patterns in RDO-6B suggest that groundwater is entering the well from the upper fine sand unit (-123 ft AMSL), flowing downwards and exiting in the medium sand/gravel unit at -125 ft AMSL. Further down the well, groundwater again appears to be flowing into the well (-129 ft AMSL) and exiting in the sand/gravel layer found at the bottom of the well (-131 ft AMSL). The normalized *K* profile (Figure 4.6 and Table 4.10) for RDO-6B shows a pattern of high *K* zones near the top (medium sand with gravel) and bottom of the screen (sandy gravel), separated by a zone of low *K* between -126 and -129 ft AMSL.

4.2.5.3.1 Pre- / Post- EVO Injection Comparison

The pre- and post-EVO injection flow rate profiles from RDO-3A and RDO-6B under pumping conditions are shown in Figure 4.7. As stated above, the riser installed on RDO-6A following the EVO injection prevented the use of a collar on the

EBF probe. Thus, the data collected from the post-EVO EBF survey of this well was deemed unusable and will not be presented.

As seen in Figure 4.7, a decrease in the normalized flow rate of pre- *versus* post-injection was seen within the higher conductivity portions of the aquifer encountered in RDO-3A. There was minimal impact seen within the shallower, low conductivity portions of the aquifer. Given that these higher conductivity layers are likely to conduct the majority of the EVO, it is reasonable that the majority of the reductions in soil permeability will be observed in these layers. A quantitative evaluation of the observed permeability reduction cannot be performed due to the differences in pumping rates utilized for the pre- and post- injection tests. However, examination of Figure 4.7 flow data implies that the maximum permeability reduction is no more than 50%. Similar impacts are seen in localized areas of RDO-6B corresponding to the highest conductivity zones (e.g., sandy gravel layer encountered at -129 ft AMSL); however, the reductions in permeability seen in RDO-6B are not as large as those seen in RDO-3A.

This conclusion is supported by Figure 4.8 which shows normalized hydraulic conductivity as a function of test elevation for the pre-EVO injection test and the post-EVO injection test for RDO-3A and RDO-6B. For RDO-3A, the post-EVO survey shows a slight decrease in relative *K* across the bottom two feet of the screen (coarse sand interval), and a corresponding increase in relative *K* in the two foot interval immediately above this zone relative to the pre-EVO survey. Little change is seen in the shallower low permeability region of this well. A slight change in the normalized hydraulic conductivity profile is also noted for RDO-6B. The normalized hydraulic conductivity of the bottom most test interval (approximately -129 ft AMSL; sandy gravel layer) is reduced in the post-EVO injection test, and the normalized hydraulic conductivity of the finer grained layers above this are correspondingly higher, indicating a lower contribution of groundwater from the high K zones and a corresponding higher contribution from the low K zones following EVO injection.

4.2.6 EVO Field Injection Study

An EVO injection field study was initiated on September 28, 2005 to address remedial design uncertainties and to collect sufficient data to allow for the development of a numerical model that will be used for optimization and design of the full-scale bioremediation conceptual design. The numerical model is provided as the Appendix A of the Remedial Design document (of which the Pilot Study is Appendix

D). This section presents a discussion of the objectives, methods, and results of the EVO field injection study.

4.2.6.1 Objectives

EVO tests were conducted to determine: (i) the achievable ROI of the emulsified oil around the injection well in each aquifer unit; (ii) the achievable EVO injection rates in representative locations in the shallow aquifer and in the First and Second Sand aquifers; and (iii) the impact of emulsified oil on the permeability of the soil in each area where oil is injected (discussed in Section 4.2.5.4.1). The ROI achieved affects well spacing and the number of wells required, while the achievable injection rate provides an estimate of the length of time to achieve the desired ROI and the associated labor costs.

4.2.6.2 Methods

The EVO injections were carried out following the SOPs as outlined in Section A.7 of the SOP (GeoSyntec, 2005a). Minor modifications to the methodology outlined in Section A.7 of the SOP were necessary; these are noted in the text below. The following sections summarize the required supplies (equipment and amendments) and the EVO injection protocol followed throughout the EVO injection tests.

4.2.6.2.1 Required Supplies

Required amendments used for the EVO injection tests were as follows:

- **Emulsified Vegetable Oil.** EVO was delivered to the site pre-emulsified in 264 gallon (gal) totes. Three totes of Newman Zone EVO were supplied by Remediation and Natural Attenuation Services Inc. (RNAS) and one tote of EOS 450 (another brand of EVO) was supplied by EOS Remediation Inc. (EOS). EVO was obtained from the two separate suppliers to allow for a comparison of injection efficiency and impact on soil permeability between products at RDO-6A and RDO-6B. Two totes of Newman Zone were amended to RDO-3A to target distribution of the oil at 1% of the pore volume throughout an ROI of 12 ft. Similarly, one tote of Newman Zone and one tote of EOS 450 were amended to RDO-6B and RDO-6A respectively to target distribution of oil at 0.5% of the pore volume throughout an ROI of 12 ft.

- **Water.** The injections required large volumes of water (24,155 gallons of water for the RDO-3A test, 17,894 gallons of water for the RDO-6A test *[Note: this is less than the 31,670 gallons specified in the SOP due to the decision to reduce the screen length of RDO-6A by half]*, and 22,507 gallons of water for the RDO-6B test). Groundwater was extracted for use in the injections from the targeted depth interval before the EVO injection commenced and stored in water tanks.

- **Bromide.** Bromide was used as a conservative tracer at a concentration of 15.0, 12.5 and 12.2 milligrams per liter (mg/l) for injections at RDO-3A, RDO-6A and RDO-6B, respectively. A concentrated bromide solution was dissolved in a separate vessel, mixed with the groundwater stored in each storage tank, and used to dilute the EVO during the injection tests.

4.2.6.2.2 EVO Injection

Pre-injection activities were conducted as outlined in Section A.7.3 of the SOP (GeoSyntec, 2005a). The injection equipment was assembled as depicted in Figures 4.9 and 4.10. The EVO injections were completed at the site at three injection wells (RDO-3A, RDO-6A, and RDO-6B) over 14 consecutive days, with daily operating periods of 8 to 10 hours, according to the procedure outlined in Section A.7.4 of the SOP. Deviations from the procedure outlined in the SOP included (i) the maximum well head pressure was limited to 15 psi; (ii) chase water was not added at the end of each injection day; and (iii) decontamination of the injection manifold was performed after the completion of each EVO injection. Water level readings, flow totalizer readings, well-head pressure gauge readings, dose ratio, and remaining EVO volumes were recorded at the intervals noted in the SOP. A copy of the field log sheets is included in Appendix D-E. Samples for bromide, Total Organic Carbon (TOC), and turbidity analysis were obtained after injection of every 450 gallons of EVO (bromide and turbidity only) and 900 gallons (all parameters). A summary of the EVO injection is presented in Table 4.11.

4.2.6.3 Results and Discussion

The following sections summarize and discuss the results of each injection.

4.2.6.3.1 EVO Injection at RDO-3A

A total of 237 gallons of oil (495 gallons Newman Zone Emulsified Oil and water mixture) and 24,155 gallons of water were injected into RDO-3A in 51 non-consecutive hours. The injection flow rate and well head pressure changed very slowly from 10 gpm at 0 psi in the early stages of the injection to 5.3 gpm and 3 psi in the latter part of the injection. This flow rate drop and pressure head increase indicated that the ability of the formation to accept fluid was decreasing and that maximum sustainable injection rates for full-scale implementation are likely to not exceed 5 gpm in the Upper Fines Unit.

Groundwater elevations recorded by the pressure transducer installed in RDO-3B and MW-70-01 over the course of the injection study are shown in Figure 4.11. Because the water levels in RDO-3B remain relatively constant during the EVO injection in RDO-3A, it is unlikely that a direct hydraulic connection exists between the First Sand Unit (RDO-3B) and the Upper Fines Unit where RDO-3A is screened. The groundwater elevations recorded by a second pressure transducer installed in MW-70-01 suggests that there is a strong hydraulic connection between this monitoring well and the injection well RDO-3A.

Groundwater samples were collected during the EVO injection from monitoring well MW-70-01 (located 11.9 ft away from RDO-3A) to determine bromide and EVO breakthrough. Bromide was used to confirm hydraulic connection between the injection and the monitoring wells and track breakthrough of the amended fluid to the monitoring well. TOC and turbidity were used as indirect measures of the emulsified vegetable oil. A milky appearance to the groundwater also provided a visual method for detecting breakthrough of higher concentrations of the emulsified vegetable oil.

Figure 4.12 presents bromide, turbidity, and TOC concentrations for samples collected from MW-70-01 over the course of the injection. Bromide breakthrough, defined as one half the bromide concentration in the injected (feed tank) fluid, occurred after 7,756 gallons of groundwater and EVO had been injected (i.e., approximately 76% of the volume required to theoretically achieve distribution of the injected fluid ~12 ft away from the injection well, assuming a bulk porosity of 0.3). Bromide concentrations in MW-70-01 reached 100% of the amended concentration after approximately

12,000 gallons of water and EVO were injected, which is 850 gallons greater than should theoretically have been required to distribute the amended fluid ~12 ft away from RDO-3A, suggesting the porosity is greater than 0.3.

TOC concentrations slowly increased at the same rate as the bromide, and asymptotically reached a maximum concentration of 319 mg/L at approximately 12,000 gallons. The EVO was not visually observed to breakthrough, except for a transient detection after approximately 17,531 gallons of fluid was injected. TOC concentrations at this time were on the order of 280 mg/L, and turbidity was also seen to transiently increase slightly. The maximum TOC concentration of the 1% oil injectate solution was 5,980 mg/L (see Table 4.11), indicating that the downgradient TOC concentrations corresponded to ~0.05% oil, which is too dilute for visual detection of the EVO. Given that the measured TOC concentrations were consistent over the last 12,000 gallons and that bromide concentrations achieved 100% breakthrough, it can be concluded that achievement of distribution of substantial amounts of EVO within an ROI of 12 ft is not likely to be achievable within this unit, and a smaller ROI should be assumed for full-scale implementation where lateral coverage of EVO is critical.

4.2.6.3.2 EVO Injection at RDO-6A

A total of 93 gallons of oil (196 gallons EOS 450 emulsion) and 17,894 gallons of water were injected into RDO-6A in approximately 78 non-consecutive hours. Based on calculations made prior to commencement of field work, this was enough fluid to achieve a ROI of 16 ft. The injection flow rate and well head pressure changed from approximately 5 gpm at 8 psi in the early stages of the injection to 3 gpm and 9 psi in the latter part of the injection. This flow rate drop and pressure head increase indicated that the ability of the formation to accept fluid was decreasing and that maximum sustainable injection rates for full-scale implementation are not likely to exceed 3 gpm in the Shell Horizon.

Groundwater elevations, which were manually measured in MW-70-08 over the duration of the injection study (Figure 4.11), suggest that there is a hydraulic connection between this monitoring well and the injection well RDO-6A.

Groundwater samples were collected during the EVO injection from monitoring well MW-70-08 (located 12.1 ft away from RDO-6A) to determine bromide and EVO breakthrough. Figure 4.13 presents bromide, turbidity, and TOC concentrations for samples collected from MW-70-08 over the course of the injection. Bromide breakthrough, defined as one half the maximum measured bromide concentration in the injection (feed tank) water (180 mg/L), occurred after 16,389 gallons of emulsion had been injected (i.e., approximately 91% of the theoretical volume required to achieve ~16 ft ROI assuming horizontal distribution of the injected fluid). Breakthrough of the bromide at 100% of the injected concentration was not observed, possibly due to vertical spreading.

TOC concentrations slowly increased at the same rate as the bromide concentrations to a maximum of 110 mg/L and did not reach an asymptotic level at any time. The EVO was not visually observed to breakthrough. The maximum TOC concentration of the 0.5% oil injectate solution was 2,990 mg/L, indicating that the downgradient TOC concentrations corresponded to ~0.02% oil, which is too dilute for visual detection of the EVO. Given that both bromide and TOC were still increasing at termination of the injection test, it is unclear whether an ROI of 12 ft is achievable within the Shell Horizon. It is clear, however, that excess fluid will need to be injected to achieve a targeted ROI within this unit. Better distribution of EVO may be achieved by extracting groundwater from a well located laterally within the biobarrier (which will help to pull the injected fluid horizontally) during injection, and a smaller ROI should likely be assumed for full-scale implementation where lateral coverage of EVO is critical.

4.2.6.3.3 EVO Injection at RDO-6B

A total of 109 gallons of oil (228 gallons Newman Zone Emulsified Oil) and 20,891 gallons of water were injected into RDO-6B in approximately 32 non-consecutive hours based on pre-injection calculations. This was sufficient fluid to theoretically achieve an ROI of 17.2 ft. The injection flow rate and wellhead pressure changed from approximately 15 gpm at a negative pressure (suction) in the early stages of the injection to 12.5 gpm and 2 psi in the latter part of the injection. Therefore, maximum sustainable injection rates for full-scale implementation are not likely to exceed 12 gpm in the Second Sand. Figure 4.11 presents the groundwater elevations measured in MW-70-31 during the injection, which suggest a hydraulic connection between this monitoring well and the injection well RDO-6B.

Groundwater samples were collected during the EVO injection from monitoring well MW-70-31 (located 12.5 ft away from RDO-6B) to monitor bromide and EVO breakthrough. Figure 4.14 presents bromide, turbidity, and TOC concentrations for samples collected from MW-70-31 over the course of the injection. Bromide breakthrough, defined as one half the maximum measured bromide concentration in injection (feed tank) water (175 mg/L), occurred after 16,393 gallons of emulsion had been injected (i.e., approximately 78% of the theoretical volume required to achieve ~17 ft ROI assuming horizontal distribution of the injected fluid). Breakthrough of the bromide at 100% of the injected concentration occurred after ~20,000 gallons of fluid had been injected (i.e., corresponding to a theoretical ROI of ~16.7 ft, which is larger than the actual distance of 12.5 ft between injection and monitoring well). This slight discrepancy may be the result of an incorrect assumption for soil porosity, homogeneity of the sediments in the formation, or may reflect some vertical spreading of the injected fluid.

TOC concentrations slowly increased at the same rate as the bromide concentrations to a maximum of 386 mg/L at approximately the same time that bromide breakthrough achieved 100% of the injected concentration. Turbidity was also observed to slowly increase at the same rate as TOC and is likely the result of the presence of EVO in the groundwater. The EVO was visually observed (i.e., a milky quality to the groundwater was observed) after 10,100 gallons had been injected. Based on this information, it is apparent that an ROI of 12.5 ft is achievable; however, excess fluid may be required to achieve this ROI to account for potential vertical spreading outside of the targeted region.

4.2.6.3.4 Discussion of Results of the EVO Injection Field Testing

From the observations noted above and the result of the tracer testing and monitoring for TOC and turbidity breakthrough, the following conclusions may be drawn:

- Injection of EVO into more permeable units should be achievable at reasonable injection rates (12 gpm) and throughout a reasonable ROI (12 ft), based on EVO distribution behavior in the Second Sand. Some correction may be necessary for the volumes of injection fluid required to account for some vertical spreading of the injectate.

- In less permeable units (i.e., the Shell Horizon and the Upper Fines Unit), a smaller ROI will likely be achievable (<10 ft) and lower injection rates are likely to be sustainable (2-5 gpm). This will require tighter well spacing and longer injection durations.

- The required volume to achieve a particular ROI in the Shell Horizon will need to be corrected to account for EVO loss due to vertical spreading.

- The heterogeneous nature of the Upper Fines Unit appears to result in uneven vertical distribution of the EVO throughout the targeted region, resulting in preferential distribution of the EVO within the more permeable layers.

- A comparison of the EBF survey before and after the EVO injection in RDO-3A and RDO-6B indicated some loss in permeability, particularly in the high K layers. Numerical modeling indicates that this loss of permeability will have minimal impact in the full scale implementation. The remedial design was drafted with the possibility of a permeability loss of up to 50% in the finer units.

- The comparison between the distribution of the two EVO products (Newman Zone™ and EOS™) was inconclusive, as variability in the geology intersected in the screened intervals of RDO-6A and RDO-6B significantly influenced the EVO distribution. The pre- and post-injection EBF data from RDO-6A (the only well in which the EOS was injected) was also inconclusive, and thus comparative impacts to soil permeability also could not be evaluated.

4.2.7 Microcosm Study

4.2.7.1 Objectives

A microcosm laboratory study was conducted by SiREM (a biotechnology laboratory and wholly owned subsidiary of GeoSyntec) to evaluate the natural and enhanced anaerobic degradation processes and rates for TCE and its breakdown products (cis-1,2-DCE, and VC). Anaerobic treatments were constructed to assess the rate and extent of reductive dechlorination that can be achieved by the indigenous microbial populations under natural *in situ* conditions (intrinsic controls) and when stimulated through the addition of a slow release electron donor such as emulsified oil combined with bioaugmentation with KB-1™ halorespiring microbial culture.

As indicated in Table 4.12, microcosms for the intrinsic control were collected from three locations at the site (the First Sand, the Shell Horizon [Fine-grained Sands] and the Second Sand Unit). Microcosms for the biostimulated/bioaugmented microcosms using Newman Zone™ EVO were collected from two locations (the source area [Upper Fines (UF) Unit] and the Shell Horizon

[Fine-grained Sands Unit]). A third biostimulated/bioaugmented microcosm for the Shell Horizon Unit using an alternative EVO source (EOS 450, EOS Remediation Inc.) was also conducted to evaluate the effect, if any, of the type of EVO utilized .

The microcosm study used geologic materials and groundwater from the site collected from intervals of interest during the CPT/Geoprobe soil sampling activities and the mud rotary drilling soil sampling activities. Soil and groundwater were collected from the source area in the Upper Fines Unit (sample depth of 20 to 60 feet), the First Sand (sample depth of 70 to 80 feet), the Second Sand (sample depth of 130 to 140 feet) and the Shell Horizon (sample depth 80 to 100 ft). Samples were collected by using a sterilized split-spoon sampler and placed into pre-cleaned, sterile brass 6-inch liners, according to SiREM’s standard soil sampling procedure (SOP Section A.8.1, GeoSyntec 2005a). End caps were placed on the liners, and the liners were shipped on blue ice packs to SiREM. Up to two (2) liters of groundwater from each interval or location (Upper Fines Unit, First and Second Sands, and Shell Horizon) were collected for the microcosm studies.

4.2.7.2 Microcosm Construction and Treatments

The microcosms were constructed by filling 250 milliters (mL) (nominal volume) glass bottles with approximately 180 mL of associated groundwater and 60 grams (g) of site geologic material leaving a nominal headspace for gas production (e.g., ethene, carbon dioxide, methane). All treatments and controls were constructed in triplicate. Geologic materials added to the sterile control microcosms were autoclaved and groundwater used in these microcosms was amended with mercuric chloride and sodium azide to inhibit microbial activity. The intrinsic control microcosms, designed to measure intrinsic biodegradation activity, did not receive electron donor or microbial culture amendments. Treatment microcosms were amended with the electron donors at 10 times the stoichiometric demand of the chlorinated VOCs (cVOCs) and selected inorganic compounds (i.e., nitrate and sulfate).

All treatment and control microcosms were amended with TCE to reach desired target concentrations (see Table 4.12), as required. The donor treatment microcosms amended with emulsified oil were also bioaugmented with a dehalorespiring microbial consortium (KB-1™) to assess the enhancement of the biodegradation rate and confirm the ability of these bacteria to promote or accelerate complete dechlorination. Bioaugmentation of these microcosms was conducted three or four weeks after the initiation of the study.

One replicate of each treatment was amended with resazurin to monitor redox conditions. Resazurin is clear under anaerobic conditions but turns pink when exposed to oxygen. Microcosms were sealed with Mininert™ valves to allow repetitive sampling of each microcosm and to allow addition of electron donors/acceptors to sustain metabolic/biodegradation activities. In order to maintain anaerobic conditions, construction of the microcosms was conducted in a disposable anaerobic glove-bag. In addition, the anaerobic microcosms were stored and sampled in an anaerobic chamber.

Microcosms were incubated for a period of four to six months. Samples were collected from the treatment microcosms every two to three weeks and from the control microcosms on a monthly basis for analysis of cVOCs and their expected degradation intermediates and end products (e.g., ethane and/or ethene). At selected time points, samples were collected for analysis of combined volatile fatty acids (lactate acetate, propionate) and dissolved organic carbon (DOC) analysis for assessment of levels of remaining slow release electron donor. Other analyses included the measurement of pH, methane, ethene, and anions (i.e., sulfate, nitrate, chloride and phosphate). Sample intervals for individual treatments were modified (either shorter or longer intervals) during the treatability study based on observed microbial activity, VOC degradation rates, and depletion of electron donors/acceptors.

4.2.7.3 Results and Discussion

Figures 4.15 and 4.16 present VOC and anion data, respectively, for the sterile control and the three treatment microcosms (source zone amended with Newman Zone™ and KB-1™, Shell Horizon with Newman Zone™ and KB-1™, and Shell Horizon with EOS™ and KB-1™) as a function of time. Figure 4.17 presents VOC data for the three active control microcosms (the First Sand, the Shell Horizon [Fine-grained Sands] and the Second Sand Unit). All VOC concentrations are given in units of millimoles (mmol) per microcosm bottle (mmol/bottle) to demonstrate mass balance on a molar basis.

4.2.7.3.1 Sterile Control

In Figure 4.15, the sterile control shows no TCE reduction, as anticipated. No volatile losses of TCE occurred during the incubation period.

4.2.7.3.2 Active Controls

The three active controls (the First Sand, the Shell Horizon (Fine-grained Sands) and the Second Sand Unit), which indicate natural (intrinsic) biodegradation activity, show little to no TCE reduction (see Figure 4.17). This slow level of activity is indicative of a low level of natural biodegradation, with a TCE half-life exceeding three years.

4.2.7.3.3 Biostimulated / Bioaugmented Treatments

The source zone treatment (amended with buffered Newman Zone™ and KB-1™) presented in Figure 4.15 shows complete TCE reduction from 0.011 mmoles/bottle (~7.3 mg/L) to non-detect levels during the first 26 days (7 days following amendment with KB-1™ at Day 19). This trend is marked by an order of magnitude increase in cis-1,2-DCE concentration from 0.0021 mmol/bottle (on Day 19) to 0.022 mmol/bottle (on Day 26). These relatively high 1,2-DCE concentrations persist for a 42 day (6 week) lag period until Day 68, then decrease to non-detect levels by Day 103. VC is first observed on Day 34, but does not reach a maximum concentration (0.100 mmol/bottle) until Day 89, following the 1,2-DCE lag period. No lag period is observed for VC. Complete conversion of all VOCs to ethene occurred in this microcosm within 84 days (12 weeks) of bioaugmentation (by Day 103). Ethane production was not observed during the test. Methane is present throughout this test; however, concentrations did not appreciably increase from the initial conditions. The calculated degradation half-lives for the source zone treatment (amended with Newman Zone™ and KB-1™) are 1.3 days, 10.4 days and 3.4 days for TCE, 1,2,-DCE and VC, respectively.

In the microcosms using soil from the Shell Horizon and amended with EOS and KB-1™, complete TCE reduction is observed by day 63. However, almost an order of magnitude decrease in TCE concentrations occurs over a 7 day period following KB-1™ amendment on Day 27 (from 0.0019 mmol/bottle on Day 27 to 0.00023 mmol/bottle on Day 34). Again, this reduction in TCE was accompanied by an increase in cis-1,2-DCE and VC concentration (to 0.0029 mmol/bottle by Day 41 for cis-1,2-DCE and to 0.0016 mmol/bottle by Day 48 for VC), followed by a reduction in cis-1,2-DCE and VC concentrations to non-detect levels on day 90. No lag period was observed for 1,2-DCE as in the source zone treatment. Ethene production is observed on Day 48 (0.0023 mmoles/bottle) and complete conversion of all VOCs to ethene occurred by day 90. Methane production increased from trace levels at the outset of the test to stabilize at a concentration of 0.87 mmoles/bottle by Day 83, indicating the presence and activity of methanogenic bacteria. The calculated degradation half-lives for the Shell Horizon (amended with EOS and KB-1™) treatment are 2.3 days, 8.0 days and 13.3 days for TCE, 1,2,-DCE and VC, respectively.

In the microcosms using soil from the Shell Horizon and amended with Newman Zone™ and KB-1™, complete TCE reduction is observed by Day 47. However, similar to the pattern observed in the EOS™ and KB-1™ microcosm test, more than an order of magnitude decrease in TCE concentrations occurs over a 7 day period (following KB-1™ amendment on Day 19) from 0.003 mmol/bottle on Day 19 to 0.00006 mmol/bottle on Day 26. Again, this reduction in TCE is accompanied by an increase in cis-1,2-DCE and VC concentrations (to a maximum of 0.0075 mmol/bottle on Day 34 for cis-1,2-DCE and to a maximum of 0.0035 mmoless/bottle by Day 54 for VC), followed by a reduction in cis-1,2-DCE and VC concentrations to non-detect levels for both compounds by Day 82. Ethene production is observed throughout the test and complete conversion of all VOCs to ethene occurred by day 82. Once again, ethane production was not observed. Similar to the Shell Horizon treatment amended with EOS and KB-1™, methane was being produced with a maximum concentration of 0.047 mmol/bottle on Day 82, indicating the presence and activity of methanogenic bacteria. In contrast to the Newman Zone™ and KB-1™ source zone treatment, the Shell Horizon Newman Zone™ and KB-1™ test did not include a lag period for 1,2-DCE. The calculated degradation half-lives for the Shell Horizon (amended with Newman Zone™ and KB-1™) treatment are 1.2 days, 9.3 days and 9.3 days for TCE, 1,2,-DCE and VC, respectively.

In each of the three treatment microcosms (in particular, the Shell Horizon with EOS™ and KB-1™ and the Source zone microcosm), total ethene concentrations are seen to increase almost immediately following amendment with KB-1™. The TCE added to each microcosm will initially partition into the EVO and to soil, due to its similar organic nature, thus decreasing the apparent total ethene concentration present in the dissolved phase. As the TCE is biodegraded to lower chlorinated compounds that have a weaker affinity to the EVO and thus partition less strongly, the apparent total ethene concentration in the dissolved phase will increase over time.

In summary, the Source zone treatment differed from the two Shell Horizon treatments in two respects: 1) a 1,2-DCE lag period was observed; and, 2) little to no methane was produced. High concentrations of chlorinated solvents (e.g. 1,2,-DCE) have been shown to inhibit methanogenesis (Yang and McCarty, 2000), which is the likely cause of the 1,2-DCE lag period.

4.2.7.3.4 Comparison of EOS 450 and Newman Zone^{TM}

The VOC profiles for the two Shell Horizon treatments (the Newman Zone^{TM} abd EOS 450^{TM}) are similar. Both treatments show complete TCE, 1,2-DCE and VC dechlorination, without a lag period, and substantial methane production. In general, the test results indicate that microbially-mediated TCE reduction can be induced by the amendment of either EOS and KB-1^{TM} or Newman Zone^{TM} and KB-1^{TM} in either the source area or the Shell Horizon.

4.2.7.3.5 Anion Data

In Figure 4.16, the sterile control shows no appreciable change in anion constituent concentrations, as anticipated. None of the treatment microcosms show appreciable chloride concentration increases, as would be expected given that chloride is a daughter product of the dechlorination reaction. In addition, no changes in nitrate and nitrite concentrations were observed for the three treatment microcosms. However, a sulfate concentration reduction from a high of 925 mg/L on Day 19 to 2 mg/L on Day 103 was observed for the source zone treatment (amended with buffered Newman Zone^{TM} and KB-1^{TM}). Similar trends of reducing sulfate concentrations were observed for the two Shell Horizon (Fine-grained Sands) Unit microcosms (from 361 mg/L on Day 0 to 3 mg/L on Day 74 for the EOS^{TM} and KB-1^{TM} microcosm, and from a high of 451 mg/L on Day 28 to 7 mg/L on Day 112 for the Newman Zone^{TM} and KB-1^{TM} microcosm). These decreasing sulphate concentrations as a function of time are indicative of the presence and activity of sulfate-reducing bacteria..

4.2.8 Survey

All monitoring well points for this project were surveyed by a State-licensed land surveyor. The survey data were collected in North America Datum (NAD) 83 coordinates and North American Vertical Datum (NAVD) 88, 1995 Adjusted Orange County Surveyor elevations and subsequently converted to National Geodetic Vertical Datum (NGVD) 29.

The survey team marked a permanent location at each well head (typically, on the north side of the top of the blank casing) for measuring the reference elevation.

4.3 Investigation-Derived Waste Disposal

Investigation-derived waste (*i.e.*, drill cuttings, drilling mud, and well development, and purge water) were stored in Department of Transportation (D.O.T.)-approved containers or rolloff bins, sampled and analyzed to determine the appropriate method for disposal. No hazardous materials were generated. All investigation-derived waste was disposed of in an appropriate manner.

4.4 Data Quality Assessment

Project staff reviewed field and laboratory data generated during the pilot test for internal and external consistency in accordance with the Sampling Analytical Plan (SAP) (GeoSyntec 2005a) and field quality control data were reviewed for deficiencies.

Laboratory data generated under the SWDIV Program are generally validated by an independent validation subcontractor. However, according to SWDIV Environmental Work Instruction 4EN.1 (SWDIV 1999), pilot studies do not require independent data validation. Therefore, the Pilot Test data were not validated.

4.4.1 Data Verification

Field and laboratory data were managed by using manual and electronic systems. Analytical data are included in Attachment A.

When re-analyses and dilutions were performed in the laboratory, multiple sets of results were reported. Project personnel reviewed the multiple sets of results during the data verification process and selected one result for each sample and analyte that was the most practicable. When dilutions were performed, the result from the lowest dilution that was still in range was used. When re-analyses were performed because of quality control issues, the results associated with acceptable quality control were used.

4.4.2 Field Quality Control

Field quality control samples were specified by the SAP and collected and tested to help maintain the required level of confidence in the field data and to provide cross-checking on the laboratory contracted to perform the analyses. The following quality control samples were specified:

- Trip blanks were specified by the SAP and included, as required, in each shipment to the laboratory containing water samples for VOC analysis. Results were used to detect contamination introduced during sample handling and shipping. Trip blanks were prepared by the laboratory using the same type of container, from the same batch of containers, as was used to store the samples. The trip blank consisted of distilled water of known quality with the same preservative as was used for the samples. The trip blank was carried to the field and returned to the laboratory without being opened. Trip blank samples were analyzed for VOCs.

- Field blanks were specified by the SAP and are prepared by using deionized water and sample bottles randomly selected from the bottles prepared for environmental samples, additionally, the water used for decontamination of equipment should be used in preparation of the field blanks. The field blanks should be assigned unique sample numbers so as not to be identified by the analytical laboratory as field blank samples. One field blank should have been prepared each day that the environmental samples were collected. Field blanks should have been analyzed by the same methods as were the pilot-test samples. Results would be used to assess the potential for contamination from water used for decontamination. Only one field blank was collected during the entire 14-day groundwater sampling event.

- An equipment rinsate blank was specified by the SAP to assure proper equipment decontamination after sample collection prior to collection of a subsequent sample. Equipment rinsate blanks should be prepared at the site by passing distilled water of known quality through decontaminated sampling equipment. No rinsate blanks were collected at the Site, although Grundfos pumps were used for some of the sample collection and decontaminated between samples.

- Field duplicates were specified by the SAP and are defined as two samples of the same matrix, to the extent practicable, collected at the same time and location and using the same sampling technique. The duplicate samples were specified to be collected at a frequency of 1 for every 10 samples. The duplicate samples were analyzed for the same constituents as the associated site samples. Field duplicates for soil samples were not collected at the frequency specified in the SAP, six duplicate samples should have been collected whereas only four duplicate samples were collected. The desired frequencies for groundwater were achieved. The results obtained were used to evaluate precision.

- Matrix spike and matrix spike duplicates (MS/MSD) were specified by the SAP to be analyzed at a frequency of 1 per every 20 samples. Triple the amount or volume of the sample matrix is collected for the designated MS/MSD samples. The MS/MSD sample is used to evaluate the precision of the sample preparation and the analytical method for that matrix. MS/MSDs were not specified on the chain-of-custodies at the required frequencies for the sampling event; however, laboratory batch QC using project specific samples accounted for the correct frequency of 1 per 20 for all analyses except for VOC analysis by EPA Method 8260 in soil where the required number of samples was not met at all (0 of 3 required) and metal analyses in groundwater where the frequency fell short by two MS/MSD samples, three MS/MSD samples were required to achieve the specified frequency.

Trip blanks, field blanks, and equipment rinsate blanks were generally free of contamination. Overall, field duplicate results demonstrate acceptable precision.

4.4.3 Work Plan Modifications

Deviations from the RDO work plan [GeoSyntec, 2005a] included the following.

- The five identical wells in the transect of wells were changed from 50-ft screens to 40-ft screens based on lithologic log and apparent presence of clayey sediments above a depth of approximately 65 feet and a bottom depth of 105 feet.

- The five identical wells in the transect of wells were changed to 4-in. diameter wells to preserve the possibility of using them for injection at a later date and to allow discrete sampling which required two pumps.

- All wells were constructed by using schedule 40 PVC instead of schedule 80 PVC because all wells were constructed as 4-inch diameter wells instead of 2-inch diameter wells (4-inch schedule 40 thickness is greater than 2-inch schedule 40). The majority of pre-existing wells on site are also constructed of schedule 40 PVC.

- RDO-3A and RDO-3B were originally planned to be nested wells. RDO-6A and RDO-6B were also originally planned to be nested wells. This was changed to two separate boreholes in each situation due to the position of downgradient monitoring wells for EVO injection. To optimize the EVO injection test, downgradient monitoring wells needed to be approximately 12 feet away from the injection wells. This would have been impossible with the nested wells, as proposed originally in the work plan.

- RDO-6A was constructed with 10 feet of screen instead of 20 feet in order to mimic the construction of the downgradient well and its screened interval.

4.4.4 SOP Deviations

Deviations from the SOPs include the following:

- During CPT soil sampling, discrete samples were not taken for laboratory analysis and PID screening due to the small volume of sample that could be extracted from any given depth with the CPT rig. The same sample was used for both. Minimal impact to the study.

- Samples were collected every 10 feet instead of every 5 feet during CPT soil sampling to provide five evenly distributed samples between 20 feet and 60 feet, the total depth of a CPT boring. The CPT sampler was able to sample to greater depths than originally believed. The same number of samples were collected from each boring as originally proposed. This provided a more representative cross section of the zone of interest, 25 to 60 feet bgs.

- QA/QC samples were not collected of drilling mud at the point of discharge as no drilling mud was disposed on site. All mud was contained within roll-offs, profiled, and disposed of off site under proper non-hazardous manifests. No impact to the project.

- PID readings were not recorded on the boring logs as stipulated by the SAP. PID readings were not documented but were taken, poor quality control procedures on documentation but little impact to project.

- Blue ice was only used to chill samples shipped internationally. All other samples were kept cold using sealed bags of ice and shipped by courier. No impact to the project as sample were received at acceptable standards.

- Oxidation reduction potential and dissolved oxygen were not recorded during sampling as the field equipment was not equipped to take these measurements. Resulted in loss of field data which may have a slight impact on the project. Results of this data could help define EVO demand during full scale implementation. Other lab analyses can provide some of the data to allow calculation of EVO demand.

- Depth discrete sampling was only conducted using two pumps where EBF survey data indicated vertical flow was present. The extraction pump was moved above or below the sampling points depending on the EBF survey results in order to cancel the effects of the vertical flow from higher flow zones. The depth discrete sampling was targeted on the zones of distinct flow defined in the EBF survey. Data support that the two pump sampling process provided better data quality by allowing more discrete sampling of the high flow zones.

- Only 15,835 gallons of water were required to inject oil into RDO-6A due to the reduction in screen length necessary to match RDO-6A to the downgradient monitoring well (MW-70-08 screened from 95 to 105 ft bgs) instead of the 31,670 gallons originally planned. No significant impact.

- Instead of adding bromide to the EVO stream using a metering pump, bromide was added to the water in the tank directly and mixed using a pump as this was considered easier to control. Bromide levels (concentrations measured by a bromide specific probe) were checked in the tanks of water prior to injection to ensure proper mixing had occurred. The goal of the mixing was to achieve a bromide concentration of approximately 200 parts per million (ppm). Several samples from various parts of the tank were collected to confirm this concentration. Bromide was detected in all of the down gradient wells to indicate break through. There was no apparent impact to the project due to this deviation. Concentrations ranged from:

- 212-255 ppm in water injected into RDO-3A
- 167-178 ppm in water injected into RDO-6A
- 164-188 ppm in water injected into RDO-6B

- Pressure at the well head was monitored to ensure it remained below 15 pounds per square inch (psi) in order to maintain the proper seals within the well. May have reduced the rate of injection for the EVO but overall did not significantly impact the project.

- Clean, non-EVO/bromide water was not injected during EVO injection at the end of each day due to the difficulty in obtaining fresh water on site. No significant fouling occurred and this deviation did not impact the project.

The deviations outlined above resulted in little to no impact on the usability of the data and the overall project. While these deviations must be noted, the variation introduced to the analyses were taken into account and corrected during data compilation and analysis.

4.4.5 SAP Deviations

Deviations from the SAP include the following:

- X-ray diffractions samples and geotechnical samples were not sent in for CPT soil samples. CPT sampling produced small volumes of soil, so extra samples were sent in from monitoring wells. Soils representative of each zone were selected from the following borings for XRD analysis: shallow soils as represented by RDO-3A, First Sand zone as represented by borings RDO-1 through RDO-5 and 6A, and the Second sand as represented by RDO-6B.

- Some documentation of decontamination and field instrument calibrations were done on forms separate from the bound field log books. These forms have been filed appropriately and are available for all project personnel to review.

- Monitoring wells were air-knifed only to a depth of 7 feet due to the presence of groundwater at this depth and the verbal assurance from the public works departments on base, that all base utilities should be no deeper than 5 feet. CPT borings were hand augered until groundwater was encountered. All points were cleared using geophysical utility clearance methods prior to air knifing or hand augering. No utilities were encountered in any of the boring locations.

- Soil samples collected and sent in for analysis during monitoring well installation were labeled using an abbreviated sample name. The project sample log kept during this phase identifies both the abbreviated sample name and the full sample name as outlined in the SAP.

- Duplicate soil samples were not collected during monitoring well installation.

- Only one field blank was collected over 14 days of groundwater sampling.

- Although dedicated (new) tubing was used to sample each well and each depth, rinsate blanks were not collected after samples were taken by using the Grundfos pumps to confirm that they were free of contamination after decontamination procedures. All equipment was thoroughly cleaned and decontaminated between each borehole and/or groundwater sample collected according to the procedures outlined in the SAP.

- Due to oversight, samples to be used for MS/MSD purposes were not specified on the chain-of-custodies during the sampling event. Because of this, the required frequency of MS/MSD analyses as specified by the SAP was not achieved for VOC analysis in soil and metal analyses in groundwater.

- Field duplicates were not collected at the correct frequency for soils.

The deviations outlined above resulted in little to no impact on the usability of the data for PS purposes. The deviations listed above will be used when preparing future SAPs for the site.

5. CONCEPTUAL SITE MODEL

The conceptual site model has been refined for the IR Site 70 remediation project based on the supplemental data collected during the PS activities. The existing geologic model focuses on the geologic nature of the soils grouping similar soil types and behaviors. The refined hydrogeologic model focuses on the aquifer characteristics of the soils, grouping higher hydraulic conductivities soils and lower conductivity soils into separate units. This refined grouping allows for a more focused design. The goals of the conceptual model refinements are to:

- Identify the hydrogeologic units that are governing the contaminant migration behavior;
- Identify the degree of vertical and horizontal spatial variability in hydraulic conductivity and temporal and spatial variability in hydraulic gradient within the dissolved plume;
- Refine our understanding of the lateral and vertical extent of contamination within the plume and source area; and
- Aid in identifying data gaps in the definition of the contaminant plume;

The site conceptual models hydrogeologic layer geometry and spatial distribution, estimated hydraulic conductivities, concentration data, and water level contours will be used as direct input into a numerical model to support remedial design efforts for the enhanced in situ bioremediation system.

The description of the refined site conceptual model has been divided into sections addressing site hydrogeology (Section 5.1) and site plume morphology (Section 5.2). Identified data gaps are discussed in Section 5.3.

5.1 Site Hydrogeology

GeoSyntec revised the geologic conceptual model to address the hydrogeologic conditions for IR Site 70 based on the field and analytical data collected in the PS investigation in combination with lithological data extracted from existing borehole logs. This model is based on the identification of hydrostratigraphic units, with consideration of the plume fate and transport as illustrated with three-dimensional characterization of the extent of the dissolved-phase plume (discussed in detail in Section 5.2 below).

The refined conceptual model of the local hydrogeology is shown in cross-section view in Figure 5.1. The hydrogeologic conceptual site model currently contains six separate hydrostratigraphic units. These intervals vary throughout the site, but the approximate depths are as follows. Upper Fines Unit (ground surface to approximately 60 ft bgs); First Sand (60-105 ft bgs); Shell Horizon (105–135 ft bgs); Second Sand (135–170 ft bgs); Deep Clay (170–190 ft bgs); and Deep Sand (190 ft bgs and below).

The Upper Fines Unit extends from ground surface to a depth of approximately 60 feet bgs and comprises three zones: a shallow zone of surficial soils and recent clayey sediments; an intermediate zone of interbedded silts, clays, and sandy silts and clays that includes the semi-perched zone; and a lower zone of interbedded silts, clays, and fine to coarse-grained, silty to clayey sands. A zone of organic material, mainly wood chips, was encountered in a number of boreholes at a depth of approximately 45 to 50 feet bgs.

The First Sand is characterized by poorly-graded fine-grained sands and silty sands and extends from approximately 60 to 105 ft bgs. A coarse sand/fine gravel layer was encountered in several borings between 80 and 95 feet bgs. This coarse layer lies just above or slightly within the Shell Horizon. The First Sand varies in thickness from approximately 30 to 50 feet [BEI, 2003a].

The Shell Horizon is characterized by a sequence of interbedded clays, silts, sands, and gravels below the source area transitioning to predominantly fine-grained sand in the vicinity of RDO-6A/B. This Unit has been subdivided into the Shell Horizon (Interbedded Clays) and Shell Horizon (Fine-grained Sands) to reflect differences in the plume migration behavior and hydrogeologic characteristics. Shell and gravel layers were encountered in some, but not all, borings: interbeds within the Shell Horizon do not appear to be spatially extensive. Wood chips were encountered in several borings at a depth of about 110 feet [BEI, 2003b]. The Shell Horizon extends from approximately 105 to 135 ft bgs, with a consistent base at 135 ft bgs.

The Second Sand is similar in character to the First Sand; however, this lower unit appears to be slightly coarser in its upper section. This unit extends from approximately 135 to 170 ft bgs. The Pump Test [BEI, 2003] provides the current interpolation for this unit.

The Deep Clay has been encountered in only a few sample points by the IR activities or other people, none of which were part of the PS investigation. Regional geological trends suggests that this Deep Clay Unit is likely continuous throughout the area of Site 70. Where it has been encountered on Site, it is described as a fat clay and is described in the literature as an interbedded unit [Bulletin No 63-2, 1968; Bulletin No 104, 1961; and Wall, 1966]. The hydraulic conductivity of the Deep Clay Unit appears low. The Deep Clay extends from approximately 170 to 190 feet bgs [BEI, 2003a].

The Deep Sand Unit has been logged in only a few sample points. The samples were logged from hydropunch borings as part of the ERSE (BNI, 1999) This unit appears to be similar in character to the First and Second Sand Units. The average depth to the Deep Sand is approximately 190 ft bgs [BEI, 2003a].

5.2 <u>Plume Morphology</u>

Plume morphology is of prime importance at this site, as it will guide the design and installation of the remediation system. The morphology, or shape of the plume, is controlled by a number of local variables, including:

- Spatial distribution of hydraulic conductivities of the different layers;
- Spatial continuity of permeable layers: that is, how far laterally and vertically continuous sands and gravels extend from the source area;
- Groundwater gradients, which in turn may be influenced by nearby pumping, recharge, and/or ocean tides;
- The sampling network; and
- Contaminant concentration.

5.2.1 Spatial Distribution of Hydraulic Conductivities

The relatively low horizontal hydraulic conductivity of the Upper Fines Unit is inferred partly from available chemical data that show few and relatively lower VOC detections within this unit between the source area and the transect wells (see Section 5.2.5 below). Thin sand lenses of various thicknesses with somewhat higher conductivities are present within the Upper Fines Unit and comprise the semi-perched aquifer. Dissolved-phase VOCs have been detected at low concentrations in at least two intervals between depths of 20 to 30 feet and 50 to 60 feet bgs. These observations indicate that there is some potential for lateral migration in the semi-perched aquifer; however, little is believed to have occurred to date. Based on the previously presented EBF data, in the area of RDO-3A, elevations between -14 ft and -17 ft AMSL (23 to 26 ft bgs) had low hydraulic conductivity (K) and consisted of clay and silt. Between -7 ft and -22 ft AMSL (26 ft bgs and 31 ft bgs), a medium to coarse-grained sand unit was encountered with conductivities an order of magnitude higher. Similar local variability in K is expected throughout the remainder of the Upper Fines Unit indicating significant heterogeneity in this Unit.

Based on a slug test conducted at the Site [BEI, 2003a], the bulk hydraulic conductivity of the First Sand is relatively high, on the order of $2.4x10^{-2}$ cm/sec (centimeter per second) horizontally. Due to the lithological similarities found in the First and Second Sand Units, the vertical conductivity of $1.5x10^{-3}$ cm/sec found in the Second Sand Unit is assumed for the First Sand as well. The zone of highest permeability (at minimum an order of magnitude higher) along the transect appeared to be between -55 and -70 ft AMSL (65 to 80 ft bgs) with RDO-2 and RDO-3B also having higher permeability zones encountered near the bottom of the well screens where sand layers containing shells were intersected. These lower permeable layers were separated from the upper permeable zone by a fine-grained lens, usually consisting of a silty/clayey sand.

The Shell Horizon hydraulic conductivity varies spatially with its composition. Near the source area, the Shell Horizon is predominantly clays and exhibits low vertically conductivities as evidenced by the plume morphology. The ERSE [BNI, 1999] investigation found that samples collected directly beneath the Shell Horizon in the Second Sand unit did not detect TCE above MCLs. Conversely, near the area of RDO-6A/B the Shell Horizon is predominantly sands with similar hydraulic conductivities as the First and Second Sand Units. Estimated ranges for hydraulic conductivities for the Shell Horizon range from approximately $1x10^{-7}$ cm/sec horizontal and $1x10^{-8}$ cm/sec vertical near the source area where the Shell Horizon is predominantly interbedded clays, to approximately $1x10^{-2}$ cm/sec horizontal and $8x10^{-4}$ cm/sec vertical for the area where the Shell Horizon is predominantly fine-grained sand [BEI, 2003a]. The results of the EBF survey in RDO-6A, which is screened in the Shell Horizon where the soil lithology is predominantly a fine-grained sand, indicates the presence of localized thin high permeability layers interbedded with finer grained, lower permeability layers. Localized variability in K range by an order of magnitude, indicating that the majority of the flow within the Shell Horizon is likely to be confined to the thinner high K layers. These high K layers have thicknesses typically on the order of one to two feet.

The bulk hydraulic conductivity of the Second Sand Unit is approximately $2.3x10^{-2}$ cm/sec horizontally and $1.5x10^{-3}$ cm/sec vertically based on the 2002 pump test [BEI, 2003a]. The EBF survey conducted in RDO-6B, which is screened in the upper coarser area of this unit, shows the variability in K is less than seen in the Shell Horizon, indicating a smaller degree of heterogeneity, although thinner layers of low permeability were observed [BEI, 2003b and BNI, 2002].

The hydraulic conductivity and thickness of the Deep Clay and Deep Sand Units are unknown.

5.2.2 Continuity of Permeable Layers

A complete review of the available boring logs was conducted to ascertain the continuity of permeable layers throughout the project area. This review led to the six hydrogeologic layers described above.

The Upper Fines Unit, the Shell Horizon (Interbedded Clays) Unit and the Deep Clay Unit exhibit geologic layers that significantly hamper the vertical migration of contaminants, likely due to their predominantly fine-grained character and lack of connected high permeability layers. However, as the Shell Horizon grades to a slightly coarser unit to the southeast, it provides vertical continuity between the First and Second Sands allowing for vertical migration of contaminants.

It appears that the First and Second Sands as well as the Deep Sand are all of sufficient horizontal and vertical conductivities to allow for both vertical and horizontal migration to occur. These layers are laterally continuous and the area of the Shell Horizon (Fine-grained Sands) provides vertical continuity between the First and Second Sands. The Deep Sand appears separated from the Second Sand in the study area by the Deep Clay.

5.2.3 Hydraulic Gradients

Water elevations, vertical head differences between units, horizontal gradients and dominant groundwater flow directions in each of the hydrogeologic units as defined in the revised site conceptual model described above were evaluated over a five-year period, beginning June 2000 and ending July 2005. To simplify the analysis, the section of the Shell Horizon (Fine-Grained Sands) was combined with the First Sand and treated as one hydraulic unit based on similarities in the water elevations in each of these units; note that the section of the Shell Horizon (Interbedded Clays) is viewed separately. The results of the analysis are summarized in Table 5.1 and Appendix D-F. Water elevation contours throughout the 2000 to 2005 period (all quarters) were all relatively similar in shape and spacing showing similar groundwater gradients and direction of flow. It should be noted that while some characteristics of the water level contours were similar, the actual head values varied by up to seven feet. The water elevation contours for the July 2005 sampling event [BEI, 2005] are shown in Appendix D-F for four different elevation intervals, to illustrate typical contour profiles over this time period. The following observations may be made, based on trends that were seen throughout the entire five year period of analysis [BEI, 2005]:

- The primary groundwater flow direction in each hydrogeologic unit is consistent over the evaluated time period (all layers having groundwater flow in a general southeasterly direction, ranging from approximately 118 to 173 degrees from north; see Table 5.1), with little seasonal variation.

- The magnitude of the horizontal hydraulic gradients in each of the units is also consistent throughout the time period, although seasonal variations between summer and winter months are consistently observed. The gradients in the winter months are generally a factor of two to three less than those in the summer months.

- The predominant direction of groundwater flow in each of the units based on the water elevation contours is consistent with the plume morphology. Groundwater flow in the First Sand Unit is nearly south (averaging approximately 169° from north), which is the direction of plume migration in the upgradient portion of the plume where it is primarily confined to this unit. Groundwater flow in the Second Sand Unit is more southeasterly (averaging approximately 120˚ from the North), resulting in a shift in the plume migration direction (more southeasterly) where the plume migrates vertically into this Unit. There is no recent contaminant data to the south of this point to indicate whether the plume in the First Sand Unit continues to migrate towards the south, and limited water elevation data in this area to allow for interpretation based on groundwater contours.

- The horizontal gradients are highest in the First Sand Unit, by approximately a factor of three in comparison to those in the Upper Fines Unit and the Second Sand.

- Seasonal fluctuations in the water elevations ranging up to 7 ft are typical in all layers.

- The vertical head difference between hydrogeologic units indicates consistent downward migration of groundwater throughout the plume and source area.

These trends suggest that the temporal variability of groundwater migration behavior at Site 70 is reasonably low over significant time intervals. The average horizontal hydraulic gradient in each unit ranges from 0.0006 ft/ft in the Upper Fines Unit, 0.0009 ft/ft in the Second Sand, up to 0.002 ft/ft in the First Sand/Shell Horizon (Fine-Grained Sands).

Potential external factors that may influence local gradients and vertical migration of groundwater include groundwater pumping (regional water supply wells) and aquifer recharge (e.g., Alamitos Injection Barrier) activities, as well as tidal influences. Groundwater pumping and aquifer recharge in the Orange County Groundwater Basin cause significant temporal fluctuations in the local groundwater elevations; however, the temporal consistency in the gradients and groundwater flow direction indicate that the overall impact to IR Site 70 groundwater flow migration is minimal and may be accounted for in the design process. As discussed in previous work at the site [BEI, 2003a], tidal influences appear negligible to areas within the site that will be impacted by remediation activities.

In the long term, variability in the groundwater migration behavior on IR Site 70 may be caused by changes in operation of the Alamitos Injection Barrier. The Alamitos Injection Barrier to the northwest of Site 70 is operated as a seawater barrier jointly by Los Angeles County, Department of Public Works, Water Replenishment District of Southern California (WRD) and Orange County Water District. This Barrier includes the injection of fresh water at depths as shallow as 27 ft bgs. The shallowest Alamitos barrier injection wells may affect the southeasterly gradient in the Second Sand Unit. These injection wells may affect the gradient and direction of flow to a lesser extent, due to lower injection rates, in the First Sand. According to the WRD, the operation of the barrier is not likely to change within the next 30 years in such a way as to affect groundwater flow in the aquifers of interest; however, future changes will be monitored and evaluated under the long-term evaluation monitoring program.

5.2.4 Spatial Distribution of Contaminants

The spatial distribution of contaminants at IR Site 70 has been modeled by GeoSyntec by using the 3D plume generator contained in Environmental Visualization Systems (EVS) software. The interpreted plume extents were presented in the RFS and were based on data obtained in the late 1990s [GeoSyntec 2005b]. As part of the current activities, data from multiple sampling events were reviewed. Based on this data review, three events were selected to visualize within EVS. They are the FS dataset [BNI, 2002], 3rd quarter 2003 data [BEI, 2003b], and 3rd quarter 2005 [BEI, 2005] supplemented by the RDO depth discrete data points. Both the FS [BNI, 2002] and 3rd quarter 2005 [BEI, 2005] data sets are relatively consistent with each other. The 3rd quarter 2003 [BEI, 2003b] data do not have enough depth discrete samples to allow quantitative analyses; however, the 2003 [BEI, 2003b] dataset does reinforce qualitatively the plume morphologies generated from the FS [BNI, 2002] and 2005 [BEI, 2005] data sets. All datasets show high TCE concentrations near the source area with a dissolved phase plume extending to the south-southeast. The Site contaminant distribution model was updated for this task to reflect recent sampling data obtained during the 3rd quarter 2005 groundwater sampling round [BEI, 2005], supplemented by groundwater samples obtained by GeoSyntec during PS activities. Figure 2.3 shows the distribution of sampling locations for the data included in the dataset used to generate the model of the 2005 contaminant mass distribution in the plume, including well screen interval depths.

A number of visualizations of the plume model were generated to show different features of the contaminant distribution at IR Site 70. Isosurfaces were generated to help the viewer see the surfaces of equal concentration. In order to illustrate the distribution of contaminants within the plume, figures have been generated in the following categories:

i) **TCE.** Figures 5.2 to 5.6 show the interpreted vertical and lateral extents of the 100 µg/L, 250 µg/L, and 1,000 µg/L concentration isosurfaces (Figures 5.2, 5.3 and 5.4 respectively), as well as the estimated contours of TCE distribution along vertical cross-sections oriented along the axis of the plume (Figure 5.5 A-A') and perpendicular to the axis of the plume as measured in the RDO transect along Kitts Highway (Figure 5.6 B-B');

ii) **cis-1,2-DCE.** Figures 5.7 to 5.10 show the interpreted vertical and lateral extents of the 70 µg/L and 200 µg/L concentration isosurfaces (Figures 5.7 and 5.8 respectively), as well as the estimated contours of cis-1,2-DCE distribution along vertical cross-sections oriented along the axis of the plume (Figure 5.9 A-A') and perpendicular to the axis of the plume as measured in the RDO transect (Figure 5.10 B-B');

iii) **VC.** Figures 5.11 to 5.13 show the interpreted vertical and lateral extents of the 0.5 µg/L concentration isosurface (Figures 5.11), as well as the estimated contours of VC distribution along vertical cross-sections oriented along the axis of the plume (Figure 5.12 A-A') and perpendicular to the axis of the plume as measured in the RDO transect (Figure 5.13 B-B'); and

iv) **Total plume mass**. Figures 5.14 to 5.18 show the interpreted vertical and lateral extents of the 50%, 75% and 90% total dissolved phase mass isosurfaces (Figures 5.14 to 5.16 respectively), as well as the estimated TCE plume mass envelopes along vertical cross-sections oriented along the axis of the plume (Figure 5.17) and perpendicular to the axis of the plume as measured in the RDO transect along Kitts Highway (Figure 5.18). For the 2005 dataset, 50% of the plume mass corresponds to the 1,680 µg/L isosurface, 75% of the plume mass corresponds to the 560 µg/L isosurface, and 90% of the plume mass corresponds to the 180 µg/L isosurface.

The data in the FS [BNI, 2002] data set suggest the presence of a localized high concentration (>11,000 µg/L) area near MW-70-40; however, the 3rd quarter 2005 [BEI, 2006] data do not. Given the more complete coverage (i.e. more depth discrete data points) in the FS [BNI 2002] data set, the potential for the existence of localized higher concentrations in this area should likely still be considered. The additional data collected in the 2005 [BEI, 2006], which included a new transect of wells near the toe of the plume and the RDO transect across the plume near the source, would suggest that the 5 µg/L plume extends a further 600 ft laterally and 600 ft further downgradient than interpreted based on the FS dataset [BNI 2002]. This apparent increase in size is due to the disparate wells sampled during the two sampling events rather than expansion of the plume. A sampling event mimicking the depth discrete sampling undertaken during the FS would likely yield a similar smaller footprint plume as seen from the FS dataset compared to the larger footprint generated from the sparser 2005 dataset. The 100 µg/L extent of the plume has not changed significantly. Of particular note is the detection of TCE at concentrations of 990 µg/L and 550 µg/L in wells MW-70-42B (screened within the Second Sand Unit) and MW-70-42A (screened within the First Sand Unit) respectively, which were newly installed near the toe of the plume. These points provide additional control for contouring the plume in the vicinity of the leading edge of the plume.

From the plume behavior shown in these figures, it is evident that the plume morphology confirms the revised site hydrogeological conceptual model. The lateral migration of contaminants within the Upper Fines Unit appears to be mostly confined to the source area. Due to the downward hydraulic gradients and the low horizontal hydraulic conductivity along with nearly flat groundwater flow gradients combined with seasonal fluctuations within this unit [BEI, 2003a] lateral migration has been apparently hampered. Further downward migration of the dissolved phase is reduced in areas of the site where the Shell Horizon predominantly consists of interbedded clay layers (i.e., beneath the source area and the upgradient portion of the plume) and the plume migrates in a horizontal south-southeaterly direction within the First Sand Unit. Further downgradient, where the Shell Horizon grades to predominantly fine-grained sands, downward migration of the plume is observed into the Second Sand Unit, and further horizontal migration of the plume within both the First and Second Sand Units is observed.

Other observations of note include the following:

- VC is primarily detected at low concentrations (a few µg/L) within the source area, with sporadic detections further downgradient in the plume at concentrations just above the detection limit. Similarly, cis-1,2-DCE is detected at low concentrations (few hundred µg/L) throughout the plume, indicating a low level of natural biological attenuation; and

- Of the total plume mass, 50% is confined to the upgradient portion of the plume within the source area and the First Sand Unit. The area comprising 90% of the total plume mass extends to the toe of the plume into the Second Sand Unit.

5.3 Data Gaps

Figure 2.3 shows a comparison between the sampling locations and depths for which the revised plume model was based on, and the estimated 5 µg/L TCE extents of the plume. From this figure, several data gaps are apparent, including:

- There is no concentration data in the area between the RDO-6 well cluster and the new wells installed by Bechtel (the MW-70-42 well cluster located approximately 800 ft downgradient). This lateral data gap creates uncertainty in the width of the plume in this area, particularly for the higher TCE concentrations. This lack of data also results in a “hole” in the interpreted higher concentration contaminant distribution data within this area. This “hole” can be seen in figure 5.3 below -100 and above -120 feet between RDO-6A/B and the new Bechtel wells. This “hole” is likely an artifact of the data distribution alone, and not a reflection of actual concentrations in this area.

- There is no concentration data for the area of the plume that is further downgradient of the MW-70-42 well cluster (i.e., the leading edge of the plume) for an approximate distance of 1,100 ft downgradient, where low detections of TCE are found. The location of the leading edge of the plume will impact the placement of the leading edge of the plume biobarrier, which is intended to contain further downgradient mass flux, and thus should be delineated further.

- There is no vertical concentration data available for depths within the First Sand Unit in areas downgradient of MW-70-08, and thus the vertical extent of contamination in the downgradient half of the plume is not currently known. This will impact the depths over which plume biobarriers must be constructed.

- To the south of MW-70-08, there is no concentration data or water elevation data that can indicate whether the plume is continuing to migrate in this direction within the First Sand Unit. If the plume is continuing to migrate in this direction, then additional biobarriers may be needed in this area to contain and prevent further plume migration in this area.

6. CONCLUSIONS

6.1 Answers to Decision Questions

a. What is the lateral and vertical extent of contamination within the source area and within the area impacted by dissolved-phase contaminants?

The plume morphology is consistent with the revised Site hydrogeological conceptual model. The additional data collected in the 2005 dataset show the estimated 100 µg/L lateral extents of the plume do not appear to have changed significantly. Of particular note is the detection of TCE at concentrations of 990 µg/L and 550 µg/L in wells MW-70-42B (screened within the Second Sand Unit) and MW-70-42A (screened within the First Sand Unit) respectively, which were newly installed near the toe of the plume. Of the total plume mass, 50% is confined to the upgradient portion of the plume within the source area and the First Sand Unit. The area comprising 90% of the total plume mass extends to the toe of the plume into the Second Sand Unit.

b. What geologic units are governing the contaminant migration behavior?

Based on the limited horizontal extent of contamination within the Upper Fines Unit the limited permeability of finer-grained layers, the downwards hydraulic gradient, the potential for the existence of vertical conduits, and the ambient downward flow in coarser-grained layers within this unit, it appears that contaminant migration in the Upper Fines Unit is occurring primarily downwards. Once the contaminant intersects the First Sand Unit, contaminant migration becomes primarily horizontal. Near the source, the plume is essentially confined to the first sand unit due to the prevalence of clays in the underlying Shell Horizon in this area, which is preventing further downward migration. Approximately 2,000 ft downgradient from the source, the Shell Horizon transitions from the interbedded clays, silts, sands, and gravels that were present below the source area to a predominantly fine-grained sand. This fine-grained sand appears to have much lower resistance to vertical flow, allowing the plume to migrate downward to the Second Sand Unit, in which plume migration becomes predominantly horizontal again.

c. What degree of temporal and spatial variability is there in hydraulic conductivity and water elevation (i.e., hydraulic gradient) with depth?

Variability in bulk hydraulic conductivity was used to delineate primary geologic units present at the site. In the Upper Fines Unit, which consists of interbedded sequences of low permeability clays/silts and higher permeability sand layers, the bulk horizontal hydraulic conductivity of the Unit is low, primarily due to the lack of horizontal continuity of the higher conductivity layers. Within the Upper Fines Unit, localized variability of K on the order of one order of magnitude or greater is typical. The First and Second Sand Units appear to have similar bulk hydraulic conductivities on the order of 10^{-2} cm/sec horizontal and 10^{-3} cm/s vertical. The localized variability of K in these layers is lower than the finer grained layers. Within the Shell Horizon, the bulk hydraulic conductivities near the source area where the soil lithology is predominantly clay, the K values are five orders of magnitude lower than the First and Second Sand Units, resulting in an effective barrier to downward migration of the flow. In downgradient areas, however, the bulk hydraulic conductivities of the Shell Horizon increase significantly in reflection of the change in soil lithology to predominantly fine sand with thin coarse-grained layers, and the bulk K's become similar in order of magnitude to the First and Second Sand Units. On a local scale, however, the localized variability in K in the Shell Horizon appears to be greater than in the surrounding Sand Units, reflecting the interbedded fine and coarse sand layers of the unit in this area.

General trends in the gradient data indicate consistent groundwater flow directions in each layer over several years, small seasonal variability in the horizontal hydraulic gradient in each layer, with the winter months generally having a gradient that was up to a factor of three lower than the gradient in the summer months, and vertical head differences that were consistent with downward flow through each layer.

d. What is the rate of natural attenuation in the shallow zone and deeper units at the site?

Preliminary results of the microcosm study indicate that the rate of natural attenuation of the TCE in all units at the site is low. No discernible degradation of TCE was seen in any of the natural attenuation microcosms within the first 90 days, indicating that the natural attenuation half life for TCE reduction will likely exceed three years.

e. What is the achievable ROI for EVO injection into the subsurface geologic units identified at Site 70?

In the more permeable units (i.e., first and second sand units), distribution of EVO should be achievable throughout a reasonable ROI (12 ft), based on EVO distribution behavior in the second sand unit. In less permeable units (i.e., the Shell Horizon and the Upper Fines Unit), a smaller ROI will likely be achievable (≤10 ft). The required volume to achieve a particular ROI in the Shell Horizon will need to be corrected (i.e., increased) to account for EVO loss due to vertical spreading. The heterogeneous nature of the Upper Fines Unit appears to result in uneven vertical distribution of the EVO throughout the targeted region, resulting in preferential distribution of the EVO within the more permeable layers.

f. What is the achievable EVO rate of injection within the shallow and deeper units at the site?

In the more permeable units (i.e., First and Second Sand Units), injection rates ranging up to 12 gpm are likely to be sustainable. In less permeable units (i.e., the Shell Horizon and the Upper Fines Unit), lower injection rates (2-5 gpm maximum) are likely to be sustainable.

g. What impact does injection of EVO have on the hydraulic conductivity of the aquifer?

Injection of the EVO was found to cause minor reductions in permeability in the coarser units (Second Sand Unit). Slightly higher reductions in permeability were observed in the finer unit (Upper Fines Unit); however, permeability reductions were unlikely to have been greater than approximately 50%.

h. Will the combination of biostimulation and bioaugmentation effectively dechlorinate site soil and groundwater based on the microcosm study and what is the biodegradation rate under these conditions in the plume and source?

Results from the biostimulated/bioaugmented treatments in the microcosm study indicate that microbially-mediated TCE reduction completely through to ethene will be induced by the addition of EVO and KB-1™. Complete reduction of TCE to ethene was observed within 62 days of bioaugmenting the microcosms.

6.2 Results of Decision Rules

Included below is a discussion of the resulting impact of the DQO analysis to design and implementation of the biobarrier treatment system.

a. Lateral and vertical extent of contamination within the source and plume:

The outer extents (vertically and horizontally) of the higher concentration portion of the plume (>500 µg/L TCE, representing 75% of the plume mass) has been adequately defined near the source and upgradient areas of the plume; however, the recent detection of TCE concentrations of 990 µg/L and 550 µg/L in the newly installed wells MW-70-42B and MW-70-42A respectively suggest that the extent of the higher concentration plume is larger than previously thought. Similarly, the lower concentration portion of the plume near the source area and the upgradient portion of the plume have also been adequately defined for remedial design purposes; however, the toe of the plume has not been sufficiently defined in the vertical and longitudinal direction in the area downgradient of the MW-70-42 well cluster. Another uncertainty in the plume interpretation exists in the area between the RDO-6 well cluster and the MW-70-42 well cluster. Further delineation of the groundwater elevations and contaminant distribution to the south of MW-70-08 within the First Sand Unit should be completed to assess whether the plume is continuing to migrate in a south-southeasterly direction in the First Sand Unit. We recommend addressing these data gaps prior to installation of the full-scale plume remedy as the uncertainties in the delineation of the plume in these areas could significantly impact the effectiveness and cost of remedy implementation and ongoing maintenance.

b. Geologic units that govern the contaminant migration behavior:

Based on our current understanding of plume morphology, it appears that biobarrier placement may be safely confined to the First Sand, Second Sand and Shell Horizon (Fine-Grained Sands) Units. Source treatment will adequately address contaminants present in the Upper Fines Unit. Given the downward gradients throughout the plume, we recommend some limited sampling of the Deep Sand Unit to confirm that the plume has not breached the Deep Clay.

c. Temporal and spatial variability in hydraulic conductivity and water elevations/hydraulic gradients:

The consistency in the hydraulic gradients and groundwater flow direction over several years indicates that the impact to the biobarrier placement and remedial effectiveness should be minimal. Sensitivity runs for the modeling will be completed to further investigate the potential impact of the seasonal variations in the gradient, and the biobarrier design will be modified as necessary to account for any potential influence. Given the presence of downward vertical gradients throughout the plume, nested EVO injection wells confined within each lithological unit to the extent possible is recommended, to avoid potential further downward migration of contaminants.

The localized variability in K will impact the distribution of EVO around each injection point,thus causing variable residence time of the groundwater contaminant within the bioactive zone and impacting the lateral continuity of the bioactive zone within each biobarrier. To mitigate the impacts of local variations in K, the ROI will be selected to allow for overlap of the EVO distribution to prevent “holes” in the biobarriers. To account for the potential for vertical spreading of the injectate in the Shell Horizon, the injected volume of fluid will be increased by a factor of 1.7 over the theoretical volume required (i.e., corresponding to the volume of a cylinder with a radius equal to the targeted ROI and height of the screened interval of the well adjusted for the porosity of the soil).

d. Rate of natural attenuation:

Analysis of the results of the anaerobic control microcosms were inconclusive with regards to a natural attenuation rate, outside of the fact that the degradation rate appears to be fairly slow (>3 years). Therefore, Site TCE concentration data along the center line of the plume (monitoring wells MW-70-37, MW-70-38 and MW-70-08) will be used to estimate a natural biodegradation rate for use in the design optimization numerical modeling for plume biobarrier design.

e. The maximum ROI for biobarrier design:

For biobarrier construction in finer units (i.e., the Shell Horizon and the Upper Fines Unit), a maximum ROI of 10 feet will be assumed. For biobarrier construction in more permeable units (First and Second Sand Units), a maximum ROI of 12 feet will be assumed.

f. The maximum sustainable EVO injection rate:

For biobarrier construction in finer units, the maximum sustainable EVO injection rate will be assumed to be around 3 gpm. For more permeable units, a value of 12 gpm will be assumed during biobarrier design and costing. Injection rates will be adjusted during field implementation to target maximum injection rates possible to lower injection durations and labor costs.

g. Impact to permeability within biobarriers:

The EBF survey indicated some hydraulic conductivity reduction following EVO injection. Therefore, a sensitivity analysis examining the effect of up to 50% hydraulic conductivity reduction in the biobarriers zones will be conducted during the remedial design numerical modeling. The results of this sensitivity analysis will be used to assess any treatment design modifications that may be required (see Appendix A of the RD).

h. Effectiveness and rates of biodegradation in biostimulated/bioaugmented areas:

Biostimulation combined with bioaugmentation was shown to be effective at completely dechlorinating soil and groundwater within 68 days in the microcosm study. The biobarriers will be designed to provide a minimum of 70 days groundwater residence time within each biobarrier. If the width of the biobarrier is not sufficient, then multiple barriers at each location will need to be constructed to provide sufficient residence time.

7. REFERENCES

Bechtel Environmental, Inc. 2003a. Final IR Site 70 Aquifer Test Report, Naval Weapons Station Seal Beach, Seal Beach, California, February.

Bechtel Environmental, Inc. 2003b. Final 3rd Annual Groundwater Monitoring Report IR Sites 40 and 70, Naval Weapons Station, Seal Beach, California, December.

Bechtel Environmental, Inc. 2006. Draft Fifth Annual Groundwater Monitoring Report IR Sites 40 and 70, Naval Weapons Station, Seal Beach, California, November.

BEI-See Bechtel Environmental Inc.

Bechtel National, Inc. 1996. Final Removal Site Evaluation (RSE) Report for the Research, Testing and Evaluation (RT&E) Area, Naval Weapons Station, Seal Beach, California. November.

Bechtel National, Inc. 1996b. Summary of Results for the Relative Risk Site Evaluation Model (RRSEM) Data Collection Effort, Naval Weapons Station, Seal Beach, California. February.

Bechtel National, Inc. 1999. Final Extended Removal Site Evaluation Report, Installation Restoration Sites 40 and 70, Naval Weapons Station, Seal Beach, Seal Beach, California. CTO-0127/0549. October.

Bechtel National, Inc. 2002. Final Groundwater Feasibility Study Report, Installation Restoration Program Sites 40 and 70, Naval Weapons Station, Seal Beach, Seal Beach, California. CTO 0127/0609. June.

Bechtel National, Inc. 2004. Draft Pilot Test Report for In Situ Enhanced Bioremediation at IR Site 40, Naval Weapons Station Seal Beach, Seal Beach, California. CTO 0127/0609.

BNI-See Bechtel National Inc.

Cooper, H.H. and Jacob, C.E. 1946. “A Generalized Graphical Model For Evaluating Formation Constants and Evaluating Well Field History,” Transactions the American Geophysical Union, Volume 27.

GeoSyntec. 2005a. Draft Remedial Design Optimization Work Plan Installation Restoration Program Site 70, Naval Weapons Station, Seal Beach, dated 8 July 2005

.

GeoSyntec. 2005b. Final Revised Groundwater Feasibility Study Report, Site 70, Naval Weapons Station Seal Beach, August 2005.

GeoSyntec. 2005c. Bioremediation of DNAPL and Dissolved Phase Chlorinated Plumes, Site 70, Naval Weapons Station Seal Beach, Phase II Proposal, dated 17 February 2005.

Jacobs Engineering Group, Inc. 1994. Draft Preliminary Assessment (PA) Report for the Research, Testing, and Evaluation Area, Naval Weapons Station, Seal Beach, California. 22 July.

Molz, J.G. and Young, S.C. 1993. Development and application of borehole flowmeters for environmental assessment, The Log Analyst, v3, Jan-Feb., 13-23.

Southwest Division Naval Facilities Engineering Command. 1999. Environmental Work Instruction 4EN.1, Chemical Data Validation, SWDIV EWI#1. October

State of California Department of Water Resources Southern District, Bulletin No. 104, 1961 (reprinted 1990), “Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County Appendix A Ground Water Geology”

State of California Department of Water Resources, Bulletin No. 63-2 1968, “Sea-Water Intrusion: Bolsa-Sunset Area Orange County”.

United States Environmental Protection Agency. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. OSWER Directive 9355.1.EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October

United States Environmental Protection Agency. 1992. Guide for Conducting Treatability Studies under CERCLA. EPA/540/R-92/071. October

United States Environmental Protection Agency. 1994. Guidance for the Data Quality Objectives Process (Final). September.

United States Environmental Protection Agency (EPA), 2000. Guidance for the Data Quality Objectives Process, EPA QA/G-4 (EPA, 2000)

Wall, J. R. , Moreland, J. A., and Cordes, E. H. [1966, USGS Open-File Report], "An Investigation of Potential Salt-Water Intrusion from Inland Waterways in the Shallow Alluvial and Coastal Deposits of Sunset and Bolsa Gaps, Orange County, California", United States Geological Survey.

Yang, Y., and McCarty, P.L. 2000. Biologically enhanced dissolution of tetrachloroethene DNAPL, Environmental Science and Technology, v34, 2979-2984.

Table 4.1
Source Area Soil Samples
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Sample Name	Sample Date	Depth (Feet bgs)
CPT-B1	S70-CPT-B1-SS-050908-30	9/8/2005	30
CPT-B1	S70-CPT-B1-SS-050908-50	9/8/2005	50
CPT-B2	S70-CPT-B2-SS-050908-40	9/8/2005	40
CPT-B2	S70-CPT-B2-SS-050908-60	9/8/2005	60
CPT-E1	S70-CPT-E1-SS-050829-30	8/29/2005	30
CPT-E1	S70-CPT-E1-SS-050829-50	8/29/2005	50
CPT-E2	S70-CPT-E2-SS-050829-40	8/29/2005	40
CPT-E2	S70-CPT-E2-SS-050829-60	8/29/2005	60
CPT-E3	S70-CPT-E3-SS-050830-50	8/30/2005	50
CPT-E3	S70-CPT-E3-SS-050830-60	8/30/2005	60
CPT-N1	S70-CPT-N1-SS-050830-20	8/30/2005	20
CPT-N1	S70-CPT-N1-SS-050830-50	8/30/2005	50
CPT-N2	S70-CPT-N2-SS-050830-45	8/30/2005	45
CPT-N2	S70-CPT-N2-SS-050830-60	8/30/2005	60
CPT-N3	S70-CPT-N3-SS-050908-50	9/8/2005	50
CPT-N3	S70-CPT-N3-SS-050908-60	9/8/2005	60
CPT-NW1	S70-CPT-NW1-SS-050908-21	9/8/2005	21
CPT-NW1	S70-CPT-NW1-SS-050908-60	9/8/2005	60
CPT-S1	S70-CPT-S1-SS-050831-40	8/31/2005	40
CPT-S1	S70-CPT-S1-SS-050831-50	8/31/2005	50
CPT-S2	S70-CPT-S2-SS-050901-45	9/1/2005	45
CPT-S2	S70-CPT-S2-SS-050901-55	9/1/2005	55
CPT-S3	S70-CPT-S3-SS-050901-40	9/1/2005	40
CPT-S3	S70-CPT-S3-SS-050901-50	9/1/2005	50
CPT-SE1	S70-CPT-SE1-SS-050831-40	8/31/2005	40
CPT-SE1	S70-CPT-SE1-SS-050831-60	8/31/2005	60
CPT-SE2	S70-CPT-SE2-SS-050901-45	9/1/2005	45
CPT-SE2	S70-CPT-SE2-SS-050901-55	9/1/2005	55
CPT-SW1	S70-CPT-SW1-SS-050902-30	9/2/2005	30
CPT-SW1	S70-CPT-SW1-SS-050902-40	9/2/2005	40
CPT-SW2	S70-CPT-SW2D-SS-050902-20	9/2/2005	20*
CPT-SW2	S70-CPT-SW2D-SS-050902-60	9/2/2005	60*
CPT-SW2	S70-CPT-SW2-SS-050902-20	9/2/2005	20
CPT-SW2	S70-CPT-SW2-SS-050902-60	9/2/2005	60
CPT-W1	S70-CPT-W1-SS-050902-30	9/2/2005	30
CPT-W1	S70-CPT-W1-SS-050902-45	9/2/2005	45
CPT-W2	S70-CPT-W2-SS-050906-50	9/6/2005	50
CPT-W2	S70-CPT-W2-SS-050906-60	9/6/2005	60
CPT-W3	S70-CPT-W3-SS-050906-40	9/6/2005	40
CPT-W3	S70-CPT-W3-SS-050906-50	9/6/2005	50
CPT-W4	S70-CPT-W4D-SS-050906-40	9/6/2005	40*
CPT-W4	S70-CPT-W4D-SS-050906-60	9/6/2005	60*
CPT-W4	S70-CPT-W4-SS-050906-40	9/6/2005	40
CPT-W4	S70-CPT-W4-SS-050906-60	9/6/2005	60

Notes:

*-Denotes duplicate samples

bgs-below ground surface

CPT-Cone Penetrometer Test

N-North, S-South, E-East, W-West, B-Boundary

SS-Soil Sample

Table 4.2
Source Area Groundwater Samples
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Sample Name	Sample Date	Depth (Feet bgs)
CPT-B1	S70-CPT-B1-GW-050908-60	9/8/2005	60
CPT-B2	S70-CPT-B2-GW-050908-60	9/8/2005	60
CPT-E1	S70-CPT-E1-GW-050829-60	8/29/2005	60
CPT-E2	S70-CPT-E2-GW-050829-60	8/29/2005	60
CPT-E3	S70-CPT-E3-GW-050830-60	8/30/2005	60
CPT-N1	S70-CPT-N1-GW-050830-60	8/30/2005	60
CPT-N2	S70-CPT-N2-GW-050830-60	8/30/2005	60
CPT-N3	S70-CPT-N3-GW-050908-60	9/8/2005	60
CPT-NW1	S70-CPT-NW1-GW-050908-60	9/8/2005	60
CPT-S1	S70-CPT-S1-GW-050831-60	8/31/2005	60
CPT-S2	S70-CPT-S2-GW-050901-45	9/1/2005	45
CPT-S3	S70-CPT-S3-GW-050901-50	9/1/2005	50
CPT-SE1	S70-CPT-SE1-GW-050831-60	8/31/2005	60
CPT-SE2	S70-CPT-SE2-GW-050901-45	9/1/2005	45
CPT-SW1	S70-CPT-SW1-GW-050902-60	9/2/2005	60
CPT-SW2	S70-CPT-SW2D-GW-050902-50	9/2/2005	50*
CPT-SW2	S70-CPT-SW2-GW-050902-50	9/2/2005	50
CPT-W1	S70-CPT-W1-GW-050902-60	9/2/2005	60
CPT-W2	S70-CPT-W2-GW-050906-60	9/6/2005	60
CPT-W3	S70-CPT-W3-GW-050906-60	9/6/2005	60
CPT-W4	S70-CPT-W4D-GW-050906-50	9/6/2005	50*
CPT-W4	S70-CPT-W4-GW-050906-50	9/6/2005	50

Notes:
*-Denotes duplicate samples
bgs-below ground surface
CPT-cone penetrometer test
N-North, S-South, E-East, W-West, B-Boundary
GW-Groundwater

Table 4.3
Detections of Trichloroethene and Degradation Products in Source Area Soil Samples
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Depth	Sample Date	Analyte	Result	Qualifier
CPT-N3	50	9/8/2005	Trichloroethene	1.8	J
CPT-N1	50	8/30/2005	Trichloroethene	3.2	J
CPT-W3	50	9/6/2005	Trichloroethene	3.7	J
CPT-S3	40	9/1/2005	Trichloroethene	5.5	
CPT-SE1	60	8/31/2005	Trichloroethene	11	
CPT-SW2	20*	9/2/2005	Trichloroethene	29	
CPT-S2	45	9/1/2005	Trichloroethene	30	
CPT-SW2	20	9/2/2005	Trichloroethene	40	
CPT-N1	20	8/30/2005	Trichloroethene	45	
CPT-S1	50	8/31/2005	Trichloroethene	76	
CPT-W2	60	9/6/2005	Trichloroethene	100	
CPT-W2	50	9/6/2005	Trichloroethene	120	
CPT-SE1	40	8/31/2005	Trichloroethene	130	
CPT-NW1	60	9/8/2005	Trichloroethene	180	J
CPT-SE2	45	9/1/2005	Trichloroethene	180	
CPT-NW1	21	9/8/2005	Trichloroethene	190	
CPT-N2	45	8/30/2005	Trichloroethene	200	
CPT-N2	60	8/30/2005	Trichloroethene	200	
CPT-SW1	40	9/2/2005	Trichloroethene	220	
CPT-W3	40	9/6/2005	Trichloroethene	250	
CPT-SW1	30	9/2/2005	Trichloroethene	590	
CPT-S1	40	8/31/2005	Trichloroethene	730	
CPT-W1	45	9/2/2005	Trichloroethene	810	
CPT-W1	30	9/2/2005	Trichloroethene	12000	D
CPT-S3	50	9/1/2005	cis-1,2-Dichloroethene	1.9	J
CPT-S3	40	9/1/2005	cis-1,2-Dichloroethene	2.8	J
CPT-W3	50	9/6/2005	cis-1,2-Dichloroethene	3.9	J
CPT-SE2	55	9/1/2005	cis-1,2-Dichloroethene	4.1	J
CPT-SE1	60	8/31/2005	cis-1,2-Dichloroethene	6.1	
CPT-NW1	21	9/8/2005	cis-1,2-Dichloroethene	6.8	
CPT-W2	60	9/6/2005	cis-1,2-Dichloroethene	7.4	
CPT-S2	45	9/1/2005	cis-1,2-Dichloroethene	12	
CPT-N2	45	8/30/2005	cis-1,2-Dichloroethene	15	
CPT-SW2	20*	9/2/2005	cis-1,2-Dichloroethene	17	
CPT-S1	50	8/31/2005	cis-1,2-Dichloroethene	19	
CPT-SW2	20	9/2/2005	cis-1,2-Dichloroethene	22	
CPT-W2	50	9/6/2005	cis-1,2-Dichloroethene	31	
CPT-SW1	40	9/2/2005	cis-1,2-Dichloroethene	36	
CPT-W3	40	9/6/2005	cis-1,2-Dichloroethene	47	
CPT-SE2	45	9/1/2005	cis-1,2-Dichloroethene	49	
CPT-SE1	40	8/31/2005	cis-1,2-Dichloroethene	63	
CPT-SW1	30	9/2/2005	cis-1,2-Dichloroethene	88	
CPT-W1	45	9/2/2005	cis-1,2-Dichloroethene	150	
CPT-S1	40	8/31/2005	cis-1,2-Dichloroethene	180	
CPT-W1	30	9/2/2005	cis-1,2-Dichloroethene	750	D
CPT-S1	50	8/31/2005	Vinyl chloride	2.3	J
CPT-SW1	30	9/2/2005	Vinyl chloride	2.7	J
CPT-W3	40	9/6/2005	Vinyl chloride	2.7	J
CPT-W1	45	9/2/2005	Vinyl chloride	3.6	J
CPT-W1	30	9/2/2005	Vinyl chloride	3.7	J
CPT-S1	40	8/31/2005	Vinyl chloride	3.8	J
CPT-SE2	45	9/1/2005	Vinyl chloride	3.9	J
CPT-SE1	40	8/31/2005	Vinyl chloride	4.2	J

Notes:

*-Denotes duplicate samples

J- Denotes estimated concentration. Analyte detected above method detection limit but below method reporting limit.

D- Denotes result from dilution.

All concentrations in micrograms per kilogram

N-North, S-South, W-West, E-East

CPT-Cone Penetrometer Test

Table 4.4
Detections of Trichloroethene and Degradation Products in Source Area Groundwater Samples
IR Site 70
Naval Weapons Station, Seal Beach California

Location	Depth	Sample Date	Analyte	RESULT	QUALIFIER
CPT-B1	60	9/8/2005	Trichloroethene	4.9	
CPT-E1	60	8/29/2005	Trichloroethene	2.8	
CPT-N1	60	8/30/2005	Trichloroethene	5.1	
CPT-N2	60	8/30/2005	Trichloroethene	490	D
CPT-N3	60	9/8/2005	Trichloroethene	4.5	
CPT-NW1	60	9/8/2005	Trichloroethene	2300	D
CPT-S1	60	8/31/2005	Trichloroethene	72	
CPT-S2	45	9/1/2005	Trichloroethene	11	
CPT-S3	50	9/1/2005	Trichloroethene	1.6	
CPT-SE1	60	8/31/2005	Trichloroethene	120	D
CPT-SE2	45	9/1/2005	Trichloroethene	18	
CPT-SW1	60	9/2/2005	Trichloroethene	4.7	
CPT-SW2	50	9/2/2005	Trichloroethene	190	D
CPT-SW2	50	9/2/2005	Trichloroethene	160	D
CPT-W1	60	9/2/2005	Trichloroethene	4000	D
CPT-W2	60	9/6/2005	Trichloroethene	1900	D
CPT-W3	60	9/6/2005	Trichloroethene	4.8	
CPT-B1	60	9/8/2005	cis-1,2-Dichloroethene	1	
CPT-E1	60	8/29/2005	cis-1,2-Dichloroethene	1.9	
CPT-N1	60	8/30/2005	cis-1,2-Dichloroethene	1.1	
CPT-N2	60	8/30/2005	cis-1,2-Dichloroethene	11	D
CPT-N3	60	9/8/2005	cis-1,2-Dichloroethene	0.97	
CPT-S1	60	8/31/2005	cis-1,2-Dichloroethene	39	
CPT-S2	45	9/1/2005	cis-1,2-Dichloroethene	8.8	
CPT-S3	50	9/1/2005	cis-1,2-Dichloroethene	50	
CPT-SE1	60	8/31/2005	cis-1,2-Dichloroethene	100	D
CPT-SE2	45	9/1/2005	cis-1,2-Dichloroethene	15	
CPT-SW1	60	9/2/2005	cis-1,2-Dichloroethene	20	
CPT-SW2	50	9/2/2005	cis-1,2-Dichloroethene	420	D
CPT-SW2*	50	9/2/2005	cis-1,2-Dichloroethene	340	D
CPT-W1	60	9/2/2005	cis-1,2-Dichloroethene	220	D
CPT-W2	60	9/6/2005	cis-1,2-Dichloroethene	230	D
CPT-W3	60	9/6/2005	cis-1,2-Dichloroethene	15	
CPT-S1	60	8/31/2005	Vinyl chloride	2.4	
CPT-S2	45	9/1/2005	Vinyl chloride	1.6	
CPT-S3	50	9/1/2005	Vinyl chloride	5.1	
CPT-SE1	60	8/31/2005	Vinyl chloride	8	D
CPT-SE2	45	9/1/2005	Vinyl chloride	2.9	
CPT-SW1	60	9/2/2005	Vinyl chloride	3.7	
CPT-W3	60	9/6/2005	Vinyl chloride	0.43	J
CPT-SW2	50	9/2/2005	Ethene	1.1	J
CPT-SW2*	50	9/2/2005	Ethene	1.3	J

Notes:

*-Denotes duplicate samples

J- Denotes estimated concentration. Analyte detected above method detection limit but below method reporting limit.

D- Denotes result from dilution.

All concentrations in micrograms per liter

CPT-Cone Penetrometer Test

N-North, S-South, W-West, E-East, B-Boundary

Table 4.5
Detections of Volatile Organic Chemicals in Soil Samples from RDO Borings
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Depth	Sample Date	Analyte	RESULT	QUALIFIER
MW-RDO-1	85.5	8/19/2005	cis-1,2-Dichloroethene	1.7	J
		8/19/2005	Acetone	7.2	J,C,H
		8/19/2005	Trichloroethene	31	
	100	8/19/2005	Acetone	6.7	J,C,H
MW-RDO-2	90.5	8/18/2005	cis-1,2-Dichloroethene	5	J
		8/18/2005	Acetone	7.5	J,C
		8/18/2005	Carbon disulfide	3.7	J
		8/18/2005	Trichloroethene	260	E
	100.5	8/18/2005	cis-1,2-Dichloroethene	7.6	
		8/18/2005	Acetone	5.1	J,C
		8/18/2005	Trichloroethene	140	
MW-RDO-3B	90.5	8/23/2005	cis-1,2-Dichloroethene	24	
		8/23/2005	Acetone	5.1	J,C
		8/23/2005	Trichloroethene	480	
	100.5	8/23/2005	Acetone	4.9	J,C
		8/23/2005	Trichloroethene	4.5	
MW-RDO-4	95.5	8/17/2005	cis-1,2-Dichloroethene	43	
		8/17/2005	Acetone	4.9	J,C
		8/17/2005	Methylene chloride	2.1	J
		8/17/2005	Trichloroethene	190	
	105.5	8/17/2005	Acetone	5.5	J,C
MW-RDO-5	90.5	8/15/2005	cis-1,2-Dichloroethene	3.4	J
		8/15/2005	Acetone	5.9	J,C
		8/15/2005	Trichloroethene	72	
	95.5	8/15/2005	cis-1,2-Dichloroethene	10	
		8/15/2005	Acetone	7	J,C
		8/15/2005	1,1-Dichloroethene	2.3	J
		8/15/2005	Trichloroethene	240	E
MW-RDO-6A	100	8/29/2005	Toluene	2	J
		8/29/2005	cis-1,2-Dichloroethene	46	
		8/29/2005	trans-1,2-Dichloroethene	3.8	J
		8/29/2005	Acetone	9.8	J,H
		8/29/2005	Trichloroethene	370	
MW-RDO-6B	70.5	8/25/2005	Acetone	7.1	J,C
		8/25/2005	Trichloroethene	1.9	J
	112.5	8/25/2005	cis-1,2-Dichloroethene	35	
		8/25/2005	trans-1,2-Dichloroethene	4.6	J
		8/25/2005	Acetone	5.7	J,C
		8/25/2005	Trichloroethene	300	
	139	8/25/2005	Acetone	6.2	J,C
		8/25/2005	Trichloroethene	5	J

Notes

*-Denotes duplicate samples

All concentrations in micrograms per kilogram

J-Denotes Estimated Concentration. Analyte detected above method detection limit but below method reporting limit.

C- Denotes samples for which relative standard deviation of all analytes in the calibration was greater than 15%

H- Denotes sample results less than twenty times the level found in the Method Blank.

E-Denotes analyte concentration above the calibration range

MW-Monitoring Well

RDO-Remedial Design Optimization

Table 4.6
Construction Details for
RDO Wells
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Ground Surface Elevation	Top of Casing Elevation	Screen Interval (Feet Below Ground Surface)	Groundwater Elevation (September 2005)	Total Depth (feet below ground surface)
MW-RDO-1	8.13	10.41	65.1-105.1	-3.99	105.1
MW-RDO-2	7.46	9.53	65.1-105.1	-4.05	105.1
MW-RDO-3A	7.09	9.28	20-30	-0.6	30
MW-RDO-3B	7.06	9.21	65-105	-4.11	105
MW-RDO-4	6.94	9.11	65-105	-4.43	105
MW-RDO-5	6.53	8.62	65-105	-4.13	105
MW-RDO-6A	9.28	11.3	95-105	-7.7	105
MW-RDO-6B	8.44	10.6	130-140	-7.87	140

Notes:

Elevations in feet above mean seal level, NGVD29 (North Geodetic Vertical Datum)

MW-Monitoring Well

RDO-Remedial Design Optimization

Table 4.7
Detections of Volatile Organic Chemicals in Bulk Groundwater Samples from RDO Wells
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Sample Date	Analyte	Result	Qualifier
MW-RDO-1	9/13/2005	cis-1,2-Dichloroethene	53	D
		Trichloroethene	800	D
MW-RDO-2	9/13/2005	cis-1,2-Dichloroethene	81	D
		Trichloroethene	2400	D
MW-RDO-3A	9/12/2005	1,2-Dichloroethane	0.43	J
		cis-1,2-Dichloroethene	20	
		trans-1,2-Dichloroethene	1.2	
		Vinyl chloride	1.2	
		1,1-Dichloroethane	0.47	J
		1,1-Dichloroethene	0.59	
		1,1,2-Trichlorotrifluoroethane	1.5	J
		Trichloroethene	21	
MW-RDO-3B	9/14/2005	cis-1,2-Dichloroethene	190	D
		Trichloroethene	5200	D
MW-RDO-4	9/14/2005	cis-1,2-Dichloroethene	180	D
		Trichloroethene	3600	D
MW-RDO-5	9/14/2005	cis-1,2-Dichloroethene	9.8	D
		Trichloroethene	250	D
MW-RDO-6A*	9/12/2005	cis-1,2-Dichloroethene	180	D
		Trichloroethene	3000	D
MW-RDO-6A	9/12/2005	cis-1,2-Dichloroethene	180	D
		Trichloroethene	3000	D
MW-RDO-6B	9/12/2005	cis-1,2-Dichloroethene	94	D
		Trichloroethene	2100	D

Notes

*-denotes duplicate sample

D-Denotes diluted sample

J-Denotes estimated concnetration. Analyte detected above method detection limit, but below method reporting limit.

all concentrations in micrograms per liter

MW-Monitoring Well

RDO-Remedial Design Optimization

Table 4.8
Detections of Volatile Organic Chemicals in Depth Specific Groundwater Samples from RDO Wells
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Depth	Sample Date	Analyte	Result	Qualifier
MW-RDO-1	70	9/15/2005	cis-1,2-Dichloroethene	41	D
		9/15/2005	Vinyl chloride	3.6	J,D
		9/15/2005	Trichloroethene	510	D
	80	9/13/2005	cis-1,2-Dichloroethene	49	D
		9/13/2005	Vinyl chloride	3.7	J,D
		9/13/2005	Trichloroethene	700	D
	85	9/13/2005	cis-1,2-Dichloroethene	53	D
		9/13/2005	Trichloroethene	770	D
	100	9/15/2005	cis-1,2-Dichloroethene	47	D
		9/15/2005	Vinyl chloride	4.2	J,D
		9/15/2005	Trichloroethene	650	D
MW-RDO-2	68	9/15/2005	cis-1,2-Dichloroethene	49	D
		9/15/2005	Trichloroethene	1500	D
	75	9/15/2005	cis-1,2-Dichloroethene	60	D
		9/15/2005	Trichloroethene	1800	D
	100	9/14/2005	cis-1,2-Dichloroethene	55	D
		9/14/2005	Trichloroethene	1300	D
	107	9/15/2005	cis-1,2-Dichloroethene	54	D
		9/15/2005	Trichloroethene	1500	D
MW-RDO-3B	72*	9/14/2005	cis-1,2-Dichloroethene	180	D
		9/14/2005	Trichloroethene	4700	D
	72	9/14/2005	cis-1,2-Dichloroethene	180	D
		9/14/2005	Trichloroethene	4600	D
	85	9/16/2005	cis-1,2-Dichloroethene	160	D
		9/16/2005	Trichloroethene	4300	D
	95	9/16/2005	cis-1,2-Dichloroethene	160	D
		9/16/2005	Trichloroethene	4300	D
MW-RDO-4	68	9/15/2005	cis-1,2-Dichloroethene	110	D
		9/15/2005	Trichloroethene	2300	D
	78	9/15/2005	cis-1,2-Dichloroethene	160	D
		9/15/2005	Trichloroethene	3400	D
MW-RDO-5	70	9/16/2005	cis-1,2-Dichloroethene	7.5	D
		9/16/2005	Trichloroethene	220	D
	90	9/16/2005	cis-1,2-Dichloroethene	8.6	D
		9/16/2005	Trichloroethene	210	D
	90*	9/16/2005	cis-1,2-Dichloroethene	8	D
		9/16/2005	Trichloroethene	210	D
	103	9/16/2005	cis-1,2-Dichloroethene	8	D
		9/16/2005	Trichloroethene	180	D

Notes

*-denotes duplicate sample

D-Denotes diluted sample

J-Denotes estimated concnetration. Analyte detected above method detection limit, but below method reporting limit.

all concentrations in micrograms per liter

all depths in feet below top of casing

MW-Monitoring Well

RDO-Remedial Design Optimization

TABLE 4.9
Electromagnetic Borehole Flowmeter Survey Probe Specifications
IR Site 70
Naval Weapons Station Seal Beach, California

Parameter	1-inch Inside Diameter Probe Performance Specifications
Minimum Flow Rate	40 mL/min (0.011 gpm*)
Minimum Velocity	0.131 cm/sec (0.0043 fps**)
Maximum Flow Rate	40 L/min (10.6 gpm*)
Maximium Velocity	131 cm/sec (4.3 fps**)

Notes:
mL/min - milliliters per minute
cm/sec - centimeters per second
L/min - Liters per minute
* gallons per minute
** feet per second

TABLE 4.10
Summary of Soil Lithology, Hydraulic Conductivity, and VOC Contaminant Profiles By Depth
IR Site 70
Naval Weapons Station Seal Beach, California

Well	Depth (ft bTOC)	Elevation (ft aMSL)	Naval Weapons Station Seal Beach, California	Normalized K (K_i as a % of K_{bulk})	Relative K (K_i/K_{bulk}, ft/day)
TRANSECT WELL RDO-1	65 ft	-54.59	silty poorly graded SAND (SM)	18.1%	1.47
	70 ft	-59.59	silty poorly graded SAND (SM)	6.8%	0.55
	75 ft	-64.59	silty poorly graded SAND (SM)	2.9%	0.24
	80 ft	-69.59	medium to fine SAND (SP)	11.8%	0.96
	85 ft	-74.59	GRAVEL with sand/silt/clay	38.6%	3.13
	90 ft	-79.59	fine-grained SAND (SP)	8.4%	0.68
	95 ft	-84.59	SAND (SP), trace silt/gravel	8.4%	0.68
	100 ft	-89.59	silty CLAY (CH)	1.5%	0.12
	105 ft	-94.59	fat CLAY (CH), trace sand/silt	3.4%	0.28
	Bulk Sample		NA	100%	
TRANSECT WELL RDO-2	65 ft	-55.47	SILT (ML) with clay, 20% fine to coarse sand	30.3%	2.50
	70 ft	-60.47	silty SAND (SM) with clay, well graded	25.6%	2.12
	75 ft	-65.47	silty SAND (SM), trace clay	12.1%	1.00
	80 ft	-70.47	silty SAND (SM) with clay	0.2%	0.02
	85 ft	-75.47	clayey SILT (ML) interbedded with fine sand	1.4%	0.12
	90 ft	-80.47	SAND (SP), trace shells, thin stringers fat clay	0.2%	0.02
	95 ft	-85.47	SAND (SP), 5% shells, thin stringers fat clay	2.6%	0.22
	100 ft	-90.47	SAND (SP), 5% shells, thin stringers fat clay	22.0%	1.82
	105 ft	-95.47	SAND (SP), 1 to 3% shells	5.4%	0.45
	110 ft	-100.47	SILT (ML) with clay	0.0%	
	Bulk Sample		NA	100%	
SHALLOW WELL RDO-3A	20 ft	-10.72	fat CLAY (CH; 20-20.5 ft), overlying SILT (ML)	7.8%	0.45
	25 ft	-15.72	SILT (ML; 25 to 26 ft) to clayey silt with sand	32.2%	0.39
	30 ft	-20.72	medium to coarse SAND (SP; 26 -30 ft), trace silt	60.0%	1.70
	Bulk Sample		NA	100%	
TRANSECT WELL RDO-3B	65 ft	-55.79	medium to coarse SAND (SP), trace silt	22.0%	1.76
	70 ft	-60.79	medium to coarse SAND (SP), trace silt	21.3%	1.70
	75 ft	-65.79	medium to coarse SAND (SP), trace silt	1.4%	0.11
	80 ft	-70.79	medium to coarse SAND (SP) with silty clay	12.3%	0.99
	85 ft	-75.79	clayey SAND (SC) with silt	14.4%	1.15
	90 ft	-80.79	very fine to fine SAND (SP)	16.1%	1.29
	95 ft	-85.79	fine SAND (SP), trace shells (clay @ 96-98 ft)	9.1%	0.73
	100 ft	-90.79	fine SAND (SP), 5-10% shells, clay, clayey sand	3.0%	0.24
	105 ft	-95.79	fine SAND (SP), 5-10% shells, clay, clayey sand	0.4%	0.03
	Bulk Sample		NA	100%	
TRANSECT WELL RDO-4	65 ft	-55.89	medium to fine SAND (SP), silt/clay	19.5%	1.56
	70 ft	-60.89	medium SAND (SP), trace silt/gravel	17.1%	1.36
	75 ft	-65.89	fine SAND (SP), trace silt/10% gravel	58.9%	4.71
	80 ft	-70.89	fine SAND (SP), trace silt	4.3%	0.34
	85 ft	-75.89	fine SAND (SP), trace shells, 20% gravel	0.0%	0.00
	90 ft	-80.89	fine SAND (SP), trace shells, 20% gravel	0.0%	0.00
	95 ft	-85.89	fine SAND (SP), trace shells	0.0%	0.00
	100 ft	-90.89	silt/CLAY (CH/MH), fine sand	0.0%	0.00
	105 ft	-95.89	fine SAND (SP), trace shells	0.3%	0.02
	110 ft	-100.89	CLAY (CH)	0.0%	0.00
	Bulk Sample		NA	100%	

Well	Depth (ft bTOC)	Elevation (ft aMSL)	Soil Lithology	Normalized K (K_i as a % of K_{bulk})	Relative K (K_i/K_{bulk}, ft/day)
TRANSECT WELL RDO-5	65 ft	-56.38	medium to fine SAND (SP), silt/clay	22.2%	1.78
	70 ft	-61.38	medium SAND (SP), trace silt/gravel	56.0%	4.48
	75 ft	-66.38	fine SAND (SP), trace silt/10% gravel	3.2%	0.25
	80 ft	-71.38	fine SAND (SP), trace silt	0.0%	0.00
	85 ft	-76.38	fine SAND (SP), trace shells, 20% gravel	0.0%	0.00
	90 ft	-81.38	fine SAND (SP), trace shells, 20% gravel	0.0%	0.00
	95 ft	-86.38	fine SAND (SP), trace shells	4.1%	0.33
	100 ft	-91.38	silt/CLAY (CH/MH), fine sand	14.5%	1.16
	105 ft	-96.38	fine SAND (SP), trace shells	0.0%	0.00
	110 ft	-101.38	CLAY (CH)	0.0%	0.00
	Bulk Sample		NA	100%	
RDO-6A	95 ft	-83.70	fine SAND (SP), 1-3% shells	34.8%	0.14
	100 ft	-88.70	coarse SAND (SW), gravel, 20% shells	27.6%	0.10
	105 ft	-93.70	very fine SAND (SP) with silt (98-105 ft)	37.6%	0.56
	Bulk Sample		NA	100%	
RDO-6B	130 ft	-119.40	interbedded fine SAND (SP), trace shells; medium	36.4%	0.00
	135 ft	-124.40	SAND, gravel; clayey SILT	25.3%	1.29
	140 ft	-129.40	sandy GRAVEL, trace shells	38.3%	0.52
	Bulk Sample		NA	100%	

Notes:

ft-feet
ft bTOC- feet below top of casing
ft aMSL-feet above mean sea level
ft/day-feet per day
NA-not applicable
% percent

K-Hydraulic conductivity
Ki-Local Hydraulic conductivity
Kbulk-Bulk Hydraulic Conductivity
MH-Inorganic silts
ML-Inorganic silts and very fine sands
CH-Inorganic clays

SP-Poorly graded sand
SC-Clayey sands
SW-Well graded sand
SM-Silty sand

TABLE 4.11
Summary of Emulsified Vegetable Oil Injections
IR Site 70
Naval Weapons Station Seal Beach, California

Injection Well ID	Injection Well Screen (ft bgs)		Monitoring Well ID	Distance from Injection Well (ft)	Injection Flow Rate (gpm)			Well Head Pressure (PSI)			Hours per Injection	Total Volume Injected (gal)				Maximum Bromide Concentration (mg/L)[2]	Maximum TOC Concentration (mg/L)[3]	Approximate Breakthrough[1] (gal)	
	Top	Bottom			Average	Maximum	Minimum	Average	Maximum	Minimum		Oil Vendor	Emulsion	Oil	Injectate			Bromide	TOC
RDO-3A	20	30	MW70-01	11.9	8.8	10.0	5.3	0.9	5.0	negative	51.0	RNAS	495	237	24,650	215	5980	7,756	--
RDO-6A	95	105	MW70-08	12.1	4.6	12.0	2.2	10.1	17.0	1.5	78.4	EOS	196	93	18,090	180	2990	16,389	--
RDO-6B	130	140	MW70-31	12.5	13.1	16.0	6.2	0.1	1.0	negative	31.6	RNAS	228	109	21,119	175	2990	16,393	--
											2.0	EOS	18	8	1,634				

Notes:

ft bgs - feet below ground surface
gpm - gallons per minute
PSI - pounds force per square inch
mg/L - milligrams per liter
TOC - total organic carbon
RNAS - Remediation and Natural Attenuation Services, Inc.
EOS - EOS Remediation Inc.
ID-Identification
ft- feet
gal-gallons
-- Did not occur

[1] - occurance of breakthrough calculated to be 1/2 of maximum concentration
[2] - maximum bromide concentration measured in groundwater feed tank
[3] - maximum TOC concentration determined by laboratory analysis of groundwater with 1% oil

TABLE 4.12
Treatments and Controls for the Microcosm Study
IR Site 70
Naval Weapons Station Seal Beach, California

Treatment		Description	Number of Replicates	Target Spiking Concentration
1	Anaerobic Sterile Control	Autoclaved and amended with mercuric chloride and sodium azide	3	TCE - 10000 µg/L; cDCE - 220 µg/L
2	Anaerobic Intrinsic Control 1	Soil and groundwater from First Sand Unit; No amendments	3	TCE - 730 µg/L; cDCE - 51 µg/L
3	Anaerobic Intrinsic Control 2	Soil and groundwater from Second Sand Unit; No amendments	3	TCE - 710 µg/L; cDCE - 94 µg/L
4	Anaerobic Intrinsic Control 3	Soil and groundwater from Shell Horizon (Fine-grained Sands) Unit; No amendments	3	TCE - 3000 µg/L; cDCE - 180 µg/L
5	Biostimulated/Bioaugmented 1	Soil and groundwater from the source area; Amended with Newman Zone™ as electron donor and KB-1™	3	TCE - 10000 µg/L; cDCE - 220 µg/L
6	Biostimulated/Bioaugmented 2	Soil and groundwater from Shell Horizon (Fine-grained Sands) Unit; Amended with EOS 450 as electron donor and KB-1™	3	TCE - 3000 µg/L; cDCE - 180 µg/L
7	Biostimulated/Bioaugmented 3	Soil and groundwater from Second Sand Unit; Amended with Newman Zone™ as electron donor and KB-1™	3	TCE - 3000 µg/L; cDCE - 180 µg/L

Notes:
TCE - trichloroethene
cDCE - *cis* -1,2-dichloroethene
µg/L - micrograms per litre
EOS - EOS Remediation Inc
KB-1™ - Mixed dehalorespiring bacterial culture

TABLE 5.1
Hydraulic Gradient and Groundwater Flow
IR Site 70
Naval Weapons Station Seal Beach, California

Location and Date	Hydraulic Gradient (ft/ft)	Groundwater Flow Direction (Degrees from North)	Vertical Head Difference with Layer Below[a]	
			Source Area[b] (ft)	Downgradient[c] (ft)
Upper Fines Unit				
Most Recent Quarters				
Mar-04	0.0005	140	0.0	-1.0
Jun-04	0.0008	140	-0.6	-3.1
Sep-04	0.0007	130	-0.6	-3.1
Dec-04	0.0004	140	-0.2	-1.2
Jul-05	0.0004	140	0.6	-1.7
Average	0.0006	138	-0.2	-2.0
Summer, All Years				
Jun-00	0.0008	150	-1.8	-3.8
Jun-01	0.0011	150	-2.0	-4.0
Jun-03	0.0007	140	-1.6	-3.5
Jun-04	0.0008	140	-0.6	-3.1
Average	0.0008	145	-1.5	-3.6
Winter, All Years				
Dec-00	0.0003	160	-1.3	-2.8
Dec-01	0.0004	150	-1.1	-2.2
Dec-03	0.0002	140	-0.1	-0.7
Dec-04	0.0004	140	-0.3	-1.2
Average	0.0003	148	-0.7	-1.7
First Sand Unit and Shell Horizon (Fine-grained Sands) Unit				
Most Recent Quarters				
Mar-04	0.0011	150	-	-
Jun-04	0.0027	170	-	-0.6
Sep-04	0.0024	160	-	-0.4
Dec-04	0.0010	160	-	-0.3
Jul-05	0.0030	160	-	-0.4
Average	0.0020	160	-	-0.4
Summer, All Years				
Jun-00	0.0022	170	-	-0.5
Jun-01	0.0025	170	-	-0.6
Jun-03	0.0021	180	-	-0.3
Jun-04	0.0027	170	-	-0.6
Average	0.0024	173	-	-0.5
Winter, All Years				
Dec-00	0.0016	170	-	-0.4
Dec-01	0.0013	170	-	-0.7
Dec-03	0.0006	160	-	-
Dec-04	0.0010	160	-	-0.3
Average	0.0011	165	-	-0.4

Location and Date	Hydraulic Gradient (ft/ft)	Groundwater Flow Direction (Degrees from North)
Second Sand Unit		
Most Recent Quarters		
Mar-04	-	-
Jun-04	0.0010	120
Sep-04	0.0008	110
Dec-04	0.0005	120
Jul-05	0.0007	120
Average	0.0007	118
Summer, All Years		
Jun-00	0.0010	120
Jun-01	0.0012	120
Jun-03	0.0009	120
Jun-04	0.0010	120
Average	0.0010	120
Winter, All Years		
Dec-00	0.0008	120
Dec-01	0.0008	120
Dec-03	-	-
Dec-04	0.0005	120
Average	0.0007	120

Notes:
'-' Insufficient Data
[a]Negative Head Difference indicates downward flow
[b]Head difference calculated from water level contours in the vicinity of the IR Site 70 Source Area
[c]Head difference calculated from water level contours in the vicinity of MW-70-41A/B
ft-feet

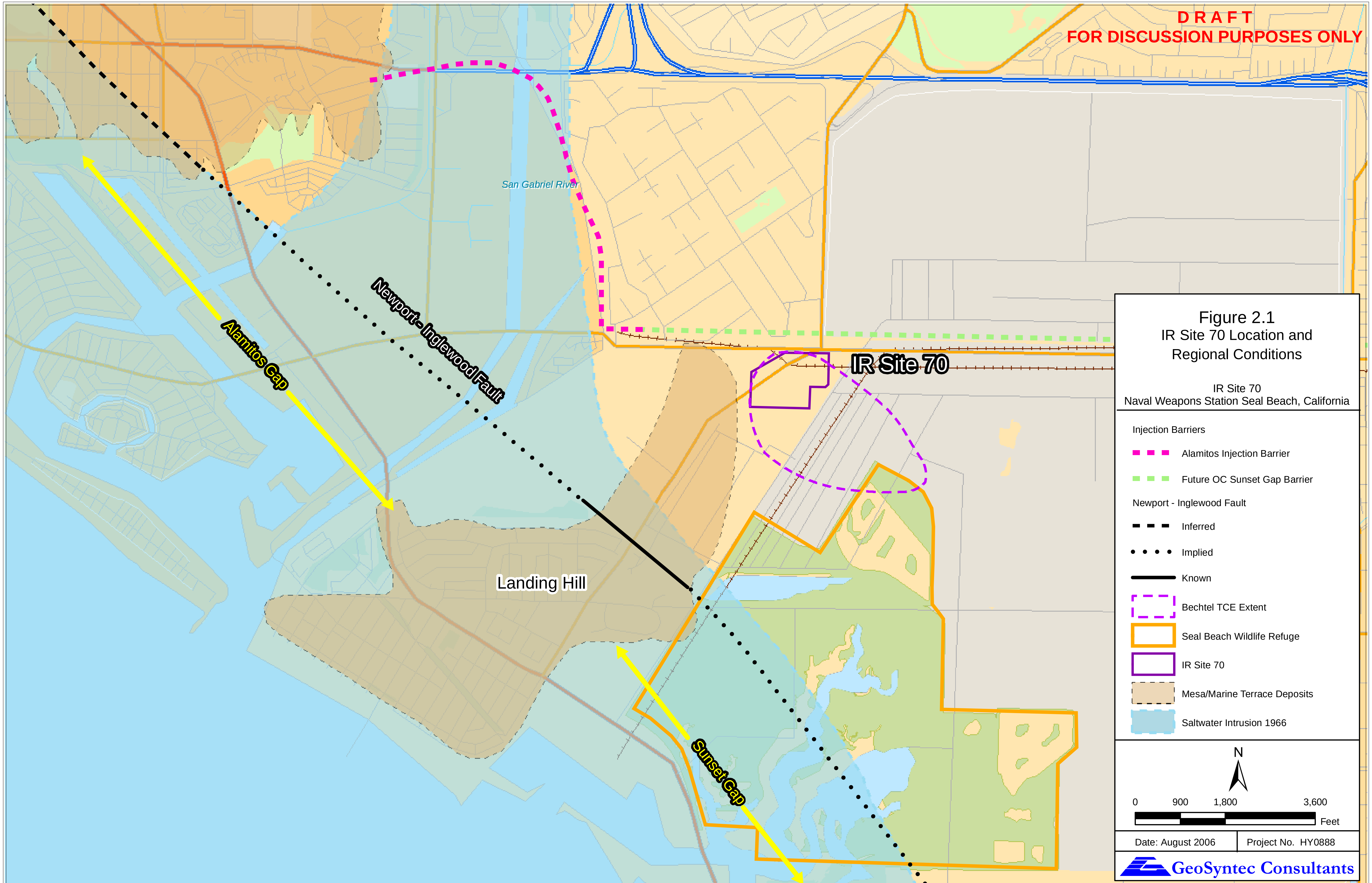

Figure 2.1
IR Site 70 Location and Regional Conditions

IR Site 70
Naval Weapons Station Seal Beach, California

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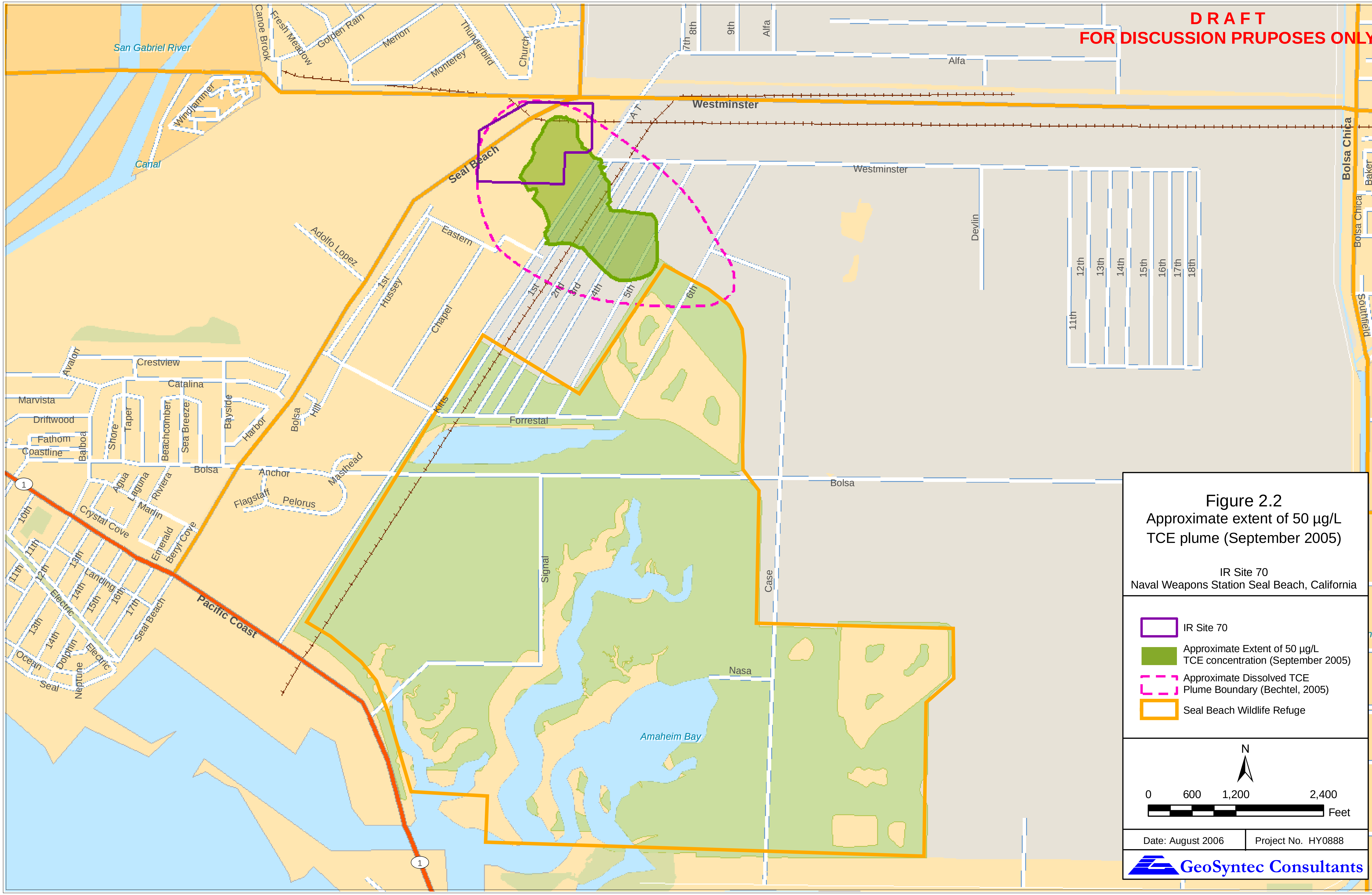

Figure 2.2
Approximate extent of 50 µg/L TCE plume (September 2005)

IR Site 70
Naval Weapons Station Seal Beach, California

Figures 2.3 and 4.1 through 4.4

These detailed station maps have been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.

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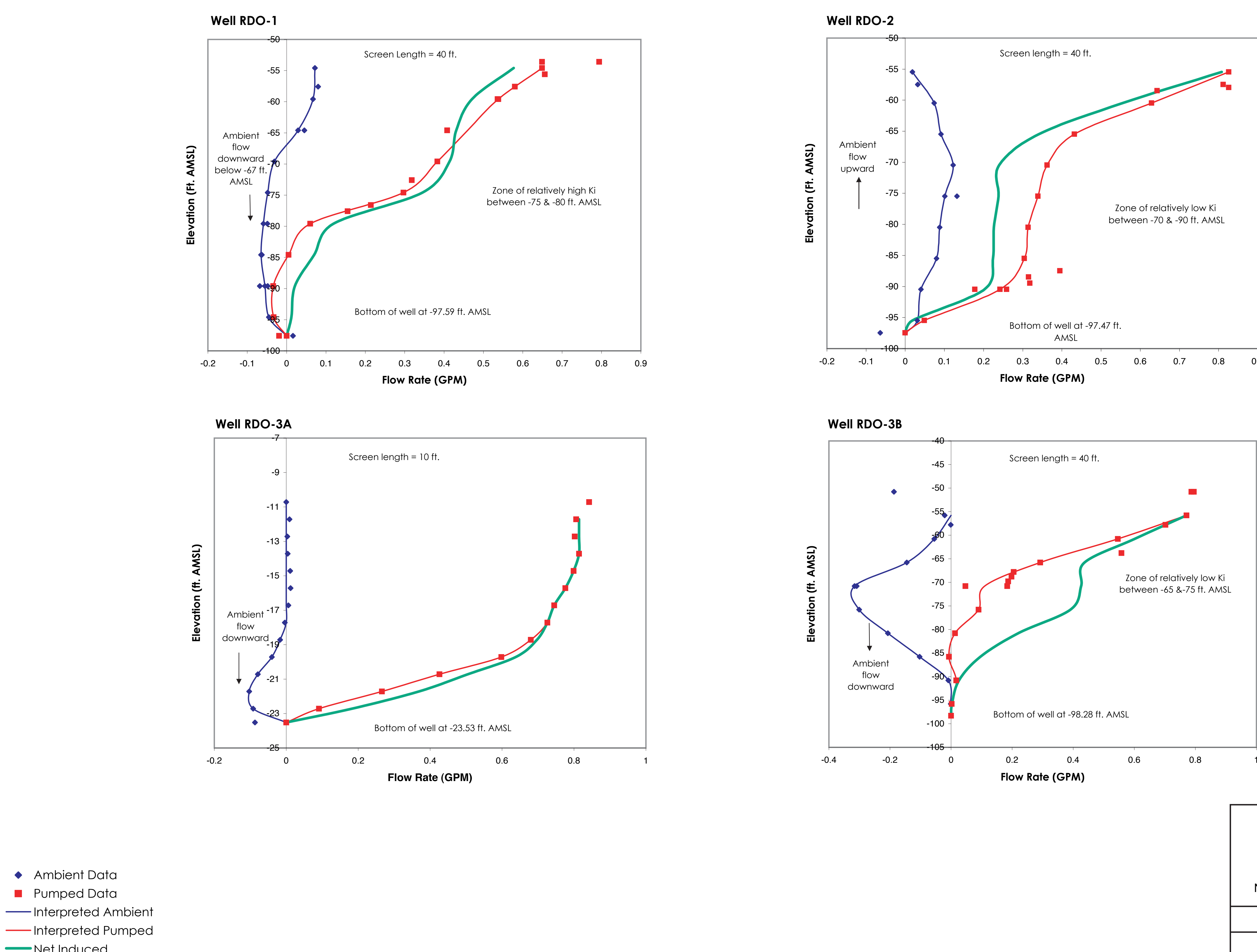

Figure: 4.5
(i of ii)
EBF Survey Flow Rate Profiles

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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Graph figures_HY0888.ai

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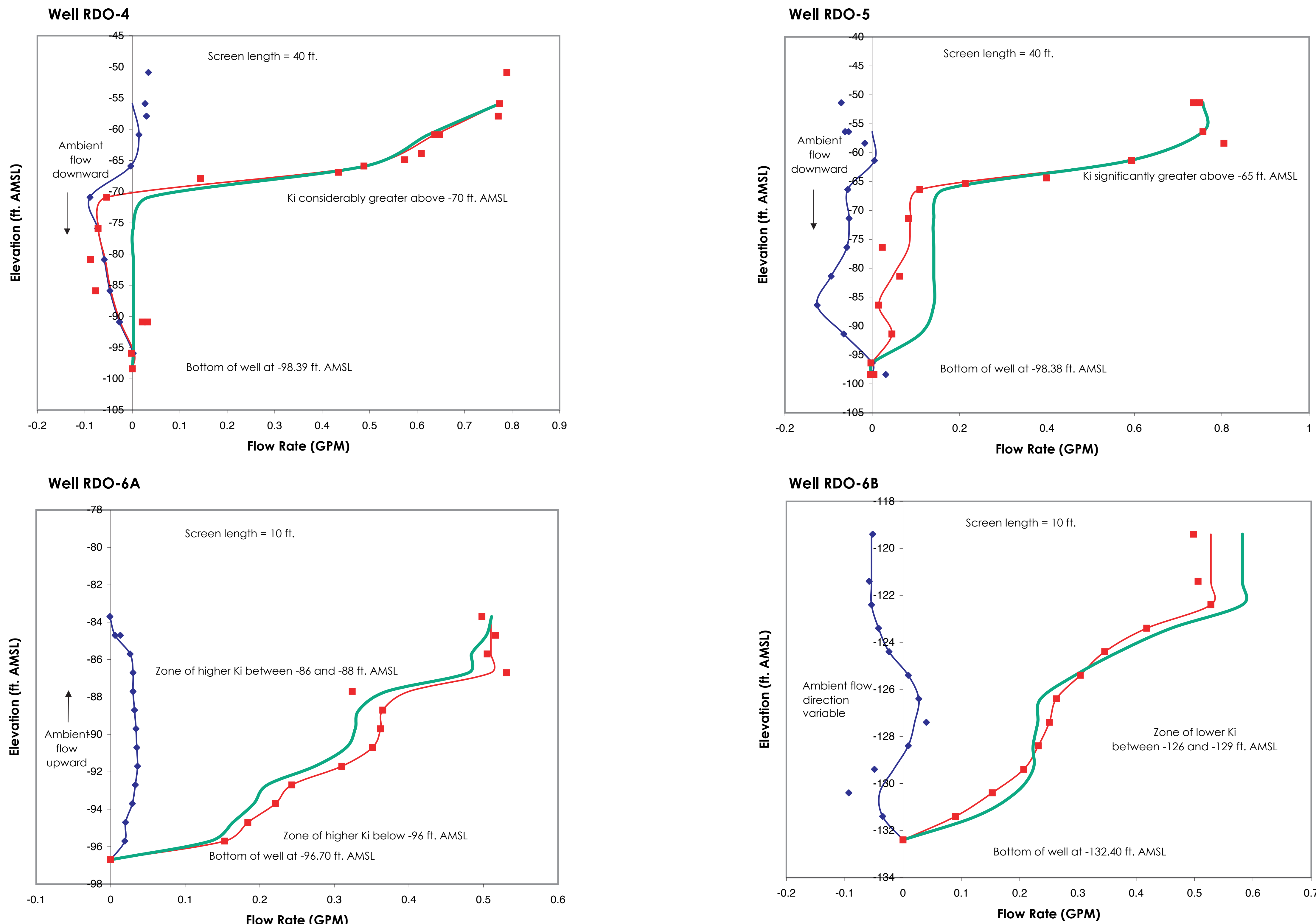

- Ambient Data
- Pumped Data
- Interpreted Ambient
- Interpreted Pumped
- Net Induced

ft amsl - feet above mean sea level
gpm - gallons per minute
K - hydraulic conductivity
RDO - remedial design optimization
EBF - electromagnetic borehole flowmeter
IR - installation restoration

Figure: 4.5
(ii of ii)
EBF Survey Flow Rate Profiles

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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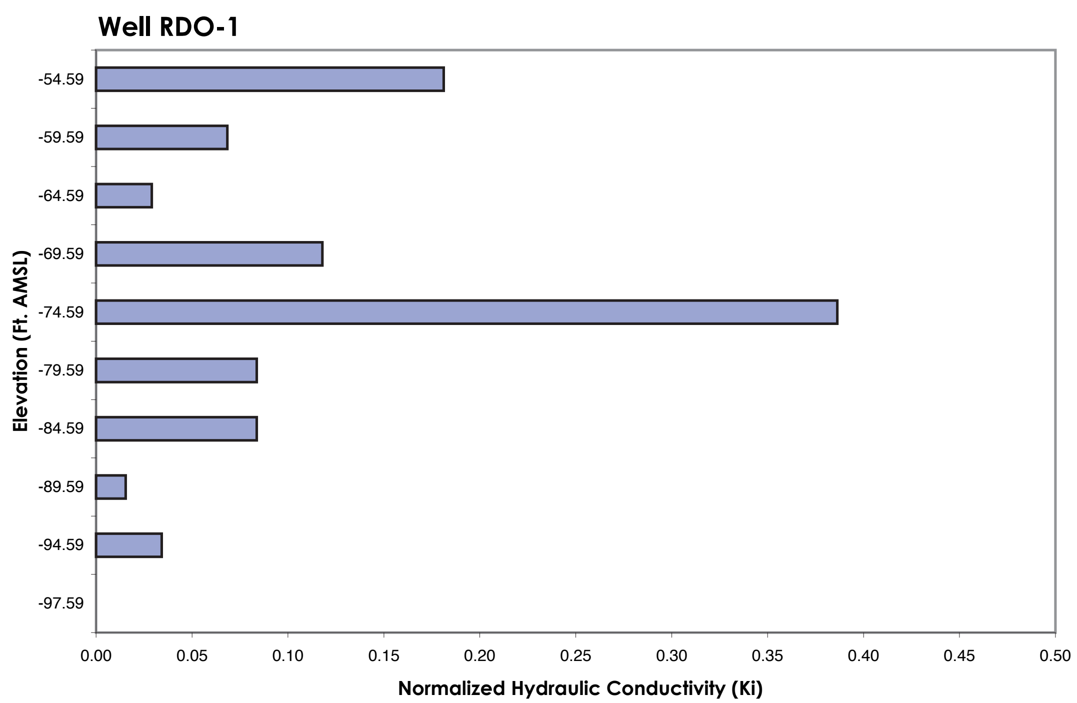

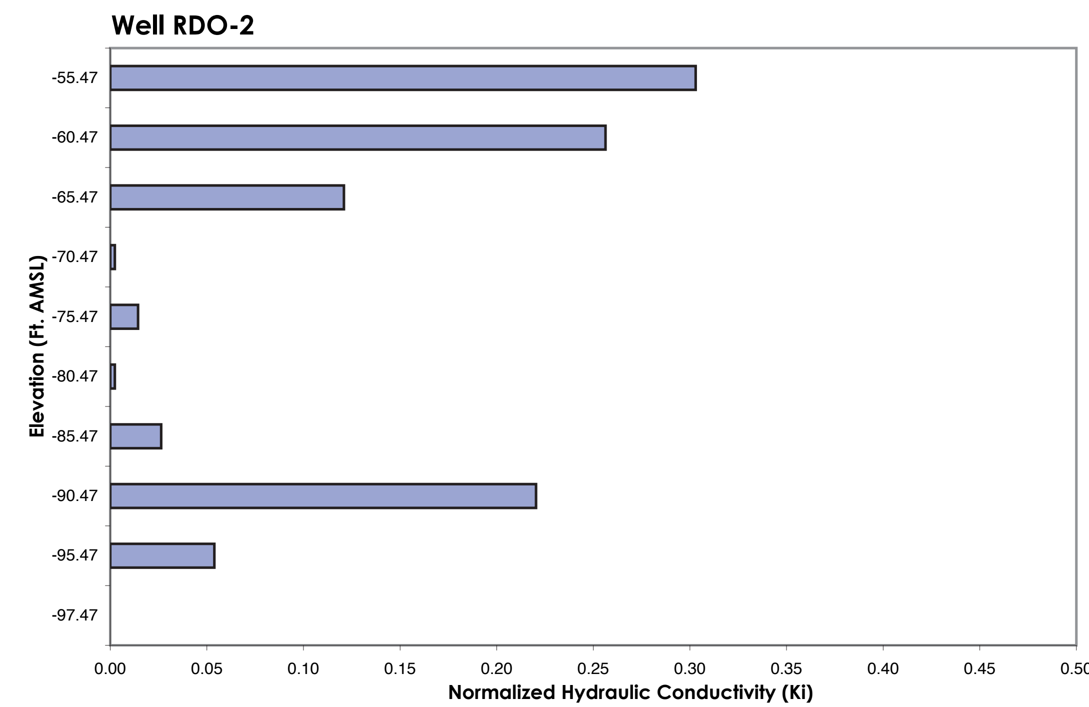

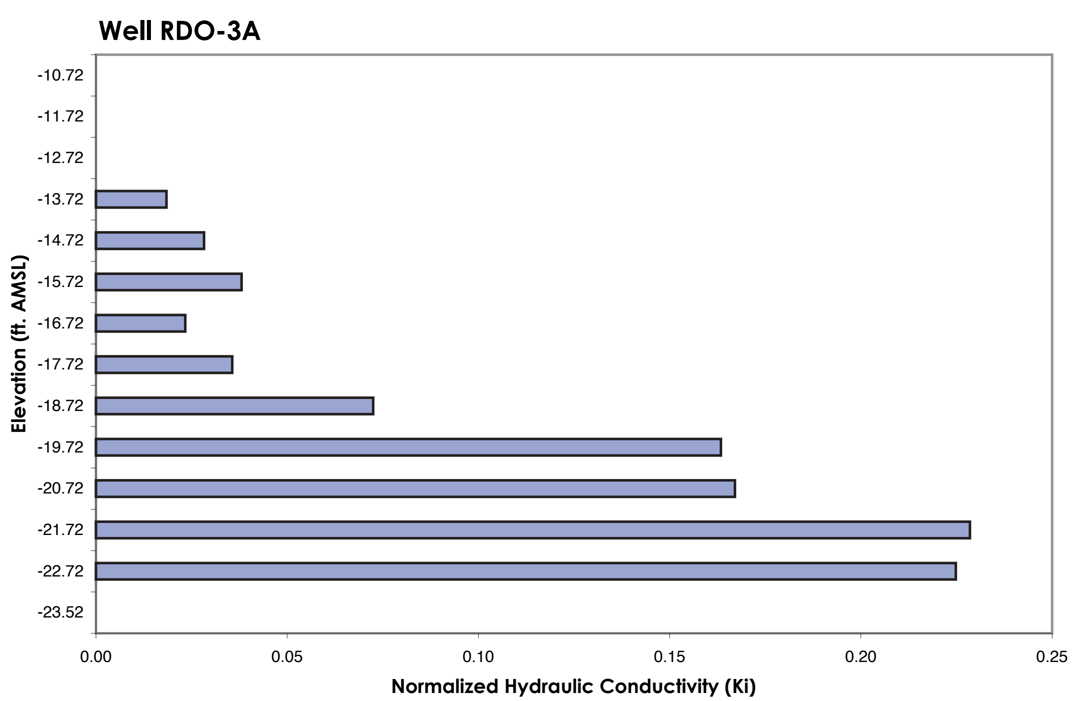

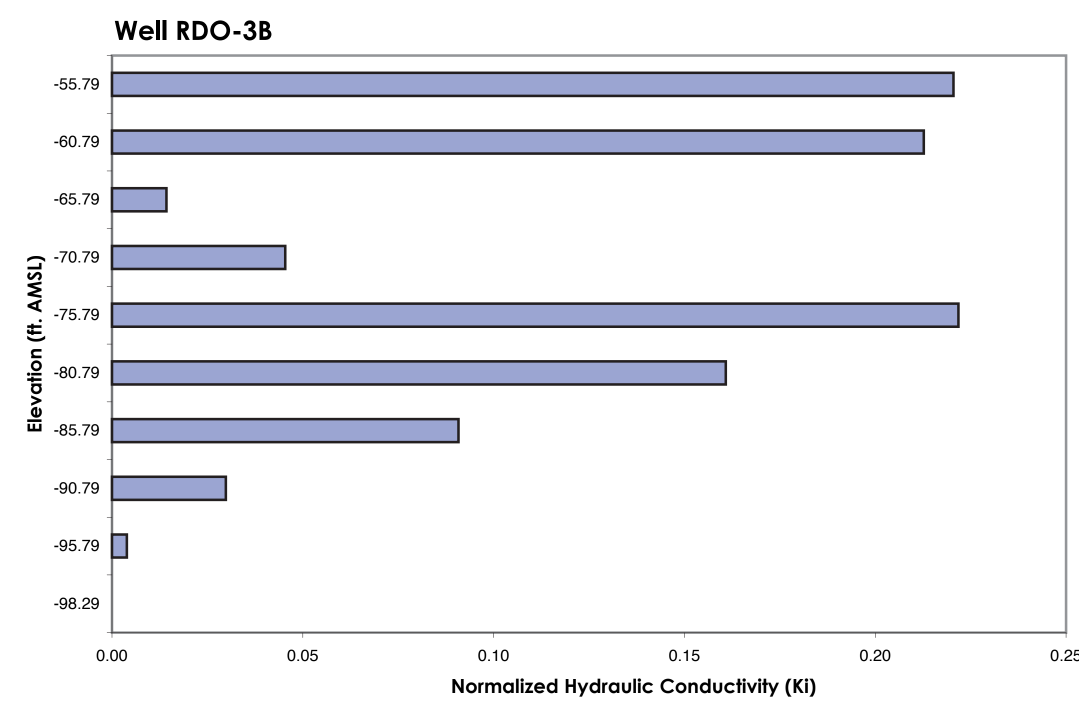

ft amsl - feet above mean sea level
gpm - gallons per minute
K - hydraulic conductivity
RDO - remedial design optimization
EBF - electromagnetic borehole flowmeter
IR - installation restoration

Figure: 4.6
(i of ii)
EBF Survey: Normalized Hydraulic Conductivity Profiles

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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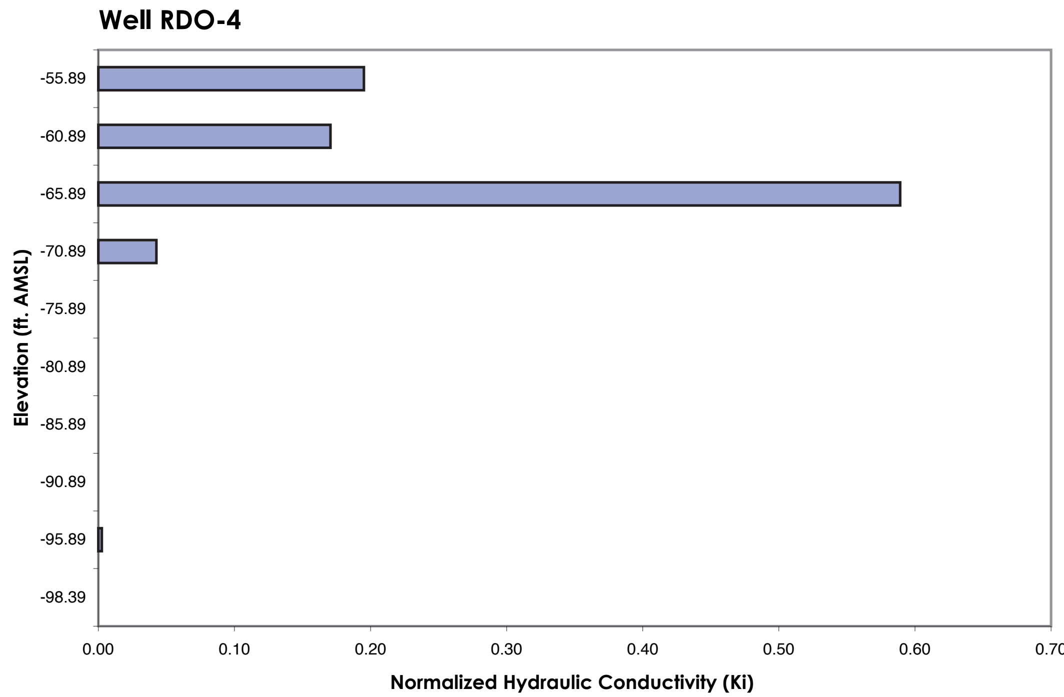
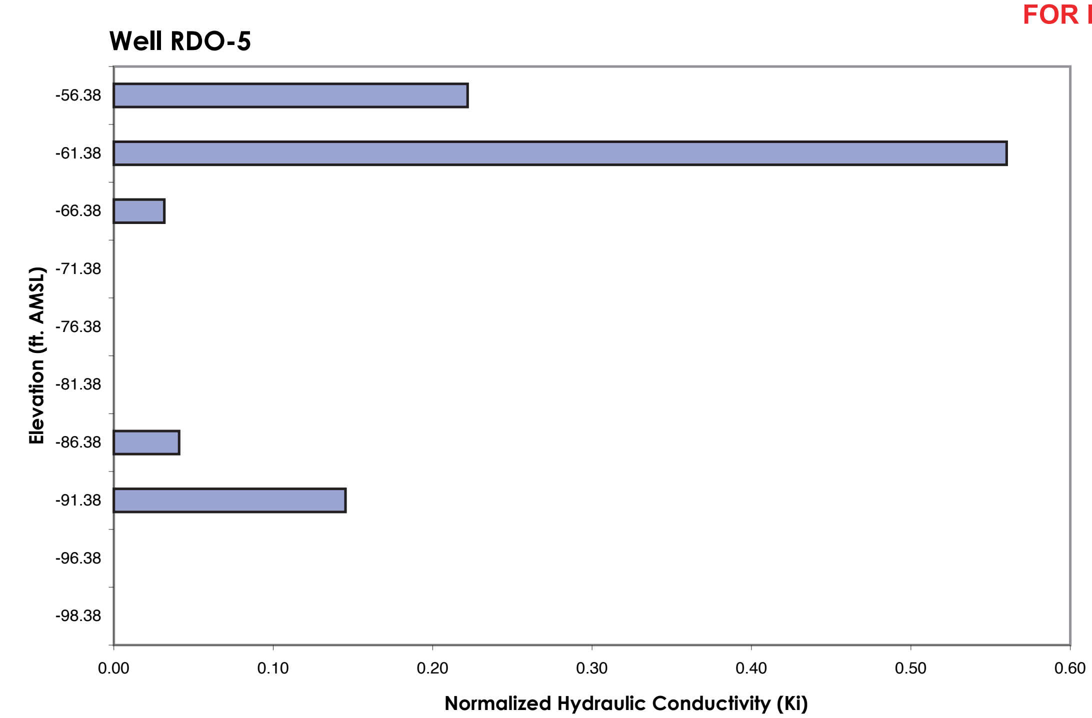
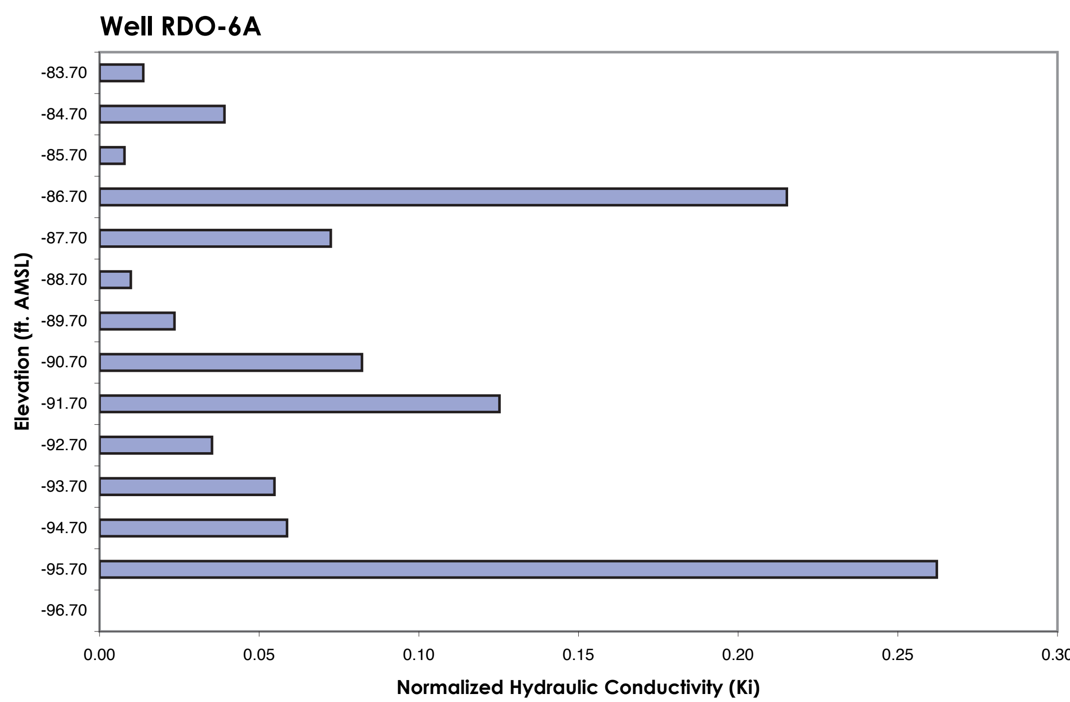
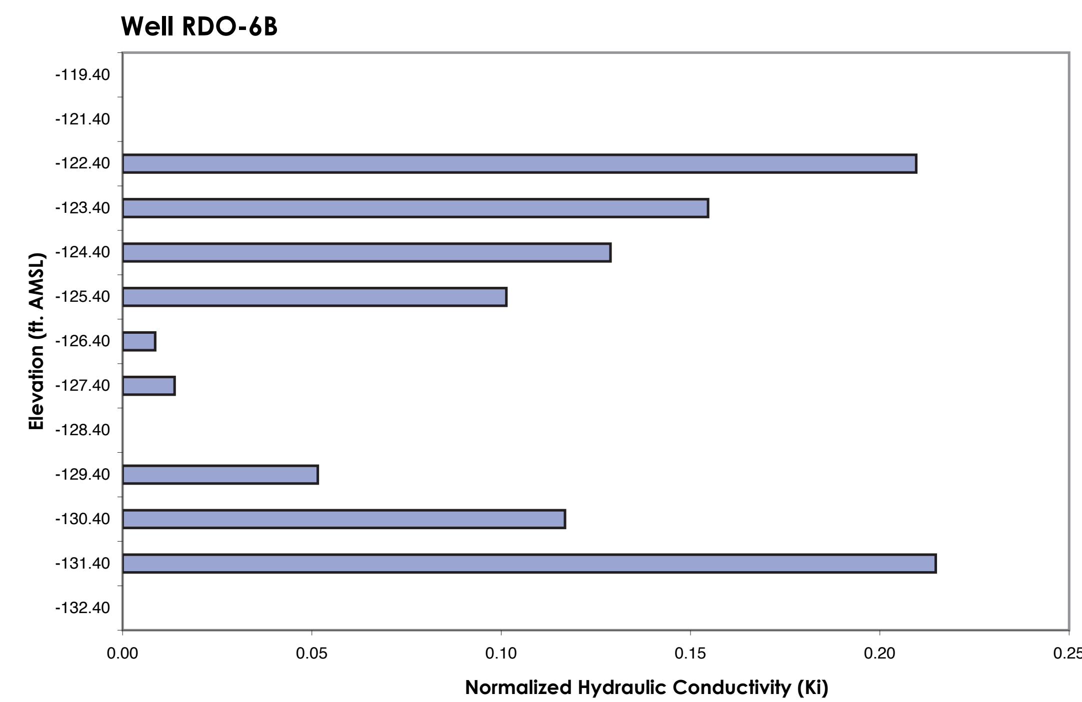
Graph figures_HY0888.ai









ft amsl - feet above mean sea level
gpm - gallons per minute
K - hydraulic conductivity
RDO - remedial design optimization
EBF - electromagnetic borehole flowmeter
IR - installation restoration

Figure: 4.6
(ii of ii)
EBF Survey: Normalized Hydraulic Conductivity Profiles

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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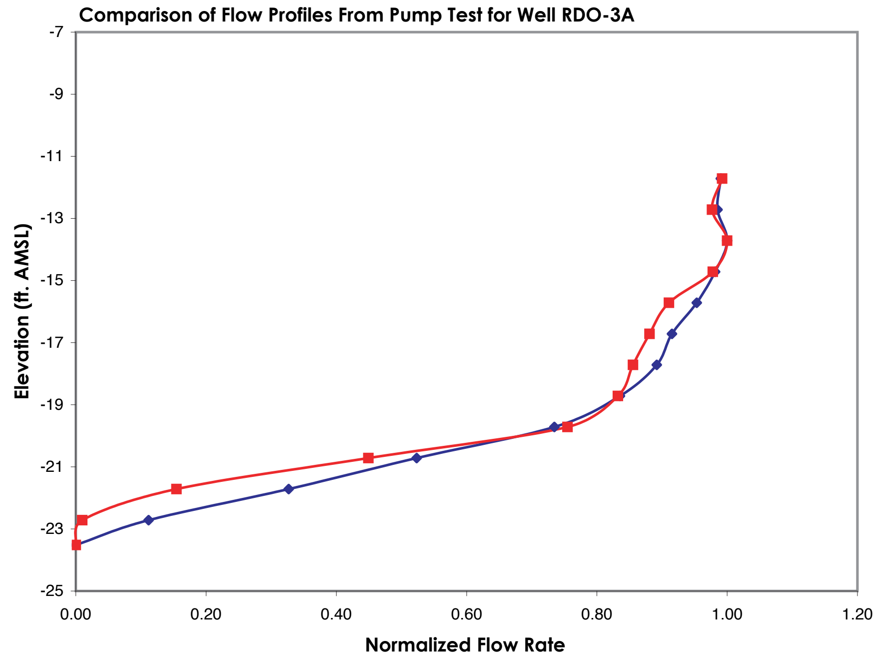

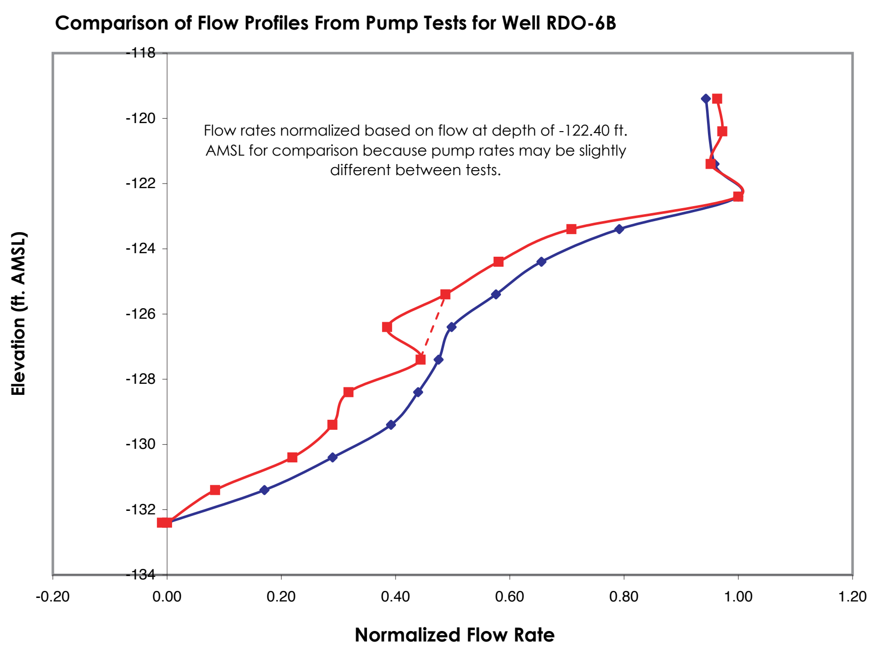

Pre-EVO Injection
Post-EVO Injection

Figure: 4.7 **EBF Survey Pre-/Post-EVO Injection Comparison:** **Normalized Hydraulic Conductivity Profiles** IR Site 70 Naval Weapons Station Seal Beach, California	
Date: March 2006	Project No. HY0888
GeoSyntec Consultants	

Graph figures_HY0888.ai

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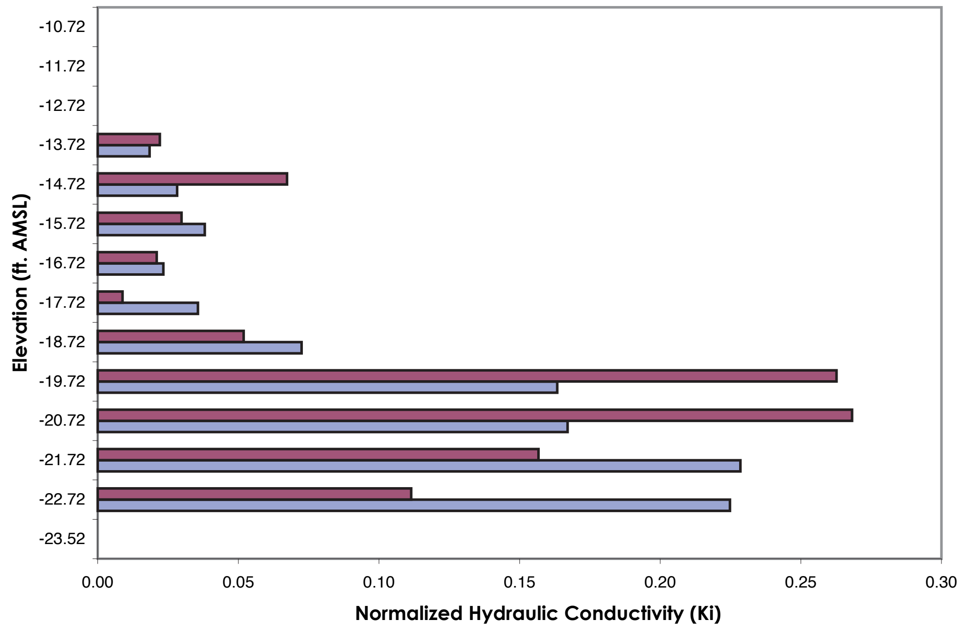
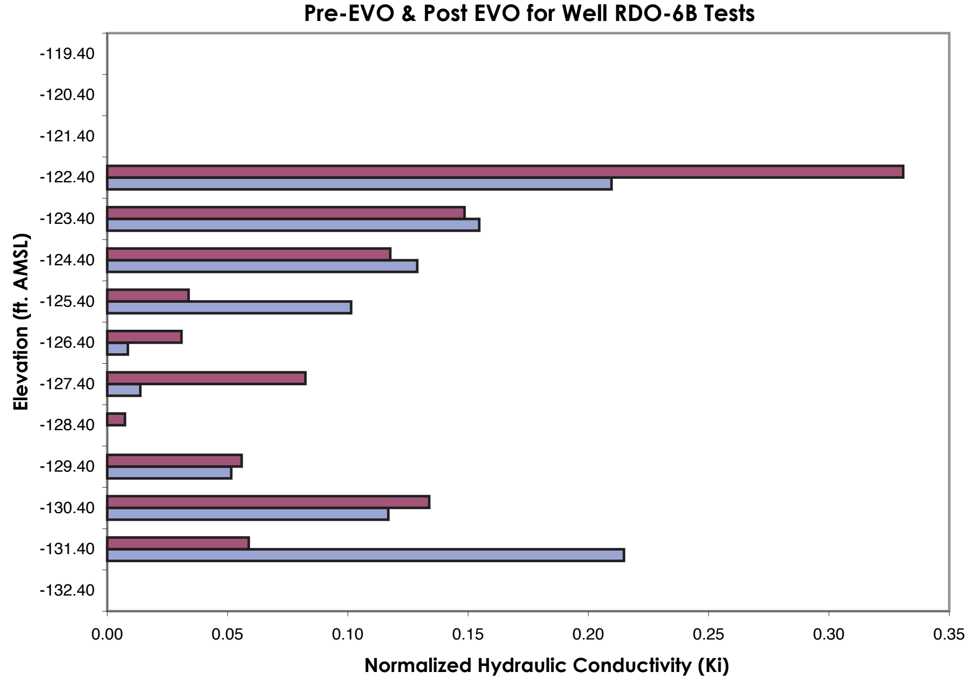
Comparison of Normalized Hydraulic Conductivity Between Pre-EVO & Post-EVO Tests for Well RDO-3A



Comparison of Profile of Hydraulic Conductivity Between Pre-EVO & Post EVO for Well RDO-6B Tests



Post-EVO
Pre-EVO

Graph figures_HY0888.ai

Figure: 4.8
EBF Survey Pre-/Post-EVO Injection Comparison: Flow Rate Profiles

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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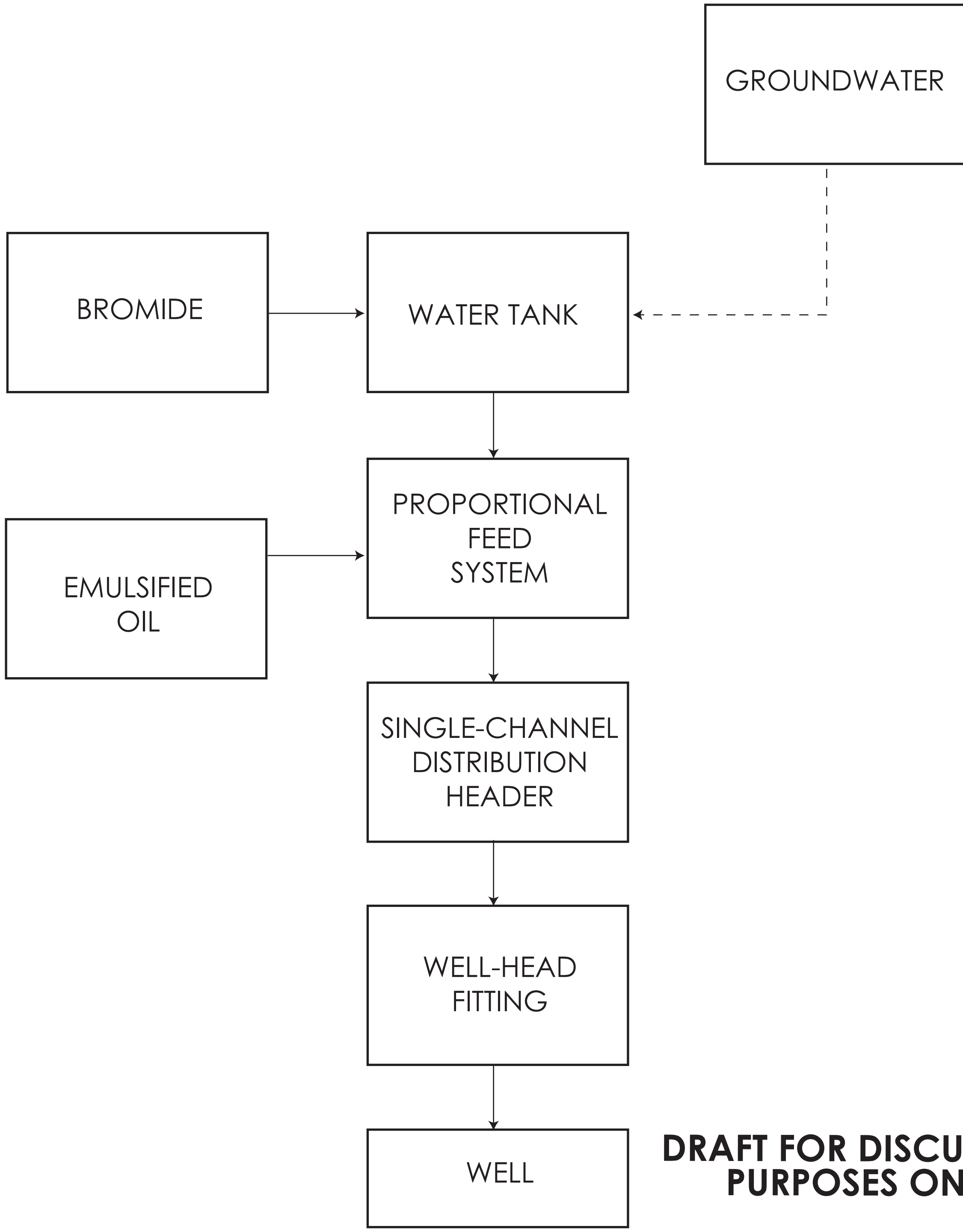

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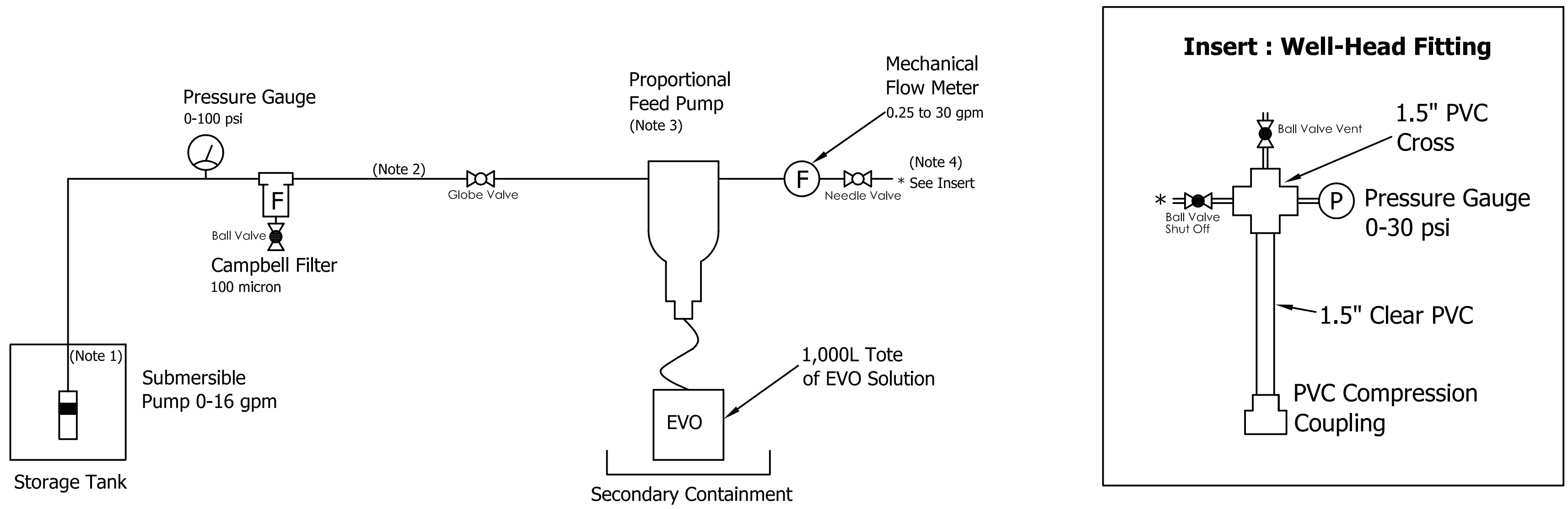
PROCESS FLOW SCHEMATIC FOR EMULSIFIED OIL INJECTION
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	4.9
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

Process Flow Schematic.ai



Note:

1. 20,000 gallon tank of site water and NaBr. NaBr was dissolved in separate mixing vessels prior to addition to 20,000 gal storage tank

2. Delivery system piping material is constructed of both rigid and flexible PVC.

3. Dosmatic™A30 Proportional Feed Pump
Flowrate: 0.25-30 gpm
Amendment dose ratio: 0.4-5%
Operating pressure: max. 100psi

4. Delivery system connects to well head fitting with 3/4" braided PVC hose using quick connects.

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EMULSIFIED OILPROPORTIONAL DELIVERY SYSTEM
IR SITE 70
NAVAL WEAPONS STATION SEAL BEACH, CALIFORNIA

FIGURE NO.	4.10
PROJECT NO.	HY0888
DOCUMENT NO.	
DATE:	MAR. 2006

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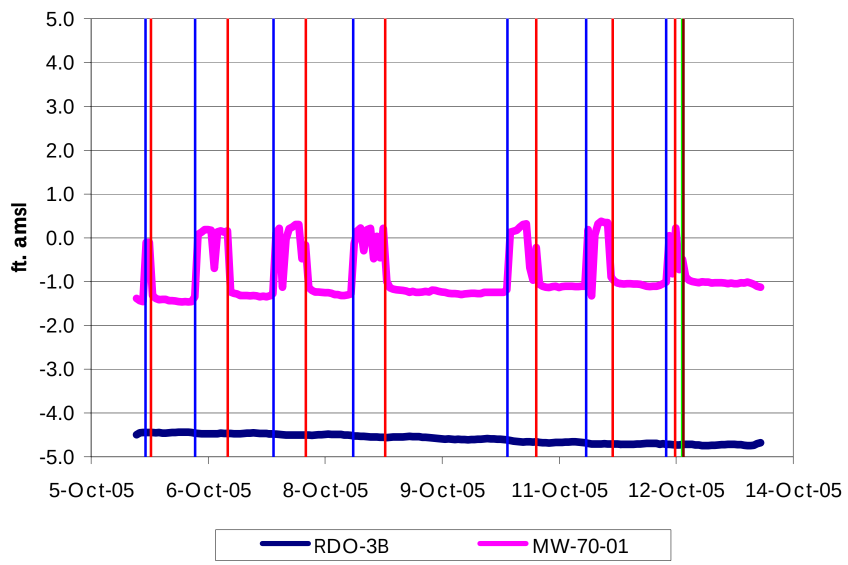
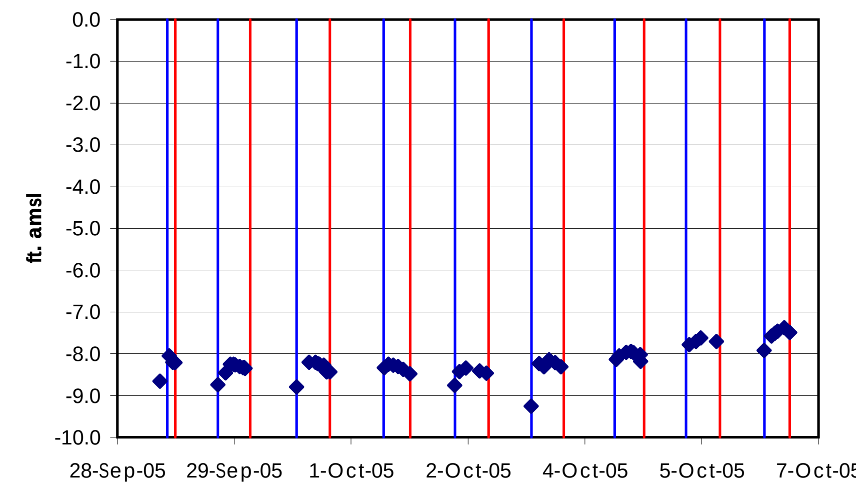
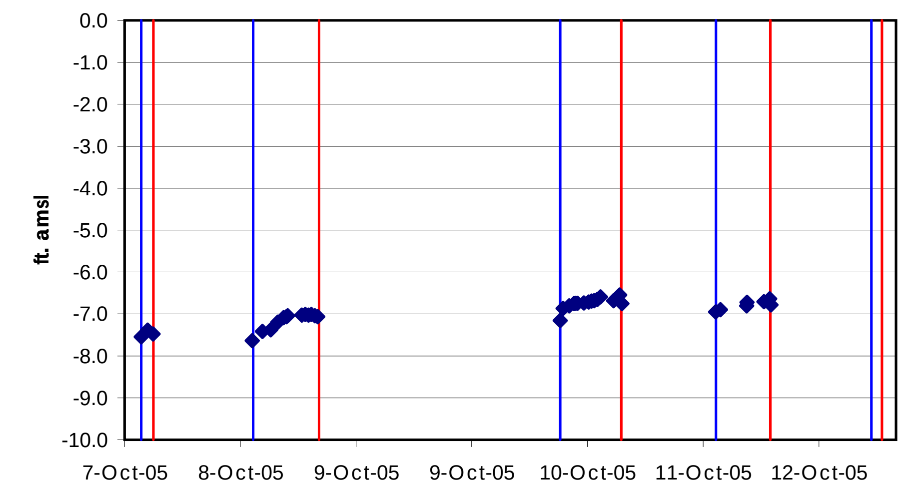
A. Groundwater Elevations at MW-70-01 and RDO-3B During EVO Injections at RDO-3A



B. Groundwater Elevations at MW-70-08 During EVO Injection at RDO-6A



C. Groundwater Elevations at MW-70-31 During EVO Injection at RDO-6B



Vertical lines represent startup (Blue) / shutdown (Red) periods
Water levels were recorded in MW-70-01 and RDO-3B by pressure transducers
Water levels were recorded manually in MW-70-08 and MW-70-31

Figure 4.11
Groundwater Elevations at Monitoring Wells During EVO Injections

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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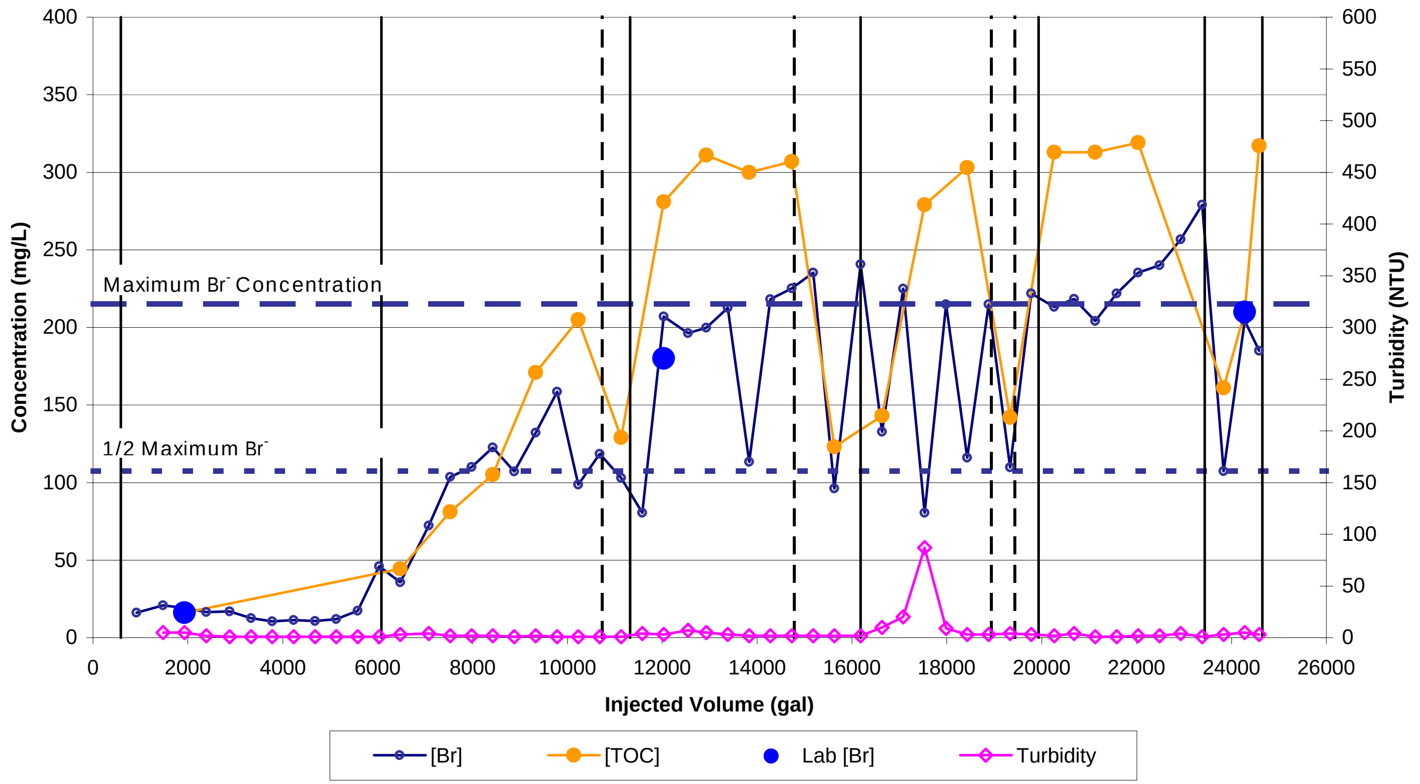

Emulsified Oil product injected - Newman Zone Emulsified Oil, 1% oil
Vertical lines represent shutdown / startup periods
Vertical dashed lines represent temporary shutdowns over an injection day
Maximum Bromide concentration = 215 mg/L
Maximum TOC concentration = 5,980 mg/L

Figure 4.12
RDO3A - Breakthrough Curve For Bromide, TOC and Turbidity

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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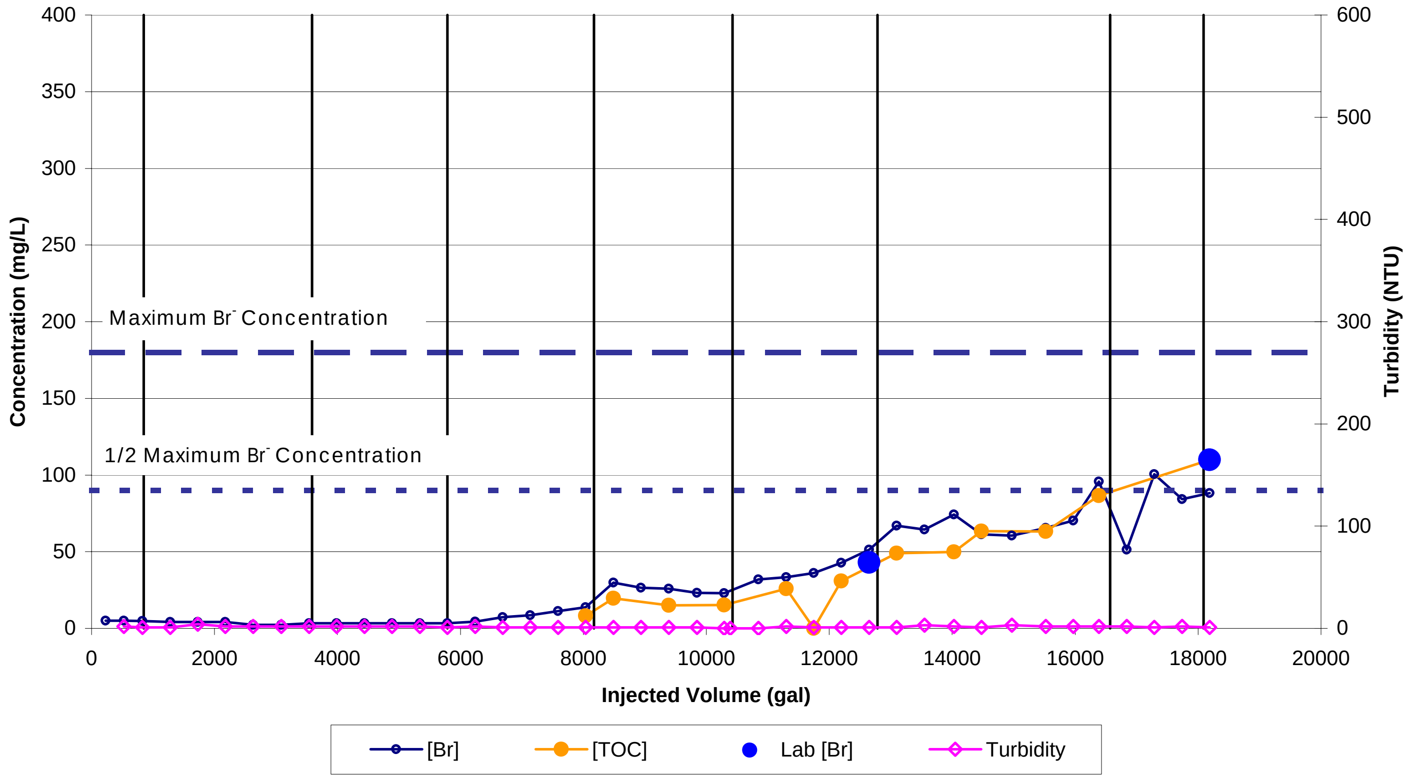

Emulsified Oil product injected - EOS 450, 0.5% oil
Vertical lines represent shutdown / startup periods
Maximum Bromide concentration = 180 mg/L
Maximum TOC concentration = 2,990 mg/L

Figure 4.13
RDO6A - Breakthrough Curve For Bromide, TOC and Turbidity

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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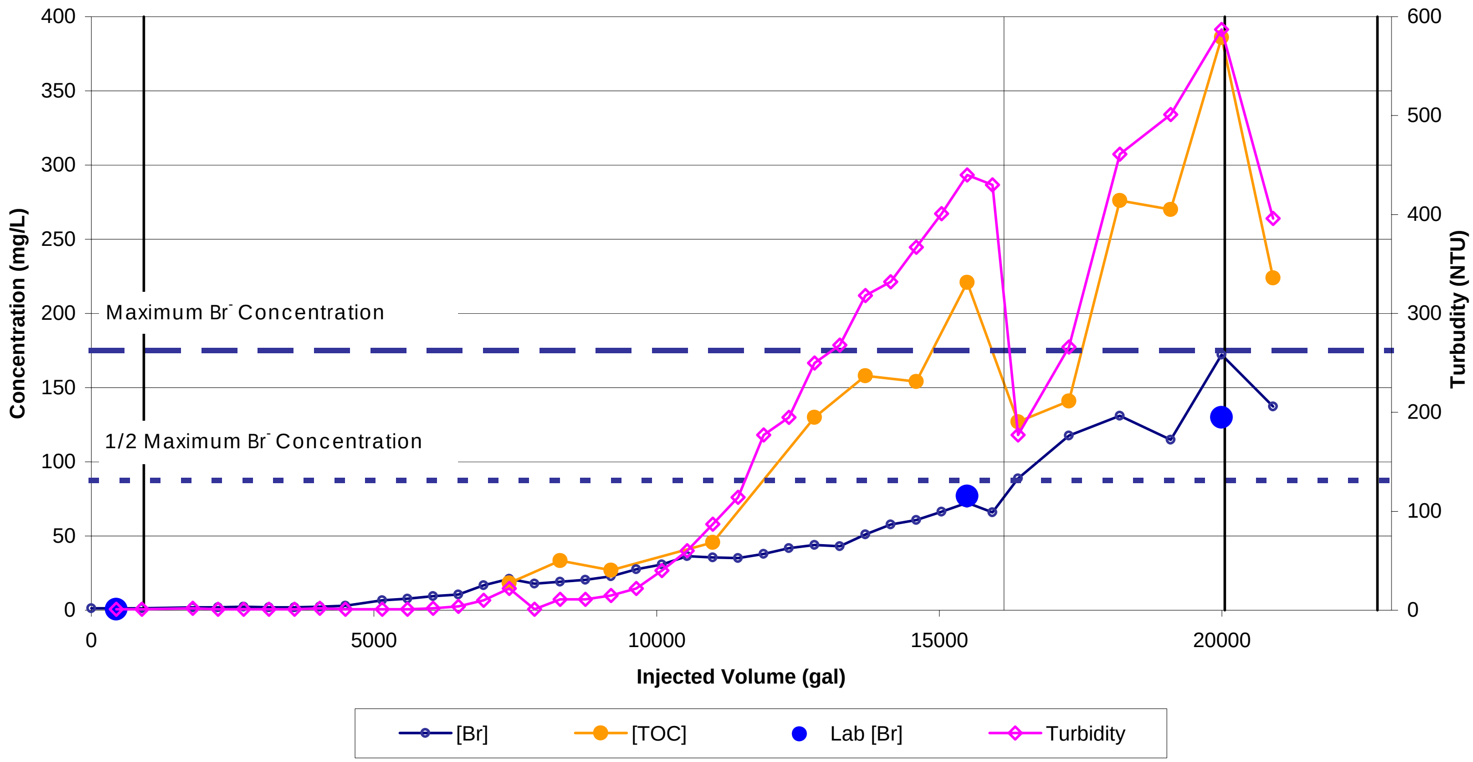

Emulsified Oil product injected - Newman Zone Emulsified Oil, 0.5% oil
Vertical lines represent shutdown / startup periods
Maximum Bromide concentration = 175 mg/L
Maximum TOC concentration = 2,990 mg/L

Figure 4.14
RDO6B - Breakthrough Curve For Bromide, TOC and Turbidity

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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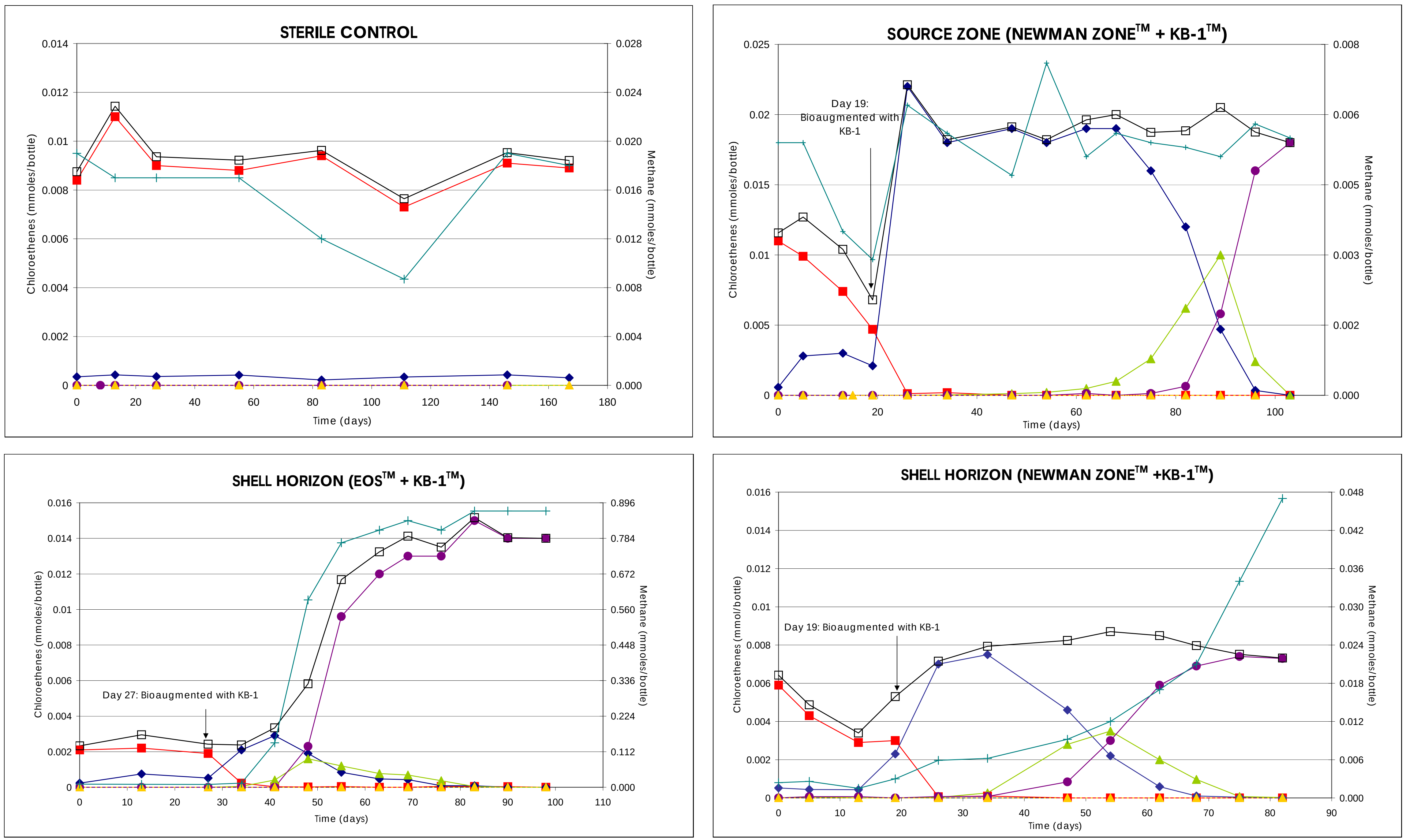

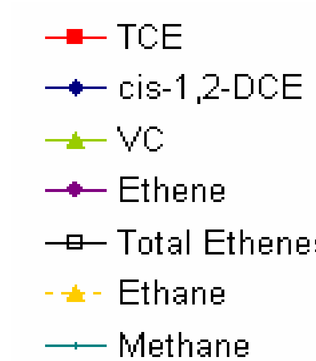

Acronyms

TCE - trichloroethene
cis-1,2-DCE - cis-1,2-dichloroethene
VC - vinyl chloride
VOC - volatile organic compounds

Notes

Data shown represents average behaviour of the three replicate microcosms.

Figure 4.15
VOC Concentration Trends in the Biotreatability Study

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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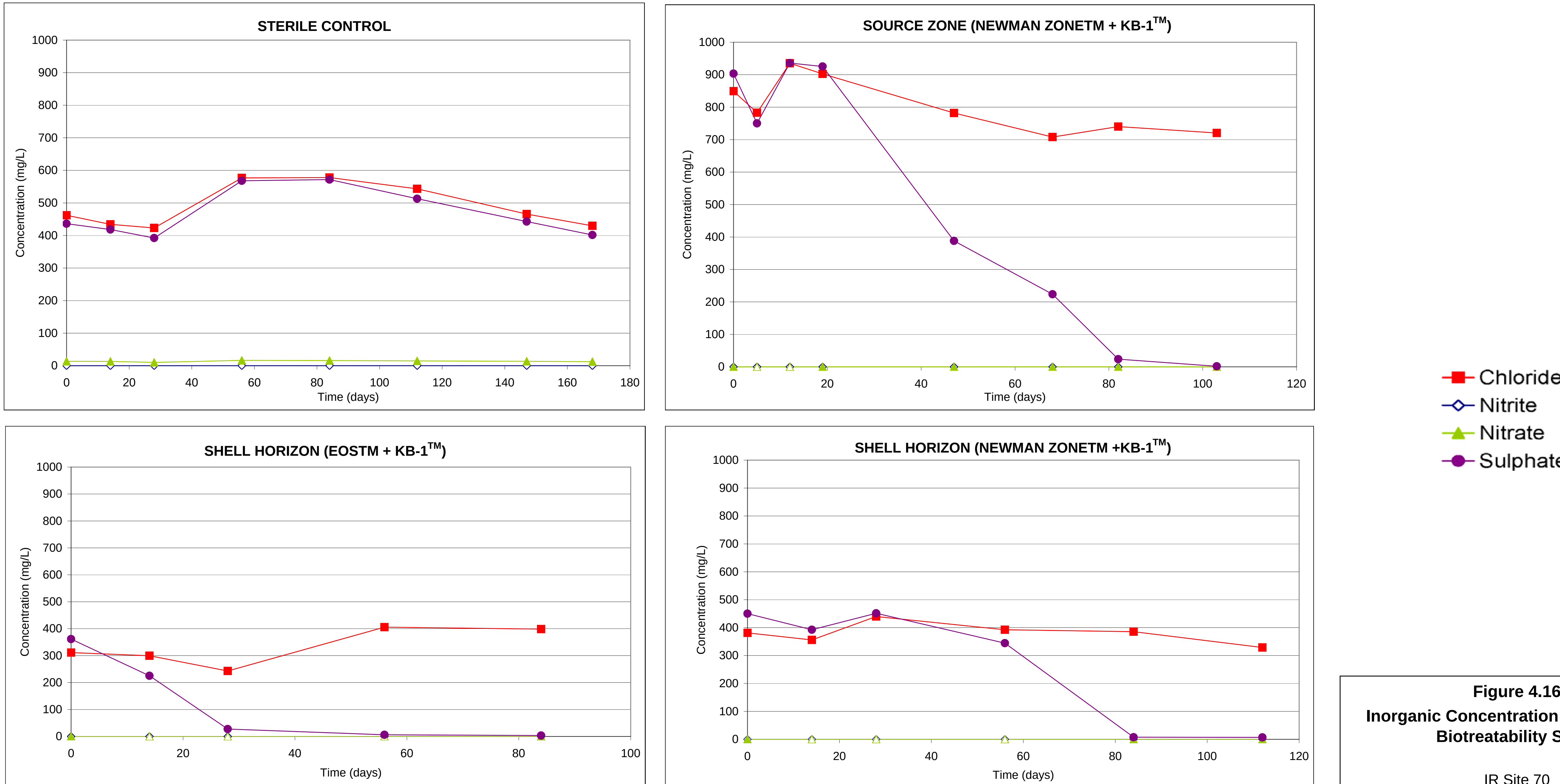


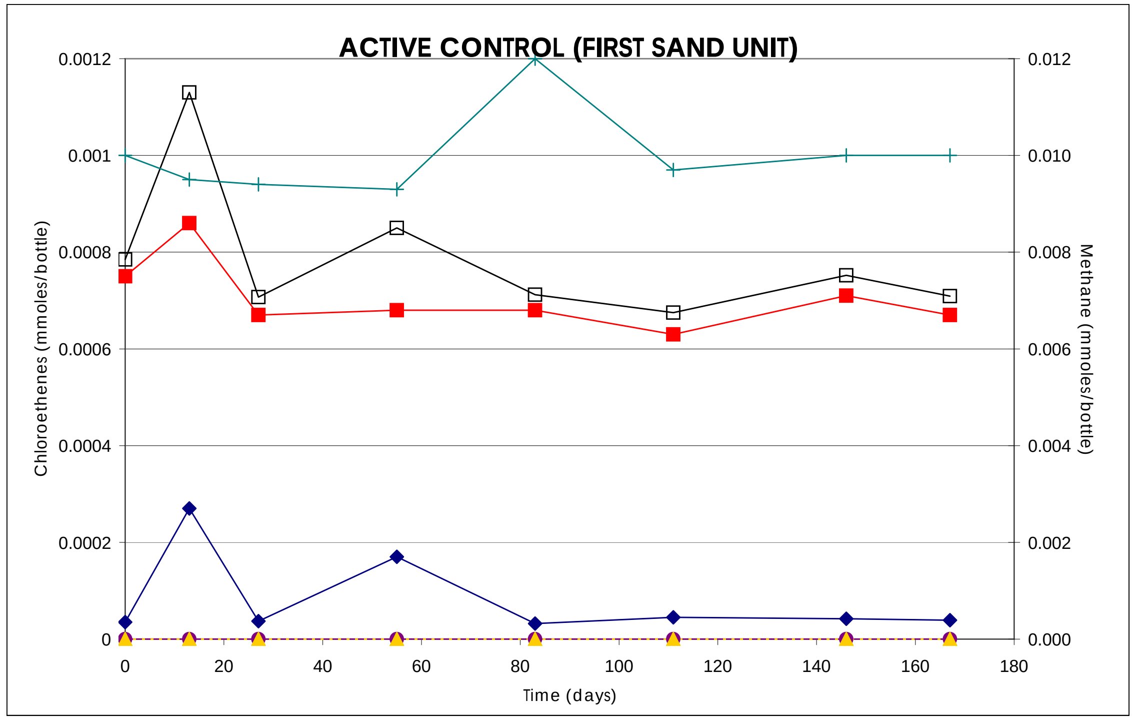
Data shown represents average behaviour of the three replicate microcosms.
Open symbols represent non-detects. Values shown are the detection limits for that compound.

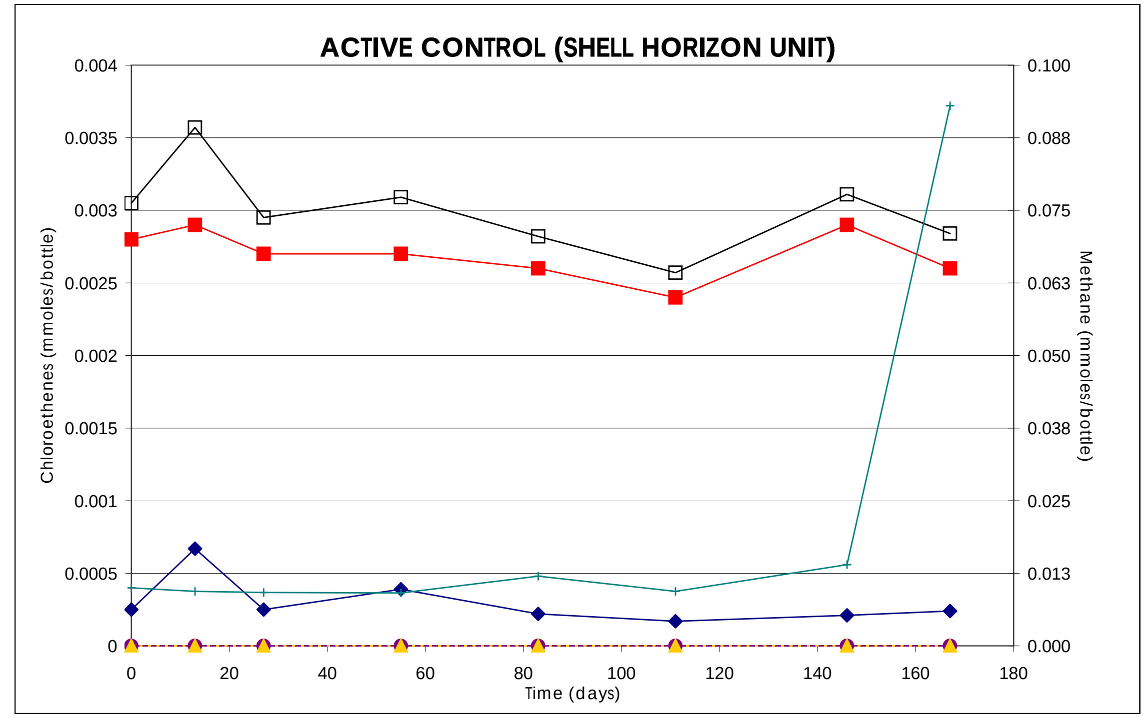
Figure 4.16
Inorganic Concentration Trends in the Biotreatability Study

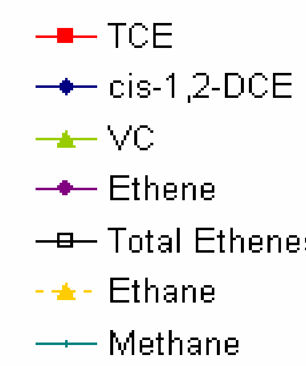
IR Site 70
Naval Weapons Station Seal Beach, California

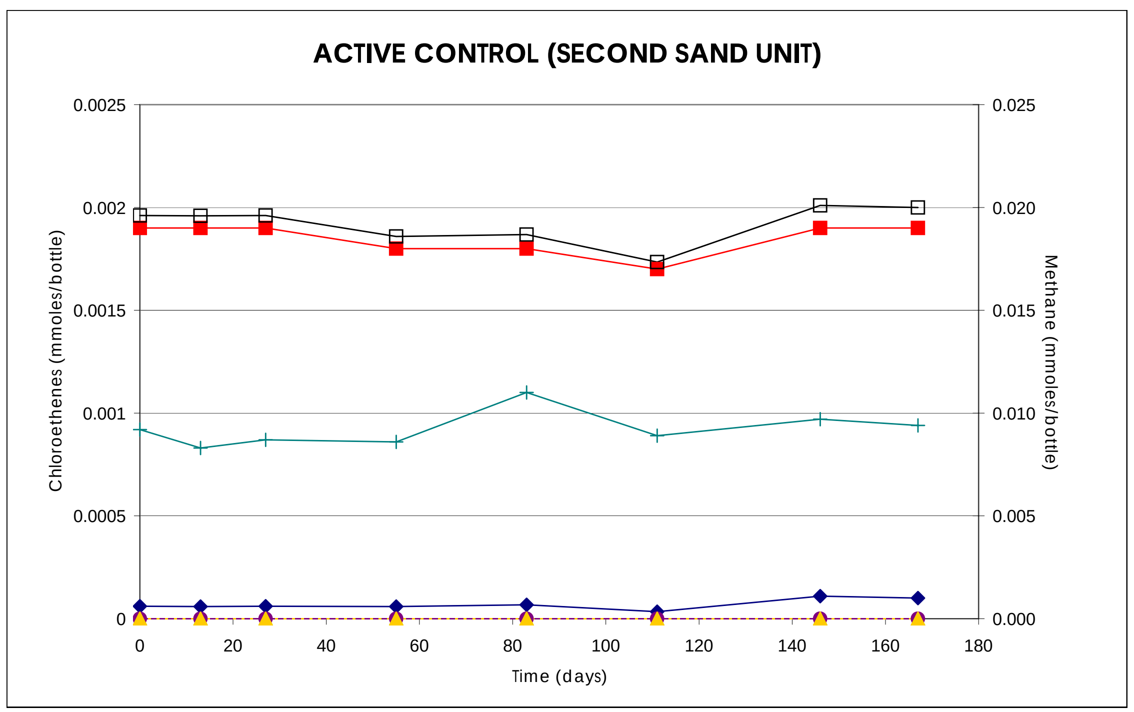
Date: March 2006	Project No. HY0888

GeoSyntec Consultants









Notes
Data shown represents average behaviour of the three replicate microcosms.

Acronyms
TCE - trichloroethene
cis-1,2-DCE - cis-1,2-dichloroethene
VC - vinyl chloride
VOC - volatile organic compounds

Figure 4.17
VOC Concentration Trends in the Active Control Microcosms

IR Site 70
Naval Weapons Station Seal Beach, California

Date: March 2006	Project No. HY0888

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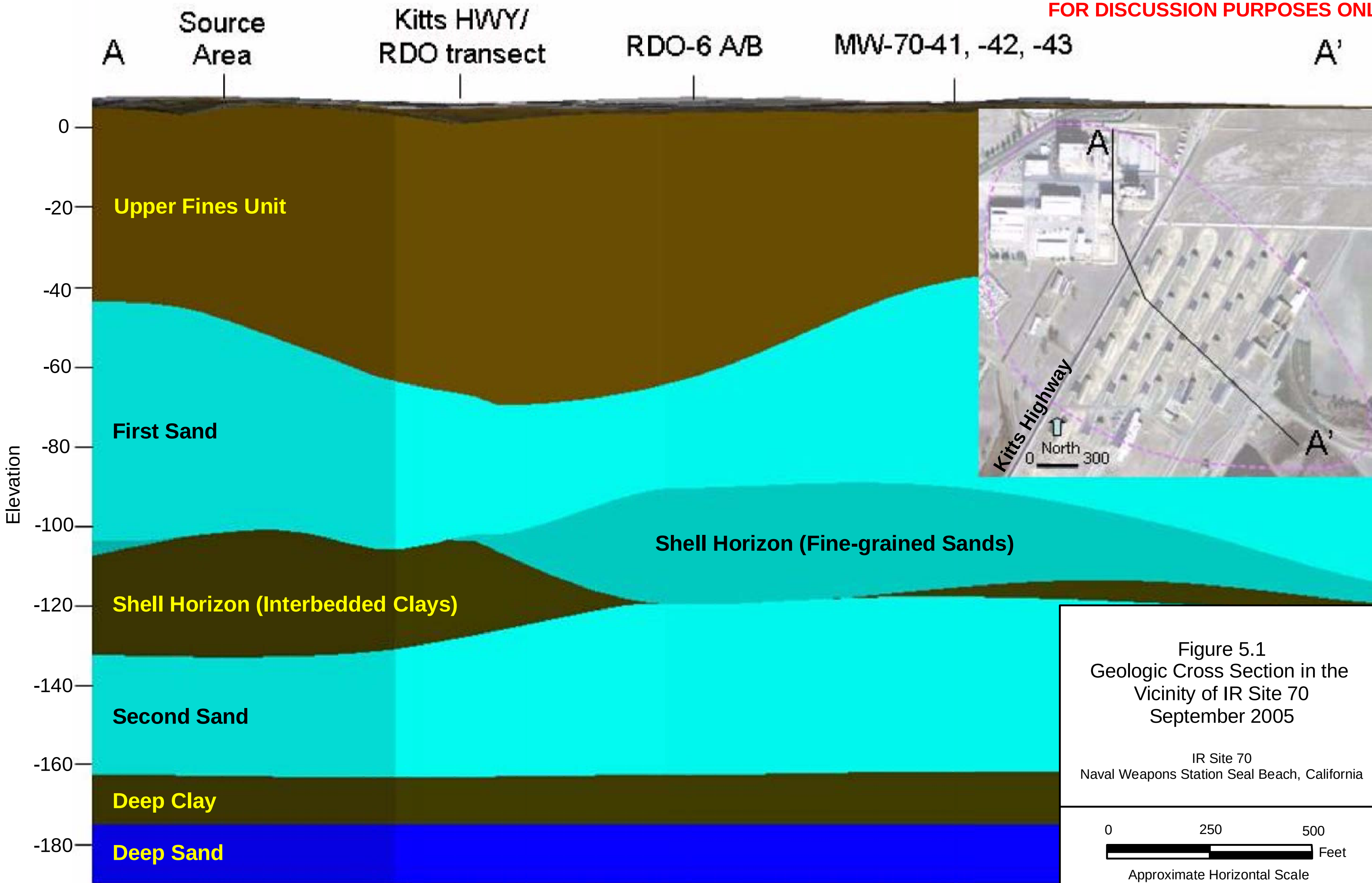

Figure 5.1
Geologic Cross Section in the Vicinity of IR Site 70
September 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006

Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)

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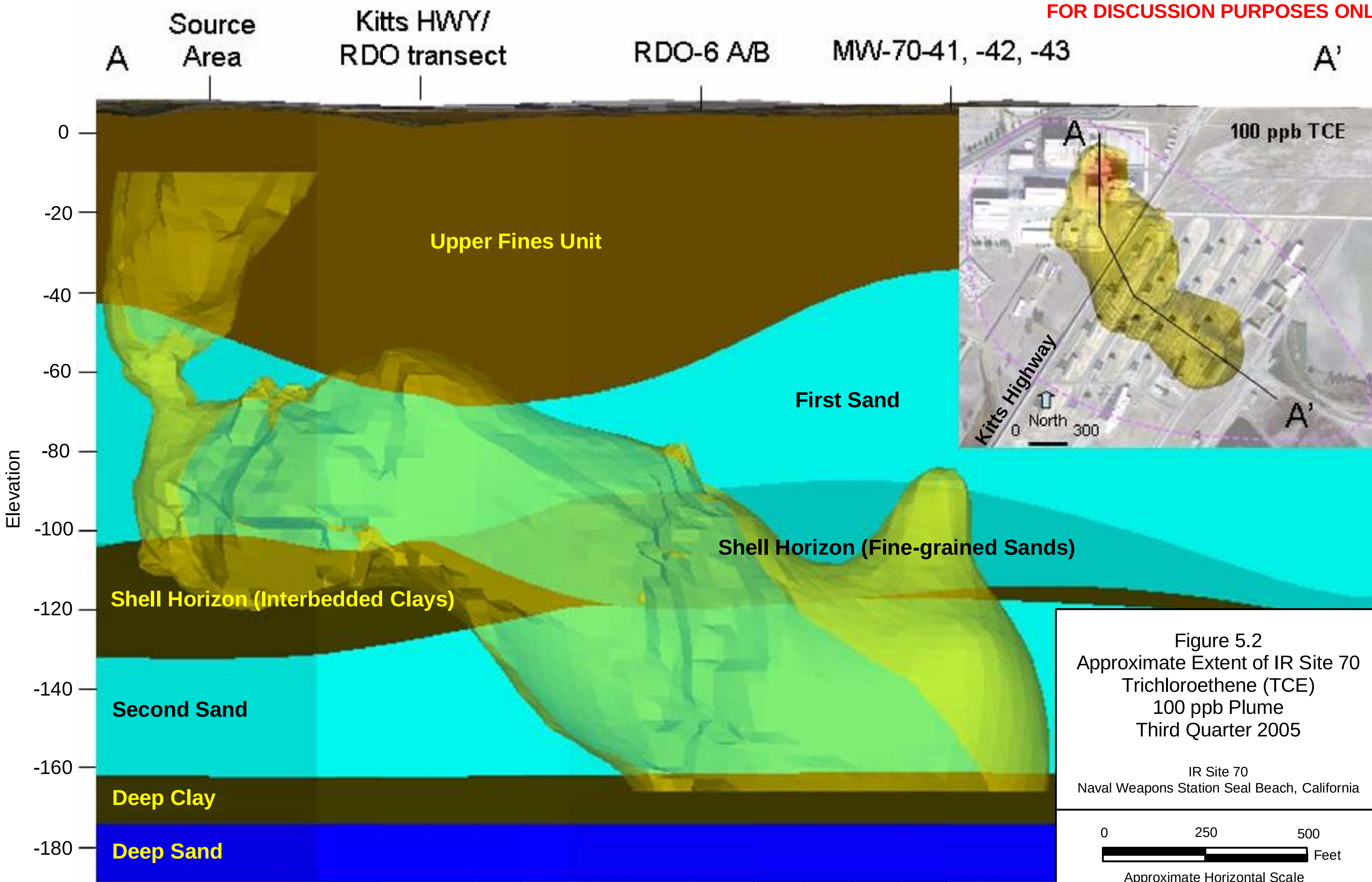

Figure 5.2
Approximate Extent of IR Site 70
Trichloroethene (TCE)
100 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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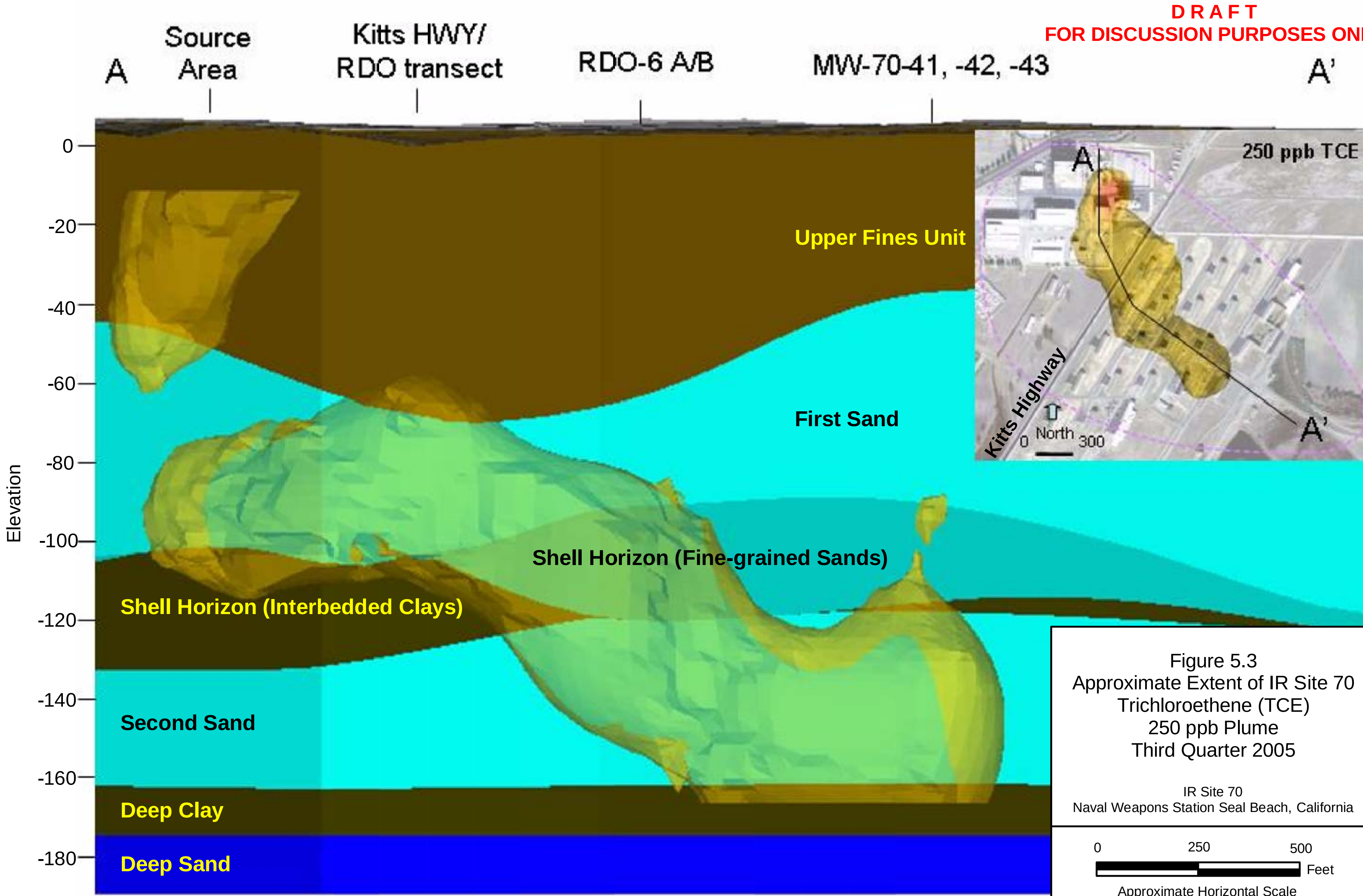

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 5.3
Approximate Extent of IR Site 70
Trichloroethene (TCE)
250 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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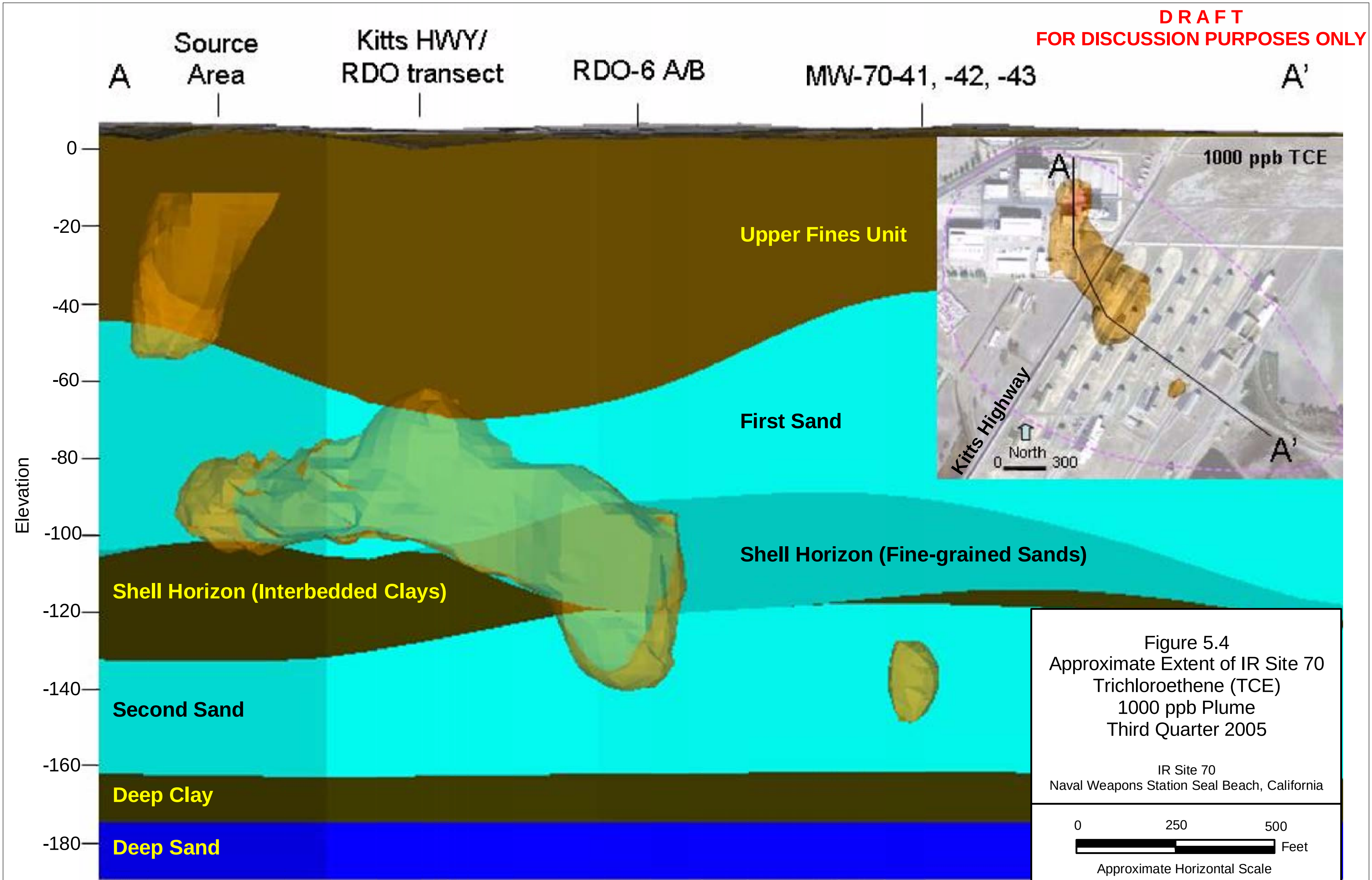

Figure 5.4
Approximate Extent of IR Site 70
Trichloroethene (TCE)
1000 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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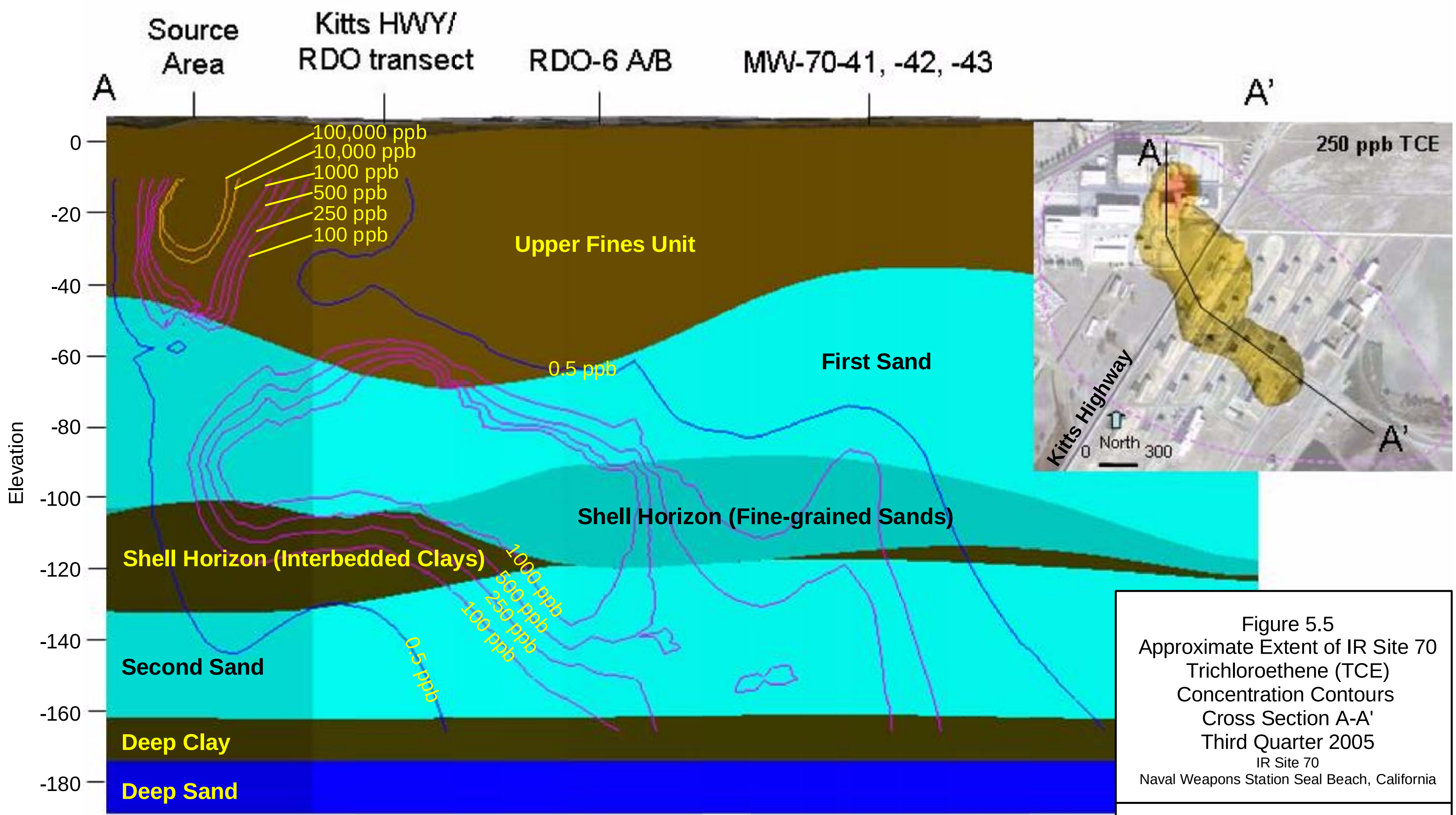

Figure 5.5
Approximate Extent of IR Site 70
Trichloroethene (TCE)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet

Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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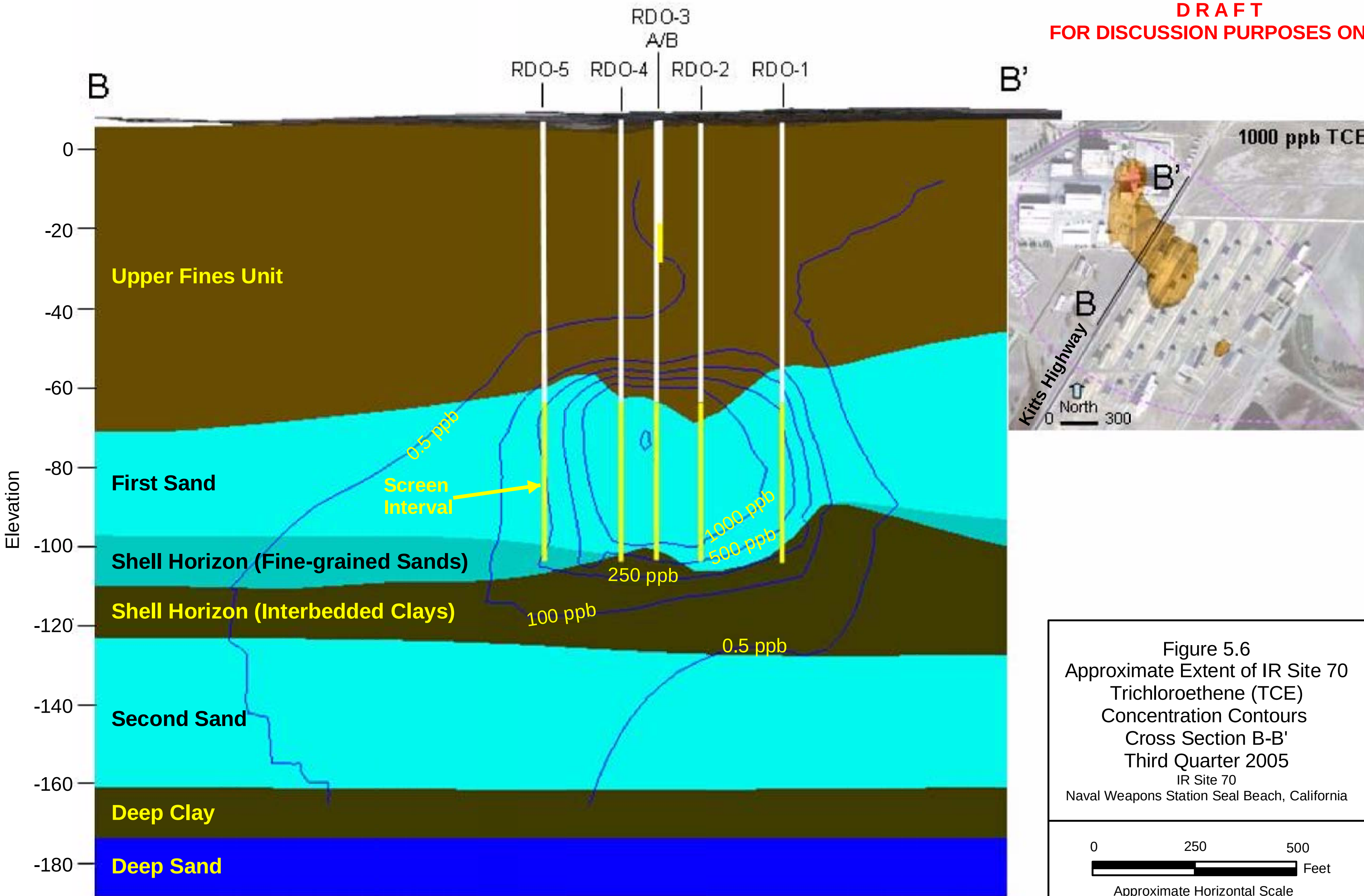

Figure 5.6
Approximate Extent of IR Site 70
Trichloroethene (TCE)
Concentration Contours
Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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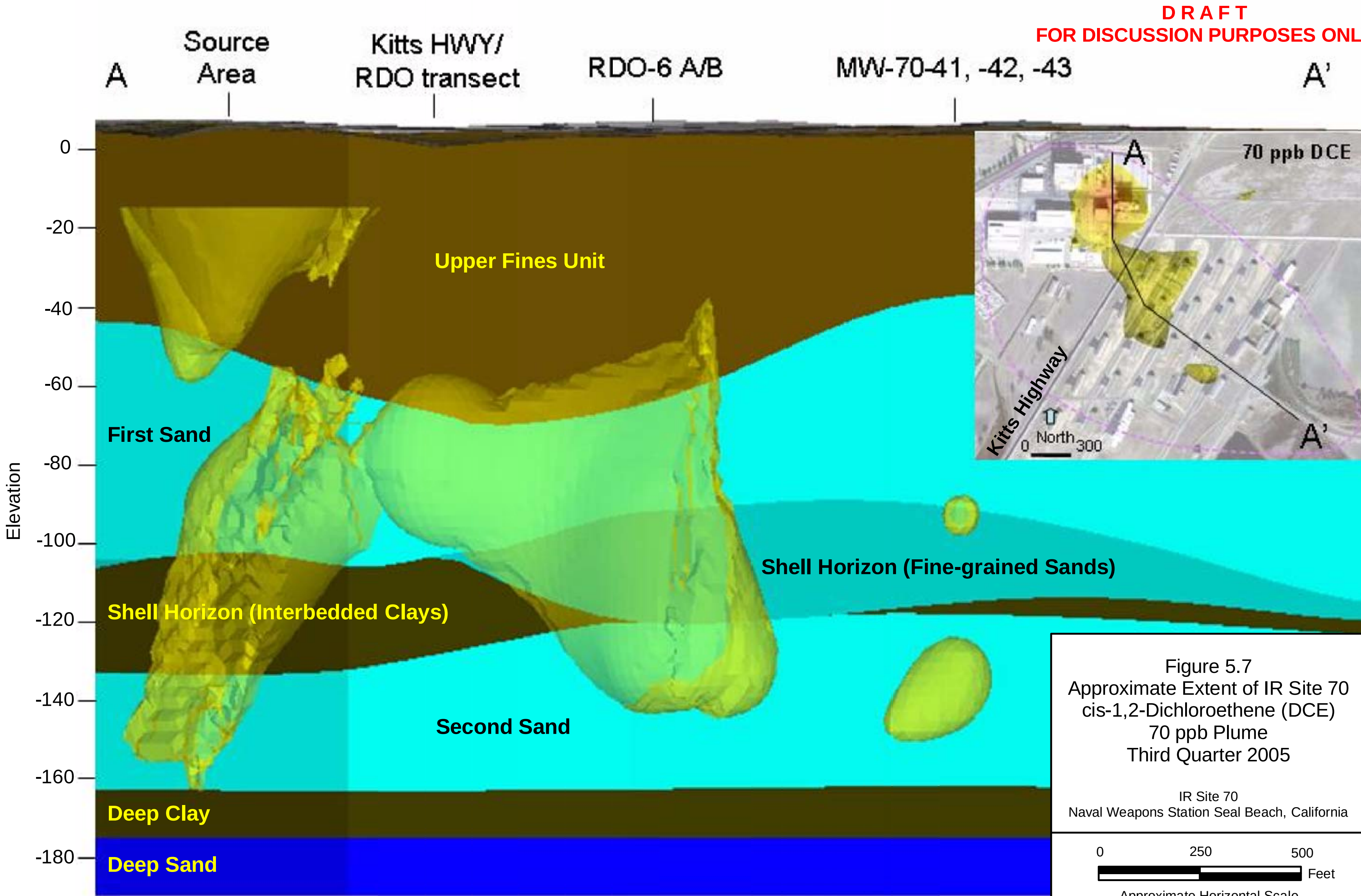

Figure 5.7
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
70 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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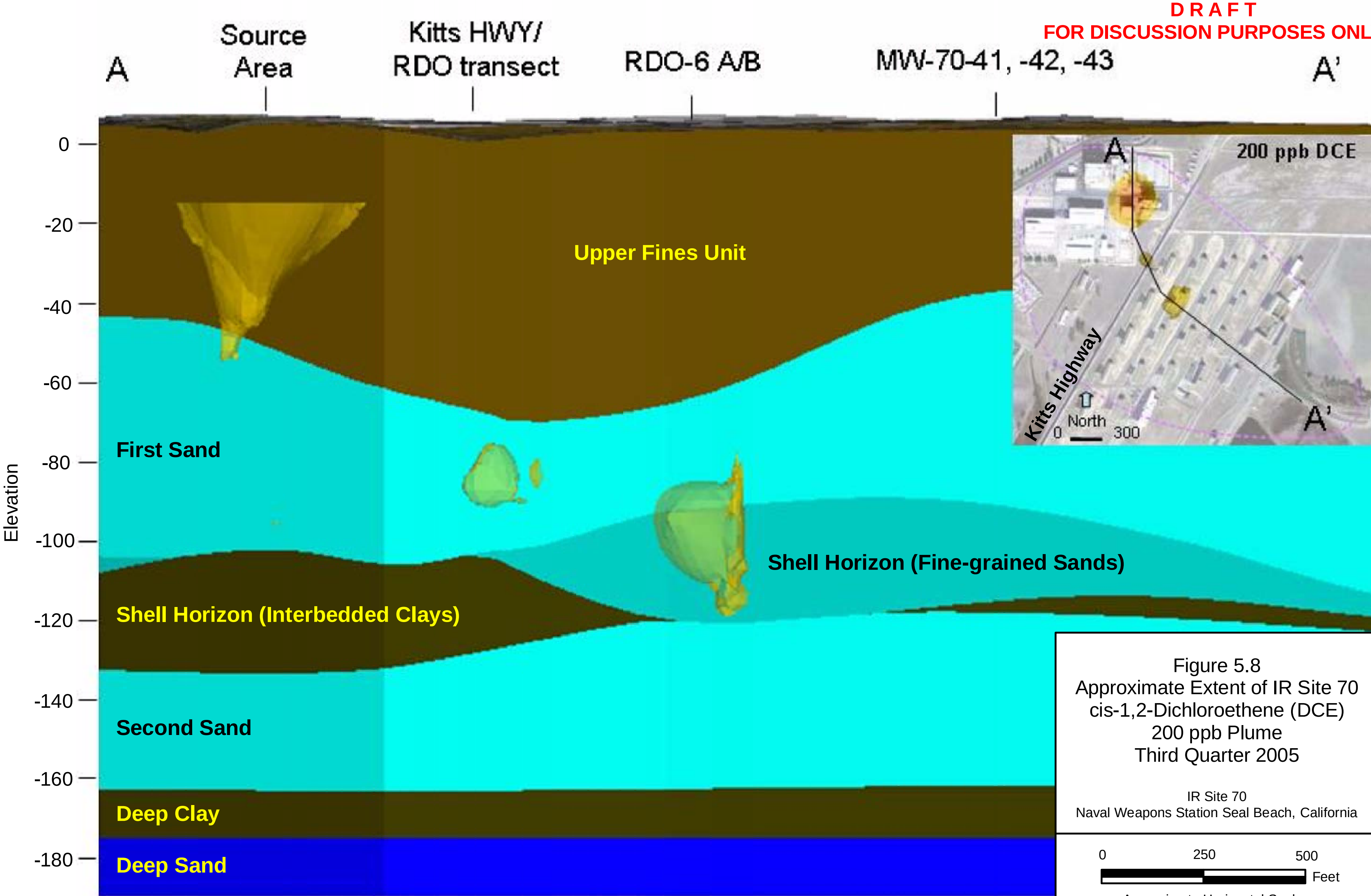

Figure 5.8
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
200 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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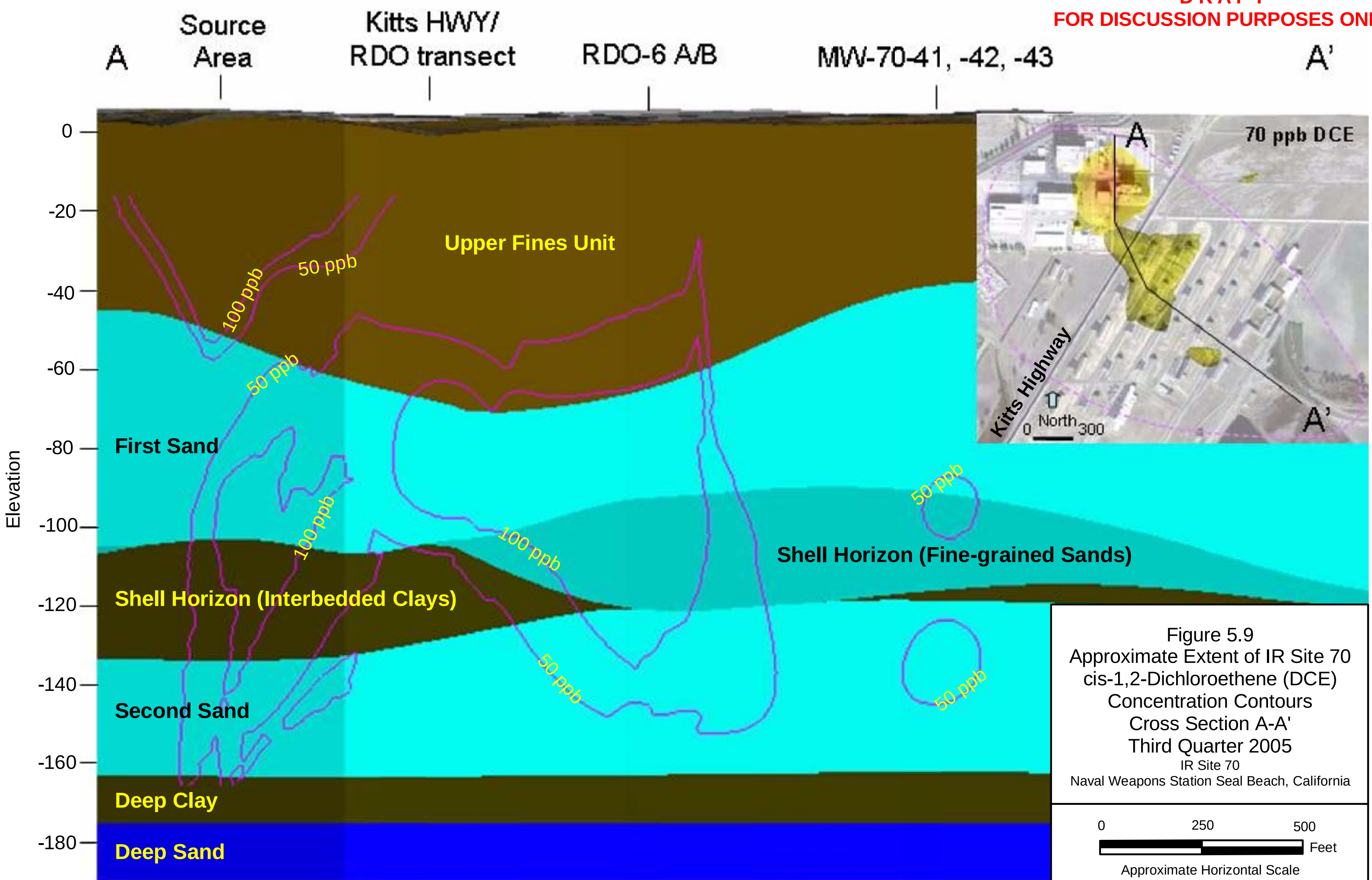

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 5.9
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

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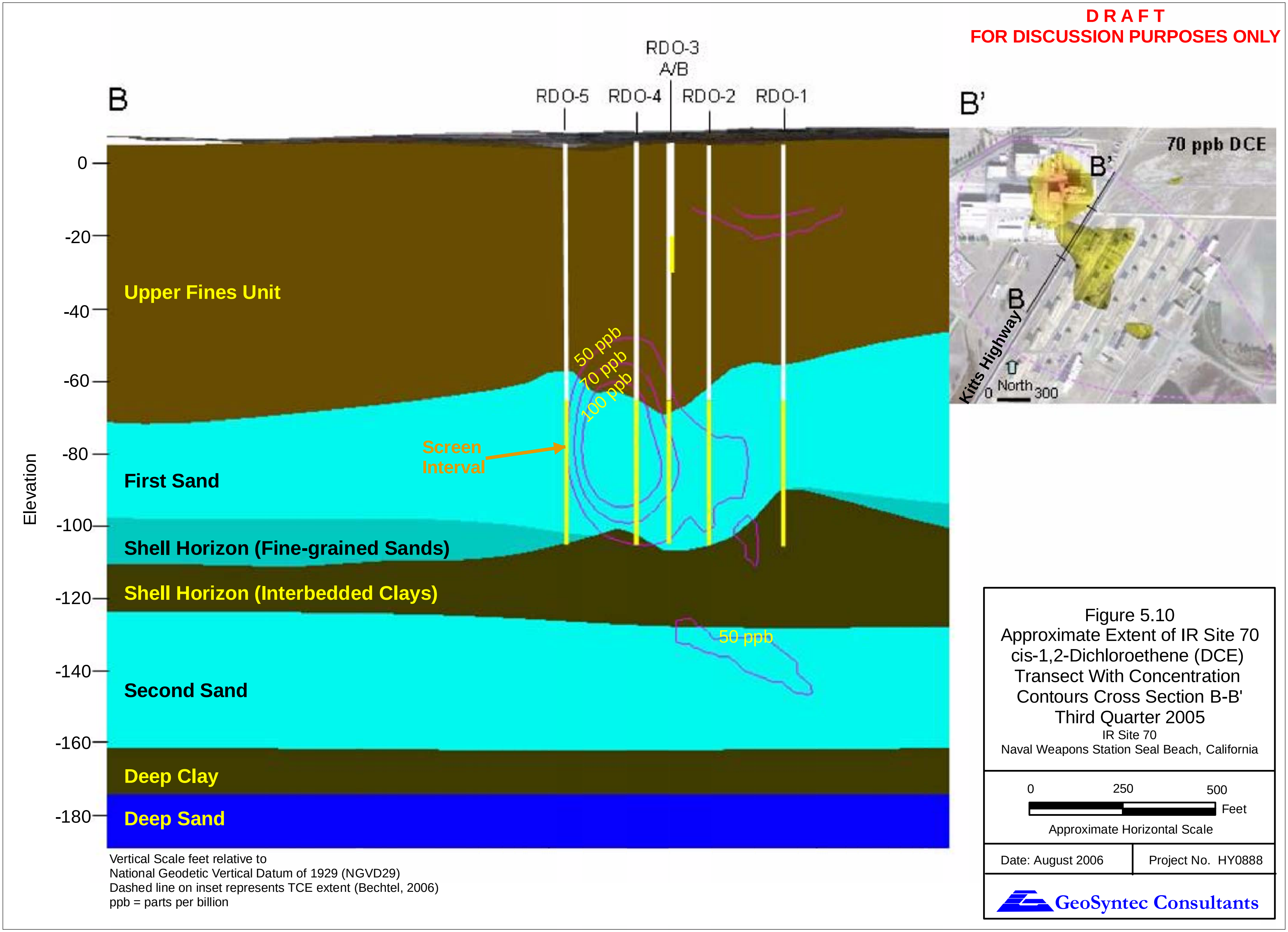

Figure 5.10
Approximate Extent of IR Site 70
cis-1,2-Dichloroethene (DCE)
Transect With Concentration
Contours Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

Date: August 2006 | Project No. HY0888

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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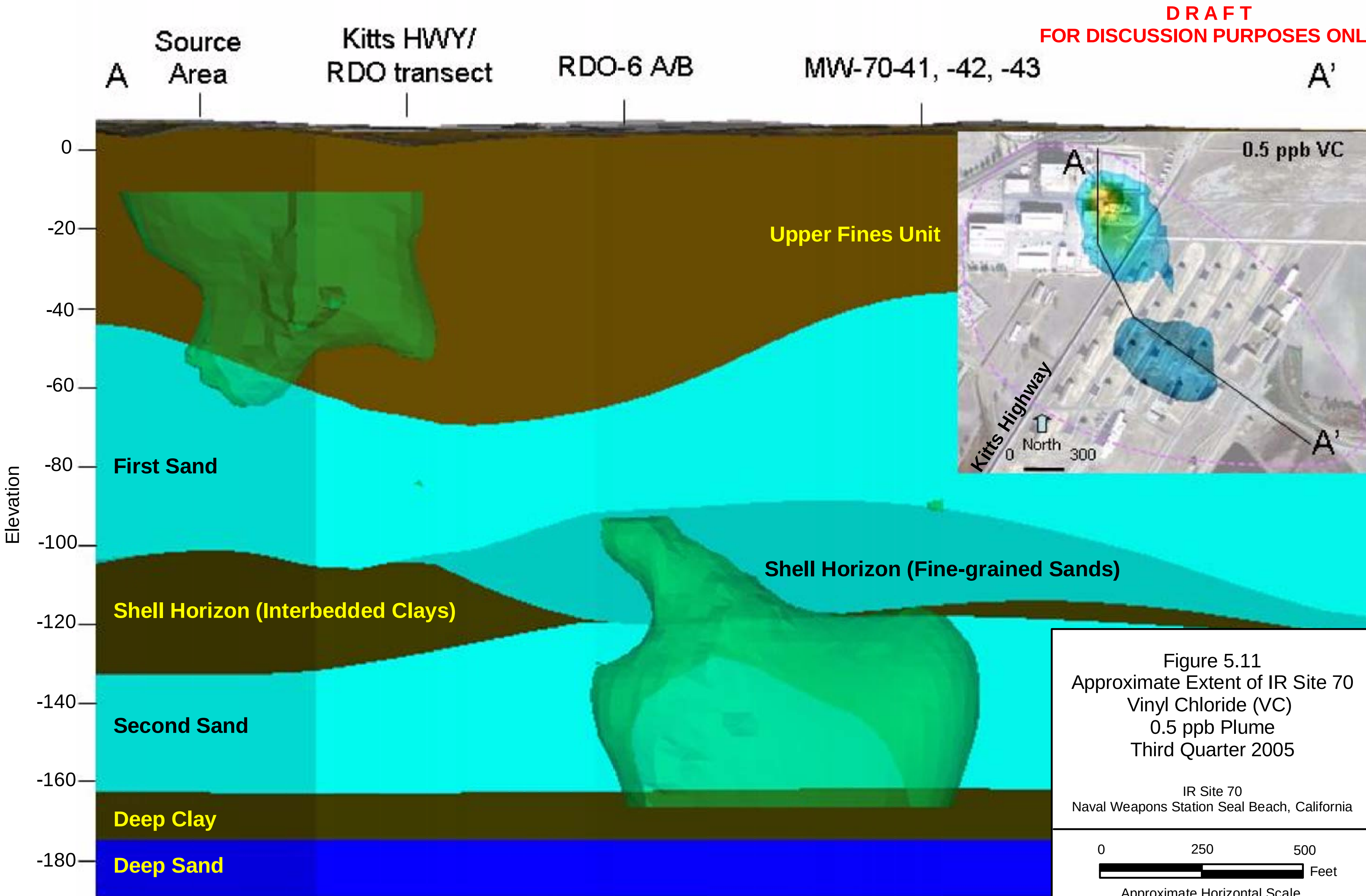

Figure 5.11
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
0.5 ppb Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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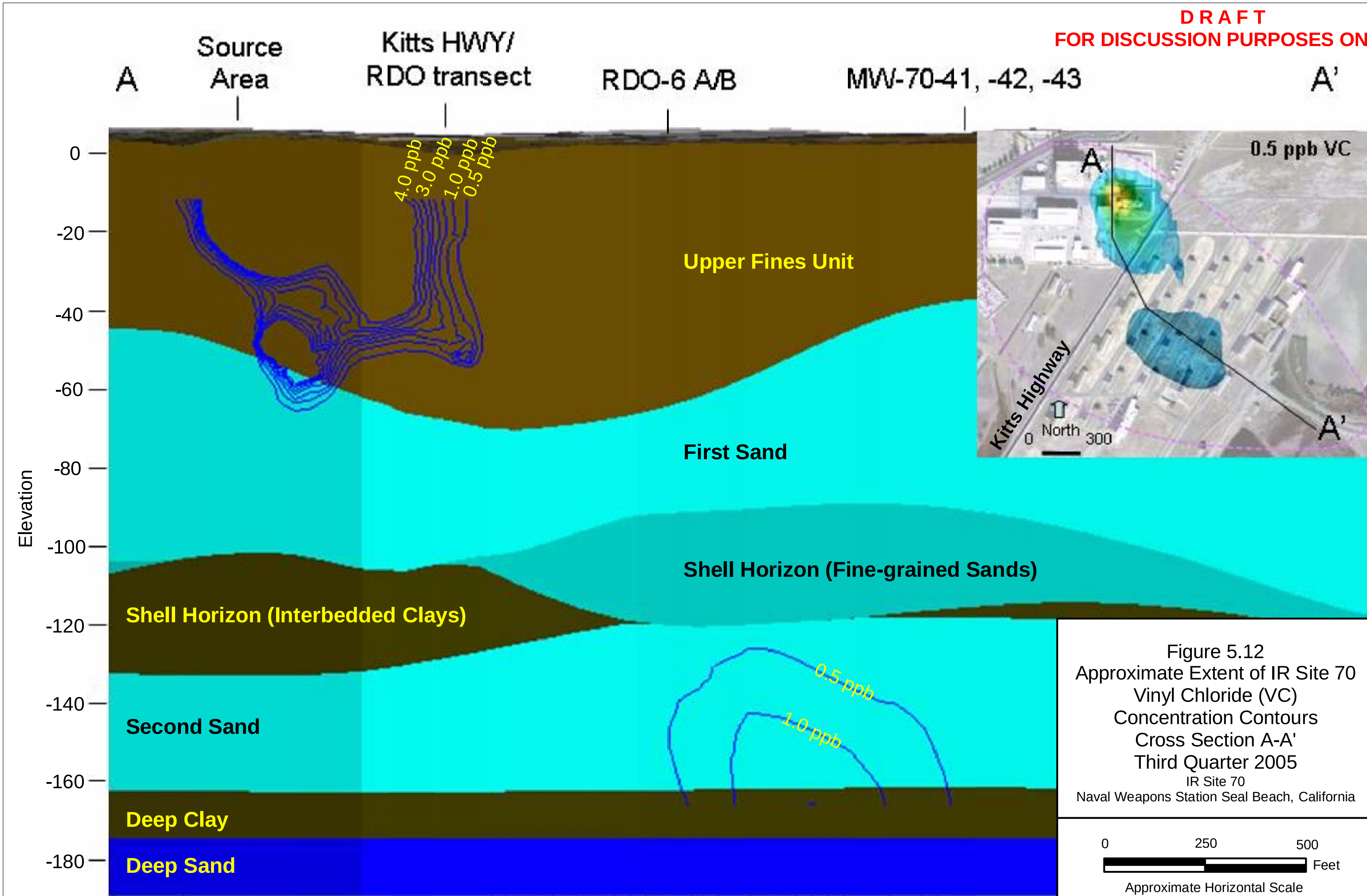

Figure 5.12
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
Concentration Contours
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
Contours in intervals of 0.5 ppb
ppb = parts per billion

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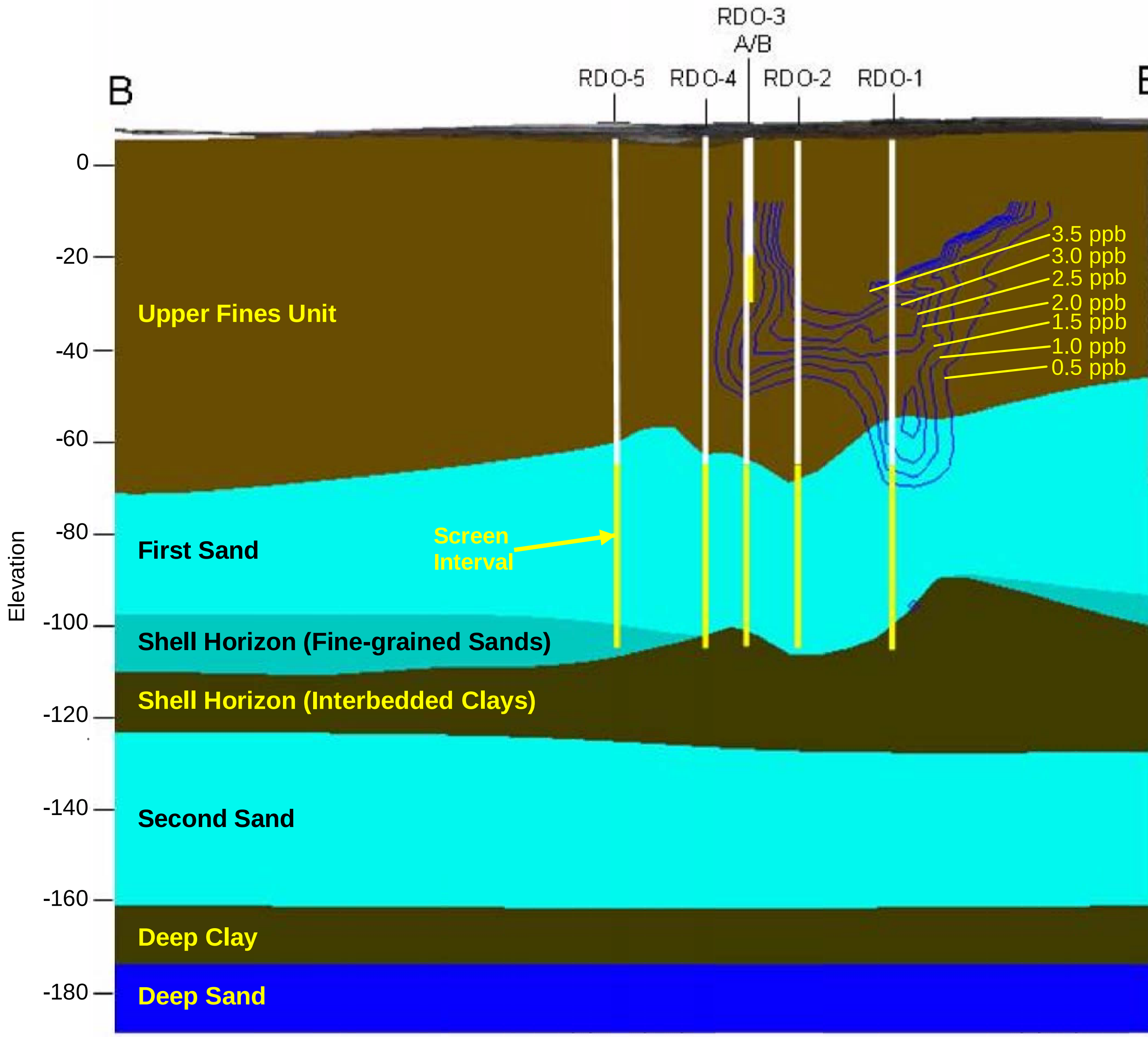

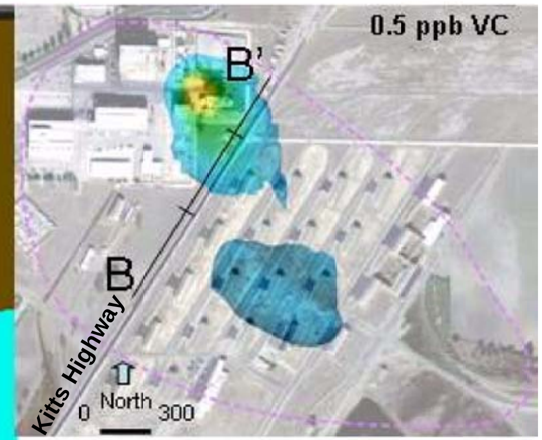

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 5.13
Approximate Extent of IR Site 70
Vinyl Chloride (VC)
Transect With Concentration
Contours Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

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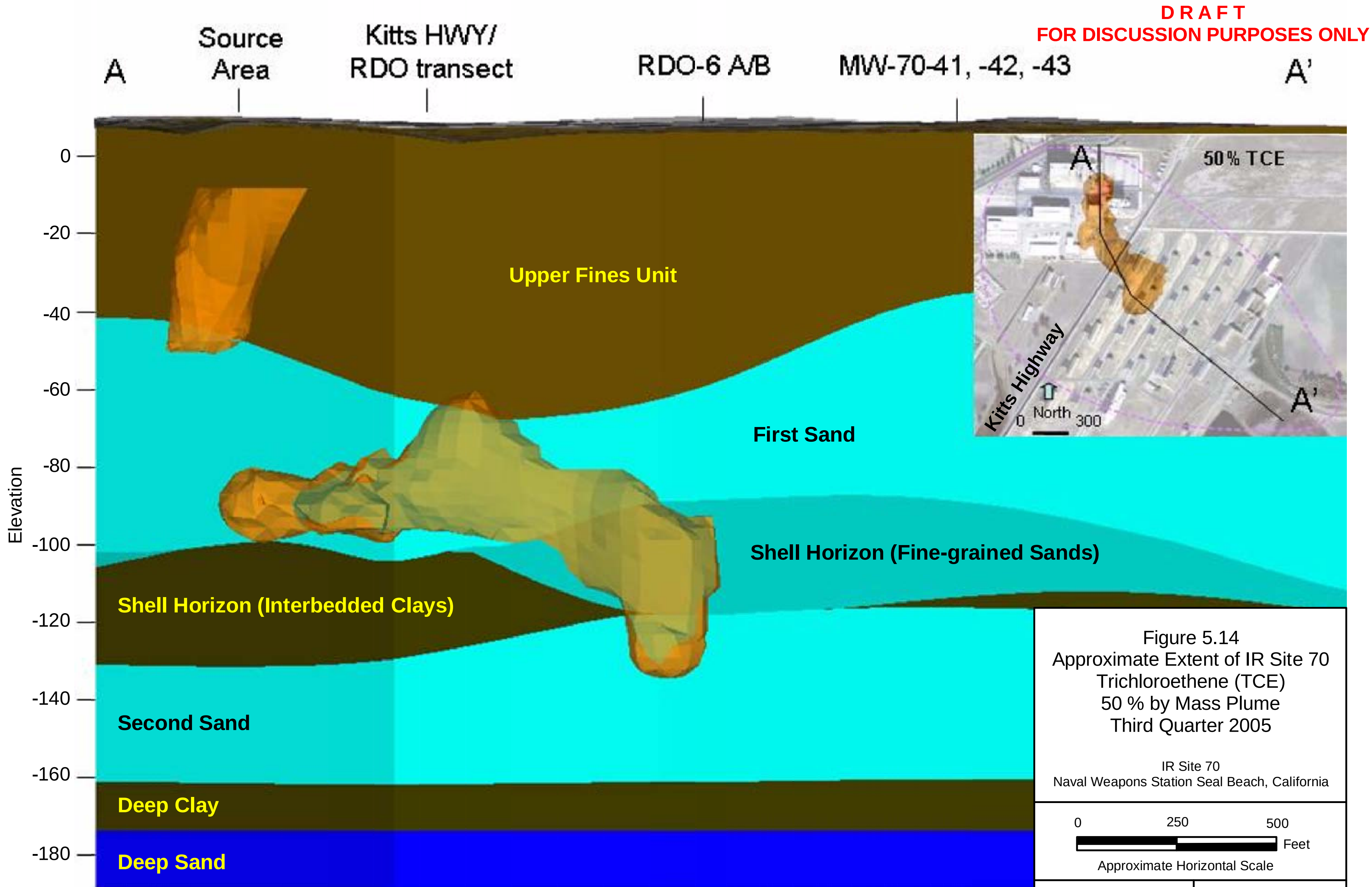

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

Figure 5.14
Approximate Extent of IR Site 70
Trichloroethene (TCE)
50 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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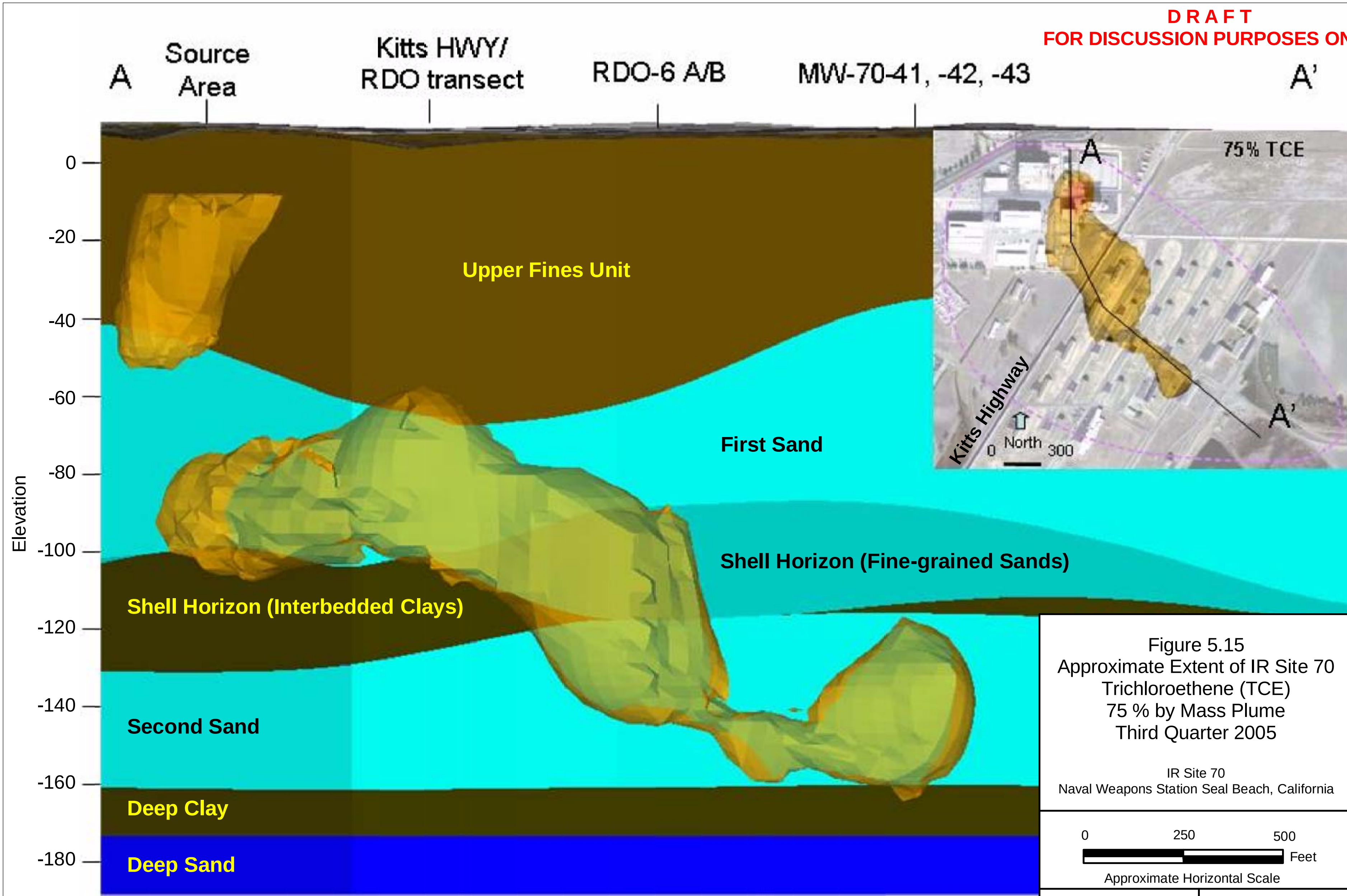

Figure 5.15
Approximate Extent of IR Site 70
Trichloroethene (TCE)
75 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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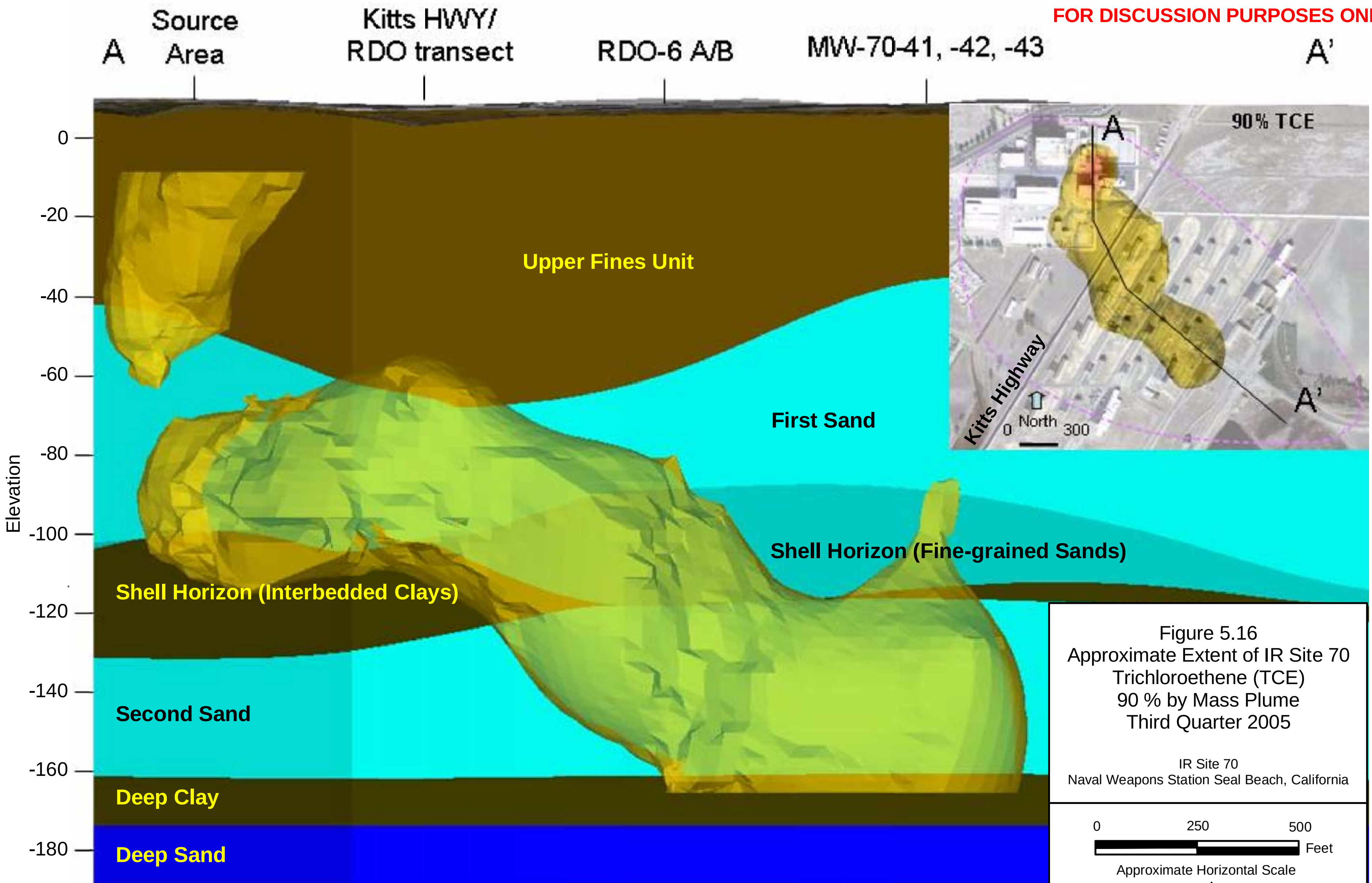

Figure 5.16
Approximate Extent of IR Site 70
Trichloroethene (TCE)
90 % by Mass Plume
Third Quarter 2005

IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

GeoSyntec Consultants

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)
ppb = parts per billion

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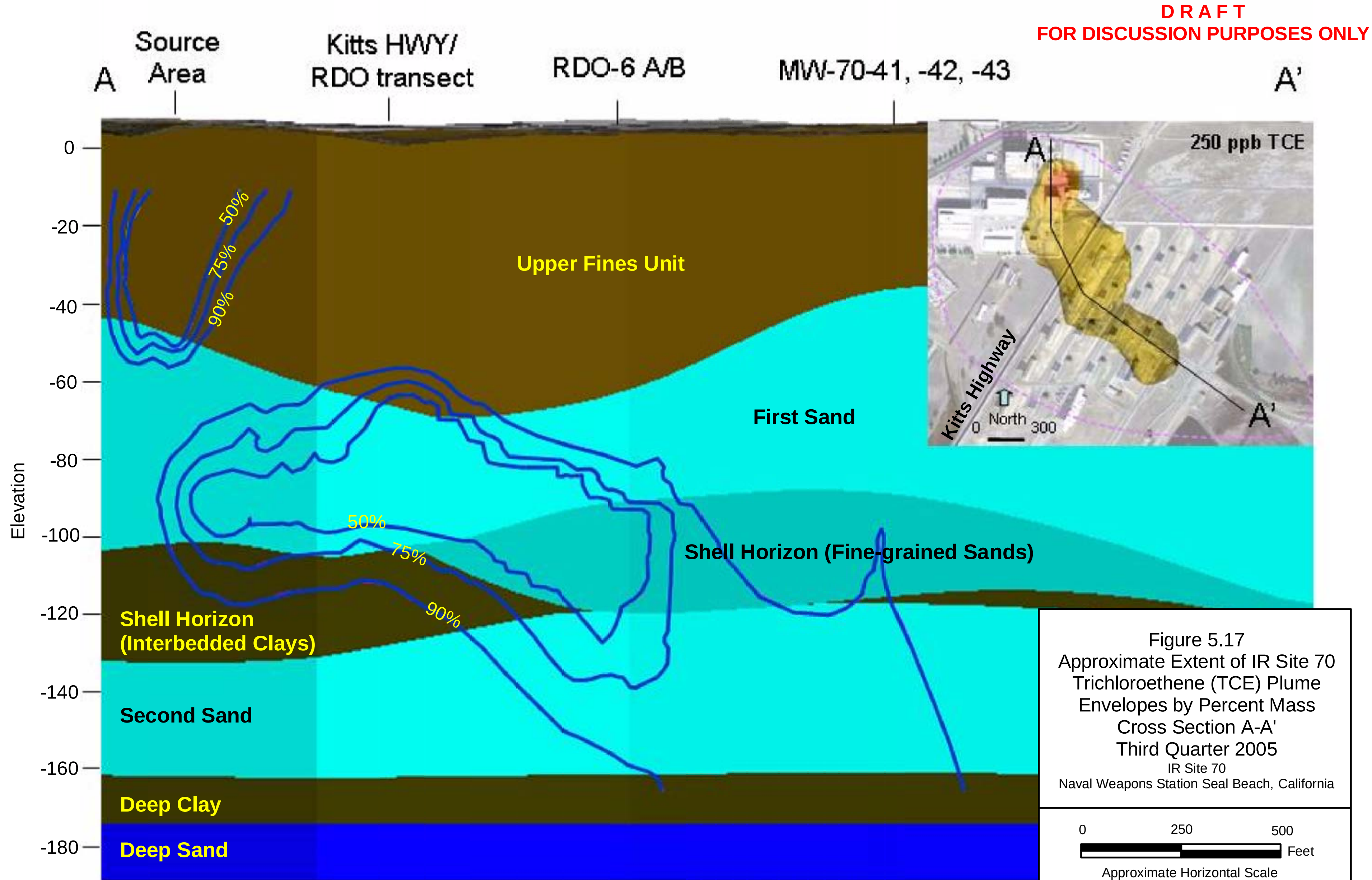

Figure 5.17
Approximate Extent of IR Site 70
Trichloroethene (TCE) Plume
Envelopes by Percent Mass
Cross Section A-A'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006 | Project No. HY0888

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Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)

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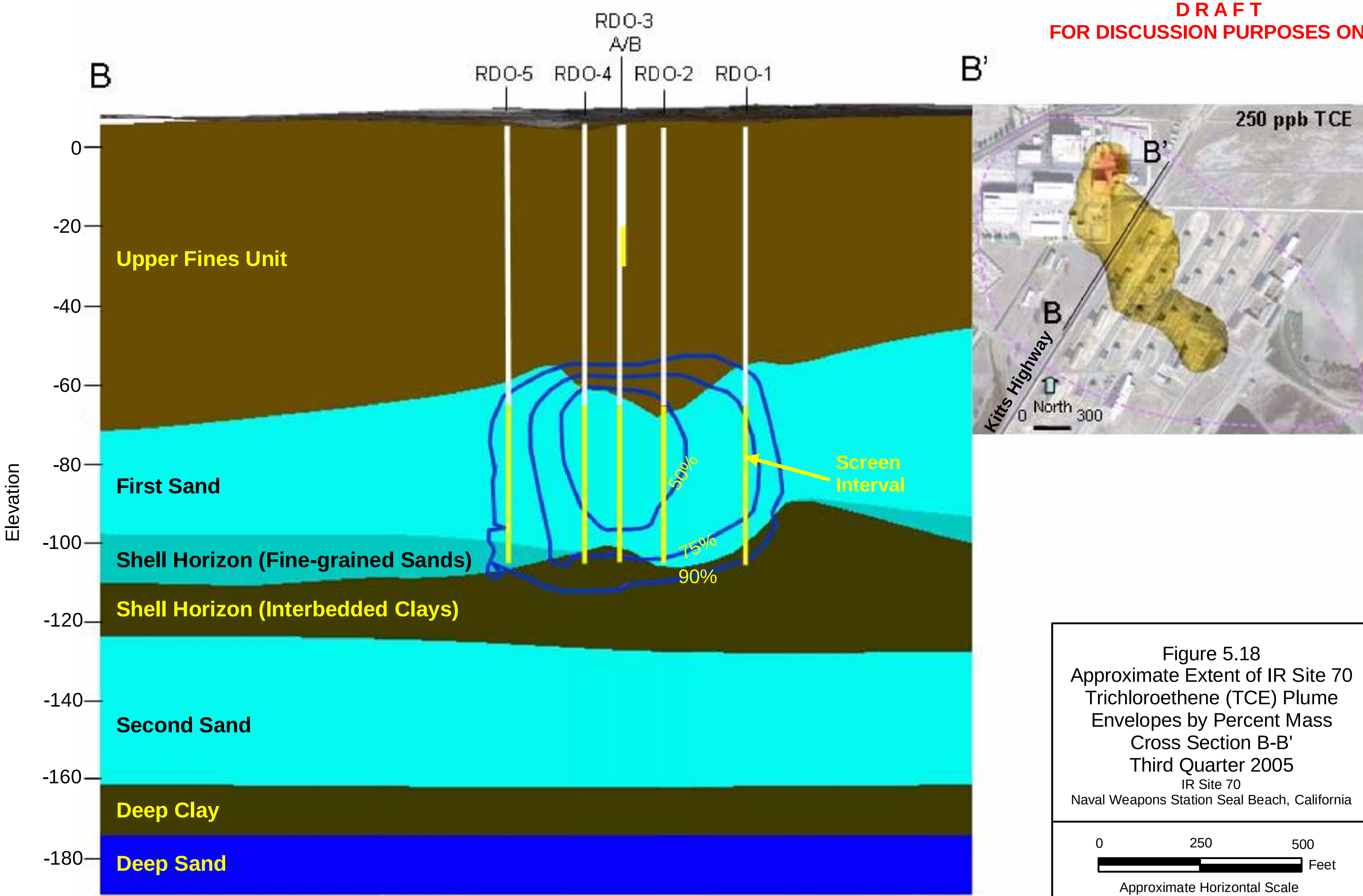

Vertical Scale feet relative to
National Geodetic Vertical Datum of 1929 (NGVD29)
Dashed line on inset represents TCE extent (Bechtel, 2006)

Figure 5.18
Approximate Extent of IR Site 70
Trichloroethene (TCE) Plume
Envelopes by Percent Mass
Cross Section B-B'
Third Quarter 2005
IR Site 70
Naval Weapons Station Seal Beach, California

0 250 500 Feet
Approximate Horizontal Scale

Date: August 2006	Project No. HY0888

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APPENDIX D-A
Analytical Data

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1,2-Trichloroethane	2.7	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	1.7	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	2.9	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	4.1	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	9.3	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	9.6	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	15	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1,2-Trichlorotrifluoroethane	120	UG/KG
CPT-SW2	S70-CPT-SW2D-SS-050902-20	FD	Soil	20	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethane	1.7	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethane	2.3	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethane	2.4	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	1,1-Dichloroethane	2.8	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethene	2	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	1,1-Dichloroethene	2.1	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethene	2.1	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	1,1-Dichloroethene	18	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Acetone	4.4	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Acetone	4.6	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	VOCs	EPA 8260B	Acetone	5	UG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	VOCs	EPA 8260B	Acetone	5.1	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Acetone	5.1	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	VOCs	EPA 8260B	Acetone	5.2	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Acetone	5.5	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	VOCs	EPA 8260B	Acetone	5.9	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	Acetone	5.9	UG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	VOCs	EPA 8260B	Acetone	6	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	VOCs	EPA 8260B	Acetone	6	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	Acetone	6.2	UG/KG
CPT-SW2	S70-CPT-SW2D-SS-050902-60	FD	Soil	60	9/2/2005	VOCs	EPA 8260B	Acetone	6.6	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	Acetone	6.6	UG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	VOCs	EPA 8260B	Acetone	7.3	UG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	Acetone	7.3	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	Acetone	7.4	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	Acetone	7.5	UG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	VOCs	EPA 8260B	Acetone	7.6	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	VOCs	EPA 8260B	Acetone	7.8	UG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	VOCs	EPA 8260B	Acetone	7.9	UG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	VOCs	EPA 8260B	Acetone	7.9	UG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	VOCs	EPA 8260B	Acetone	8	UG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Acetone	8.1	UG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	VOCs	EPA 8260B	Acetone	8.2	UG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	Acetone	8.3	UG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	VOCs	EPA 8260B	Acetone	8.3	UG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	Acetone	8.3	UG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	VOCs	EPA 8260B	Acetone	8.8	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	Acetone	8.9	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	VOCs	EPA 8260B	Acetone	9	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	VOCs	EPA 8260B	Acetone	9.1	UG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	VOCs	EPA 8260B	Acetone	9.2	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	VOCs	EPA 8260B	Acetone	9.2	UG/KG
CPT-SW2	S70-CPT-SW2D-SS-050902-20	FD	Soil	20	9/2/2005	VOCs	EPA 8260B	Acetone	9.2	UG/KG
CPT-W4	S70-CPT-W4D-SS-050906-40	FD	Soil	40	9/6/2005	VOCs	EPA 8260B	Acetone	9.2	UG/KG
CPT-W4	S70-CPT-W4D-SS-050906-60	FD	Soil	60	9/6/2005	VOCs	EPA 8260B	Acetone	9.2	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	VOCs	EPA 8260B	Acetone	9.4	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	VOCs	EPA 8260B	Acetone	10	UG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	Acetone	10	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	VOCs	EPA 8260B	Acetone	11	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	VOCs	EPA 8260B	Acetone	12	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	Acetone	12	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Acetone	20	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Antimony	3.5	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Antimony	4.4	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Antimony	6.5	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Antimony	8.3	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6020	Arsenic	0.73	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6020	Arsenic	0.81	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6020	Arsenic	0.84	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6020	Arsenic	1	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6020	Arsenic	1	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6020	Arsenic	1.2	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6020	Arsenic	1.2	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6020	Arsenic	1.3	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6020	Arsenic	1.3	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6020	Arsenic	1.4	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6020	Arsenic	1.5	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6020	Arsenic	1.5	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6020	Arsenic	1.6	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6020	Arsenic	1.7	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6020	Arsenic	1.7	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6020	Arsenic	1.9	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6020	Arsenic	2	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6020	Arsenic	2	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6020	Arsenic	2.1	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6020	Arsenic	2.4	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6020	Arsenic	2.6	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6020	Arsenic	2.7	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6020	Arsenic	2.8	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6020	Arsenic	3	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6020	Arsenic	3.3	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6020	Arsenic	3.3	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6020	Arsenic	3.3	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6020	Arsenic	4.4	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6020	Arsenic	5	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6020	Arsenic	5.2	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6020	Arsenic	6.2	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6020	Arsenic	8.2	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6020	Arsenic	8.5	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Barium	12	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Barium	15	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Barium	15	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Barium	16	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Barium	16	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Barium	18	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Barium	20	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Barium	20	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Barium	20	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Barium	21	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Barium	22	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Barium	22	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Barium	23	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Barium	24	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Barium	29	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Barium	29	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Barium	30	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Barium	30	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Barium	31	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Barium	35	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Barium	35	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Barium	39	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Barium	42	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Barium	44	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Barium	53	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Barium	53	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Barium	54	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Barium	67	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Barium	74	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Barium	75	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Barium	77	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Barium	81	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Barium	82	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Barium	86	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Barium	99	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Barium	104	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Barium	104	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Barium	112	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Barium	124	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Barium	531	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Beryllium	0.06	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Beryllium	0.07	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Beryllium	0.08	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Beryllium	0.1	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Beryllium	0.2	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Beryllium	0.3	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Beryllium	0.3	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Beryllium	0.3	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Beryllium	0.3	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Beryllium	0.4	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Beryllium	0.4	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Beryllium	0.4	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Beryllium	0.4	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Beryllium	0.4	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Beryllium	0.5	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Beryllium	0.5	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Beryllium	0.6	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Beryllium	0.6	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Beryllium	0.6	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Beryllium	0.7	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Beryllium	0.8	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Beryllium	0.8	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Beryllium	1.2	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Inorganic	EPA 9056	Bromide	2	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Inorganic	EPA 9056	Bromide	3	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Bromide	3	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Inorganic	EPA 9056	Bromide	4	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Bromide	5	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Cadmium	0.6	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Cadmium	0.9	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Calcium	1210	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Calcium	1310	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Calcium	1350	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Calcium	1420	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Calcium	1490	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Calcium	1500	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Calcium	1560	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Calcium	1610	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Calcium	1640	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Calcium	1820	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Calcium	1820	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Calcium	1880	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Calcium	2090	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Calcium	2110	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Calcium	2110	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Calcium	2140	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Calcium	2360	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Calcium	2410	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Calcium	2730	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Calcium	2840	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Calcium	2910	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Calcium	2990	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Calcium	3200	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Calcium	3320	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Calcium	3720	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Calcium	4100	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Calcium	4280	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Calcium	5210	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Calcium	5350	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Calcium	5850	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Calcium	6530	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Calcium	7540	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Calcium	7680	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Calcium	8950	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Calcium	9670	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Calcium	12900	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Calcium	14100	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Calcium	14700	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Calcium	17300	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Calcium	19300	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Inorganic	EPA 9056	Chloride by IC	9.9	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Chloride by IC	14	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Chloride by IC	20	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Inorganic	EPA 9056	Chloride by IC	23	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Inorganic	EPA 9056	Chloride by IC	25	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Inorganic	EPA 9056	Chloride by IC	29	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Inorganic	EPA 9056	Chloride by IC	32	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Chloride by IC	33	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Inorganic	EPA 9056	Chloride by IC	37	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Inorganic	EPA 9056	Chloride by IC	37	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Inorganic	EPA 9056	Chloride by IC	38	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Inorganic	EPA 9056	Chloride by IC	39	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Inorganic	EPA 9056	Chloride by IC	47	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Inorganic	EPA 9056	Chloride by IC	47	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Inorganic	EPA 9056	Chloride by IC	49	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Inorganic	EPA 9056	Chloride by IC	51	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Inorganic	EPA 9056	Chloride by IC	52	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Inorganic	EPA 9056	Chloride by IC	53	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Inorganic	EPA 9056	Chloride by IC	56	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Inorganic	EPA 9056	Chloride by IC	57	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Inorganic	EPA 9056	Chloride by IC	71	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Inorganic	EPA 9056	Chloride by IC	74	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Inorganic	EPA 9056	Chloride by IC	79	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Inorganic	EPA 9056	Chloride by IC	88	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Inorganic	EPA 9056	Chloride by IC	89	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Inorganic	EPA 9056	Chloride by IC	100	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Inorganic	EPA 9056	Chloride by IC	160	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Inorganic	EPA 9056	Chloride by IC	190	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Inorganic	EPA 9056	Chloride by IC	210	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Inorganic	EPA 9056	Chloride by IC	230	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Inorganic	EPA 9056	Chloride by IC	230	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Inorganic	EPA 9056	Chloride by IC	230	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Inorganic	EPA 9056	Chloride by IC	250	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Inorganic	EPA 9056	Chloride by IC	450	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Inorganic	EPA 9056	Chloride by IC	490	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Inorganic	EPA 9056	Chloride by IC	700	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Inorganic	EPA 9056	Chloride by IC	800	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Chloride by IC	800	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Inorganic	EPA 9056	Chloride by IC	840	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Chloride by IC	1100	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	Chloroform	2.2	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Chloroform	2.8	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	VOCs	EPA 8260B	Chloroform	6.4	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Chloroform	12	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	Chloroform	15	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Chromium (Total)	3	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Chromium (Total)	3.1	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Chromium (Total)	3.2	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Chromium (Total)	4	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Chromium (Total)	4.3	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Chromium (Total)	4.9	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Chromium (Total)	5.1	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Chromium (Total)	5.5	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Chromium (Total)	6.8	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Chromium (Total)	7	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Chromium (Total)	7.4	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Chromium (Total)	7.5	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Chromium (Total)	7.7	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Chromium (Total)	8.2	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Chromium (Total)	9	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Chromium (Total)	9.4	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Chromium (Total)	9.6	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Chromium (Total)	9.7	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Chromium (Total)	10	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Chromium (Total)	10	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Chromium (Total)	11	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Chromium (Total)	12	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Chromium (Total)	12	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Chromium (Total)	12	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Chromium (Total)	12	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Chromium (Total)	13	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Chromium (Total)	13	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Chromium (Total)	13	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Chromium (Total)	14	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Chromium (Total)	16	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Chromium (Total)	16	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Chromium (Total)	17	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Chromium (Total)	20	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Chromium (Total)	21	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Chromium (Total)	23	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Chromium (Total)	28	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Chromium (Total)	28	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Chromium (Total)	29	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Chromium (Total)	44	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Chromium (Total)	2040	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	1.9	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	2.8	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	3.9	UG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	4.1	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	6.1	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	6.8	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	7.4	UG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	12	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	15	UG/KG
CPT-SW2	S70-CPT-SW2D-SS-050902-20	FD	Soil	20	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	17	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	19	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	22	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	31	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	36	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	47	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	49	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	63	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	88	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	150	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	180	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	cis-1,2-Dichloroethene	750	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Cobalt	0.8	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Cobalt	1	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Cobalt	1.1	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Cobalt	1.2	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Cobalt	1.4	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Cobalt	1.4	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Cobalt	1.4	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Cobalt	1.6	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Cobalt	1.6	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Cobalt	1.7	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Cobalt	2	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Cobalt	2.1	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Cobalt	2.1	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Cobalt	2.4	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Cobalt	2.4	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Cobalt	2.4	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Cobalt	2.5	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Cobalt	2.9	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Cobalt	3.1	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Cobalt	3.4	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Cobalt	3.5	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Cobalt	3.6	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Cobalt	4	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Cobalt	4.4	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Cobalt	4.4	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Cobalt	4.9	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Cobalt	4.9	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Cobalt	5	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Cobalt	5.5	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Cobalt	5.7	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Cobalt	6.2	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Cobalt	7.4	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Cobalt	7.7	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Cobalt	8.2	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Cobalt	8.5	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Cobalt	8.8	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Cobalt	8.9	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Cobalt	9.9	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Cobalt	10	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Cobalt	14	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Copper	0.5	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Copper	0.7	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Copper	0.8	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Copper	1	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Copper	1.2	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Copper	1.3	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Copper	1.4	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Copper	1.4	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Copper	1.5	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Copper	1.5	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Copper	1.6	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Copper	1.6	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Copper	1.8	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Copper	1.8	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Copper	1.9	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Copper	2.3	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Copper	2.3	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Copper	2.5	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Copper	2.6	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Copper	2.6	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Copper	3.4	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Copper	3.7	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Copper	3.8	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Copper	4.5	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Copper	6.4	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Copper	7	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Copper	7.6	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Copper	7.7	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Copper	8.9	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Copper	10	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Copper	11	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Copper	11	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Copper	11	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Copper	14	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Copper	16	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Copper	17	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Copper	19	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Copper	22	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Copper	34	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Copper	44	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Iron	3710	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Iron	4190	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Iron	4740	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Iron	5490	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Iron	5690	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Iron	6230	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Iron	6370	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Iron	6460	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Iron	6550	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Iron	6570	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Iron	7030	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Iron	7100	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Iron	7320	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Iron	7340	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Iron	7590	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Iron	7600	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Iron	9560	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Iron	12300	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Iron	12900	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Iron	12900	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Iron	13000	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Iron	13100	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Iron	13300	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Iron	14600	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Iron	14800	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Iron	14800	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Iron	15300	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Iron	15500	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Iron	15700	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Iron	16800	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Iron	17900	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Iron	18100	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Iron	18500	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Iron	20400	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Iron	21600	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Iron	22000	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Iron	23000	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Iron	23400	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Iron	24500	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Iron	30500	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Lead	4.4	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Lead	4.8	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Lead	5.3	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Lead	6.6	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Lead	7.8	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Lead	8.6	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Lead	8.9	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Lead	9.9	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Lead	9.9	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Lead	10	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Lead	11	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Lead	11	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Lead	12	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Lead	13	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Lead	13	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Lead	13	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Lead	14	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Lead	14	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Lead	15	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Lead	15	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Lead	15	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Lead	18	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Lead	19	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Lead	20	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Lead	21	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Lead	21	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Lead	22	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Lead	24	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Lead	24	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Lead	27	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Lead	27	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Lead	28	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Lead	38	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Lead	42	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Lead	47	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Lead	53	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Lead	60	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Lead	69	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Magnesium	917	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Magnesium	1070	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Magnesium	1090	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Magnesium	1260	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Magnesium	1270	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Magnesium	1320	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Magnesium	1350	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Magnesium	1390	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Magnesium	1650	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Magnesium	1710	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Magnesium	1750	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Magnesium	1750	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Magnesium	1770	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Magnesium	1930	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Magnesium	2020	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Magnesium	2130	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Magnesium	2130	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Magnesium	2310	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Magnesium	2320	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Magnesium	2900	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Magnesium	2910	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Magnesium	3130	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Magnesium	3240	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Magnesium	3640	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Magnesium	3640	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Magnesium	3940	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Magnesium	3960	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Magnesium	4560	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Magnesium	4870	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Magnesium	5060	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Magnesium	5080	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Magnesium	5870	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Magnesium	6280	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Magnesium	7020	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Magnesium	8160	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Magnesium	8320	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Magnesium	9400	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Magnesium	9520	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Magnesium	10200	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Magnesium	13300	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 7471A	Mercury	0.007	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 7471A	Mercury	0.008	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 7471A	Mercury	0.009	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 7471A	Mercury	0.009	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 7471A	Mercury	0.009	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 7471A	Mercury	0.01	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 7471A	Mercury	0.01	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 7471A	Mercury	0.011	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 7471A	Mercury	0.011	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 7471A	Mercury	0.012	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 7471A	Mercury	0.014	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 7471A	Mercury	0.014	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 7471A	Mercury	0.015	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 7471A	Mercury	0.016	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 7471A	Mercury	0.017	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 7471A	Mercury	0.021	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 7471A	Mercury	0.028	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 7471A	Mercury	0.032	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 7471A	Mercury	0.033	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 7471A	Mercury	0.033	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 7471A	Mercury	0.033	MG/KG
CPT-SW2	S70-CPT-SW2D-SS-050902-20	FD	Soil	20	9/2/2005	VOCs	EPA 8260B	Methylene chloride	1.7	UG/KG
CPT-W4	S70-CPT-W4D-SS-050906-40	FD	Soil	40	9/6/2005	VOCs	EPA 8260B	Methylene chloride	1.7	UG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	VOCs	EPA 8260B	Methylene chloride	1.8	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	Methylene chloride	1.8	UG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	Methylene chloride	1.9	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Methylene chloride	2.1	UG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	VOCs	EPA 8260B	Methylene chloride	2.2	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	VOCs	EPA 8260B	Methylene chloride	2.2	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	VOCs	EPA 8260B	Methylene chloride	2.2	UG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	VOCs	EPA 8260B	Methylene chloride	2.3	UG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	VOCs	EPA 8260B	Methylene chloride	2.4	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	Methylene chloride	2.4	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	VOCs	EPA 8260B	Methylene chloride	2.7	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	Methylene chloride	2.8	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Methylene chloride	2.8	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	VOCs	EPA 8260B	Methylene chloride	2.9	UG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	Methylene chloride	3.1	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	VOCs	EPA 8260B	Methylene chloride	3.7	UG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Molybdenum	0.7	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Molybdenum	0.7	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Molybdenum	0.8	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Molybdenum	0.9	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Molybdenum	1	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Molybdenum	1	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Molybdenum	1	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Molybdenum	1	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Molybdenum	1.1	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Molybdenum	1.2	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Molybdenum	1.3	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Molybdenum	1.3	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Molybdenum	1.5	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Molybdenum	2.1	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Molybdenum	2.3	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Molybdenum	5	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Nickel	4.2	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Nickel	5.3	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Nickel	5.4	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Nickel	5.5	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Nickel	6.4	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Nickel	6.4	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Nickel	6.5	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Nickel	6.6	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Nickel	6.6	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Nickel	7.3	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Nickel	7.5	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Nickel	8.6	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Nickel	9	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Nickel	9.1	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Nickel	9.7	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Nickel	9.7	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Nickel	10	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Nickel	11	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Nickel	12	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Nickel	12	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Nickel	13	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Nickel	15	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Nickel	16	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Nickel	17	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Nickel	24	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Nickel	26	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Nickel	26	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Nickel	27	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Nickel	35	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Potassium	11	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Potassium	15	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Potassium	18	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Potassium	36	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Potassium	39	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Potassium	44	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Potassium	511	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Potassium	518	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Potassium	574	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Potassium	594	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Potassium	630	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Potassium	695	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Potassium	716	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Potassium	752	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Potassium	776	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Potassium	780	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Potassium	847	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Potassium	851	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Potassium	876	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Potassium	967	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Potassium	980	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Potassium	1130	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Potassium	1210	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Potassium	1220	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Potassium	1430	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Potassium	1670	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Potassium	1710	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Potassium	1890	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Potassium	1920	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Potassium	2320	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Potassium	2320	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Potassium	3020	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Potassium	3110	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Potassium	3150	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Potassium	3420	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Potassium	3720	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Potassium	3750	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Potassium	3880	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Potassium	4360	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Potassium	4600	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6020	Selenium	0.29	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6020	Selenium	0.46	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Silver	0.7	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Sodium	112	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Sodium	125	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Sodium	131	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Sodium	150	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Sodium	150	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Sodium	151	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Sodium	153	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Sodium	170	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Sodium	174	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Sodium	176	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Sodium	177	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Sodium	181	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Sodium	181	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Sodium	194	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Sodium	198	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Sodium	205	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Sodium	209	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Sodium	212	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Sodium	213	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Sodium	220	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Sodium	221	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Sodium	221	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Sodium	231	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Sodium	235	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Sodium	238	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Sodium	244	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Sodium	248	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Sodium	267	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Sodium	272	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Sodium	280	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Sodium	377	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Sodium	423	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Sodium	535	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Sodium	574	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Sodium	587	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Sodium	599	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Sodium	1110	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Sodium	1140	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Sodium	1290	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Sodium	1940	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Inorganic	EPA 9056	Sulfate	23	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Sulfate	26	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Sulfate	29	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Inorganic	EPA 9056	Sulfate	34	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Inorganic	EPA 9056	Sulfate	45	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Inorganic	EPA 9056	Sulfate	47	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Inorganic	EPA 9056	Sulfate	50	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Inorganic	EPA 9056	Sulfate	55	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Inorganic	EPA 9056	Sulfate	68	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Inorganic	EPA 9056	Sulfate	72	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Inorganic	EPA 9056	Sulfate	74	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Inorganic	EPA 9056	Sulfate	77	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Inorganic	EPA 9056	Sulfate	79	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Inorganic	EPA 9056	Sulfate	87	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Inorganic	EPA 9056	Sulfate	91	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Inorganic	EPA 9056	Sulfate	93	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Inorganic	EPA 9056	Sulfate	93	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Inorganic	EPA 9056	Sulfate	100	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Inorganic	EPA 9056	Sulfate	110	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Inorganic	EPA 9056	Sulfate	110	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Inorganic	EPA 9056	Sulfate	120	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Sulfate	130	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Inorganic	EPA 9056	Sulfate	130	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Inorganic	EPA 9056	Sulfate	140	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Inorganic	EPA 9056	Sulfate	140	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Inorganic	EPA 9056	Sulfate	150	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Inorganic	EPA 9056	Sulfate	160	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Inorganic	EPA 9056	Sulfate	160	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Inorganic	EPA 9056	Sulfate	160	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Inorganic	EPA 9056	Sulfate	170	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Inorganic	EPA 9056	Sulfate	230	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Inorganic	EPA 9056	Sulfate	240	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Inorganic	EPA 9056	Sulfate	250	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Inorganic	EPA 9056	Sulfate	300	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Inorganic	EPA 9056	Sulfate	400	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Inorganic	EPA 9056	Sulfate	430	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Inorganic	EPA 9056	Sulfate	500	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Inorganic	EPA 9056	Sulfate	510	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Inorganic	EPA 9056	Sulfate	610	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Inorganic	EPA 9056	Sulfate	1200	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Tetrachloroethene	4.1	UG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Tetrachloroethene	8.1	UG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6020	Thallium	0.02	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6020	Thallium	0.02	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6020	Thallium	0.03	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6020	Thallium	0.04	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6020	Thallium	0.046	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6020	Thallium	0.048	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6020	Thallium	0.056	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6020	Thallium	0.06	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6020	Thallium	0.062	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6020	Thallium	0.07	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6020	Thallium	0.073	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6020	Thallium	0.078	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6020	Thallium	0.08	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6020	Thallium	0.088	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6020	Thallium	0.09	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6020	Thallium	0.09	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6020	Thallium	0.098	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6020	Thallium	0.1	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6020	Thallium	0.12	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6020	Thallium	0.12	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6020	Thallium	0.15	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6020	Thallium	0.15	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6020	Thallium	0.16	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6020	Thallium	0.16	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6020	Thallium	0.21	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6020	Thallium	0.22	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6020	Thallium	0.22	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6020	Thallium	0.22	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6020	Thallium	0.22	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6020	Thallium	0.26	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6020	Thallium	0.27	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6020	Thallium	0.28	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6020	Thallium	0.3	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	TOC	WBLACK	Total Organic Carbon	315	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	TOC	WBLACK	Total Organic Carbon	315	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	TOC	WBLACK	Total Organic Carbon	315	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	TOC	WBLACK	Total Organic Carbon	317	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	TOC	WBLACK	Total Organic Carbon	317	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	TOC	WBLACK	Total Organic Carbon	317	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	TOC	WBLACK	Total Organic Carbon	472	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	TOC	WBLACK	Total Organic Carbon	476	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	TOC	WBLACK	Total Organic Carbon	476	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	TOC	WBLACK	Total Organic Carbon	476	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	TOC	WBLACK	Total Organic Carbon	476	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	TOC	WBLACK	Total Organic Carbon	634	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	TOC	WBLACK	Total Organic Carbon	634	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	TOC	WBLACK	Total Organic Carbon	634	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	TOC	WBLACK	Total Organic Carbon	634	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	TOC	WBLACK	Total Organic Carbon	793	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	TOC	WBLACK	Total Organic Carbon	951	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	TOC	WBLACK	Total Organic Carbon	1110	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	TOC	WBLACK	Total Organic Carbon	1260	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	TOC	WBLACK	Total Organic Carbon	1430	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	TOC	WBLACK	Total Organic Carbon	1590	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	TOC	WBLACK	Total Organic Carbon	1900	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	TOC	WBLACK	Total Organic Carbon	2380	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	TOC	WBLACK	Total Organic Carbon	2380	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	TOC	WBLACK	Total Organic Carbon	3800	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	TOC	WBLACK	Total Organic Carbon	4120	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	TOC	WBLACK	Total Organic Carbon	4910	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	TOC	WBLACK	Total Organic Carbon	5070	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	TOC	WBLACK	Total Organic Carbon	14000	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	TOC	WBLACK	Total Organic Carbon	14100	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	1.6	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	1.9	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	2.3	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	3.9	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	5	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	6.4	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	8.3	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	8.6	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	trans-1,2-Dichloroethene	28	UG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	VOCs	EPA 8260B	Trichloroethene	1.8	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	VOCs	EPA 8260B	Trichloroethene	3.2	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	Trichloroethene	3.7	UG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	VOCs	EPA 8260B	Trichloroethene	5.5	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	VOCs	EPA 8260B	Trichloroethene	11	UG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-SW2	S70-CPT-SW2D-SS-050902-20	FD	Soil	20	9/2/2005	VOCs	EPA 8260B	Trichloroethene	29	UG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Trichloroethene	30	UG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	VOCs	EPA 8260B	Trichloroethene	40	UG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	VOCs	EPA 8260B	Trichloroethene	45	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	VOCs	EPA 8260B	Trichloroethene	76	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	VOCs	EPA 8260B	Trichloroethene	100	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	VOCs	EPA 8260B	Trichloroethene	120	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Trichloroethene	130	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	VOCs	EPA 8260B	Trichloroethene	180	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Trichloroethene	180	UG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	VOCs	EPA 8260B	Trichloroethene	190	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	VOCs	EPA 8260B	Trichloroethene	200	UG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	VOCs	EPA 8260B	Trichloroethene	200	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	VOCs	EPA 8260B	Trichloroethene	220	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	Trichloroethene	250	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Trichloroethene	590	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Trichloroethene	730	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	Trichloroethene	810	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Trichloroethene	12000	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Vanadium	6.9	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Vanadium	7.2	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Vanadium	7.8	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Vanadium	11	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Vanadium	11	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Vanadium	12	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Vanadium	12	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Vanadium	12	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Vanadium	13	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Vanadium	13	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Vanadium	14	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Vanadium	14	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Vanadium	15	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Vanadium	16	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Vanadium	16	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Vanadium	17	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Vanadium	18	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Vanadium	22	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Vanadium	25	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Vanadium	27	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Vanadium	27	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Vanadium	28	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Vanadium	28	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Vanadium	30	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Vanadium	31	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Vanadium	31	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Vanadium	32	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Vanadium	32	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Vanadium	33	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Vanadium	33	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Vanadium	37	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Vanadium	39	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Vanadium	41	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Vanadium	41	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Vanadium	42	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Vanadium	43	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Vanadium	45	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Vanadium	47	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Vanadium	49	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Vanadium	57	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	VOCs	EPA 8260B	Vinyl chloride	2.3	UG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Vinyl chloride	2.7	UG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	VOCs	EPA 8260B	Vinyl chloride	2.7	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	VOCs	EPA 8260B	Vinyl chloride	3.6	UG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	VOCs	EPA 8260B	Vinyl chloride	3.7	UG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Vinyl chloride	3.8	UG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	VOCs	EPA 8260B	Vinyl chloride	3.9	UG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	VOCs	EPA 8260B	Vinyl chloride	4.2	UG/KG
CPT-W2	S70-CPT-W2-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Zinc	6.9	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-50	FS	Soil	50	8/29/2005	Metals	EPA 6010B	Zinc	7.5	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-60	FS	Soil	60	8/31/2005	Metals	EPA 6010B	Zinc	7.8	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Zinc	8	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Zinc	8.5	MG/KG
CPT-W2	S70-CPT-W2-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Zinc	8.7	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Zinc	9.8	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Zinc	11	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-60	FS	Soil	60	9/8/2005	Metals	EPA 6010B	Zinc	11	MG/KG
CPT-E3	S70-CPT-E3-SS-050830-50	FS	Soil	50	8/30/2005	Metals	EPA 6010B	Zinc	12	MG/KG
CPT-N3	S70-CPT-N3-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Zinc	12	MG/KG

Table D-A-1 CPT SOIL DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Matrix	Depth	Sample Date	Suite	Method	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-SS-050831-50	FS	Soil	50	8/31/2005	Metals	EPA 6010B	Zinc	12	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-50	FS	Soil	50	9/1/2005	Metals	EPA 6010B	Zinc	13	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-50	FS	Soil	50	9/6/2005	Metals	EPA 6010B	Zinc	13	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-60	FS	Soil	60	8/29/2005	Metals	EPA 6010B	Zinc	15	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-45	FS	Soil	45	9/2/2005	Metals	EPA 6010B	Zinc	15	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-40	FS	Soil	40	9/2/2005	Metals	EPA 6010B	Zinc	16	MG/KG
CPT-S1	S70-CPT-S1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Zinc	17	MG/KG
CPT-SE1	S70-CPT-SE1-SS-050831-40	FS	Soil	40	8/31/2005	Metals	EPA 6010B	Zinc	17	MG/KG
CPT-E2	S70-CPT-E2-SS-050829-40	FS	Soil	40	8/29/2005	Metals	EPA 6010B	Zinc	21	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-45	FS	Soil	45	8/30/2005	Metals	EPA 6010B	Zinc	22	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-20	FS	Soil	20	9/2/2005	Metals	EPA 6010B	Zinc	22	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Zinc	23	MG/KG
CPT-W3	S70-CPT-W3-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Zinc	24	MG/KG
CPT-N1	S70-CPT-N1-SS-050830-20	FS	Soil	20	8/30/2005	Metals	EPA 6010B	Zinc	25	MG/KG
CPT-S3	S70-CPT-S3-SS-050901-40	FS	Soil	40	9/1/2005	Metals	EPA 6010B	Zinc	27	MG/KG
CPT-NW1	S70-CPT-NW1-SS-050908-21	FS	Soil	21	9/8/2005	Metals	EPA 6010B	Zinc	34	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-40	FS	Soil	40	9/6/2005	Metals	EPA 6010B	Zinc	34	MG/KG
CPT-B2	S70-CPT-B2-SS-050908-40	FS	Soil	40	9/8/2005	Metals	EPA 6010B	Zinc	37	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-50	FS	Soil	50	9/8/2005	Metals	EPA 6010B	Zinc	38	MG/KG
CPT-N2	S70-CPT-N2-SS-050830-60	FS	Soil	60	8/30/2005	Metals	EPA 6010B	Zinc	46	MG/KG
CPT-SW2	S70-CPT-SW2-SS-050902-60	FS	Soil	60	9/2/2005	Metals	EPA 6010B	Zinc	46	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-55	FS	Soil	55	9/1/2005	Metals	EPA 6010B	Zinc	50	MG/KG
CPT-SW1	S70-CPT-SW1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Zinc	54	MG/KG
CPT-E1	S70-CPT-E1-SS-050829-30	FS	Soil	30	8/29/2005	Metals	EPA 6010B	Zinc	55	MG/KG
CPT-S2	S70-CPT-S2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Zinc	58	MG/KG
CPT-W4	S70-CPT-W4-SS-050906-60	FS	Soil	60	9/6/2005	Metals	EPA 6010B	Zinc	59	MG/KG
CPT-SE2	S70-CPT-SE2-SS-050901-45	FS	Soil	45	9/1/2005	Metals	EPA 6010B	Zinc	63	MG/KG
CPT-B1	S70-CPT-B1-SS-050908-30	FS	Soil	30	9/8/2005	Metals	EPA 6010B	Zinc	66	MG/KG
CPT-W1	S70-CPT-W1-SS-050902-30	FS	Soil	30	9/2/2005	Metals	EPA 6010B	Zinc	83	MG/KG

Notes
FS-Field Sample
FD-Field Duplicate
mg/kg-milligrams per kilogram
ug/kg-micrograms per kilogram
CPT-cone penetrometer testing

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	7.6	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	1.2	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	0.63	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	2.1	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	0.9	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	2.1	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	75-34-3	1,1-Dichloroethane	1.9	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	75-35-4	1,1-Dichloroethene	0.43	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	75-35-4	1,1-Dichloroethene	0.55	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	75-35-4	1,1-Dichloroethene	0.53	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	75-35-4	1,1-Dichloroethene	0.26	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	VOCs	EPA 8260B	107-06-2	1,2-Dichloroethane	0.81	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	107-06-2	1,2-Dichloroethane	0.59	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	VOCs	EPA 8260B	78-87-5	1,2-Dichloropropane	0.4	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	67-64-1	Acetone	2.8	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	67-64-1	Acetone	3.2	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	67-64-1	Acetone	6.6	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.4	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6020	7440-38-2	Arsenic	5.4	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.1	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.8	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.5	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.3	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6020	7440-38-2	Arsenic	7.2	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6020	7440-38-2	Arsenic	0.94	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6020	7440-38-2	Arsenic	0.35	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6020	7440-38-2	Arsenic	2.6	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6020	7440-38-2	Arsenic	15	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6020	7440-38-2	Arsenic	2.8	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6020	7440-38-2	Arsenic	3	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6020	7440-38-2	Arsenic	9.6	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6020	7440-38-2	Arsenic	4	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6020	7440-38-2	Arsenic	0.8	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6020	7440-38-2	Arsenic	1.1	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6020	7440-38-2	Arsenic	7	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6020	7440-38-2	Arsenic	9.2	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6020	7440-38-2	Arsenic	2.5	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6020	7440-38-2	Arsenic	2.3	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6020	7440-38-2	Arsenic	2.6	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	3.5	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	6.9	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	12	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	5.5	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	2.8	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	2.9	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	6	MG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	3.2	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	5.4	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	7.9	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	5	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	6.6	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	7.1	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	7.4	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	4.1	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	29	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	19	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	24	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	25	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	9.9	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	7.5	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	General Chemistry	EPA 405.1	BOD	Biological Oxygen Demand	5.6	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1.3	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.3	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	2	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	2	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.7	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	3	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	22	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	1	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	2	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	15	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.6	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.8	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.8	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.8	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.9	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.9	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.3	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 300.0	24959-67-9	Bromide	0.3	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-70-2	Calcium	123000	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-70-2	Calcium	86700	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7440-70-2	Calcium	364000	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7440-70-2	Calcium	354000	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-70-2	Calcium	357000	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-70-2	Calcium	333000	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-70-2	Calcium	525000	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-70-2	Calcium	116000	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-70-2	Calcium	204000	UG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7440-70-2	Calcium	559000	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7440-70-2	Calcium	2380000	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	7440-70-2	Calcium	379000	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7440-70-2	Calcium	432000	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7440-70-2	Calcium	1470000	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7440-70-2	Calcium	251000	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	7440-70-2	Calcium	428000	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	7440-70-2	Calcium	400000	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7440-70-2	Calcium	323000	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7440-70-2	Calcium	392000	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7440-70-2	Calcium	387000	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6010B	7440-70-2	Calcium	139000	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6010B	7440-70-2	Calcium	133000	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	8.7	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	140	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	170	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	180	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	140	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	230	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	29	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	20	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	120	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	330	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	140	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	130	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	190	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	54	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	99	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	90	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	100	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	90	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	83	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	60	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	General Chemistry	EPA 410.4	COD	Chemical Oxygen Demand	58	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	200	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	66	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	340	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	280	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	200	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	510	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	950	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	120	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	270	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	780	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	6700	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	390	MG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	620	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	4300	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	200	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	320	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	310	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	250	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	260	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	400	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	75	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 300.0	16887-00-6	Chloride by IC	74	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	108-90-7	Chlorobenzene	0.1	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	75-00-3	Chloroethane	0.35	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	67-66-3	Chloroform	1.4	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	67-66-3	Chloroform	1.2	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	1	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	1.9	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	1.1	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	11	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	0.97	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	39	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	8.8	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	50	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	100	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	15	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	20	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	420	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	340	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	220	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	230	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	156-59-2	cis-1,2-Dichloroethene	15	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.44	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.37	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.35	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Organic Gases	RSK 175	74-84-0	Ethane	3	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.41	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Organic Gases	RSK 175	74-84-0	Ethane	1.7	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Organic Gases	RSK 175	74-84-0	Ethane	1.7	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Organic Gases	RSK 175	74-84-0	Ethane	2.6	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.68	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-84-0	Ethane	3.1	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.65	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-84-0	Ethane	0.66	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Organic Gases	RSK 175	74-85-1	Ethene	1.1	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Organic Gases	RSK 175	74-85-1	Ethene	1.3	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-89-6	Iron	31	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-89-6	Iron	28	UG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-89-6	Iron	90	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-89-6	Iron	219	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-89-6	Iron	21	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-89-6	Iron	389	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-89-6	Iron	42	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-89-6	Iron	42	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-89-6	Iron	336	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	7439-89-6	Iron	169	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-89-6	Iron	546	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-89-6	Iron	737	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-89-6	Iron	34	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	7439-89-6	Iron	68	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	7439-89-6	Iron	105	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-89-6	Iron	42	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-95-4	Magnesium	21300	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-95-4	Magnesium	14500	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-95-4	Magnesium	76100	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-95-4	Magnesium	78400	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-95-4	Magnesium	75700	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-95-4	Magnesium	68000	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-95-4	Magnesium	101000	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-95-4	Magnesium	20100	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-95-4	Magnesium	33300	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-95-4	Magnesium	109000	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-95-4	Magnesium	463000	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	7439-95-4	Magnesium	71100	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-95-4	Magnesium	81800	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-95-4	Magnesium	311000	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-95-4	Magnesium	42900	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	7439-95-4	Magnesium	73400	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	7439-95-4	Magnesium	68500	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-95-4	Magnesium	57200	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7439-95-4	Magnesium	66700	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7439-95-4	Magnesium	68100	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6010B	7439-95-4	Magnesium	24200	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6010B	7439-95-4	Magnesium	23500	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-96-5	Manganese	99	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-96-5	Manganese	63	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-96-5	Manganese	419	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7439-96-5	Manganese	364	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-96-5	Manganese	389	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-96-5	Manganese	412	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7439-96-5	Manganese	491	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-96-5	Manganese	105	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7439-96-5	Manganese	154	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-96-5	Manganese	571	UG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-96-5	Manganese	3430	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	7439-96-5	Manganese	312	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7439-96-5	Manganese	333	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7439-96-5	Manganese	1830	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-96-5	Manganese	219	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	7439-96-5	Manganese	369	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	7439-96-5	Manganese	357	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7439-96-5	Manganese	276	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7439-96-5	Manganese	262	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7439-96-5	Manganese	317	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6010B	7439-96-5	Manganese	112	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6010B	7439-96-5	Manganese	110	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Organic Gases	RSK 175	74-82-8	Methane	5.6	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Organic Gases	RSK 175	74-82-8	Methane	1.1	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Organic Gases	RSK 175	74-82-8	Methane	5.9	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Organic Gases	RSK 175	74-82-8	Methane	1.1	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Organic Gases	RSK 175	74-82-8	Methane	0.7	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Organic Gases	RSK 175	74-82-8	Methane	2.3	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Organic Gases	RSK 175	74-82-8	Methane	2.4	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Organic Gases	RSK 175	74-82-8	Methane	2.9	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Organic Gases	RSK 175	74-82-8	Methane	1.5	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Organic Gases	RSK 175	74-82-8	Methane	5.3	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Organic Gases	RSK 175	74-82-8	Methane	7.2	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Organic Gases	RSK 175	74-82-8	Methane	14	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Organic Gases	RSK 175	74-82-8	Methane	28	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Organic Gases	RSK 175	74-82-8	Methane	5	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Organic Gases	RSK 175	74-82-8	Methane	32	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Organic Gases	RSK 175	74-82-8	Methane	21	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Organic Gases	RSK 175	74-82-8	Methane	25	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Organic Gases	RSK 175	74-82-8	Methane	27	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-82-8	Methane	70	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-82-8	Methane	12	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Organic Gases	RSK 175	74-82-8	Methane	12	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Organic Gases	RSK 175	74-82-8	Methane	3.3	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Organic Gases	RSK 175	74-82-8	Methane	2.5	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.06	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.1	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.1	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.09	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.09	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.05	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.1	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 300.0	14797-55-8	Nitrate	0.05	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.014	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.027	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.66	MG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.4	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.091	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.022	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.3	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.014	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.065	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.046	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.012	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.011	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.064	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.028	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.003	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.009	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.014	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.027	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.047	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.14	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.02	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 354.1	14797-65-0	Nitrogen, Nitrite	0.03	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	9/7/7440	Potassium	8170	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	9/7/7440	Potassium	6780	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	9/7/7440	Potassium	9920	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	9/7/7440	Potassium	17100	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	9/7/7440	Potassium	12900	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	9/7/7440	Potassium	16500	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	9/7/7440	Potassium	17200	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	9/7/7440	Potassium	10700	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	9/7/7440	Potassium	16900	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	9/7/7440	Potassium	9810	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	9/7/7440	Potassium	19200	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	9/7/7440	Potassium	16800	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	9/7/7440	Potassium	39200	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	9/7/7440	Potassium	15100	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	9/7/7440	Potassium	10100	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	9/7/7440	Potassium	13900	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	9/7/7440	Potassium	10100	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	9/7/7440	Potassium	10200	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	9/7/7440	Potassium	11400	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	9/7/7440	Potassium	27700	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6010B	9/7/7440	Potassium	9620	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6010B	9/7/7440	Potassium	9460	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-23-5	Sodium	63000	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-23-5	Sodium	54500	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7440-23-5	Sodium	292000	UG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Metals	EPA 6010B	7440-23-5	Sodium	222000	UG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-23-5	Sodium	166000	UG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-23-5	Sodium	306000	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Metals	EPA 6010B	7440-23-5	Sodium	435000	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-23-5	Sodium	168000	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Metals	EPA 6010B	7440-23-5	Sodium	196000	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7440-23-5	Sodium	201000	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7440-23-5	Sodium	1690000	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Metals	EPA 6010B	7440-23-5	Sodium	172000	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Metals	EPA 6010B	7440-23-5	Sodium	260000	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Metals	EPA 6010B	7440-23-5	Sodium	1100000	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7440-23-5	Sodium	78000	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Metals	EPA 6010B	7440-23-5	Sodium	136000	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Metals	EPA 6010B	7440-23-5	Sodium	130000	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Metals	EPA 6010B	7440-23-5	Sodium	103000	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7440-23-5	Sodium	128000	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Metals	EPA 6010B	7440-23-5	Sodium	140000	UG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Metals	EPA 6010B	7440-23-5	Sodium	75700	UG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Metals	EPA 6010B	7440-23-5	Sodium	75000	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	89	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	110	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	870	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	800	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	620	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	680	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	900	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	300	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	360	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	760	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	860	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	570	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	790	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	820	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	400	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	930	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	870	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	510	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	670	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	760	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	290	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 300.0	14808-79-8	Sulfate	290	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	127-18-4	Tetrachloroethene	0.26	UG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	108-88-3	Toluene	0.12	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	820	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	500	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2330	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2020	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2000	MG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2240	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	3440	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1050	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1260	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	3290	MG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	14800	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1830	MG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2750	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	10300	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1190	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2420	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2290	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1510	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	1870	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	2130	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	790	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	Inorganic	EPA 160.1	TDS	Total Dissolved Solids (TDS)	780	MG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	3.9	MG/L
CPT-B2	S70-CPT-B2-GW-050908-60	FS	60	9/8/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	5.9	MG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	9	MG/L
CPT-E2	S70-CPT-E2-GW-050829-60	FS	60	8/29/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	7.3	MG/L
CPT-E3	S70-CPT-E3-GW-050830-60	FS	60	8/30/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	3.5	MG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	4.3	MG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	5.3	MG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	11.3	MG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	4.9	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	3	MG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	2.4	MG/L

TABLE D-A-2 CPT GROUNDWATER DETECTIONS
IR Site 70
Naval Weapons Station Seal Beach, California

Location	Client Sample Name	Sample Type	Depth (feet)	Sample Date	Suite	Method	CASNO	Analyte	RESULT	UNITS
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	3.7	MG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	2.9	MG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	1.4	MG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	5	MG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	4.2	MG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	3.4	MG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	11.8	MG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	6.7	MG/L
CPT-W4	S70-CPT-W4D-GW-050906-50	FD	50	9/6/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	1	MG/L
CPT-W4	S70-CPT-W4-GW-050906-50	FS	50	9/6/2005	TOC	EPA 415.1	TOC	Total Organic Carbon	1.4	MG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	2.9	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	0.44	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	1.1	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	5.6	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	0.67	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	0.98	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	18	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	VOCs	EPA 8260B	156-60-5	trans-1,2-Dichloroethene	16	UG/L
CPT-B1	S70-CPT-B1-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	4.9	UG/L
CPT-E1	S70-CPT-E1-GW-050829-60	FS	60	8/29/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	2.8	UG/L
CPT-N1	S70-CPT-N1-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	5.1	UG/L
CPT-N2	S70-CPT-N2-GW-050830-60	FS	60	8/30/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	490	UG/L
CPT-N3	S70-CPT-N3-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	4.5	UG/L
CPT-NW1	S70-CPT-NW1-GW-050908-60	FS	60	9/8/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	2300	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	72	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	11	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	1.6	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	120	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	18	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	4.7	UG/L
CPT-SW2	S70-CPT-SW2D-GW-050902-50	FD	50	9/2/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	190	UG/L
CPT-SW2	S70-CPT-SW2-GW-050902-50	FS	50	9/2/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	160	UG/L
CPT-W1	S70-CPT-W1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	4000	UG/L
CPT-W2	S70-CPT-W2-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	1900	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	79-01-6	Trichloroethene	4.8	UG/L
CPT-S1	S70-CPT-S1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	2.4	UG/L
CPT-S2	S70-CPT-S2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	1.6	UG/L
CPT-S3	S70-CPT-S3-GW-050901-50	FS	50	9/1/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	5.1	UG/L
CPT-SE1	S70-CPT-SE1-GW-050831-60	FS	60	8/31/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	8	UG/L
CPT-SE2	S70-CPT-SE2-GW-050901-45	FS	45	9/1/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	2.9	UG/L
CPT-SW1	S70-CPT-SW1-GW-050902-60	FS	60	9/2/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	3.7	UG/L
CPT-W3	S70-CPT-W3-GW-050906-60	FS	60	9/6/2005	VOCs	EPA 8260B	75-01-4	Vinyl chloride	0.43	UG/L

Notes:
CPT-cone penetrometer test
FS-Field Sample
FD-Field Duplicate

APPENDIX D-B
Soil Boring Logs

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

PROJECT Seal Beach NAVWPNSTA
PROJECT LOCATION Seal Beach, CA
PROJECT NUMBER HY0888

KEY SHEET - CLASSIFICATIONS AND SYMBOLS

GS FORM: KEY/SYMBOLS 01/04

EMPIRICAL CORRELATIONS WITH STANDARD PENETRATION RESISTANCE N VALUES *

FINE GRAINED SOILS

N VALUE * (BLOWS/FT)	CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ FT)
0 - 2	VERY SOFT	<0.25
3 - 4	SOFT	0.25 - 0.50
5 - 8	FIRM	0.50 - 1.00
9 - 15	STIFF	1.00 - 2.00
16 - 30	VERY STIFF	2.00 - 4.00
31 - 50	HARD	>4.00
>50	VERY HARD	

COARSE GRAINED SOILS

N VALUE * (BLOWS/FT)	RELATIVE DENSITY
0 - 4	VERY LOOSE
5 - 10	LOOSE
11 - 30	MEDIUM DENSE
31 - 50	DENSE
>50	VERY DENSE

* ASTM D 1586; NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 IN. O.D., 1.4 IN. I.D. SAMPLER ONE FOOT.

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

MAJOR DIVISIONS			SYMBOLS	DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL -SAND-CLAY MIXTURES
MORE THAN 50% OF MATERIAL COARSER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO.4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL FINER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT

NOTE: DUAL SYMBOLS USED FOR BORDERLINE CLASSIFICATIONS

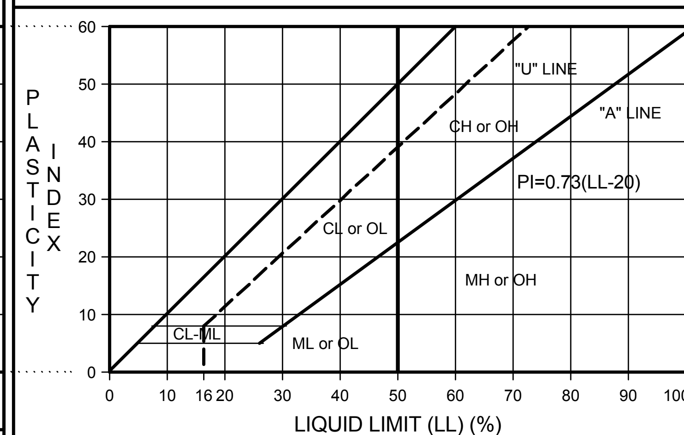
PARTICLE SIZE IDENTIFICATION

USCS (SOILS ONLY) *		SEDIMENTARY (ROCK ONLY)	
BOULDER	>300 mm	BOULDER	>256 mm
COBBLE	75 - 300 mm	COBBLE	64 - 256 mm
GRAVEL: COARSE	20 - 75 mm	PEBBLE	4 - 64 mm
GRAVEL: FINE	4.75 - 20 mm	GRANULE	2 - 4 mm
		SAND: V. COARSE	1 - 2 mm
SAND: COARSE	2 - 4.75 mm	SAND: COARSE	0.5 - 1 mm
SAND: MEDIUM	0.42 - 2 mm	SAND: MEDIUM	0.25 - 0.5 mm
SAND: FINE	0.074 - 0.42 mm	SAND: FINE	0.125 - 0.25 mm
		SAND: V. FINE	0.063 - 0.125 mm
SILT/CLAY	<0.074 mm	SILT	0.004 - 0.063 mm
		CLAY	<0.004 mm

* WELL GRADED - HAVING WIDE RANGE OF GRAIN SIZES AND APPRECIABLE AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES
* POORLY GRADED - PREDOMINANTLY ONE GRAIN SIZE, OR HAVING A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING

PERCENTAGE OF PARTICLE TYPE IN DECREASING ORDER OF PARTICLE SIZE (GRAVEL,SAND,FINES)

PLASTICITY CHART



OTHER MATERIAL SYMBOLS

- Conglomerate
- Sandstone
- Silty Sandstone
- Clayey Sandstone
- Sandy Siltstone
- Siltstone
- Claystone
- Clayey Siltstone/ Silty Claystone
- Sandy Claystone
- Granitic/Intrusive
- Volcanic/Extrusive
- Metamorphic
- Limestone
- Dolomite
- Glacial Till
- Landslide Debris
- Marker Bed
- Artificial Fill
- Refuse
- Concrete/Asphalt

WELL SYMBOLS

- CONCRETE
- GROUT
- BENTONITE SEAL
- TRANSITION SAND
- SAND/GRAVEL PACK
- NATIVE/SLOUGH
- CENTRALIZER

SAMPLE TYPE AND OTHER SYMBOLS

- BULK SAMPLE
- STANDARD PENETRATION TEST
- MODIFIED CALIFORNIA SAMPLE
- CORE SAMPLE
- SHELBY TUBE
- DRIVE SAMPLE

- Water Level at Time Drilling, or as Shown
- Static Water Level
- Pump Inlet
- Loss of Drilling Fluid
- MSL: Mean Sea Level
- AGS: Above Ground Surface
- BGS: Below Ground Surface
- BTOC: Below Top of Casing
- HSA: Hollow Stem Auger

01-KEY/SYMBOLS SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 21/9/05

GEOSYNTEC CONSULTANTS 2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	**BORING** B-1 **SHEET** 1 **OF** 3 **START DRILL DATE** 8 Sep 05 **ELEVATION DATA:** **FINISH DRILL DATE** 8 Sep 05 **GROUND SURF.** **LOCATION** Seal Beach, CA **TOP OF CASING** **PROJECT** Seal Beach NAVWPNSTA **DATUM** **NUMBER** HY0888
GS FORM: CORE4 5/01	

BOREHOLE LOG

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0645 on 8 September 2005.
5											Began drilling at 0710 on 8 September 2005.
10											
15											
20	SAND (SP): light olive brown [2.5Y 5/3]; wet; fine- to medium-grained sand; (0,100,0)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Huntington Beach, CA 92648
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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	B-1	**SHEET** 2 **OF** 3	
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	Clayey SAND (SC): dark grayish brown [2.5Y 4/2]; wet; fine-grained sand; (0,75,25)										Collected sample S70-CPT-B1-SS-050908-3(
35											
40	SAND (SP): yellowish brown [10YR 5/4]; fine-grained sand with pods of clay; (0,95,5)										
45											
50	SAND with Clay (SP-SC): dark gray [2.5Y 4/1]; wet; fine-grained sand; (0,90,10)										Collected sample S70-CPT-B1-SS-050908-5(
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING B-1 — **SHEET** 3 **OF** 3
START DRILL DATE 8 Sep 05
FINISH DRILL DATE 8 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
	SAND (SP): gray [2.5Y 5/1]; wet; mostly fine-grained sand; some medium-grained sand; (0,95,5)										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0810 on 8 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	B-2		**SHEET 1 OF 3**
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0650 on 8 September 2005.
5											Began drilling at 0800 on 8 September 2005.
10											
15											
20	SAND with Clay (SP-SC): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,90,10)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	B-2	**SHEET** 2 **OF** 3	
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY (CH): grayish brown [2.5Y 5/2]; wet; lens of fine-grained sand; (0,5,95); medium plasticity										
35											
40											Collected Sample S70-CPT-B2-SS-050908-4(No Recovery
45	Clayey SAND (SC): dark gray [2.5Y 4/1]; wet; fine-grained sand; (0,60,40)										
50	@ 50' - increase in sand content; (0,85,15); color change to dark gray [5Y 4/1]										
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING B-2 **SHEET** 3 **OF** 3
START DRILL DATE 8 Sep 05
FINISH DRILL DATE 8 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	SAND (SP): gray [5Y 5/1]; wet; medium- to coarse-grained sand; (0,100,0)										Collected Sample S70-CPT-B2-SS-050908-6(
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1015 on 8 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS 2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	**BORING** CPT-E1	**SHEET** 1 **OF** 3
GS FORM: CORE4 5/01	**START DRILL DATE** 29 Aug 05	**ELEVATION DATA:**
BOREHOLE LOG	**FINISH DRILL DATE** 29 Aug 05	**GROUND SURF.**
	LOCATION Seal Beach, CA	**TOP OF CASING**
	PROJECT Seal Beach NAVWPNSTA	**DATUM**
	NUMBER HY0888	

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
											Began drilling at 0830 on 29 August 2005.
5											
10											
15											
20											
25											
30											

CONTRACTOR Gregg Drilling	**NORTHING**	**REMARKS:**
EQUIPMENT C9	**EASTING**	
DRILL MTHD	**ANGLE** Vertical	
DIAMETER		
LOGGER MD	**REVIEWER** KK	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING CPT-E1 **SHEET** 2 **OF** 3
START DRILL DATE 29 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 29 Aug 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
											Collected Sample S70-CPT-E1-SS-050829-3(
35	CLAY (CH): light brownish gray [10YR 6/2]; wet; (0,0,100); stiff										
40	SAND with Clay (SP-SC): brown [10YR 5/3]; wet; fine-grained sand; (0,70,30)										
45											
	Clayey SAND (SC): grayish brown [10YR 5/2]; moist; fine-grained sand; (0,70,30)										
50											Collected Sample S70-CPT-E1-SS-050829-5(
55	SAND (SW): gray [2.5Y 5/1]; wet; coarse- to fine-grained sand; (0,95,5)										
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS
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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E1	**SHEET** 3 **OF** 3	
START DRILL DATE	29 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	29 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	SAND (SP): gray [2.5Y 6/1]; wet; fine- to medium-grained sand; (0,95,5)										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1210 on 29 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

GEOSYNTEC CONSULTANTS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E2	**SHEET** 1 **OF** 3	
START DRILL DATE	29 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	29 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began drilling at 1300 on 29 August 2005.
5											
10											
15											
20	Sandy CLAY (CH): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,40,60)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E2	**SHEET** 2 **OF** 3	
START DRILL DATE	29 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	29 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	@ 30' - decrease in sand content; color change to olive [5Y 5/3]										
35											
40											Collected Sample S70-CPT-E2-SS-050829-4(
45											
50	SAND (SW): grayish brown [2.5Y 5/2]; wet; fine- to medium-grained sand; (0,95,5)										
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E2	**SHEET** 3 **OF** 3	
START DRILL DATE	29 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	29 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
											Collected Sample S70-CPT-E2-SS-050829-6(
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1500 on 29 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E3	**SHEET** 1 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began drilling at 0715 on 30 August 2005.
5											
10											
15											
20	CLAY (CH): light brownish gray [2.5Y 6/2]; wet; fine-grained sand; (0,5,95)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING CPT-E3 **SHEET** 2 **OF** 3
START DRILL DATE 30 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 30 Aug 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	Sandy CLAY (CH): light olive brown [2.5Y 5/3]; wet; fine-grained sand; (0,40,60)										
35											
40	Clayey SAND (SC): light olive brown [2.5Y 5/4]; wet; fine-grained sand; (0,70,30)										
45											
50											Collected Sample S70-CPT-E3-SS-050830-5(
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-E3	**SHEET** 3 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
											Collected Sample S70-CPT-E3-SS-050830-6(
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0920 on 30 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-N1	**SHEET** 1 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
0											Began drilling at 0940 on 30 August 2005.
5											
10											
15											
20	SAND (SP): gray [5Y 5/1]; wet; fine- to medium-grained sand; (0,95,5)										Collected Sample S70-CPT-N1-SS-050830-2
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-N1	**SHEET** 2 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	CLAY with Sand (CH): light brownish gray [2.5Y 6/2]; wet; fine-grained sand; (0,10,90)										
35											
40	SAND (SP): light yellowish brown [2.5Y 6/3]; wet; fine- to medium-grained sand; (0,95,5)										
45											
50	@ 50' - color change to light greenish gray [Gley1 7/1]; increase in medium-grained sand; (0,100,0)										Collected Sample S70-CPT-N1-SS-050830-5(
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING CPT-N1 **SHEET** 3 **OF** 3
START DRILL DATE 30 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 30 Aug 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	SAND with Gravel and Clay (SP): light greenish gray [Gley1 7/1]; wet; fine- to coarse-grained sand; fine gravel; (25,65,10)										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1150 on 30 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling **NORTHING**
EQUIPMENT C9 **EASTING**
DRILL MTHD **ANGLE** Vertical
DIAMETER
LOGGER MD **REVIEWER** KK

REMARKS:

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CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-N2	**SHEET** 1 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
0											Began drilling at 1225 on 30 August 2005.
5											
10											
15											
20	SAND (SP): dark grayish brown [2.5Y 4/2]; wet; fine-grained sand; (0,95,5)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING CPT-N2 **SHEET** 2 **OF** 3
START DRILL DATE 30 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 30 Aug 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY (CH): light olive brown [2.5Y 5/3]; wet; (0,0,100)										
35											
40	SAND (SP): olive gray [5Y 5/2]; wet; fine-grained sand; some medium-grained sand; (0,100,0)										
45											Collected Sample S70-CPT-N2-SS-050830-4
50	@ 50' - color change to dark gray [5Y 4/1]; fine-grained sand; (0,90,10)										
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-N2			**SHEET** 3 **OF** 3	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**			
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**			
LOCATION	Seal Beach, CA	**TOP OF CASING**			
PROJECT	Seal Beach NAVWPNSTA	**DATUM**			
NUMBER	HY0888				

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
	Clayey SAND (SC): gray [5Y 5/1]; wet; medium- to coarse-grained sand; (0,80,20)										Collected Sample S70-CPT-N2-SS-050830-6(
	Completed CPT at 61 ft-bgs										Completed drilling CPT at 1500 on 30 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-S1	**SHEET** 1 **OF** 3	
START DRILL DATE	31 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	31 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began drilling at 0740 on 31 August 2005.
5											
10											
15											
20											Sampling for microcosm from 20 to 29 ft-bgs.
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING CPT-S1 — **SHEET** 2 **OF** 3

START DRILL DATE 31 Aug 05
FINISH DRILL DATE 31 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888

ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY (CH): olive gray [5Y 5/2]; wet; (0,0,100); medium plasticity; stiff										
35											
40	SAND (SP): olive grown [2.5Y 4/4]; wet; fine- to medium-grained sand; (0,100,0)										Collected Sample S70-CPT-S1-SS-050831-4(
45											
50	@ 50' - color change to gray [5Y 5/1]; increase in medium-grained sand										Collected Sample S70-CPT-S1-SS-050831-5(
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	CPT-S1	**SHEET** 3 **OF** 3	
START DRILL DATE	31 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	31 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	@ 60' - color change to dark gray [5Y 4/1]; increase in fine-grained sand; (0,70,30)										
	Completed CPT at 61 ft-bgs										Completed drilling CPT at 1140 on 31 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	N3	**SHEET**	1 **OF** 3
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
											Began hand augering at 1255 on 8 September 2005.
5											Began drilling at 1315 on 8 September 2005.
10											
15											
20											
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	N3	**SHEET**	2 OF 3
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
35											
40											
45											
50	SAND (SP): gray [5Y 5/1]; wet; fine- to medium-grained sand; (0,100,0)										Collected Sample S70-CPT-N3-SS-050908-5(
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS 2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	**BORING** N3		**SHEET** 3 **OF** 3
GS FORM: CORE4 5/01	**START DRILL DATE** 8 Sep 05	**ELEVATION DATA:**	
BOREHOLE LOG	**FINISH DRILL DATE** 8 Sep 05	**GROUND SURF.**	
	LOCATION Seal Beach, CA	**TOP OF CASING**	
	PROJECT Seal Beach NAVWPNSTA	**DATUM**	
	NUMBER HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
	SAND (SW): gray [2.5Y 5/1]; wet; medium- to coarse-grained sand; (0,100,0)										Collected Sample S70-CPT-N3-SS-050908-6(
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1405 on 8 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling	**NORTHING**	**REMARKS:**	
EQUIPMENT C4	**EASTING**		
DRILL MTHD	**ANGLE** Vertical		
DIAMETER			
LOGGER MD	**REVIEWER** KK	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS	

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	NW1	**SHEET** 1 **OF** 3	
START DRILL DATE	8 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	8 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
0											Began hand augering at 1100 on 8 September 2005.
5											Began drilling at 1135 on 8 September 2005.
10											
15											
20	Clayey SAND (SC): light olive brown [2.5Y 5/3]; wet; fine-grained sand; (0,70,30)										Collected Sample S70-CPT-NW1-SS-050908
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING NW1 **SHEET** 2 **OF** 3
START DRILL DATE 8 Sep 05
FINISH DRILL DATE 8 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
35											
40	SAND with Clay (SP-SC): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,90,10)										
45											
50											
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING NW1 **SHEET** 3 **OF** 3
START DRILL DATE 8 Sep 05 **ELEVATION DATA:**
FINISH DRILL DATE 8 Sep 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	SAND with Gravel (SW): light gray [5Y 7/1]; wet; fine- to coarse-grained sand; fine gravel; (20,75,5)										Collected Sample S70-CPT-NW1-SS-050908
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1220 on 8 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling **NORTHING**
EQUIPMENT C4 **EASTING**
DRILL MTHD **ANGLE** Vertical
DIAMETER
LOGGER MD **REVIEWER** KK

REMARKS:

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CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	S2	**SHEET** 1 **OF** 2	
START DRILL DATE	1 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	1 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
											Began drilling at 1015 on 1 September 2005.
5											
10											
15											
20											
25											
	Clayey SAND (SP): light olive brown [2.5Y 5/3]; wet; fine- to medium-grained sand; (0,60,40); very loose										
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	S2	**SHEET** 2 **OF** 2	
START DRILL DATE	1 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	1 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	Sandy CLAY (CH): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,15,85); high plasticity										
35	SAND (SP): light yellowish brown [2.5Y 6/3]; wet fine-grained sand (0,100,0);										
	SAND with Clay (SW): light yellowish brown [2.5Y 6/3]; wet; fine-grained sand; trace gravel; (0,85,15)										
40											
45	@ 45' - alternating layers of SAND (SP): light olive brown [2.5Y 5/3]; wet; fine-grained sand; (0,100,0) and CLAY (CH): gray [5Y 5/1]; wet; (0,0,100); high plasticity										Collected Sample S70-CPT-S2-SS-050901-4
50											
55	SAND with Clay (SC): dark gray [5Y 4/1]; wet; fine-grained sand; (0,80,20)										Collected Sample S70-CPT-S2-SS-050901-5
	Completed CPT at 56 ft-bgs.										Completed drilling CPT at 1135 on 1 September 2005. Backfilled borehole with bentonite grout.
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING S3 **SHEET** 1 **OF** 3
START DRILL DATE 1 Sep 05 **ELEVATION DATA:**
FINISH DRILL DATE 1 Sep 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
0											Began drilling at 1230 on 1 September 2005.
5											
10											
15											
20	Sandy CLAY (CH): light olive brown [2.5Y 5/3]; with reddish brown staining [2.5YR 4/3]; wet; fine-grained sand; (0,40,60); medium plasticity										
25											
30											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING S3 **SHEET** 2 **OF** 3
START DRILL DATE 1 Sep 05 **ELEVATION DATA:**
FINISH DRILL DATE 1 Sep 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
	SAND (SP): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,95,5)										
35											
40	@ 40' - color change to light olive brown [2.5Y 5/3]										Collected Sample S70-CPT-S3-SS-050901-4(
45											
50	@ 50' - color change to dark gray [5Y 4/1]; medium- to fine-grained sand										Collected Sample S70-CPT-S3-SS-050901-5(
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	S3		**SHEET** 3 **OF** 3
START DRILL DATE	1 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	1 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	CLAY (CH): dark gray [2.5Y 4/1]; wet; (0,0,100); medium plasticity; stiff; becomes clay with fine-grained sand with depth										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1355 on 1 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SE1	**SHEET** 1 **OF** 3	
START DRILL DATE	31 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	31 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began drilling at1230 on 31 August 2005.
5											
10											
15											
20	CLAY (CH): greenish gray [GLEY1 5/1] with streaks of light greenish gray [GLEY1 7/1]; wet; (0,0,100); high plasticity										
21	SAND with Clay (SP-SC): dark grayish brown [2.5Y 4/2]; wet; fine-grained sand; (0,85,15)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SE1	**SHEET** 2 **OF** 3	
START DRILL DATE	31 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	31 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	SAND (SP): grayish brown [2.5Y 5/2]; wet; (0,100,0)										
35											
40	@ 40' - color change to light olive brown [2.5Y 5/3]										Collected Sample S70-CPT-SE1-SS-050831-
45											
50	@ 50' - color change to greenish gray [5GY 5/1]; fine- to medium-grained sand										
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SE1		**SHEET** 3 **OF** 3
START DRILL DATE	31 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	31 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	@ 60' - increase in medium-grained sand; some fine-grained sand										Collected Sample S70-CPT-SE1-SS-050831-
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1500 on 31 August 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C9	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING SE2 **SHEET** 1 **OF** 3

START DRILL DATE 1 Sep 05 **ELEVATION DATA:**
FINISH DRILL DATE 1 Sep 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began drilling at 0725 on 1 September 2005.
5											
10											
15											
20											
25	SAND (SP): brown [10YR 5/3]; wet; fine-grained sand; (0,100,0)										
30											

CONTRACTOR Gregg Drilling **NORTHING**
EQUIPMENT C9 **EASTING**
DRILL MTHD **ANGLE** Vertical
DIAMETER
LOGGER MD **REVIEWER** KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING SE2 — **SHEET** 2 **OF** 3
START DRILL DATE 1 Sep 05
FINISH DRILL DATE 1 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
35	CLAY (CH): light brownish gray [2.5Y 6/2]; wet; (0,0,100); high plasticity										
40											
45	CLAY with Sand (CH): dark gray [5Y 4/1]; becoming very dark gray [5Y 3/1] with depth; wet fine-grained sand; (0,20,80); high plasticity; soft; becoming stiffer with depth										Collected Sample S70-CPT-SE2-SS-050901-
50											
55	Clayey SAND (SP): dark gray [5Y 4/1]; wet; fine-grained sand; (0,70,30); medium plasticity										Collected Sample S70-CPT-SE2-SS-050901-
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C9
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

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GEOSYNTEC CONSULTANTS 2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	**BORING** SE2		**SHEET** 3 **OF** 3
GS FORM: CORE4 5/01	**START DRILL DATE** 1 Sep 05	**ELEVATION DATA:**	
BOREHOLE LOG	**FINISH DRILL DATE** 1 Sep 05	**GROUND SURF.**	
	LOCATION Seal Beach, CA	**TOP OF CASING**	
	PROJECT Seal Beach NAVWPNSTA	**DATUM**	
	NUMBER HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	@ 60' - some medium-grained sand; becomes low plasticity										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0855 on 1 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling	**NORTHING**	**REMARKS:**
EQUIPMENT C9	**EASTING**	
DRILL MTHD	**ANGLE** Vertical	
DIAMETER		
LOGGER MD	**REVIEWER** KK	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SW1			**SHEET** 1 **OF** 3	
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**			
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**			
LOCATION	Seal Beach, CA	**TOP OF CASING**			
PROJECT	Seal Beach NAVWPNSTA	**DATUM**			
NUMBER	HY0888				

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0610 on 2 September 2005.
5											Began drilling at 0825 on 2 September 2005.
10											
15											
20	SAND (SP): gray [5Y 5/1]; wet; fine-grained sand (0,95,5)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SW1	**SHEET** 2 **OF** 3	
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY and SILT (CH-MH): olive gray [5Y 5/2]; wet; (0,5,95); medium to high plasticity										Collected Sample S70-CPT-SW1-SS-050902-
35											
40	Clayey SAND (SC): grayish grown [2.5Y 5/2]; wet; fine-grained sand; (0,70,30)										Collected Sample S70-CPT-SW1-SS-050902-
45											
50	SAND (SW): gray [5Y 5/1]; wet; fine- to medium-grained sand; (0,95,5)										
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS 2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	**BORING** SW1		**SHEET** 3 **OF** 3
GS FORM: CORE4 5/01	**START DRILL DATE** 2 Sep 05	**ELEVATION DATA:**	
BOREHOLE LOG	**FINISH DRILL DATE** 2 Sep 05	**GROUND SURF.**	
	LOCATION Seal Beach, CA	**TOP OF CASING**	
	PROJECT Seal Beach NAVWPNSTA	**DATUM**	
	NUMBER HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	@ 60 - color change to dark gray [2.5Y 4/1]; becomes fine- to coarse-grained sand										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0920 on 2 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling	**NORTHING**	**REMARKS:**
EQUIPMENT C4	**EASTING**	
DRILL MTHD	**ANGLE** Vertical	
DIAMETER		
LOGGER MD	**REVIEWER** KK	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SW2	**SHEET** 1 **OF** 3	
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0600 on 2 September 2005.
5											Began drilling at 0625 on 2 September 2005.
10											
15											
20	SAND (SP): olive brown [2.5Y 4/3]; wet; fine-grained sand; (0,95,5)										Collected Sample S70-CPT-SW2-SS-050902-
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	SW2	**SHEET**	2 OF 3
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY with Sand (CH): light olive brown [2.5Y 5/3]; wet; fine-grained sand; (0,10,90); high plasticity										
35											
40	SAND with Clay (SP-SC): olive brown [2.5Y 4/3]; wet; fine-grained sand; (0,90,10)										
45											
50	SAND (SW): dark gray [2.5Y 4/1]; wet; fine- to coarse-grained sand;(0,95,5)										
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM:
CORE4 5/01

BOREHOLE LOG

BORING SW2 **SHEET** 3 **OF** 3
START DRILL DATE 2 Sep 05
FINISH DRILL DATE 2 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	SAND with Silt (SP-SM): dark gray [2.5Y 4/1]; wet; fine-grained sand; (0,70,30)										Collected Sample S70-CPT-SW2-SS-050902-
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0720 on 2 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W1		**SHEET** 1 **OF** 3
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
0											Began hand augering at 0950 on 2 September 2005.
5											Began drilling at 1015 on 2 September 2005.
10											
15											
20	Clayey SAND (SC): dark gray [5Y 4/1]; wet; fine-grained sand; (0,70,30)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING W1 | **SHEET** 2 **OF** 3
START DRILL DATE 2 Sep 05
FINISH DRILL DATE 2 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	SILT (MH): gray [5Y 5/1]; wet; (0,0,100); low plasticity										Collected Sample S70-CPT-W1-SS-050902-3
35	CLAY (CH): olive gray [5Y 5.2]; wet; (0,0,100); high plasticity; stringers of fine- to medium-grained sand; yellowish brown [10YR 6/4]										
40	Clayey SAND (SC): dark gray [5Y 4/1]; wet; fine-grained sand; (0,75,25)										
45	SAND (SP): gray [5Y 6/1]; wet; medium-grained sand; some fine-grained sand; (0,100,0)										Collected Sample S70-CPT-W1-SS-050902-4
50	SAND (SW): greenish gray [10Y 6/1]; wet; fine- to coarse-grained sand; (0,100,0)										
55											
60											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

CORE4 SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

GEOSYNTEC CONSULTANTS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W1	**SHEET**	3 OF 3
START DRILL DATE	2 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	2 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	@ 60 ' color change to gray [5Y 5/1]; (30,70,0)										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1125 on 2 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

BOREHOLE LOG

BORING	W2		SHEET 1 OF 3
START DRILL DATE	6 Sep 05	ELEVATION DATA:	
FINISH DRILL DATE	6 Sep 05	GROUND SURF.	
LOCATION	Seal Beach, CA	TOP OF CASING	
PROJECT	Seal Beach NAVWPNSTA	DATUM	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0740 on 6 September 2005.
5											Began drilling at 0830 on 6 September 2005.
10											
15											
20	Clayey SAND (SC): olive gray [5Y 5/2]; wet; fine-grained sand; (0,75,25)										
25											
30											

CONTRACTOR	Gregg Drilling	NORTHING	
EQUIPMENT	C4	EASTING	
DRILL MTHD		ANGLE	Vertical
DIAMETER			
LOGGER	MD	REVIEWER	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W2	**SHEET**	2 OF 3
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY (CH): grayish brown [2.5Y 5/2]; wet; (0,0,100); medium plasticity										
35											
40	SAND (SP): light yellowish brown [2.5Y 6/3]; wet; medium-grained sand; some coarse-grained sand; (0,95,5)										
45											
50	SAND (SW): gray [5Y 5/1]; wet; fine- to coarse-grained sand; (0,100,0)										Collected Sample S70-CPT-W2-SS-050906-5
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING W2 **SHEET** 3 **OF** 3
START DRILL DATE 6 Sep 05
FINISH DRILL DATE 6 Sep 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	SAND (SP): gray [2.5Y 5/1]; wet medium- to coarse-grained sand; (0,100,0)										Collected Sample S70-CPT-W2-SS-050906-6
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 0930 on 6 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK
NORTHING
EASTING
ANGLE Vertical

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W3	**SHEET**	1 OF 3
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0745 on 6 September 2005.
5											Began drilling at 1035 on 6 September 2005.
10											
15											
20	SAND with Clay (SP-SC): grayish brown [2.5Y 5/2]; wet; fine-grained sand; some medium-grained sand; (0,90,10)										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W3	**SHEET** 2 **OF** 3	
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS PER 6"	SAMPLES: TIME	SAMPLES: PID READING (ppm)	COMMENTS
	CLAY (CH): olive gray [5Y5/2]; wet; (0,0,100); medium plasticity										
35											
40	SAND (SP): light olive brown [2.5Y 5/3]; wet; fine-grained sand; trace coarse-grained sand; (0,95,5)										Collected Sample S70-CPT-W3-SS-050906-4
45											
50	@ 50' - color change to gray [5Y 5/1]; sand becomes mostly medium- to coarse-grained with lenses of fine-grained sand										Collected Sample S70-CPT-W3-SS-050906-5
55											
60											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W3	**SHEET**	3 OF 3
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS PER 6"	SAMPLES TIME	SAMPLES PID READING (ppm)	COMMENTS
	@ 60' - sand becomes fine- to medium-grained; (0,100,0)										
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1135 on 6 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W4	**SHEET**	1 **OF** 3
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
0											Began hand augering at 0740 on 6 September 2005.
5											Began drilling at 1305 on 6 September 2005.
10											
15											
20	Clayey SAND (SC): grayish brown [2.5Y 5/2]; wet; fine-grained sand; (0,70,30); medium plasticity										
25											
30											

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

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GS FORM: CORE4 5/01

BOREHOLE LOG

BORING	W4	**SHEET** 2 **OF** 3	
START DRILL DATE	6 Sep 05	**ELEVATION DATA:**	
FINISH DRILL DATE	6 Sep 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
30–40	CLAY (CH): grayish brown [2.5Y 5/2]; wet; (0,0,100); low plasticity; stiff										
40–50	SAND (SW): dark gray [5Y 4/1]; wet; fine- to medium-grained sand; (0,100,0)										Collected Sample S70-CPT-W4-SS-050906-[illegible]
50–60	SAND (SP): gray [N5]; wet; fine- to medium-grained sand; (0,100,0)										

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	C4	**EASTING**	
DRILL MTHD		**ANGLE**	Vertical
DIAMETER			
LOGGER	MD	**REVIEWER**	KK

REMARKS:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: CORE4 5/01

BOREHOLE LOG

BORING W4 **SHEET** 3 **OF** 3
START DRILL DATE 6 Sep 05 **ELEVATION DATA:**
FINISH DRILL DATE 6 Sep 05 **GROUND SURF.**
LOCATION Seal Beach, CA **TOP OF CASING**
PROJECT Seal Beach NAVWPNSTA **DATUM**
NUMBER HY0888

DEPTH (ft)	MATERIAL DESCRIPTION	SYMBOLIC LOG	WELL LOG	WELL CONSTRUCTION DETAILS	ELEVATION (ft)	SAMPLES NUMBER	TYPE	BLOWS PER 6"	TIME	PID READING (ppm)	COMMENTS
	CLAY (CH): dark gray [2.5Y 4/1]; wet; trace medium-grained sand; (0,0,100); high plasticity										Collected Sample S70-CPT-W4-SS-050906-6
	Completed CPT at 61 ft-bgs.										Completed drilling CPT at 1405 on 6 September 2005. Backfilled borehole with bentonite grout.
65											
70											
75											
80											
85											
90											

CONTRACTOR Gregg Drilling
EQUIPMENT C4
DRILL MTHD
DIAMETER
LOGGER MD **REVIEWER** KK

NORTHING
EASTING
ANGLE Vertical

REMARKS:

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Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

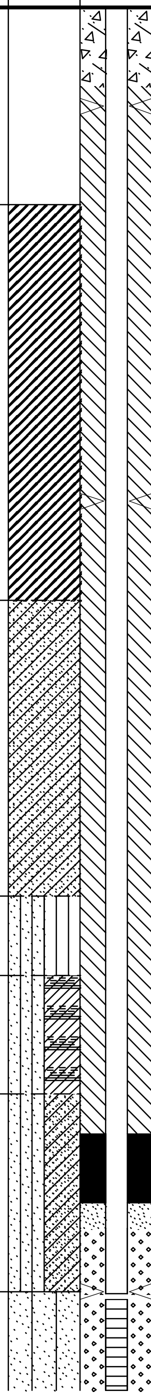
BOREHOLE LOG

BORING	RDO-1	**SHEET**	1 OF 2
START DRILL DATE	19 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	19 Aug 05	**GROUND SURF.**	8.13
LOCATION	Seal Beach, CA	**TOP OF CASING**	10.41
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring

DEPTH (ft-bgs)	DESCRIPTION	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
0–10					7 to -2							Air Knife to 10 ft-bgs on 11 August 2005.
10	CLAY with trace Silt (CL): dark grayish brown [2.5Y 4/2]; wet; fine- to coarse-grained sand; medium plasticity; soft; micaceous; no dilatancy; low to medium toughness				-3						1421	Began drilling with mud rotary on 19 August 2005. All lithologic descriptions are based on mud rotary cuttings.
15					-8						1423	
20					-13						1427	
25	@ 25' - increase in sand				-18						1429	
30	Clayey SAND (SC) with Silt: olive gray [5Y 4/2]; medium-grained; fat clay; micaceous; mottled iron oxide staining				-23						1431	
35					-28						1435	
40	@ 40' - decrease in clay				-33						1437	
45	Silty SAND to Sandy SILT (SM-ML): dark grayish brown [2.5Y 4/2]; wet				-38						1440	
49	Silty SAND to Sandy Organic SILT (SM-OL): dark grayish brown [2.5Y 4/2]; black organic (woody) material (>30%)				-43						1441	
55	Silty SAND with Clay (SM-SC) decrease in organic content; increase in sand				-48						1443	
60					-53						1445	
65	Silty SAND (SM): olive gray [2.5Y 5/2]; poorly graded; decreases in silt content with depth				-58						1447	
70					-61							



CONTRACTOR	Gregg Drilling	**NORTHING**	2223800.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006296.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

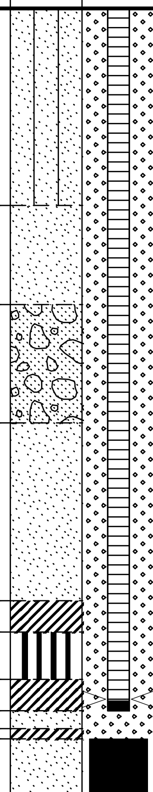
GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-1
SHEET	2 OF 2
START DRILL DATE	19 Aug 05
FINISH DRILL DATE	19 Aug 05
LOCATION	Seal Beach, CA
PROJECT	Seal Beach NAVWPNSTA
NUMBER	HY0888
ELEVATION DATA:	
GROUND SURF.	8.13
TOP OF CASING	10.41
DATUM	NAVD88

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring



DEPTH (ft-bgs)	DESCRIPTION	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
71–80			-63 to -72						1449, 1452	
80	SAND with Silt (SP): medium- to fine-grained sand with silt		-72						1455	
85	GRAVEL with Sand, Silt, and Clay (GW): dark greenish gray [10GY 4/1]; wet to moist; increasing in clay content to 86.5 ft-bgs, loose		-78			4, 5, 5	78	1.6	1507	Collected Sample RDO-1-85.5
90	SAND (SP): dark greenish gray [5G 4/1]; fine-grained; wet		-83			14, 20, 23	67	1.0	1532	Collected Sample RDO-1-90.5
95	@ 95' - trace silt; trace fine gravel; wet		-88			10, 21, 15	55	1.1	1556	
100	Silty CLAY (CH): dark greenish gray [10Y 4/1]; wet to moist; pods of fine-grained sand SILT with Clay (MH): dark greenish gray [5G 4/1]		-93			3, 4, 4	100	1.5	1627	Collected Sample RDO-1-100
105	CLAY with Silt (CH): dark greenish gray [5G 4/1; trace sand SAND with Silt (SP): dark greenish gray [5G 4/1]; trace shell fragments Silty CLAY (CH): dark greenish gray [5G 4/1]; high plasticity SAND with Silt (SP): dark greenish gray [5G 4/1]; shell fragments (to 3%) in narrow bands (<1-in) @ 110' - Hard sandstone nodules/concretions to 3 inches in shoe end of core barrel Completed borehole at 110 ft-bgs.		-98			5, 14, 22	100	0.5	1657	Completed borehole at 1735 on 19 August 2005.

Depth scale: 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140

Elevation scale: -63 through -131

CONTRACTOR	Gregg Drilling
EQUIPMENT	Versa-Drill V100
DRILL MTHD	Mud Rotary
DIAMETER	10-in
LOGGER	KK
REVIEWER	
NORTHING	2223800.00
EASTING	6006296.00
COORDINATE SYSTEM:	NAD83-CCS, Zone 6

NOTES:

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Phone: (714) 969-0800

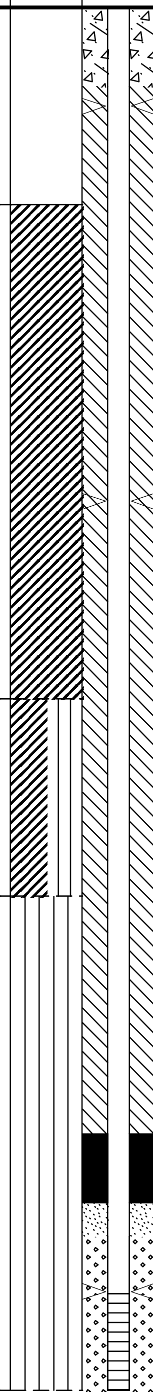
GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-2	**SHEET** 1 **OF** 2	
START DRILL DATE	18 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	18 Aug 05	**GROUND SURF.**	7.46
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.53
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GROUNDWATER OR STRUCTURE	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
0–10			0822	Air Knife to 10 ft-bgs on 11 August 2005.
10	CLAY with Silt (CH): dark grayish brown [2.5Y 4/2]; wet; trace fine- to coarse-grained sand; medium to high plasticity; soft to firm; rootlets @ 16' - decrease in rootlets with depth		0830, 0835, 0840, 0843, 0845	Began drilling with mud rotary on 18 August 2005. All lithologic descriptions are based on mud rotary cuttings. Drilling mud appearing at ground surface as far as 25 ft from borehole.
35	Silty CLAY to Clayey SILT (CH/ML): dark grayish brown [2.5Y 4/2]; wet; 10% well graded sand; trace white irregularly shaped grains of carbonate (from coarse-grained sand and to fine gravel in size); no odor	White grains react strongly to hydrochloric acid	0848, 0853	
45	SILT with Clay (ML): dark grayish brown [2.5Y 4/2]; 20% fine- to coarse-grained sand; low to medium plasticity; none to slow dilatancy; low to medium dry strength; 5% black woody organics @ 50' - decrease in organic content		0858, 0902, 0904, 0915, 0923	
70				

Column headings: GRAPHIC LOG, WELL LOG, ELEVATION (ft), SAMPLE: SAMPLE NO., TYPE, BLOWS PER 6", RECOVERY (%), PID READING (ppm)



Elevation (ft): 6 to -62

CONTRACTOR Gregg Drilling	**NORTHING** 2223625.00	**NOTES:**	
EQUIPMENT Versa-Drill V100	**EASTING** 6006183.00		
DRILL MTHD Mud Rotary	**COORDINATE SYSTEM:**		
DIAMETER 10-in	NAD83-CCS, Zone 6		
LOGGER KK	**REVIEWER**	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS	

GEOSYNTEC CONSULTANTS

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GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING RDO-2 — **SHEET** 2 **OF** 2
START DRILL DATE 18 Aug 05
FINISH DRILL DATE 18 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888

ELEVATION DATA:
GROUND SURF. 7.46
TOP OF CASING 9.53
DATUM NAVD88

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring

DEPTH (ft-bgs)	DESCRIPTION	GROUNDWATER OR STRUCTURE	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
72	Silty SAND with Clay (SM): grayish brown [2.5Y 5/2]; well graded sand; decreasing in fines content to 75 ft-bgs							0925	
75	@ 75' - decrease in clay content							0927	
80	@ 80' - increase in clay content; trace carbonate clasts	Reactive to hydrochloric acid						0928	
85	SAND (SP) / Clayey SILT (ML): very dark greenish gray [5G 3/1]; moist to dry; non-plastic; firm to hard; interbedded with fine-grained poorly graded sand; greenish gray [5G 4/1]; wet				3, 4, 7	100	1.2	0951	Driller reports drop in bit pressure - clay to sand at 88'.
90	SAND (SP): dark greenish gray [5G 4/1]; wet; micaceous; trace shell fragments; thin stringers of fat clay (<1-in) sparsely distributed to 105 ft-bgs				14, 30, 54	100	1.6	1025	Collected Sample RDO-2-90.5
95	@ 96' - increase in shell content to 3 to 5%				13, 19, 26	83	1.5	1100	
100					16, 29, 33	83	1.7	1137	Collected Sample RDO-2-100 Collected Sample RDO-2-101
105					14, 27, 44	78	1.2	1206	
110	SAND (SP) grades to SILT with Clay (ML): dark greenish gray [5G 4/1]; wet; silt moist; sand contains 1 to 3% shell fragments; sand and silt intervals are micaceous. Completed borehole at 110 ft-bgs.								Completed borehole at 1300 on 18 August 2005.

Depth scale: 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140

ELEVATION (ft): -64, -65, -66, -67, -68, -69, -70, -71, -72, -73, -74, -75, -76, -77, -78, -79, -80, -81, -82, -83, -84, -85, -86, -87, -88, -89, -90, -91, -92, -93, -94, -95, -96, -97, -98, -99, -100, -101, -102, -103, -104, -105, -106, -107, -108, -109, -110, -111, -112, -113, -114, -115, -116, -117, -118, -119, -120, -121, -122, -123, -124, -125, -126, -127, -128, -129, -130, -131, -132

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING 2223625.00
EASTING 6006183.00
COORDINATE SYSTEM: NAD83-CCS, Zone 6

NOTES:

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GS FORM: WELL BORE 01/04

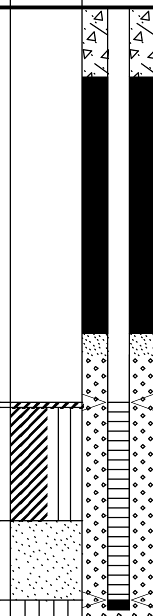
BOREHOLE LOG

BORING RDO-3A **SHEET** 1 **OF** 1

START DRILL DATE	22 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	23 Aug 05	**GROUND SURF.**	7.09
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.28
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring



DEPTH (ft-bgs)	DESCRIPTION	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
20	CLAY (CH): gray [5Y 5/1]		-13							
	SILT [ML] to CLAY [CH]: grayish brown [2.5Y 5/2\; mottled with iron oxide staining [10YR 5/8]; wet; non-plastic; micaceous; low dry strength; slow dilatancy; 5% sandy concretions formed on coral-like shell fragments; strong reaction to HCL on broken surfaces		-14	1			30			
			-15	2			0			No recovery from 21.5' to 25'
25			-18							
			-19	3			67			
			-21	4			100			Collected Sample RDO-3A-28
	SAND (SP): light yellowish brown [2.5Y 6/3]; wet; medium- to coarse-grained sand; trace silt		-22							
30	SILT [ML]: moist; micaceous		-23							Completed borehole at 1750 on 22 August 2005.
	Completed borehole at 31 ft-bgs		-24							

Depth scale: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70
Elevation scale: 6 to -62

CONTRACTOR Gregg Drilling	**NORTHING** 2223540.00	**NOTES:**	
EQUIPMENT Versa-Drill V100	**EASTING** 6006124.00		
DRILL MTHD Mud Rotary	**COORDINATE SYSTEM:**		
DIAMETER 10-in	NAD83-CCS, Zone 6		
LOGGER KK	**REVIEWER**	SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS	

07-WELL BORE SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 6/12/05

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
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GS FORM:
WELL BORE 01/04

BOREHOLE LOG

BORING RDO-3B **SHEET** 1 **OF** 2
START DRILL DATE 23 Aug 05
FINISH DRILL DATE 23 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF. 7.06
TOP OF CASING 9.21
DATUM NAVD88

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
0–10					6 to -3						1036	Air Knife to 7 ft-bgs on 23 August 2005. Began drilling with mud rotary on 23 August 2005. All lithologic descriptions are based on mud rotary cuttings.
10	CLAY with Silt (CH): gray [5Y 5/1]; high plasticity; medium to high dry strength; rootlets; no dilitancy				-4 to -8						1040	
15					-9 to -13						1042	
20	@ 20' - becomes wet; trace fine-grained sand				-14 to -18						1044	
25	Silty SAND with Clay (SM): grayish brown [2.5y 5/2]; mottled with iron oxide staining; yellowish brown [10YR 5/8]				-19 to -23						1050	
30	Silty CLAY with Sand (CL): grayish brown [2.5Y 5/2]; wet; iron oxide staining; no odor				-24 to -28						1051	
35					-29 to -32						1054	
39/40	SILT with Clay (ML): greenish gray [10Y 5/1]; wet; black fibrous woody material; no odor				-33 to -38						1057	
45	@ 45' - increase in woody material; predominantly organic with 30% silt and 10% fine- to coarse-grained sand				-39 to -43						1059	
50	Clayey SILT (MH): dark gray [2.5Y 4/1]; trace fine- to coarse-grained sand; low plasticity; no dilatancy; low dry strength				-44 to -48						1101	
55	@ 56.5 to 65' - increase in sand content				-49 to -53						1103	
60	SAND (SP): gray [5Y 6/1] to olive gray [5Y 6/2]; wet; medium- to coarse-grained sand; trace silt				-54 to -58						1104	
65–70					-59 to -62						1107	

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING 2223535.00
EASTING 6006115.00
COORDINATE SYSTEM:
NAD83-CCS, Zone 6

NOTES:

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GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	**RDO-3B**	**SHEET 2 OF 2**	
START DRILL DATE	23 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	23 Aug 05	**GROUND SURF.**	7.06
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.21
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring

DEPTH (ft-bgs)	DESCRIPTION	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
					-64						1109	
75					-69						1112	
80	@ 80' - SAND with Silty CLAY (SC); color change to gray [5Y 6/1]				-74						1117	
85	Clayey SAND (SC): dark gray [2.5Y 4/1]; wet; silt				-79						1120	
90	SAND (SP): dark greenish gray [5G 4/1]; wet; fine-grained; micaceous				-84			15 16 18	100	3.1	1152	Collected Sample RDO-3B-90.5
95	@ 95' - trace shell fragments CLAY with SILT and SAND (CL): fine-grained sand; silt				-89			12 17 20	90	1.6	1220	Collected Sample RDO-3B-95 Collected Sample RDO-3B-95.5
100	SAND (SP): dark greenish gray [5G 4/1]; wet to moist; fine-grained with 5 to 10% shell fragments; interbedded with clay and clayey sand; medium to high plasticity; firm; high dry strength				-94			4 4 4	100	2.8	1412	Collected Sample RDO-3B-100 Collected Sample RDO-3B-100.5
105					-99			7 7 6	100	2.2	1451	
	Completed borehole at 106.5 ft-bgs.				-100							Completed borehole at 1535 on 23 August 2005.

Depth scale: 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140

Elevation scale: -64, -65, -66, -67, -68, -69, -70, -71, -72, -73, -74, -75, -76, -77, -78, -79, -80, -81, -82, -83, -84, -85, -86, -87, -88, -89, -90, -91, -92, -93, -94, -95, -96, -97, -98, -99, -100, -101, -102, -103, -104, -105, -106, -107, -108, -109, -110, -111, -112, -113, -114, -115, -116, -117, -118, -119, -120, -121, -122, -123, -124, -125, -126, -127, -128, -129, -130, -131, -132

CONTRACTOR	Gregg Drilling	**NORTHING**	2223535.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006115.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

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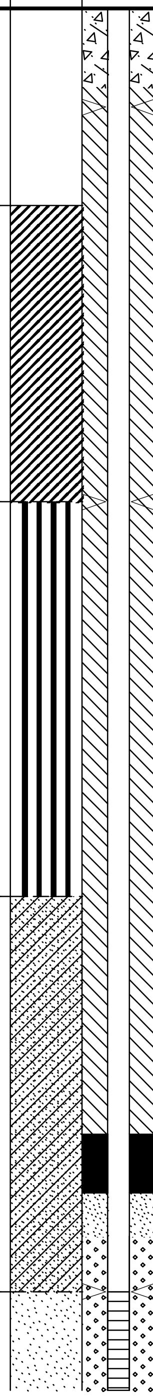
GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-4	**SHEET** 1 **OF** 2	
START DRILL DATE	16 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	16 Aug 05	**GROUND SURF.**	6.94
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.11
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring



DEPTH (ft-bgs)	DESCRIPTION	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
0–10			6 to -3						1500	Air Knife to 6.5 ft-bgs on 11 August 2005. Began drilling with mud rotary on 16 August 2005. All lithologic descriptions are base on mud rotary cuttings. Fast drilling, little resistance
10	Silty CLAY (CH): dark grayish brown [10YR 4/2]; wet; medium to high plasticity; no dilatancy; low to medium toughness; medium to high dry strength		-4						1505	
15	@ 15' - Silty CLAY with fine- to coarse-grained sand		-9						1507	
20			-14						1510	
25	Clayey SILT (MH): dark gray [10YR 4/1]; fine- to coarse-grained sand; increasing in sand content; medium plasticity; medium dry strength; no dilatancy; medium toughness		-19						1517	
30			-24						1521	
35	@ 35' - Increasing sand content to 45 ft		-29						1522	
40			-34						1523	
45	Clayey SAND (SC): grayish brown [10YR 4/1]; fine-grained sand; with fat clay and silt; medium to high plasticity; medium to high dry strength; 10% organic material (black, woody)		-39						1524	
50			-44						1532	
55	@ 55' - decrease in clay content; 1-3% woody material		-49						1534	
60			-54						1535	
65	SAND (SP): dark grayish brown [10YR 4/1]; wet; medium- to coarse-grained with silt and clay		-59						1537	
70			-63							

Elevation scale (ft): 6 to -63 in 1 ft increments.

CONTRACTOR	Gregg Drilling	**NORTHING**	2223452.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006074.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

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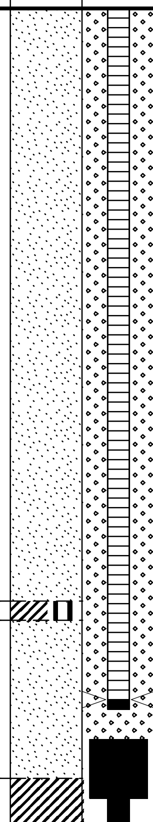
GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-4	**SHEET**	2 OF 2
START DRILL DATE	16 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	16 Aug 05	**GROUND SURF.**	6.94
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.11
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DEPTH (ft-bgs) | DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.) | GRAPHIC LOG | WELL LOG | GROUNDWATER OR STRUCTURE | ELEVATION (ft) | SAMPLE: SAMPLE NO., TYPE, BLOWS PER 6", RECOVERY (%), PID READING (ppm), TIME (00:00) | COMMENTS: 1) Rig Behavior 2) Air Monitoring



Description

- @ 70' - sand becomes medium-grained; color change to gray [5Y 5/1]; with trace silt and coarse gravel
- @ 72' - sand grades to coarse-grained sand
- @ 73' - color change to dark grayish green [5G 4/1]; sand becomes fine-grained; 10% fine to coarse gravel (subrounded)
- @ 80' - no gravel to 84.5 ft
- @ 85' - trace bivalve shells; slight increase in sand grain size; 20% fine to coarse gravel
- @ 95' - Sand becomes dark greenish gray [5G 4/1]; trace shell fragments, fine-grained; wet
- (100') SILT and CLAY (MH/CH): dark gray [2.5Y 4/1]; moist; interbedded with poorly graded sand; medium to high dry strength; dark greenish gray [5G 4/1] to 101 ft-bgs; firm; medium to high dry strength; no dilatancy
- SAND (SP): dark greenish gray [5G 4/1]; wet; fine-grained sand; trace shell fragments
- (109') CLAY (CH): dark gray [2.5Y 4/1]; medium plasticity; firm; high dry strength; no dilatancy; low to medium toughness
- Completed borehole at 111.5 ft-bgs.

Groundwater or Structure

Likely contact between shallow zone and upper sand

Samples

Elevation (ft)	Blows per 6"	Recovery (%)	PID Reading (ppm)	Time (00:00)	Comments
-64		67		1545	No recovery
-69		0		1600	
-74		90		1615	
-84	14 21 27	100	1.7	1702	Collected Sample RDO-4-90.5. End drilling at 1702 on 16 August 2005.
-89	12 24 26	100	2.2	0752	Resumed drilling at 0715 on 17 August 2005. Collected Sample RDO-4-95.5
-94	3 7 10	100	1.2	0817	
-99	4 19 15	100	1.6	0846	Collected Sample RDO-4-105.5
-104	7 7 9	100	1.3	0935	Change in drill pressure at 109'. Completed borehole at 1816 on 17 August 2005.

Depth scale: 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140 ft-bgs; Elevation scale: -64 to -133 ft.

CONTRACTOR	Gregg Drilling	**NORTHING**	2223452.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006074.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

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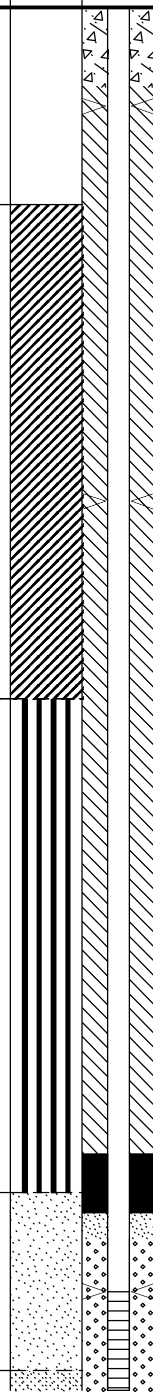
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-5	**SHEET** 1 **OF** 2	
START DRILL DATE	15 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	15 Aug 05	**GROUND SURF.**	6.53
LOCATION	Seal Beach, CA	**TOP OF CASING**	9.62
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

Column headings: DEPTH (ft-bgs); DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.); GRAPHIC LOG; WELL LOG; GROUNDWATER OR STRUCTURE; ELEVATION (ft); SAMPLE: SAMPLE NO., TYPE, BLOWS PER 6", RECOVERY (%), PID READING (ppm), TIME (00:00); COMMENTS: 1) Rig Behavior 2) Air Monitoring



DEPTH (ft-bgs)	DESCRIPTION	ELEVATION (ft)	TIME (00:00)	COMMENTS
0–10		5 to -3		Air Knife to 7 ft-bgs on 11 August 2005. Began drilling with mud rotary on 15 August 2005. All lithologic descriptions are based on mud rotary cuttings.
10	Silty CLAY (CH): dark grayish brown [10YR 4/2]; wet; trace fine- to coarse-grained sand; medium plasticity; medium dry strength; no dilatancy; low to medium toughness; variable amounts of silt and clay to approximately 30 ft-bgs; irregular grains of white carbonate (coarse-grained sand size); reacts strongly to HCl	-4	1048	
15		-9	1051	
20		-14	1055	
25		-19	1059	
30		-24	1102	
35	Clayey SILT (MH): dark grayish brown [10YR 4/2]; trace sand; fat clays; carbonate clasts to 1/2-in; react strongly to HCl	-29	1105	
40	@ 40' - increase in sand content	-34	1109	
45	@ 45' - black fibrous woody debris	-39	1111	
50		-44	1115	
55	@ 55' - sand becomes fine- to coarse-grained	-49	1117	
60	SAND (SP): medium-grained sand; silty clay	-54	1119	
65	@ 65' - decreases in silty clay	-59	1122	
70		-63		

CONTRACTOR	Gregg Drilling	**NORTHING**	2223284.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6005967.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

07-WELL BORE SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 6/12/05

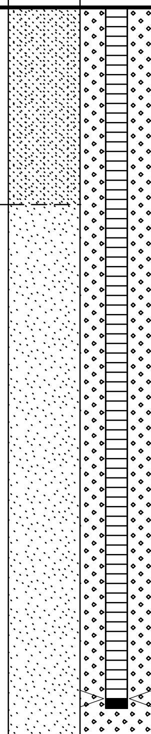
GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING RDO-5 **SHEET** 2 **OF** 2
START DRILL DATE 15 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 15 Aug 05 **GROUND SURF.** 6.53
LOCATION Seal Beach, CA **TOP OF CASING** 9.62
PROJECT Seal Beach NAVWPNSTA **DATUM** NAVD88
NUMBER HY0888

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GROUNDWATER OR STRUCTURE	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
	SAND (SW): coarse-grained sand with silt							1126	
75	@ 75' - sand becomes medium- to coarse-grained with silt and clay							1131	
80	SAND (SP): dark greenish gray [5G 4/1]; saturated; fine-grained sand; trace fine to medium gravel (subrounded)	Upper Sand						1138	
85					9 18 23	80	0.6	1210	Collected Sample RDO-5-85.5
90					12 22 32	80	3.0	1255	Collected Sample RDO-5-90
95	@ 95' - minor interbedded fat clay with sand				10 26 51	90 50	3.4	1330	
100	@ 100' - large shell fragment (to 1.5-in diameter); shell content increases to approximately 5%					80	1.9		
105							2.5		Overdilled borehole 2 ft for well installation. Completed borehole at 1500 on 15 August 2005.
107	Completed borehole at 107 ft-bgs.								



DEPTH scale: 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140

ELEVATION (ft): -65 through -133 (1-ft intervals)

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING 2223284.00
EASTING 6005967.00
COORDINATE SYSTEM: NAD83-CCS, Zone 6

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

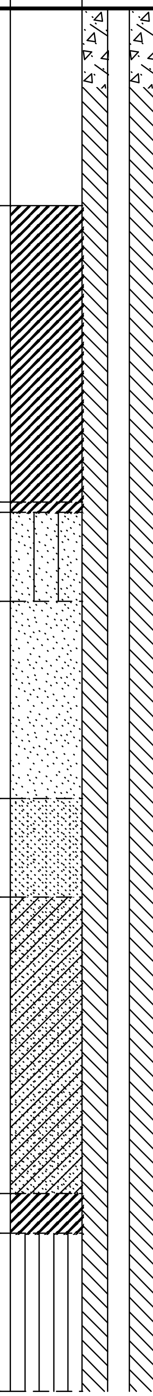
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-6A	**SHEET**	1 OF 2
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	9.28
LOCATION	Seal Beach, CA	**TOP OF CASING**	11.3
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

Column headings: DEPTH (ft-bgs); DESCRIPTION (1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)); GRAPHIC LOG; WELL LOG; GROUNDWATER OR STRUCTURE; ELEVATION (ft); SAMPLE: SAMPLE NO., TYPE, BLOWS PER 6", RECOVERY (%), PID READING (ppm), TIME (00:00); COMMENTS (1) Rig Behavior 2) Air Monitoring)



DEPTH (ft-bgs)	DESCRIPTION	ELEVATION (ft)	TIME (00:00)	COMMENTS
0–10		8 to 0	0830	Air Knife to 6 ft-bgs on 11 August 2005. Began drilling with mud rotary on 29 August 2005. All lithologic descriptions are based on mud rotary cuttings.
10	CLAY (CH): dark greenish gray [10Y 4/1]; high plasticity; high dry strength; no dilatancy; low toughness	-1	0847	
15		-6	0849	
20	@ 20' - trace fine- to coarse-grained sand; soft	-11	0852	
25	CLAY (CH): greenish gray [5G 5/1]; trace sand; highly plastic; grades to silty SAND Silty SAND (SM): grayish brown [2.5 5/2] mottled with iron oxide staining [10YR 5/6];	-16	0856	
30	SAND (SP): olive gray [5Y 5/2]; medium- to coarse-grained sand; trace silt; trace grains of white carbonate (coarse-grained sand size); react strongly to HCl	-21	0858	
35		-26	0900	Collected Sample RDO-6A-45
40	SAND (SW) transitioning to CLAY with SAND: greenish gray [5G 5/1]; carbonate (coarse sand-size) grains; trace sandy concretions	-31	0904	
45	Clayey SAND with SILT (SC): dark greenish gray [10Y 4/1]; medium- to coarse-grained sand; fat clay	-36	0909	
50		-41	0914	
55	@ 55' - Clayey SAND with Silt	-46	0916	A short deloay due to driller adjustments to equipment.
60	Silty CLAY (CH): dark greenish gray [5G 4/1]; trace sand; high plasticity; trace wood (to 1-in); trace white carbonate grains SILT with CLAY (ML): with trace sand; carbonate grains	-51	0928	
65		-56	0931	
70		-60		

CONTRACTOR	Gregg Drilling	**NORTHING**	2223072.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006285.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

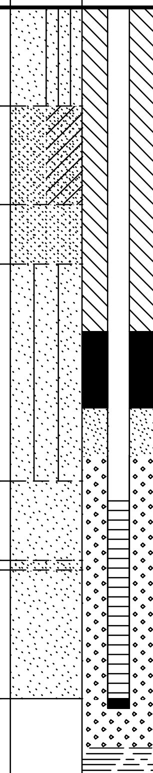
NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS	
2100 Main Street, Suite 150 Huntington Beach, CA 92648 Phone: (714) 969-0800	
GS FORM: WELL BORE 01/04	**BOREHOLE LOG**

BORING	**RDO-6A**	**SHEET 2 OF 2**	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	9.28
LOCATION	Seal Beach, CA	**TOP OF CASING**	11.3
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DEPTH (ft-bgs) — DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.) — GRAPHIC LOG — WELL LOG — GROUNDWATER OR STRUCTURE — ELEVATION (ft) — SAMPLE: SAMPLE NO., TYPE, BLOWS PER 6", RECOVERY (%), PID READING (ppm), TIME (00:00) — COMMENTS: 1) Rig Behavior 2) Air Monitoring



DEPTH (ft-bgs)	DESCRIPTION	TIME (00:00)	COMMENTS
71–75	SAND with SILT and CLAY (SP-SM): olive gray [5Y 5/2]; medium-grained	0933	
75–80	Well Graded SAND with CLAY (SW-SC): coarser grained; less silt	0935	
80–83	Well Graded SAND (SW): increasing sand grain size and decreasing silt and clay	0937	
83–95	Silty SAND with CLAY (SM): dark greenish gray [5GY 4/1]; coarse-grained sand; trace shell fragments	0940	
	@ 90' - shell fragment content increases to 1 to 3%	0945	
95–98	SAND (SP): dark greenish gray [5G 4/1]; fine-grained sand; very dense; 1 to 3% shell fragments		
98–99	SAND (SW): coarse-grained sand; gravel; 20% shell fragments; medium density		
99–105	SAND (SP): dark greenish gray [5G 4/1]; fine-grained sand; very dense		
105	Completed log at 105 ft-bgs; over drilled borehole 4 ft for well installation.		
109	Completed borehole at 109 ft-bgs.		Completed borehole at 1350 on 30 August 2005.

BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS
16, 29, 30	100	3.2	1010	Collected Sample RDO-6A-95.5
15, 32, 43	100	2.1	1042	
4, 9, 15	100	1.2	1115	
9, 17, 23	100	7.3	1147	Collected Sample RDO-6A-99.5
11, 30, 50	100	1.6	1246	
10, 33, 37	100	2.4	1317	

CONTRACTOR	Gregg Drilling	**NORTHING**	2223072.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006285.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-6B	**SHEET** 1 **OF** 3	
START DRILL DATE	25 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	25 Aug 05	**GROUND SURF.**	8.44
LOCATION	Seal Beach, CA	**TOP OF CASING**	10.6
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
0–10					7 to 0							Air Knife to 5 ft-bgs on 11 August 2005. Began drilling with mud rotary on 25 August 2005. All lithologic descriptions are based on mud rotary cuttings.
10	Clayey SILT (MH): dark gray [2.5Y 4/1]; moist; trace sand; medium toughness; low to medium plasticity				-1 to -2							
15	@ 15' - 30% sand and fine- to coarse gravel; color change to dark grayish brown [2.5Y 4/2]; trace shell fragments; grains of carbonate (coarse-grained sand size); react strongly to HCl				-7							
20	Silty CLAY (CH): dark gray [2.5Y 4/1]; wet; trace sand and carbonate grains; medium to high plasticity; trace carbonate grains				-12							
30	Silty fat CLAY (CH): dark gray [2.5Y 4/1]; wet; trace sand and fine gravel; trace carbonate grains to fine gravel size; soft				-22							
35	@ 35' - mottled with iron oxide staining				-27							
40	@ 40' - decrease in iron oxide staining				-32							
45	Sandy CLAY with SILT (CH): dark greenish gray [10Y 4/1]; medium to high plasticity; soft				-37							
50	SAND with CLAY (SP-SC): greenish gray [10Y 5/1]; wet; medium-grained sand;				-42							
55	Silty CLAY with coarse SAND (SC)				-47							
60	CLAY with SILT and SAND (CH): dark greenish gray [10GY 4/1]; sand; silt; medium to high plasticity; soft				-52							
65	@ 65' - increase in sand content				-57 to -61							
70												

CONTRACTOR	Gregg Drilling	**NORTHING**	2223059.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006258.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING	RDO-6B	**SHEET**	2 OF 3
START DRILL DATE	25 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	25 Aug 05	**GROUND SURF.**	8.44
LOCATION	Seal Beach, CA	**TOP OF CASING**	10.6
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	NAVD88
NUMBER	HY0888		

DESCRIPTION: 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)

COMMENTS: 1) Rig Behavior 2) Air Monitoring

DEPTH (ft-bgs)	DESCRIPTION
	SAND (SP): grayish brown [10YR 5/2]; trace silt; trace clay; medium density
75	SAND with GRAVEL (SW): coarse-grained sand; fine to medium gravel
	SAND with SILT (SP): fine- to medium-grained sand
80	CLAY with SILT (CH): dark greenish gray [5GY 4/1]; soft; organic odor
	SAND with CLAY (SP): dark greenish gray [5GY 4/1]; coarse-grained; trace shell fragments
90	@ 90' - SAND with Silt and Clay; medium-grained; shell fragments 3 to 5%
95	@ 95' - increase in shell fragments to 10%
100	@ 100' - increase in shell fragments to 15%
105	@ 105' - increase in shell fragments to 20%
	@ 106.5' - SAND (SP): dark greenish gray [5GY 4/1]; wet; fine-grained; dense; no shells
112	@ 112' - fine-grained sand; dark greenish gray [5GY 4/1]; trace shells; trace woody organics
120	@ 120' - fine-grained sand; dark greenish gray [5GY 4/1]; micaceous; trace shell fragments; interbedded with medium- to coarse-grained sand with fine to coarse gravel and clayey silt (MH) to silty clay (CH); soft to firm
	SAND with SILT (SP-SM): medium-grained; trace woody organics
135	Possible CLAY (CH) layer inferred from blow counts
	SAND with SILT (SP-SM): medium-grained; trace woody organics
	SAND with SILT (SP): trace shell fragments;

Elevation scale (ft): -63 to -131

ELEVATION (ft)	BLOWS PER 6"	RECOVERY (%)	TIME (00:00)	COMMENTS
-63	13, 14, 14	90	0845	Collected Sample RDO-6B-70.5
-67	7, 21, 23	100	0915	Microcosm sample #5 and collected Sample RDO-6B-75
-69	3, 3	0		Clay plugged sampler; no recover 76.5 to 78 ft
-72	2, 2, 2, 2	100		
-98	5, 13, 23	100	1125	Collected Sample RDO-6B-105
-105	11, 20	100	1203	Collected Sample RDO-6B-112.5
-107	27, 3	90	1330	
-108	7, 21, 2, 2, 3	0	1359	
-127	2, 2	0	1528	
-129	3, 14	100	1609	
-131	32	100	1647	

CONTRACTOR	Gregg Drilling	**NORTHING**	2223059.00
EQUIPMENT	Versa-Drill V100	**EASTING**	6006258.00
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	NAD83-CCS, Zone 6
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL BORE 01/04

BOREHOLE LOG

BORING RDO-6B **SHEET** 3 **OF** 3
START DRILL DATE 25 Aug 05 **ELEVATION DATA:**
FINISH DRILL DATE 25 Aug 05 **GROUND SURF.** 8.44
LOCATION Seal Beach, CA **TOP OF CASING** 10.6
PROJECT Seal Beach NAVWPNSTA **DATUM** NAVD88
NUMBER HY0888

DEPTH (ft-bgs)	DESCRIPTION 1) Unit/Formation, Mem. 2) Soil/Rock Name 3) Color 4) Moisture 5) Grain Size 6) Percentage 7) Plasticity 8) Density/Consistency 9) Structure 10) Other (Mineralization, Discoloration, Odor, etc.)	GRAPHIC LOG	WELL LOG	GROUNDWATER OR STRUCTURE	ELEVATION (ft)	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY (%)	PID READING (ppm)	TIME (00:00)	COMMENTS 1) Rig Behavior 2) Air Monitoring
	dense SAND with GRAVEL (SW) SAND (SP): dark grayish green [5GY 4/1]; wet fine-grained sand; micaceous; trace shell fragments				-133 -134 -135 -136			31 9 16 35				Collected Sample RDO-6B-139.5 Completed lithologic descriptions. Overdilled borehole 5 ft for well installation. Completed borehole at 1740 on 26 August 2005.
145	Completed log at 140 ft-bgs; over drilled borehole 5 ft for well installation. Completed borehole at 145 ft-bgs.				-137 -138 -139 -140 -141							
150					-142 -143 -144 -145 -146							
155					-147 -148 -149 -150 -151							
160					-152 -153 -154 -155 -156							
165					-157 -158 -159 -160 -161							
170					-162 -163 -164 -165 -166							
175					-167 -168 -169 -170 -171							
180					-172 -173 -174 -175 -176							
185					-177 -178 -179 -180 -181							
190					-182 -183 -184 -185 -186							
195					-187 -188 -189 -190 -191							
200					-192 -193 -194 -195 -196							
205					-197 -198 -199 -200 -201							
210												

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING 2223059.00
EASTING 6006258.00
COORDINATE SYSTEM: NAD83-CCS, Zone 6

NOTES:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

APPENDIX D-C
Well Construction Logs

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL COMP AG 01/04

WELL CONSTRUCTION LOG

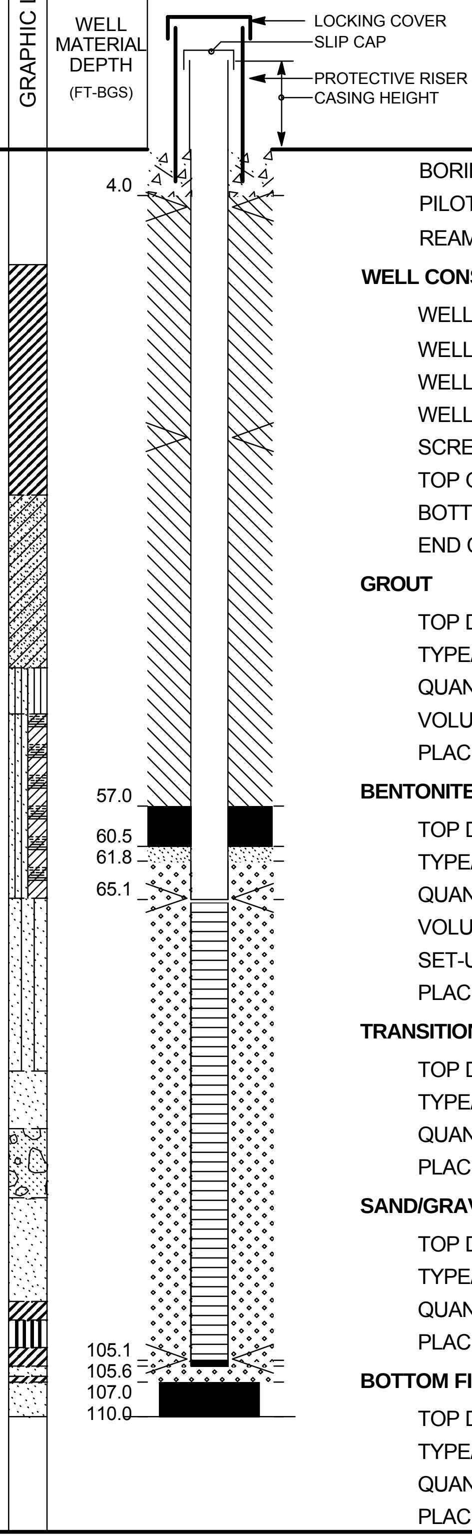
BORING RDO-1 **SHEET** 1 **OF** 1
START DRILL DATE 19 Aug 05
FINISH DRILL DATE 19 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888

ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs) | COMMENTS: 1) Groundwater 2) Surge Time 3) Dedicated Pump | GRAPHIC LOG | WELL MATERIAL DEPTH (FT-BGS)

Please see RDO-1 borehole log for a complete lithologic description.

Depth scale: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120



SURFACE COMPLETION:

TYPE	Above Ground Monument
RISER HEIGHT	2.7 ft
RISER DIAM.	4-in
WELL CASING HEIGHT	2.3 ft
CONCRETE PAD SIZE	2 ft x 2 ft x 0.5 ft
BORING DEPTH	110 ft-bgs
PILOT BORING DIAMETER	5-in
REAM BORING DIAMETER	10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE	8/19/2005
WELL DEPTH	105.6 ft-bgs
WELL CASING DIAMETER	4.0-in ID and 4.5-in OD
WELL CASING MATERIAL	Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION	Horizontal 0.02-in
TOP OF SCREEN	65.1 ft-bgs
BOTTOM OF SCREEN	105.1 ft-bgs
END CAP/SUMP LENGTH	0.5 ft

GROUT

TOP DEPTH	4 ft-bgs
TYPE/BRAND	Cement/Bentonite
QUANTITY USED	175 gal
VOLUME FLUID USED	~85 gal water
PLACEMENT METHOD	Tremied

BENTONITE SEAL

TOP DEPTH	57 ft-bgs
TYPE/BRAND	EnviroPlug Medium Bentonite Chips
QUANTITY USED	150 lbs
VOLUME FLUID USED	NA
SET-UP TIME	30 min
PLACEMENT METHOD	Free fall from surface

TRANSITION SAND

TOP DEPTH	60.5 ft-bgs
TYPE/BRAND	RMC Lapic Lustre #1C
QUANTITY USED	100 lbs
PLACEMENT METHOD	Tremied with water

SAND/GRAVEL PACK

TOP DEPTH	61.8 ft-bgs
TYPE/BRAND	RMC Lapis Lustre #2/12
QUANTITY USED	2100 lbs
PLACEMENT METHOD	Tremied with water

BOTTOM FILL

TOP DEPTH	107 ft-bgs
TYPE/BRAND	EnviroPlug Medium Bentonite Chips
QUANTITY USED	50 lbs
PLACEMENT METHOD	Free fall from surface

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING
EASTING
COORDINATE SYSTEM:

DEDICATED PUMP SYSTEM:
TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

08-WELL_COMP_AG SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

GeoSyntec Consultants

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

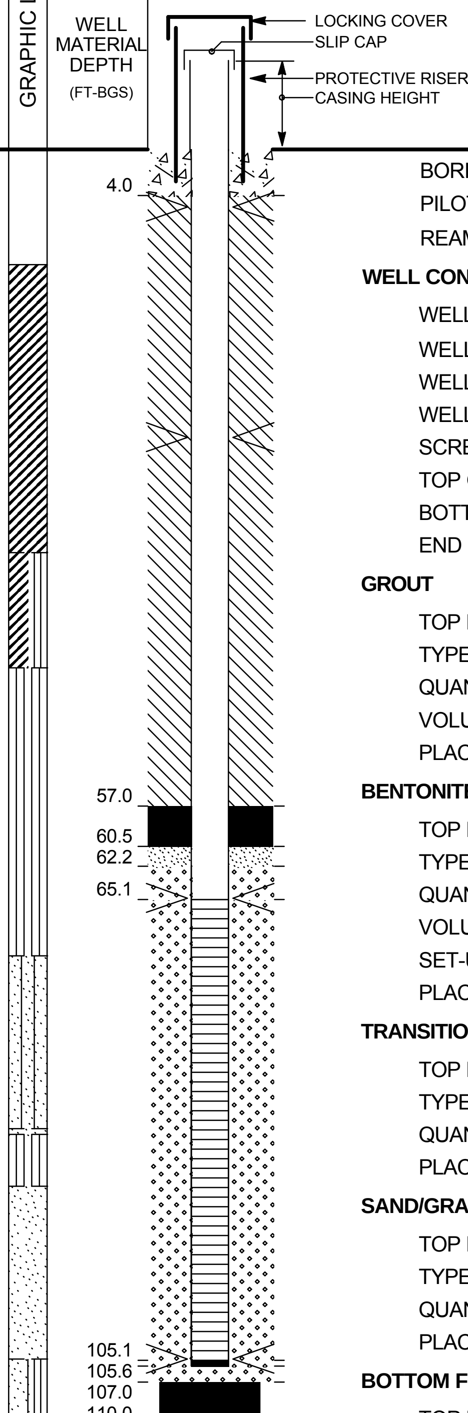
GS FORM: WELL COMP AG 01/04

WELL CONSTRUCTION LOG

BORING RDO-2 **SHEET** 1 **OF** 1
START DRILL DATE 18 Aug 05
FINISH DRILL DATE 18 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888

ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs)	COMMENTS 1) Groundwater 2) Surge Time 3) Dedicated Pump	GRAPHIC LOG	WELL MATERIAL DEPTH (FT-BGS)
	Please see RDO-2 borehole log for a complete lithologic description.		



SURFACE COMPLETION:

TYPE Above Ground Monument
RISER HEIGHT 2.4 ft
RISER DIAM. 4-in
WELL CASING HEIGHT 2.1 ft
CONCRETE PAD SIZE 2 ft x 2 ft x 0.5 ft

BORING DEPTH 110 ft-bgs
PILOT BORING DIAMETER 5-in
REAM BORING DIAMETER 10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE 8/19/2005
WELL DEPTH 105.6 ft-bgs
WELL CASING DIAMETER 4.0-in ID and 4.5-in OD
WELL CASING MATERIAL Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION Horizontal 0.02-in
TOP OF SCREEN 65.1 ft-bgs
BOTTOM OF SCREEN 105.1 ft-bgs
END CAP/SUMP LENGTH 0.5 ft

GROUT

TOP DEPTH 4 ft-bgs
TYPE/BRAND Cement/Bentonite
QUANTITY USED 175 gal
VOLUME FLUID USED ~85 gal water
PLACEMENT METHOD Tremied

BENTONITE SEAL

TOP DEPTH 57 ft-bgs
TYPE/BRAND EnviroPlug Medium Bentonite Chips
QUANTITY USED 150 lbs
VOLUME FLUID USED NA
SET-UP TIME 30 min
PLACEMENT METHOD Free fall from surface

TRANSITION SAND

TOP DEPTH 60.5 ft-bgs
TYPE/BRAND RMC Lapic Lustre #1C
QUANTITY USED 100 lbs
PLACEMENT METHOD Tremied with water

SAND/GRAVEL PACK

TOP DEPTH 62.2 ft-bgs
TYPE/BRAND RMC Lapis Lustre #2/12
QUANTITY USED 2100 lbs
PLACEMENT METHOD Tremied with water

BOTTOM FILL

TOP DEPTH 107 ft-bgs
TYPE/BRAND EnviroPlug Medium Bentonite Chips
QUANTITY USED 50 lbs
PLACEMENT METHOD Free fall from surface

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING
EASTING
COORDINATE SYSTEM:

DEDICATED PUMP SYSTEM:

TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM:
WELL COMP AG 01/04

WELL CONSTRUCTION LOG

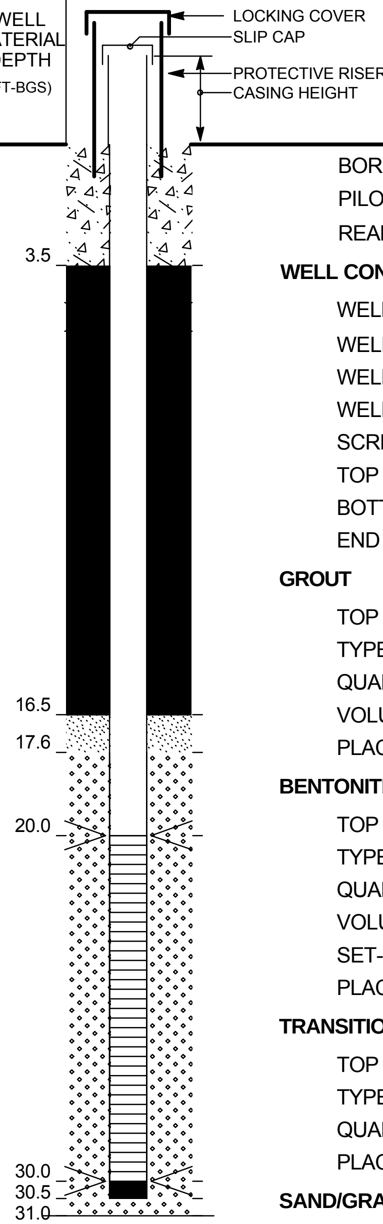
BORING	RDO-3A
SHEET	1 OF 1
START DRILL DATE	22 Aug 05
FINISH DRILL DATE	23 Aug 05
LOCATION	Seal Beach, CA
PROJECT	Seal Beach NAVWPNSTA
NUMBER	HY0888
ELEVATION DATA:	
GROUND SURF.	
TOP OF CASING	
DATUM	

DEPTH (ft-bgs) | COMMENTS | GRAPHIC LOG | WELL MATERIAL DEPTH (FT-BGS)

COMMENTS
1) Groundwater
2) Surge Time
3) Dedicated Pump

Please see RDO-3A borehole log for a complete lithologic description.

Depth scale: 10, 20, 30, 40



SURFACE COMPLETION:

TYPE	Above Ground Monument
RISER HEIGHT	2.6 ft
RISER DIAM.	4-in
WELL CASING HEIGHT	2.2 ft
CONCRETE PAD SIZE	2 ft x 2 ft x 0.5 ft

BORING DEPTH	31 ft-bgs
PILOT BORING DIAMETER	5-in
REAM BORING DIAMETER	10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE	8/23/2005
WELL DEPTH	30.5 ft-bgs
WELL CASING DIAMETER	4.0-in ID and 4.5-in OD
WELL CASING MATERIAL	Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION	Horizontal 0.02-in
TOP OF SCREEN	20 ft-bgs
BOTTOM OF SCREEN	30 ft-bgs
END CAP/SUMP LENGTH	0.5 ft

GROUT

TOP DEPTH	NA
TYPE/BRAND	NA
QUANTITY USED	NA
VOLUME FLUID USED	NA
PLACEMENT METHOD	NA

BENTONITE SEAL

TOP DEPTH	3.5 ft-bgs
TYPE/BRAND	EnviroPlug Medium Bentonite Chips
QUANTITY USED	350 ibs
VOLUME FLUID USED	NA
SET-UP TIME	NA
PLACEMENT METHOD	Free fall from surface

TRANSITION SAND

TOP DEPTH	16.5 ft-bgs
TYPE/BRAND	RMC Lapic Lustre #1C
QUANTITY USED	50 lbs
PLACEMENT METHOD	Tremied with water

SAND/GRAVEL PACK

TOP DEPTH	17.6 ft-bgs
TYPE/BRAND	RMC Lapis Lustre #2/12
QUANTITY USED	350 lbs
PLACEMENT METHOD	Tremied with water

BOTTOM FILL

TOP DEPTH	NA
TYPE/BRAND	NA
QUANTITY USED	NA
PLACEMENT METHOD	NA

CONTRACTOR	Gregg Drilling
EQUIPMENT	Versa-Drill V100
DRILL MTHD	Mud Rotary
DIAMETER	10-in
LOGGER	KK
REVIEWER	
NORTHING	
EASTING	
COORDINATE SYSTEM:	

DEDICATED PUMP SYSTEM:
TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

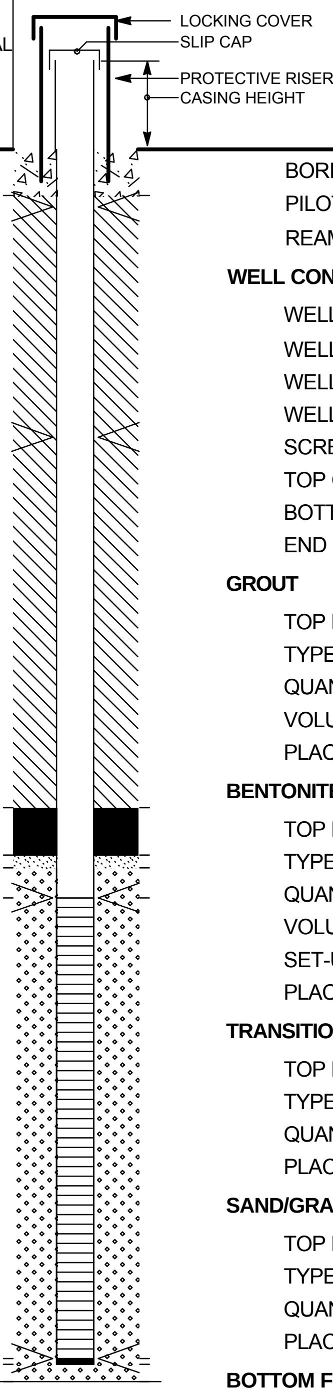
GS FORM: WELL COMP AG 01/04

WELL CONSTRUCTION LOG

BORING RDO-3B **SHEET** 1 **OF** 1
START DRILL DATE 23 Aug 05
FINISH DRILL DATE 23 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888

ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs)	COMMENTS 1) Groundwater 2) Surge Time 3) Dedicated Pump	GRAPHIC LOG	WELL MATERIAL DEPTH (FT-BGS)
	Please see RDO-3B borehole log for a complete lithologic description.		4.0
10			
20			
30			
40			
50			57.2
60			61.3 62.4 65.0
70			
80			
90			
100			105.0 105.5 107.0
110			
120			



SURFACE COMPLETION:

TYPE Above Ground Monument
RISER HEIGHT 2.6 ft
RISER DIAM. 4-in
WELL CASING HEIGHT 2.1 ft
CONCRETE PAD SIZE 2 ft x 2 ft x 0.5 ft

BORING DEPTH 107 ft-bgs
PILOT BORING DIAMETER 5-in
REAM BORING DIAMETER 10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE 8/24/2005
WELL DEPTH 105.5 ft-bgs
WELL CASING DIAMETER 4.0-in ID and 4.5-in OD
WELL CASING MATERIAL Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION Horizontal 0.02-in
TOP OF SCREEN 65 ft-bgs
BOTTOM OF SCREEN 105 ft-bgs
END CAP/SUMP LENGTH 0.5 ft

GROUT

TOP DEPTH 4 ft-bgs
TYPE/BRAND Cement/Bentonite
QUANTITY USED 175 gal
VOLUME FLUID USED ~85 gal water
PLACEMENT METHOD Tremied

BENTONITE SEAL

TOP DEPTH 57.2 ft-bgs
TYPE/BRAND EnviroPlug Medium Bentonite Chips
QUANTITY USED 200 lbs
VOLUME FLUID USED NA
SET-UP TIME NA
PLACEMENT METHOD Free fall from surface

TRANSITION SAND

TOP DEPTH 61.3 ft-bgs
TYPE/BRAND RMC Lapic Lustre #1C
QUANTITY USED 100 lbs
PLACEMENT METHOD Tremied with water

SAND/GRAVEL PACK

TOP DEPTH 62.4 ft-bgs
TYPE/BRAND RMC Lapis Lustre #2/12
QUANTITY USED 2200 lbs
PLACEMENT METHOD Tremied with water

BOTTOM FILL

TOP DEPTH NA
TYPE/BRAND NA
QUANTITY USED NA
PLACEMENT METHOD NA

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING
EASTING
COORDINATE SYSTEM:

DEDICATED PUMP SYSTEM:
TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL COMP AG 01/04

WELL CONSTRUCTION LOG

BORING	RDO-4	**SHEET** 1 **OF** 1	
START DRILL DATE	16 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	16 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

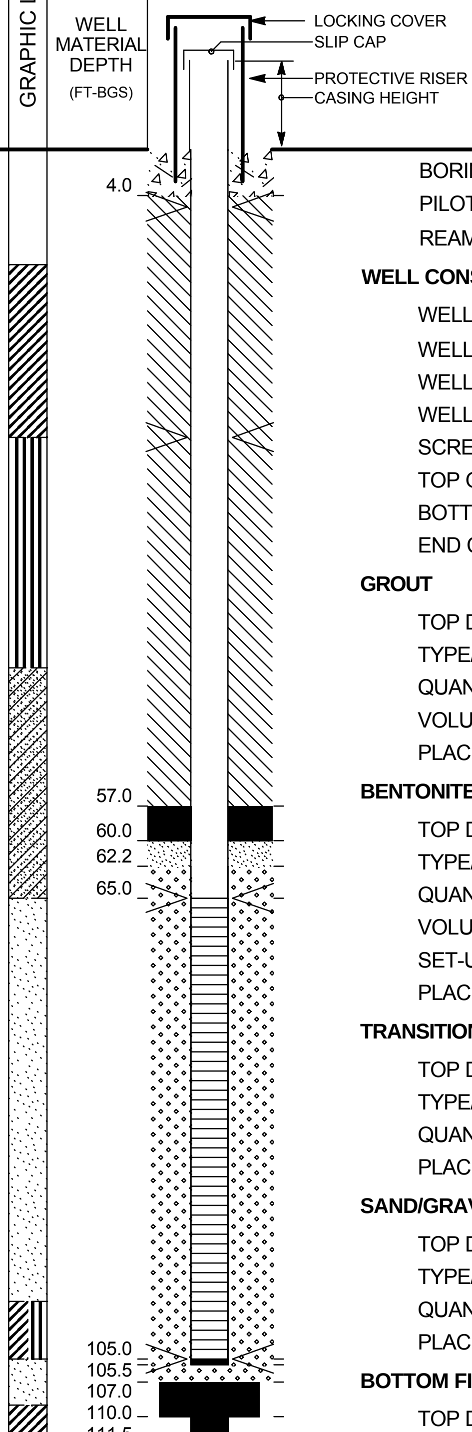
DEPTH (ft-bgs)

COMMENTS
1) Groundwater
2) Surge Time
3) Dedicated Pump

GRAPHIC LOG

WELL MATERIAL DEPTH (FT-BGS)

Please see RDO-4 borehole log for a complete lithologic description.



SURFACE COMPLETION:

- TYPE: Above Ground Monument
- RISER HEIGHT: 2.6 ft
- RISER DIAM.: 4-in
- WELL CASING HEIGHT: 2.2 ft
- CONCRETE PAD SIZE: 2 ft x 2 ft x 0.5 ft

- BORING DEPTH: 111.5 ft-bgs
- PILOT BORING DIAMETER: 5-in
- REAM BORING DIAMETER: 10-in

WELL CONSTRUCTION

- WELL CONSTRUCTION DATE: 8/17/2005
- WELL DEPTH: 105.5 ft-bgs
- WELL CASING DIAMETER: 4.0-in ID and 4.5-in OD
- WELL CASING MATERIAL: Schedule 40 PVC
- SCREEN SLOT SIZE/DIRECTION: Horizontal 0.02-in
- TOP OF SCREEN: 65 ft-bgs
- BOTTOM OF SCREEN: 105 ft-bgs
- END CAP/SUMP LENGTH: 0.5 ft

GROUT

- TOP DEPTH: 4 ft-bgs
- TYPE/BRAND: Cement/Bentonite
- QUANTITY USED: 175 gal
- VOLUME FLUID USED: ~85 gal water
- PLACEMENT METHOD: Tremied

BENTONITE SEAL

- TOP DEPTH: 57 ft-bgs
- TYPE/BRAND: EnviroPlug Medium Bentonite Chips
- QUANTITY USED: 150 lbs
- VOLUME FLUID USED: NA
- SET-UP TIME: 45 min
- PLACEMENT METHOD: Free fall from surface

TRANSITION SAND

- TOP DEPTH: 60 ft-bgs
- TYPE/BRAND: RMC Lapic Lustre #1C
- QUANTITY USED: 50 lbs
- PLACEMENT METHOD: Tremied with water

SAND/GRAVEL PACK

- TOP DEPTH: 62.2 ft-bgs
- TYPE/BRAND: RMC Lapis Lustre #2/12
- QUANTITY USED: 2200 lbs
- PLACEMENT METHOD: Tremied with water

BOTTOM FILL

- TOP DEPTH: 107 ft-bgs
- TYPE/BRAND: EnviroPlug Medium Bentonite Chips
- QUANTITY USED: 50 lbs
- PLACEMENT METHOD: Free fall from surface

CONTRACTOR Gregg Drilling	**NORTHING**
EQUIPMENT Versa-Drill V100	**EASTING**
DRILL MTHD Mud Rotary	**COORDINATE SYSTEM:**
DIAMETER 10-in	
LOGGER KK	**REVIEWER**

DEDICATED PUMP SYSTEM:

TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL COMP AG 01/04

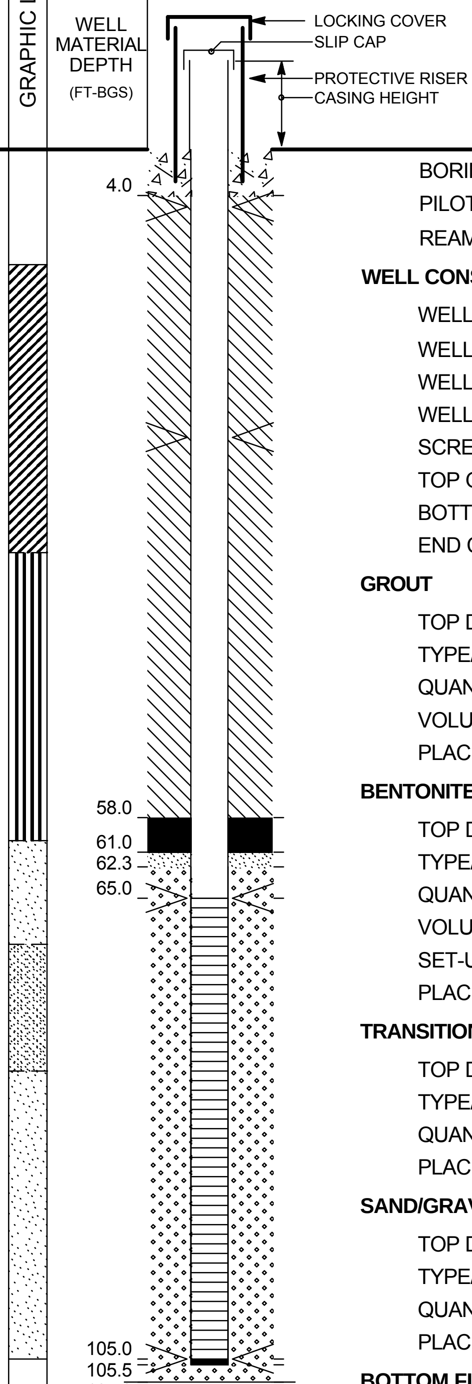
WELL CONSTRUCTION LOG

BORING	RDO-5	**SHEET** 1 **OF** 1	
START DRILL DATE	15 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	15 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft-bgs) | COMMENTS: 1) Groundwater 2) Surge Time 3) Dedicated Pump | GRAPHIC LOG | WELL MATERIAL DEPTH (FT-BGS)

Please see RDO-4 borehole log for a complete lithologic description.

Depth scale: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120



SURFACE COMPLETION:

TYPE	Above Ground Monument
RISER HEIGHT	2.5 ft
RISER DIAM.	4-in
WELL CASING HEIGHT	2.1 ft
CONCRETE PAD SIZE	2 ft x 2 ft x 0.5 ft
BORING DEPTH	107 ft-bgs
PILOT BORING DIAMETER	5-in
REAM BORING DIAMETER	10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE	8/16/2005
WELL DEPTH	105.5 ft-bgs
WELL CASING DIAMETER	4.0-in ID and 4.5-in OD
WELL CASING MATERIAL	Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION	Horizontal 0.02-in
TOP OF SCREEN	65 ft-bgs
BOTTOM OF SCREEN	105 ft-bgs
END CAP/SUMP LENGTH	0.5 ft

GROUT

TOP DEPTH	4 ft-bgs
TYPE/BRAND	Cement/Bentonite
QUANTITY USED	175 gal
VOLUME FLUID USED	NA
PLACEMENT METHOD	Tremied

BENTONITE SEAL

TOP DEPTH	58 ft-bgs
TYPE/BRAND	EnviroPlug Medium Bentonite Chips
QUANTITY USED	150 lbs
VOLUME FLUID USED	NA
SET-UP TIME	NA
PLACEMENT METHOD	Free fall from surface

TRANSITION SAND

TOP DEPTH	58 ft-bgs
TYPE/BRAND	RMC Lapic Lustre #1C
QUANTITY USED	100 lbs
PLACEMENT METHOD	Tremied with water

SAND/GRAVEL PACK

TOP DEPTH	62.3 ft-bgs
TYPE/BRAND	RMC Lapis Lustre #2/12
QUANTITY USED	2800 lbs
PLACEMENT METHOD	Tremied with water

BOTTOM FILL

TOP DEPTH	NA
TYPE/BRAND	NA
QUANTITY USED	NA
PLACEMENT METHOD	NA

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK **REVIEWER**

NORTHING
EASTING
COORDINATE SYSTEM:

DEDICATED PUMP SYSTEM:
TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

08-WELL_COMP_AG SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

GEOSYNTEC CONSULTANTS

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

GS FORM: WELL COMP AG 01/04

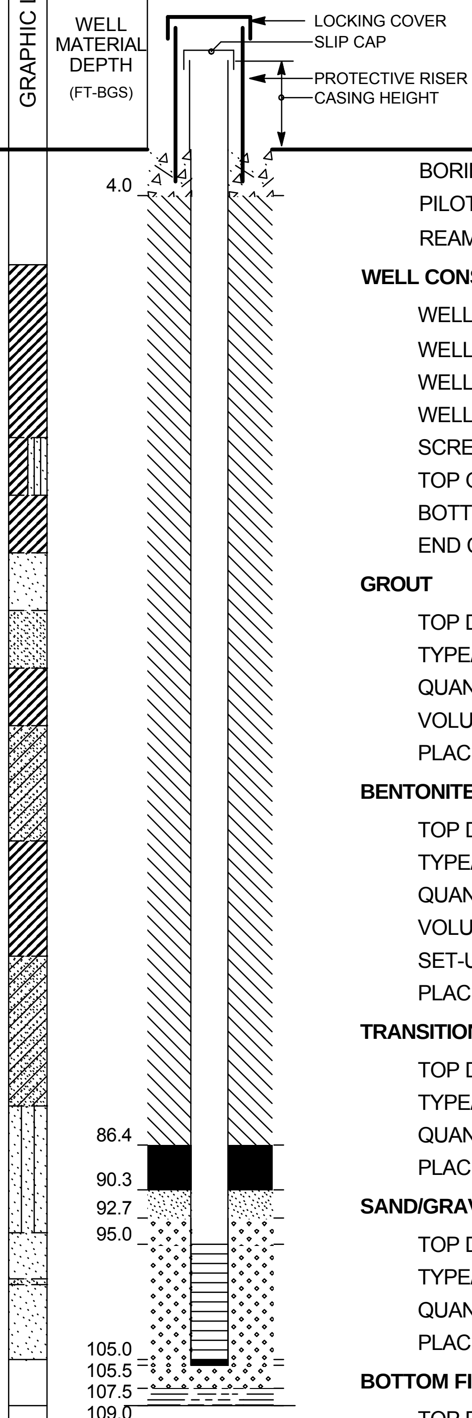
WELL CONSTRUCTION LOG

BORING	RDO-6A	**SHEET** 1 **OF** 1	
START DRILL DATE	30 Aug 05	**ELEVATION DATA:**	
FINISH DRILL DATE	30 Aug 05	**GROUND SURF.**	
LOCATION	Seal Beach, CA	**TOP OF CASING**	
PROJECT	Seal Beach NAVWPNSTA	**DATUM**	
NUMBER	HY0888		

DEPTH (ft-bgs) | COMMENTS: 1) Groundwater 2) Surge Time 3) Dedicated Pump | GRAPHIC LOG | WELL MATERIAL DEPTH (FT-BGS)

Comments: Please see RDO-6A borehole log for a complete lithologic description.

Depth scale: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120



SURFACE COMPLETION:

TYPE	Above Ground Monument
RISER HEIGHT	2.4 ft
RISER DIAM.	4-in
WELL CASING HEIGHT	2.0 ft
CONCRETE PAD SIZE	2 ft x 2 ft x 0.5 ft
BORING DEPTH	109 ft-bgs
PILOT BORING DIAMETER	5-in
REAM BORING DIAMETER	10-in

WELL CONSTRUCTION

WELL CONSTRUCTION DATE	8/30/2005
WELL DEPTH	105.5 ft-bgs
WELL CASING DIAMETER	4.0-in ID and 4.5-in OD
WELL CASING MATERIAL	Schedule 40 PVC
SCREEN SLOT SIZE/DIRECTION	Horizontal 0.02-in
TOP OF SCREEN	95 ft-bgs
BOTTOM OF SCREEN	105 ft-bgs
END CAP/SUMP LENGTH	0.5 ft

GROUT

TOP DEPTH	4 ft-bgs
TYPE/BRAND	Cement/Bentonite
QUANTITY USED	1598 lbs
VOLUME FLUID USED	140 gal
PLACEMENT METHOD	Tremied

BENTONITE SEAL

TOP DEPTH	86.4 ft-bgs
TYPE/BRAND	EnviroPlug Medium Bentonite Chips
QUANTITY USED	150 lbs
VOLUME FLUID USED	NA
SET-UP TIME	50 min
PLACEMENT METHOD	Free fall from surface

TRANSITION SAND

TOP DEPTH	90.3 ft-bgs
TYPE/BRAND	RMC Lapic Lustre #1C
QUANTITY USED	100 lbs
PLACEMENT METHOD	Tremied with water

SAND/GRAVEL PACK

TOP DEPTH	92.7 ft-bgs
TYPE/BRAND	RMC Lapis Lustre #2/12
QUANTITY USED	700 lbs
PLACEMENT METHOD	Tremied with water

BOTTOM FILL

TOP DEPTH	107.5 ft-bgs
TYPE/BRAND	NA
QUANTITY USED	NA
PLACEMENT METHOD	NA

CONTRACTOR	Gregg Drilling	**NORTHING**	
EQUIPMENT	Versa-Drill V100	**EASTING**	
DRILL MTHD	Mud Rotary	**COORDINATE SYSTEM:**	
DIAMETER	10-in		
LOGGER	KK	**REVIEWER**	

DEDICATED PUMP SYSTEM:

TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

08-WELL_COMP_AG SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

GEOSYNTEC CONSULTANTS
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Phone: (714) 969-0800

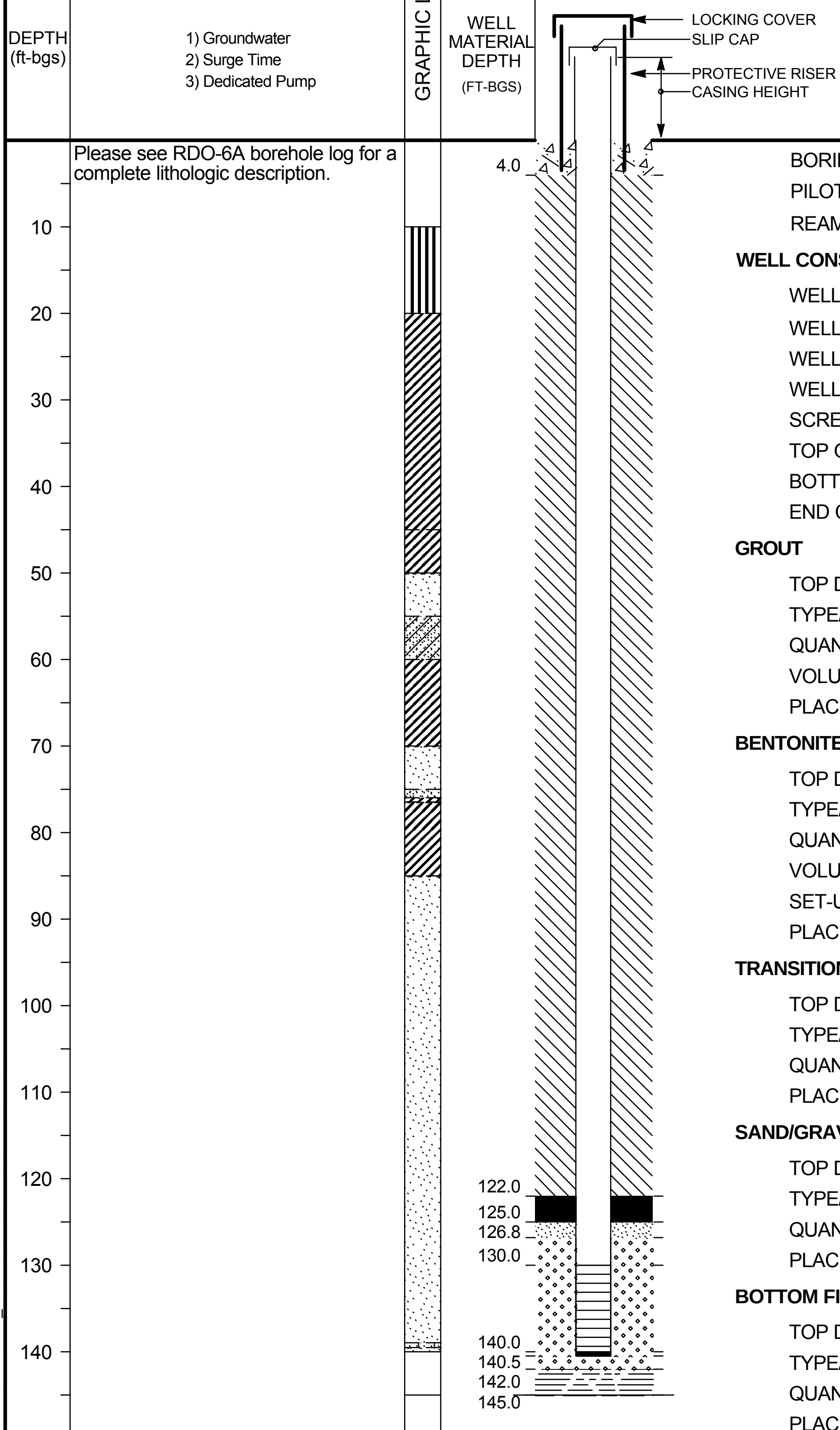
GS FORM: WELL COMP AG 01/04

WELL CONSTRUCTION LOG

BORING RDO-6B **SHEET** 1 **OF** 1
START DRILL DATE 25 Aug 05
FINISH DRILL DATE 25 Aug 05
LOCATION Seal Beach, CA
PROJECT Seal Beach NAVWPNSTA
NUMBER HY0888
ELEVATION DATA:
GROUND SURF.
TOP OF CASING
DATUM

DEPTH (ft-bgs) | COMMENTS: 1) Groundwater 2) Surge Time 3) Dedicated Pump | GRAPHIC LOG | WELL MATERIAL DEPTH (FT-BGS)

Please see RDO-6A borehole log for a complete lithologic description.



SURFACE COMPLETION:

- TYPE: Above Ground Monument
- RISER HEIGHT: 2.5 ft
- RISER DIAM.: 4-in
- WELL CASING HEIGHT: 2.2 ft
- CONCRETE PAD SIZE: 2 ft x 2 ft x 0.5 ft
- BORING DEPTH: 145 ft-bgs
- PILOT BORING DIAMETER: 5-in
- REAM BORING DIAMETER: 10-in

WELL CONSTRUCTION

- WELL CONSTRUCTION DATE: 8/26/2005
- WELL DEPTH: 140.5 ft-bgs
- WELL CASING DIAMETER: 4.0-in ID and 4.5-in OD
- WELL CASING MATERIAL: Schedule 40 PVC
- SCREEN SLOT SIZE/DIRECTION: Horizontal 0.02-in
- TOP OF SCREEN: 130 ft-bgs
- BOTTOM OF SCREEN: 140 ft-bgs
- END CAP/SUMP LENGTH: 0.5 ft

GROUT

- TOP DEPTH: 4 ft-bgs
- TYPE/BRAND: CA Portland Cement Type II/V
- QUANTITY USED: 400 gal
- VOLUME FLUID USED: 200 gal
- PLACEMENT METHOD: Tremied

BENTONITE SEAL

- TOP DEPTH: 122 ft-bgs
- TYPE/BRAND: EnviroPlug Medium Bentonite Chips
- QUANTITY USED: 150 lbs
- VOLUME FLUID USED: NA
- SET-UP TIME: 45 min
- PLACEMENT METHOD: Free fall from surface

TRANSITION SAND

- TOP DEPTH: 125 ft-bgs
- TYPE/BRAND: RMC Lapic Lustre #1C
- QUANTITY USED: 100 lbs
- PLACEMENT METHOD: Tremied with water

SAND/GRAVEL PACK

- TOP DEPTH: 126.8 ft-bgs
- TYPE/BRAND: RMC Lapis Lustre #2/12
- QUANTITY USED: 900 lbs
- PLACEMENT METHOD: Tremied with water

BOTTOM FILL

- TOP DEPTH: 142 ft-bgs
- TYPE/BRAND: NA
- QUANTITY USED: NA
- PLACEMENT METHOD: NA

CONTRACTOR Gregg Drilling
EQUIPMENT Versa-Drill V100
DRILL MTHD Mud Rotary
DIAMETER 10-in
LOGGER KK
REVIEWER
NORTHING
EASTING
COORDINATE SYSTEM:

DEDICATED PUMP SYSTEM:
TYPE/BRAND:
MODEL:
CONTROLLER TYPE:

SEE KEY SHEET FOR SYMBOLS AND ABBREVIATIONS

08-WELL_COMP_AG SEALBCHHY0888_05.GPJ GEOSNTEC.GDT 30/11/05

APPENDIX D-D
Well Development Logs

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME: NWS Seal Beach #70

WELL NO.: RD01

PROJECT NO.: HY0888-05*4

SITE: NWS

PREPARED BY: Matt Darr

METHOD
- PUMP: Submersible
- BAILER: 5 gal
- OTHER:

DEVELOPMENT CRITERIA: < 5 NTU; w/in 10% Δ in pH, Cond, Temp

REMARKS: Developed @ screen intervals of 10' to 15'.

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = 2.8

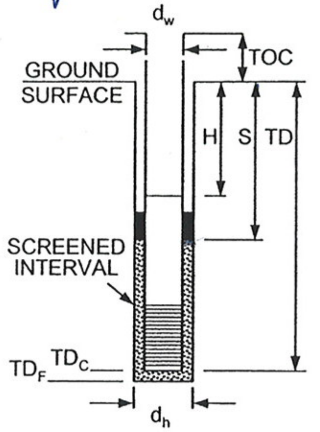
- INSIDE DIAM d_wID = 4"
- OUTSIDE DIAM d_wOD = –
- HOLE DIAMETER d_h = 10"

DEPTH TO:

- SCREENED INTERVAL 65 TO 105
- WATER LEVEL H = 13.01
- BASE OF SEAL S = 57
- BASE OF CASING TD_C = 105.86

BASE OF FILTER PACK TD_F = 107

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2 (\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)	~~Fe~~	
8/26	0813	–	13.01	0	0	–	–	–	–	–	Begin Bailing Rotary mud
	0830	–	–	35	35	–	–	–	–	–	Rotary Mud
	0835-0904	–	–	0	35	–	–	–	–	–	Surge
	0907	–	–	25	60	–	–	–	–	–	dark grey muddy H_2O.
	0929	18.9	14.75	0	60	–	–	–	–	–	pump @ 30' TOC
	0947	19.44	14.47	390	450	7.25	2.33	272	22.6	–	
	1003	19.24	14.47	250	700	7.35	2.38	66	22.0	–	
	1007	19.20	14.47	80	780	7.35	2.38	37	21.9	–	pump stop
	1029	19.00	14.44	380	1160	7.41	2.40	4	21.9	–	pump @ 67' TOC
	1035	19.24	13.99	60	1220	7.39	2.47	>999	21.9	–	pump @ 85' TOC
	1049	18.57	14.01	220	1440	7.42	2.39	2	21.9	–	stop pump
	1055	19.19	13.92	40	1480	7.40	2.42	>999	21.8	–	pump @ 95' TOC
	1114	19.19	13.97	350	1830	7.41	2.42	3	21.8	–	stop pump
	1124	18.11	13.94	130	1960	7.37	2.40	106	21.8	–	pump @ 104.5' TOC
	1130	18.11	13.95	80	~~1980~~ 2040	7.38	2.43	37	21.8	–	
	1133	18.11	13.95	80	2120	7.41	2.42	0	21.8	–	
↓	1136	18.11	13.95	35	2155	7.39	2.43	-5	21.8	–	stop pump

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME: Seal Beach

WELL NO.: RDO-2

PROJECT NO.: HY0888

SITE:

PREPARED BY: MD

METHOD
- PUMP: 4" Grundfos
- BAILER: 5 gallon stainless
- OTHER:

DEVELOPMENT CRITERIA

REMARKS

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = ______

INSIDE DIAM $d_w ID$ = ______

OUTSIDE DIAM $d_w OD$ = ______

HOLE DIAMETER d_h = ______

DEPTH TO:

SCREENED INTERVAL 65 TO 105

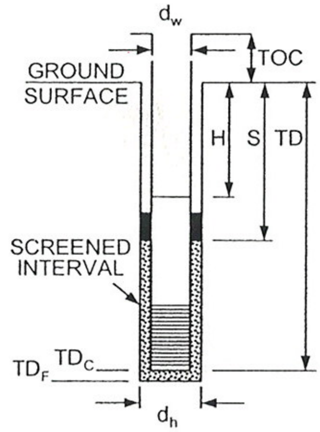
WATER LEVEL H = 10.75'

BASE OF SEAL S = ______

BASE OF CASING TD_C = ______

BASE OF FILTER PACK TD_F = ______

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_w ID}{2}\right)^2 (TD_C - H) = 3.14\left(\frac{\quad}{2}\right)^2(\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w OD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		
8-22-05	12:51		10.75	40	40					total depth 104.12', bailing	
8-22-05	13:53	14.51		—	40					turned pump on	
8-22-05	14:33	16.05	16.78	636	676	7.69	1.83	521	21.7		
8-22-05	14:43	16.76	16.10	157	833	7.70	1.80	462	21.7		
8-22-05	14:53	15.95	16.55	147	980	7.68	1.88	320	21.9		
8-22-05	15:03	16.00	16.45	165	1145	7.77	1.88	~~300~~ 434	21.8		
8-22-05	15:13	15.95	16.41	162	1307	7.72	1.74	310	21.7		
8-22-05	15:17			68	1371					turned pump off to move tip	
8-22-05	15:23	18.41			1371					resume pumping	
8-22-05	15:33	18.88	14.85	201	1572	7.69	1.75	550	21.6		
8-22-05	15:43	18.83	14.85			7.69	1.74	261	21.6		
8-22-05	15:53	16.77	14.20		1938	7.69	1.75	202	21.6		
8-22-05	16:03	16.72		147	2085	7.70	1.74	143	21.6		
8-22-05	16:13	16.72	14.19	169	2254	7.67	1.75	141	21.6		
8-22-05	16:24	16.67		189	2443	7.65	1.74	112	21.7		
8-22-05	16:34	16.72	14.10		2600	7.67	1.75	103	21.5		
8-22-05	16:39					7.67	1.75	94	21.6		
82205	16:49	16.77	14.20		2810	7.69	1.74	53	21.6		
82205	1659	16.72	14.18		2969	7.67	1.76	22	21.6		
82205	1709	16.77	14.21		3168	7.68	1.74	10	21.6		
82205	1718	16.77	14.20		3422	7.69	1.76	1	21.5		

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME		WELL NO.
NWS Seal Beach site #70		RD03A
PROJECT NO.	**SITE**	**PREPARED BY**
HY0888	NWS	Matt DARR

METHOD

- PUMP: 4" grundfos
- BAILER: 5-gal
- OTHER:

DEVELOPMENT CRITERIA

NTU < 5 ; Temp; Cond; pH Δ < 10%

REMARKS

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = 0.3 below OG

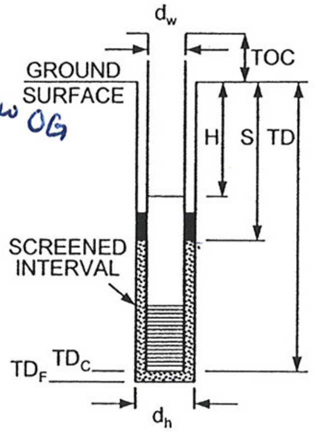
- INSIDE DIAM d_wID = 4"
- OUTSIDE DIAM d_wOD = –
- HOLE DIAMETER d_h = 10"

DEPTH TO:

- SCREENED INTERVAL 20 TO 30
- WATER LEVEL H = 6.41
- BASE OF SEAL S = 25
- BASE OF CASING TD_C = 30.2

BASE OF FILTER PACK TD_F = 31

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2(\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG

DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	TOTAL WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		COMMENTS
8/29	0750	–	6.41	0	0	–	–	–	–	–	–
↓	0758	–	–	15	15	–	–	–	–	–	Bailed
	0812-0832	–	–	–	15	–	–	–	–	–	Surged
	0835		~~13.65~~	20	35	–	–	–	–	–	Bailed
	0915	19.35	13.65	260	295	6.84	9.68	223	21.4	–	pump @ bottom
	0922	19.39	13.85	100	395	6.88	9.75	76	21.3	–	–
	0930	20.17	14.08	180	575	6.89	9.64	2	21.3	–	–
	0935	19.79	14.00	60	635	6.89	9.68	~3	21.3	–	–
	0938	19.57	14.42	60	695	6.95	8.92	311	21.3	–	pump @ 25' of TOC
	0945	19.75	14.56	125	820	6.87	9.62	~8	21.3	–	–
↓	0950	19.75	14.63	100	920	6.88	9.61	~8	21.3	–	–

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME	WELL NO.
NWS Seal Beach #70	RD03B

PROJECT NO.	SITE	PREPARED BY
HY0888-05	NWS	Matt Darr

METHOD

- PUMP: 4" grundfos
- BAILER: 5 gal
- OTHER:

DEVELOPMENT CRITERIA

NTU < 5 ; Δ 10% PH; cond; Temp.

REMARKS

Developed @ screen intervals of 10' to 15'.

WELL CONSTRUCTION DATA (ft)

WELL CASING:

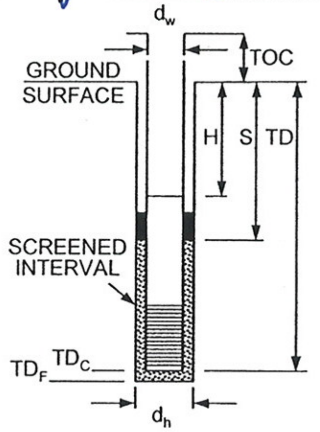
TOP OF CASING HEIGHT/DEPTH (TOC) = @ OG

- INSIDE DIAM d_wID = 4"
- OUTSIDE DIAM d_wOD = ~~10"~~
- HOLE DIAMETER d_h = 10"

DEPTH TO:

- SCREENED INTERVAL 65 TO 105
- WATER LEVEL H = 10.55
- BASE OF SEAL S = 57
- BASE OF CASING TD_C = 103.95
- BASE OF FILTER PACK TD_F = 107

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2(\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		
8/26	1210	-	10.55	45	45	-	-	-	-	-	bailed muddy grey H_2O
8/26	1229	-	-	0	45	-	-	-	-	-	begin surging
	1257	-	-	0	45	-	-	-	-	-	stop surging
	1300	-	-	30	75	-	-	-	-	-	Bailed murky H_2O
	1318	0	11.94	0	75	-	-	-	-	-	pump@ 17' TOC
	1328	19.14	11.67	210	285	7.67	~~1.5~~ 2.02	>999	22.1	-	
	1344	19.34	11.65	215	575	7.53	1.92	257	21.7	-	
	1410	19.44	11.70	415	990	7.59	1.90	137	21.6	-	stop pump
	1420	18.77	11.35	195	1185	7.60	1.88	408	21.5	-	pump@ 66' TOC
	1430	18.83	11.39	190	1375	7.60	1.88	65	21.6	-	-
	1440	18.83	11.45	175	1550	7.59	1.88	49	21.5	-	stop pump
	1446	18.53	11.08	95	1645	7.61	1.90	875	21.5	-	pump@ 85' TOC
	1505	18.77	11.11	360	2005	7.60	1.90	76	21.6	-	-
	1519	18.77	11.11	245	2250	7.59	1.90	20	21.5	-	stop pump
	1525	18.52	11.05	~~310~~ 90 (MW)	2560	7.57	1.90	77	21.5	-	pump @ 95' TOC
	1537	18.67	11.07	200	2560	7.56	1.90	18	21.5	-	stop pump
	1542	18.11	11.00	65	2625	7.59	1.90	776	21.5	-	pump @ 102.5' TOC
	1557	18.26	11.03	260	2885	7.59	1.90	21	21.6	-	-
	1608	17.95	11.01	225	3110	7.62	1.88	-6	21.7	-	-
	1610	0	11.01	38	3148	7.52	1.89	-10	21.6	-	stop pump

FORMS/WELL DEVELOPMENT LOG.DOC

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME		WELL NO.
Seal Beach		RDO-4
PROJECT NO.	SITE	PREPARED BY
HY0888	R	MD

METHOD
- PUMP: 4" Grundfos
- BAILER: 70 ~~58~~ gallons
- OTHER: ______

DEVELOPMENT CRITERIA

REMARKS

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = ______

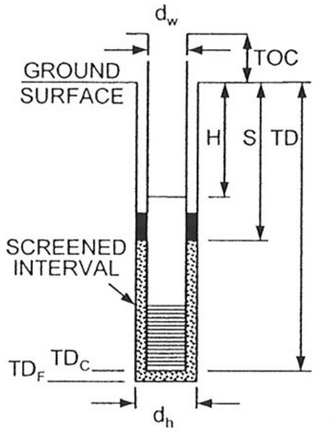
- INSIDE DIAM d_wID = ______
- OUTSIDE DIAM d_wOD = ______
- HOLE DIAMETER d_h = ______

DEPTH TO:

- SCREENED INTERVAL 65 TO 105
- WATER LEVEL H = 9.27
- BASE OF SEAL S = ______
- BASE OF CASING TD_C = ______

BASE OF FILTER PACK TD_F = ______

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2 (\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG

DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	TOTAL WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)	COMMENTS
8-22-05	07:30	–	9.27	—	—					T.D 100.6'
8-22-05	09:07	15	10.0		70					Start pump
8-22-05	09:17	18.57		177	247	7.72	1.57	999	21.6	
8-22-05	09:27	14.97	10.80	150	397	7.71	1.57	385	21.5	
8-22-05	09:37	14.97	10.80	170	567	7.75	1.58	367	21.5	
8-22-05	09:47	16.67	10.86	153	720	7.78	1.56	~~24~~ 203	21.5°	
8-22-05	09:57	16.67	10.86	169	889	7.76	1.58	140	21.5	stopped pump to raise it up
8-22-05	10:07	15		—	889					restarted pump
8-22-05	10:22	15.54	10.58	280	1169	7.76	1.56	999	21.5°	
8-22-05	10:32	18.38	10.80	187	1356	7.77	1.56	443	21.5	
8-22-05	10:42	18.36	10.80	190	1546	7.76	1.56	120	21.5	
8-22-05	10:52	18.31	10.80			7.75	1.55	68	21.5	
8-22-05	11:02	18.36	10.80		1890	7.75	1.54	14	21.5	
8-22-05	11:07	18.26	10.80	98	1988	7.77	1.50	6	21.5	
8-22-05	11:12	18.36		86	2074	7.77	1.50	1	21.4	
8-22-05	11:17	18.31	10.80	82	2156	7.77	1.49	1	21.5	stopped pump to lower
8-22-05	11:23	17.34		—	2156					restarted pump
8-22-05	11:33	17.49	10.18	184	~~229~~ 2340	7.78	1.54	63	21.5	
8-22-05	11:43	17.49	10.21	160	2500	7.78	1.53	1	21.5°	
8-22-05	11:48	17.49	10.21	100	2600	7.79	1.53	0	21.5	
8-22-05	11:53	17.54	10.21		2704	7.80	1.52	0	21.5°	end development

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME		WELL NO.
Seal Beach		RDO-5
PROJECT NO. HY0888	SITE	PREPARED BY

METHOD
- PUMP: 4" Grundfos
- BAILER: ______
- OTHER: ______

DEVELOPMENT CRITERIA

REMARKS

WELL CONSTRUCTION DATA (ft)

WELL CASING: Schedule 40 PVC

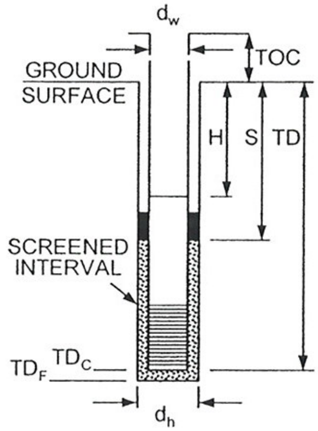
TOP OF CASING HEIGHT/DEPTH (TOC) = ______

- INSIDE DIAM d_wID = 4"
- OUTSIDE DIAM d_wOD = ______
- HOLE DIAMETER d_h = ______

DEPTH TO:
- SCREENED INTERVAL 65 TO 105
- WATER LEVEL H = 9.45'
- BASE OF SEAL S = ______
- BASE OF CASING TD_C = ______

BASE OF FILTER PACK TD_F = ______

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_C - H) = 3.14\left(\frac{\quad}{2}\right)^2(\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad$ GAL

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		
8-19-05	07:40		9.45' static								103.39' total depth
8-19-05	07:50			25	25						bailed
8-19-05	08:45		9.38'	15	40						bailed, 105.44' t.d
8-19-05	09:12	4.85	10.16			~~6.45~~ 6.67	1.20	999	22.2°		started pump at 09:10
8-19-05	09:30	4.85	10.13		145	7.28	0.98	999	22.2°		
8-19-05	09:49	4.85			239						end pumping to switch pump
8-19-05	10:42	20	~~20~~								turned 4" pump on
8-19-05	11:04	20	14.1'	432	~~432~~ 671						turned pump off to drop in screen
8-19-05	11:13	20	8.91'	—	671						turned pump on
8-19-05	12.80	19.08	11.28	279	950	7.72	0.926	352	21.8°		
8-19-05	11:43	19.08	12.85	277	1227	7.72	0.913	10	21.7°		
8-19-05	11:58	19.08	12.90	293	1520	7.70	0.899	10	21.7		turned pump off to lower
8-19	12:00	18.27	9.0	—	1520						turned pump on
8-19-05	12:15	18.90	12.68	273	1793	7.70	0.896	10	21.7°		turned pump off to lower
8-19-05	12:17	18.27	9.09	—	1793						turned pump on
8-19-05	12:27	19.03	12.49	187	1980	7.69	0.886	10	21.7		turned pump off
8-19-05	12:30	18.03		—	1980						
8-19-05	12:40	18.65	12.38	211	~~1991~~ 2191	7.71	0.887	10	21.7°		
8-19-05	12:45	18.78	12.38	80	2271	7.71	0.886	10	21.7°		
8-19-05	12:50	18.78	12.38	86	2357	7.71	0.886	10	21.7		turned pump off development complete

711
432
279

988
711
277

FORMS/WELL DEVELOPMENT LOG.DOC

GEOSYNTEC CONSULTANTS	PROJECT NAME: NWS Seal Beach #70		WELL NO.: RDO6A
WELL DEVELOPMENT LOG	PROJECT NO.: HY0888	SITE: NWS	PREPARED BY: Matt Darr

METHOD
PUMP: 4" grundfos
BAILER: 5-gal
OTHER: ____

DEVELOPMENT CRITERIA: < 5 NTU; pH, cond; temp < 10% Δ

REMARKS:

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = ____

INSIDE DIAM d_wID = 4"

OUTSIDE DIAM d_wOD = –

HOLE DIAMETER d_h = 10"

DEPTH TO:

SCREENED INTERVAL 95 TO 105

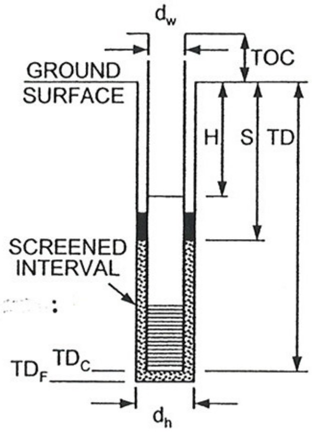
WATER LEVEL H = 20.28

BASE OF SEAL S = –

BASE OF CASING TD_C = 108.2

BASE OF FILTER PACK TD_F = 109

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2(\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		
9/2	0740	–	20.28	0	0	–	–	–	–	–	–
	0820	–	–	40	40	–	–	–	–	–	Bailed
	0840	–	–	–	–	–	–	–	–	–	Surged
	0900	–	–	40	80	–	–	–	–	–	Bailed
	0918	20.6	28.65	100	180	7.66	2.06	131	21.8	–	pump@30' Toc
	0922	19.8	28.60	100	280	7.66	2.08	83	21.7	–	–
	0925	19.8	28.60	65	345	7.65	2.10	28	21.7	–	stop pump
	0938	19.0	27.08	85	430	7.66	2.10	231	21.6	–	pump@ 100' Toc
	0943	19.0	27.08	70	500	7.65	2.10	99	21.6	–	–
	0945	19.0	27.08	60	560	7.65	2.11	25	21.6	–	stop pump
	0952	18.9	26.65	80	640	7.64	2.09	31	21.6	–	pump@ 108' Toc
	0956	18.9	26.68	70	710	7.65	2.09	14	21.6	–	–
	1009	19.0	26.77	320	1030	7.64	2.06	-10	21.6	–	pump was used as a surge
↓	1015	19.0	26.77	70	1100	7.65	2.06	-10	21.6	–	stop pump

FORMS/WELL DEVELOPMENT LOG.DOC

GEOSYNTEC CONSULTANTS

WELL DEVELOPMENT LOG

PROJECT NAME	WELL NO.
NWS Seal Beach Site #70	RD06B

PROJECT NO.	SITE	PREPARED BY
HY0888	NWS	Matt Darr

METHOD
- PUMP: 4" grundfos
- BAILER: 5 gal
- OTHER: –

DEVELOPMENT CRITERIA: NTU<5 ; temp, cond, pH Δ < 10%

REMARKS: Staged pump at different elevations.

WELL CONSTRUCTION DATA (ft)

WELL CASING:

TOP OF CASING HEIGHT/DEPTH (TOC) = 0.3' below GS

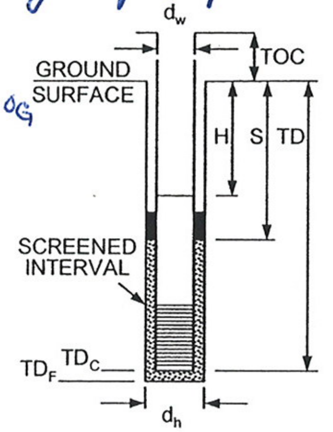
- INSIDE DIAM d_wID = 4"
- OUTSIDE DIAM d_wOD = –
- HOLE DIAMETER d_h = 10"

DEPTH TO:

- SCREENED INTERVAL 130 TO 140
- WATER LEVEL H = 18.55
- BASE OF SEAL S = 125
- BASE OF CASING TD_C = 139.6

BASE OF FILTER PACK TD_F = 142

ESTIMATED FILTER PACK POROSITY P = 0.25



WELL VOLUME CALCULATION

CASING VOLUME =

$$V_c = \pi\left(\frac{d_wID}{2}\right)^2 (TD_c - H) = 3.14\left(\frac{\quad}{2}\right)^2 (\quad - \quad) = \quad ft^3$$

FILTER PACK PORE VOLUME =

$$V_f = \pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_wOD}{2}\right)^2\right](TD_F - (S \text{ or } H))(P)$$

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](\quad - \quad)(\quad) = \quad ft^3$$

(if S > H, use S. If S < H, use H)

TOTAL WELL VOLUME =

$$V_T = V_c + V_f = \quad + \quad = \quad ft^3 \times 7.48 = \quad GAL$$

DEVELOPMENT LOG					TOTAL	WATER QUALITY					COMMENTS
DATE	TIME	FLOW RATE (gpm)	DEPTH TO WATER (ft-btoc)	WATER REMOVED (gal)	WATER REMOVED (gal)	pH	SPECIFIC CONDUCTIVITY (mS/cm)	TURBIDITY (NTU)	TEMPERATURE (Degrees C)		
8/29	1030	–	18.55	0	0	–	–	–	–	–	–
↓	1045	–	–	30	30	–	–	–	–	–	bailed
	1048–1100	–	–	0	30	–	–	–	–	–	surged
	1110	–	–	15	45	–	–	–	–	–	bailed
	1156	19.85	16.60	655	700	7.70	1.25	239	22.0	–	pump @ 30' TOC
	1209	19.80	16.59	245	945	7.72	1.26	157	21.9	–	–
	1230	19.75	16.59	390	1335	7.70	1.27	88	21.8	–	Stop pump
	1248	~~16.07~~	~~18.45~~ (NM)	55	1390	7.80	1.26	928	21.9	–	pump @ 133' TOC
	1257	18.25 18.65	16.87 16.06	145	1535	7.72	1.26	10	21.8	–	Stop pump
	1302	18.01	15.93	45	1580	7.69	1.27	231	21.8	–	Pump @ 139 TOC
	1308	18.16	15.94	140	1720	7.69	1.27	-10	21.7	–	–
↓	1312	18.06	15.95	70	1790	7.71	1.27	-10	21.7	–	Stop pump.

PAGE 1 OF 1

APPENDIX D-E
EVO Injection Logs

EMULSIFIED OIL INJECTION -
WATER LEVEL MEASUREMENTS

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Monitored By: M.Bogaart

MW-70-01			MW-70-01											
Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)
5Oct05	No measurements		8Oct05	1140	9.08									
	except during logger			1233	9.05									
	placement - MB notes			1416	9.02									
				1533	9.00									
6Oct05	No measurements			1613	8.98									
				* 1712	9.08									
7Oct05	7:20	10.58		1823	9.00									
	9:56	9.20	20Oct05	812	17.70									
	10:45	9.05		843	17.61									
	11:40	9.03		927	17.65									
	12:27	9.01												
	14:49	8.98												
	15:47	8.94												
	16:36	8.96												
	17:37	8.99												
	1802	9.10												
8Oct05	8:16	10.56												
	9.00	9.32												
	9:54	9.17												
	10:57	9.10												

* Stopped to clean filter

Last Updated: 2005.08.22

EMULSIFIED OIL INJECTION -
WATER LEVEL MEASUREMENTS

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70
Below top of Casing

Monitored By: Henry Chapman, Marlene Duffy, Matt Bogart

MW-70-08			MW-70-08											
Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)
9/28	1307	21.05	9/30	1725	20.83									
	1600	20.65	10/1	~~1005~~	~~21.04~~	STET								
	1705	20.60		1015	20.73									
	1746	20.61		1130	20.65									
				1257	20.67									
9/29	0700	21.14		1430	20.70									
	0920	20.85		1602	20.77									
	10:46	20.65		1808	20.88									
	11:46	20.65												
	12:16	20.66	10/2	7:55	21.15									
	13:41	20.70		9:22	20.82									
	14:46	20.73		11:22	20.74									
	15:20	20.75		15:35	20.81									
	15:51	20.72		17:40	20.86									
9/30	0715	21.19												
	~~8~~ 1156	20.60	10/3	7:30	21.65									
	1300	20.60		9:54	20.63									
	1345	20.63		16:38	20.71									
	1413	20.65												
	1533	20.67												
	1626	20.83												

Last Updated: 2005.08.22

562-692-5911 Will Call

EMULSIFIED OIL INJECTION - *WATER LEVEL MEASUREMENTS*

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Monitored By: ~~M. Bogaart & Marlow Duffey~~ & Duygu Tokat

Attn: Carol Aziz

MW 70-08			MW 70-08			MW 70-31								
Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)	Date	Time	Depth to Water (ft)
10/3	1126	20.55	10/6	1126	19.86	10/7	1434	18.55		10:10	17.75			
	1259	20.54		1327	19.77		1533	18.39		10:28	17.75			
	1452	20.61		1506	19.89		1625	18.48		11:27	17.74			
										12:10	17.72			
10/4	Missed start level.		~~10/7~~			10/8	850	18.64		12:37	17.70			
	9:40	20.53					927	18.42		13:01	17.69			
	10:35	20.45					1045	18.38		13:32	17.66			
	12:47	20.36					1150	18.20		14:02	17.65			
	1415	20.34					1243	18.09		16:03	17.69			
	1500	20.37					1310	18.07		17:02	17.55			
	1705	20.42					1321	18.05		1722	17.76			
							1534	18.03	10/11/05	07:57	17.96			
10/5	0710	20.58					1607	18.02		08:41	17.90			
	0810	20.18					1637	18.03		12:47	17.81			
	1012	20.10				*	1704	18.02		12:49	17.73			
	1145	20.02				°	1737	18.05		15:26	17.71			
	1636	20.10					1804	18.07		16:22	17.64			
						10/10	7:46	18.16		16:34	17.79			
10/6	0715	20.32					8:12	17.87						
10/6	09:28	19.97					9:10	17.81						
	10:33	19.90					9:53	17.76						

* when vacuum vented @ injection well, level sounder went off @ monitoring well. Injection well seems to bounce between +ve & -ve pressure

° slight +ve pressure on IW

Last Updated: 2005.08.22

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: RD03A
Monitored By: M. Boggart

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
5Oct05	1715	518.7	6.0	–	–	Start up with new pumps. may have issues
0.0	1725	580.0	8.0	0.0	2.1%	Site glass not filling – fill @ 1732 – Try fill pump again
10.0	1735	639.0	9.0	0.0		Pump @ max flow
10psi	1820	1063.5	9.4	0.0		well need air relief valve, fill open & well head full.
10psi	1825	1105.2	8.3	0.0		End of Day
6Oct05	757	1105.2	–	–	2.1%	Start up.
10	824	1338.0	8.6	0.0		
10	835	1437.0	9.0	0.0		Collect Br + TOC ~~Turbidity~~ Sample
10	936	1998.0	9.0	0.0		Collect Br + TOC + turbidity Sample
10psi	1023	2423.9	9.0	0.0	2.1%	
10psi	1029	2448.0	9.0	0.0		Collect Br + TURBidity samples
10psi	1115	2907.0	10.0	0.0		Collect Br + Turbidity
10psi	1209	3400.0	9.1	0.0		Collect Br + Turbidity + TOC
10psi	1239	3671.5	9.0	0.0		
8psi	1258	3850.0	9.4	0.0		Collect Br + Turbidity
8psi	1347	4300.0	9.2	0.0		Collect Br + Turbidity + TOC
8psi	1435	4753.0	9.4	0.0		Collect Br + Turbidity
8psi	1524	5200.0	9.1	0.0		Collected Br + Turbidity + TOC
8psi	1614	5650.0	9.0	0.0		Collect Br + Turbidity
8psi	1705	6100.0	9.0	0.0		Collect Br + Turbidity + TOC
8psi	1755	6550.0	9.0	0.0		Collect Br + Turbidity
NR	1800	6593.8	9.0	0.0		End of Day

Created: 2005.01.28

EMULSIFIED OIL INJECTION -
INJECTION FLOW MEASUREMENTS

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location: Area 70

Injection Well ID: RD03A
Monitored By: M. Bogaart

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
7Oct05	805	6595.8	—	—	2.1%	Start of Day
8.0 psi	854	7000.0	8.2	0.0		Collect Br, Turbidity + TOC
8.0 psi	1000	7600.0	9.0	0.0		Collect Br, Turb
8.0 psi	1048	8050.0	9.4	0.0		Collect Br, Turb + TOC
8 psi	1138	8500.0	9.0	0.0		Collect Br & turbidity
8 psi	1228	8950.0	9.0	0.0		Collect
8 psi	1313	9400.0	10.0	0.0		Collect Br & turbidity
8 psi	1407	9850.0	8.3	0.0		Collect Br, Turb + TOC
8 psi	1454	10300.0	9.4	0.0		Collect Br + turbidity • Slight vacuum detected on system
8 psi	1548	10750.0	8.3	0.0		Collect Br + turb + TOC
8 psi	1638	11200.0	9.0	0.0		Collect Br + turbidity — soon after, turned off generator to
8 psi	1739	11650.0		0.0		fill with gas. — Collect Br + Turbidity + TOC
8 psi	1801	11841.0		0.0		End of Day
8 psi	836	11841.0	—	—	2.1%	Start Up.
8 psi	907	12100	8.3	0.0		Very slight vacuum ← (tilt tote to get as much oil.) Collect Br + Turb.
8 psi	953	12550	9.8	0.0	2.1%	End of Tote @ 12600 = 2.1% dose. Collect Br, Turb + TOC
8 psi	1055	13000	8.8	0.0		Collect Br + Turbidity
8 psi	1141	13450	8.5	0.0		Collect Br + Turb + TOC
8 psi	1232	13900	8.8	0.0		Collect Br + Turbidity
8 psi	1323	14350	9.0	0.0		Collect Br + Turb + TOC
8 psi	1415	14800	8.8	0.0		Collect Br + Turb. — refuel generator ~ 15,000
8 psi	1532	15250	9.0	0.0		Collect Br + Turbidity + TOC
8 psi	1624	15700	8.7	0.0		Collect Br + Turbidity
8 psi	1712	16150	9.0	0.0		Collect Br + Turb + TOC ← no vacuum any more
8 psi	1828	16700		0.0		Collect Br + turbid ← no
	1830	16702.0	—	—	—	End of Day

Created: 2005.01.28

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: RDO-3A
Monitored By: Marlene Duffy

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
10-10 —	0805	16720.2	—	—	2.1%	start injection
8psi	0900	17150.0	—	3psi		collect samples - Br, TOC, turbidity, valve closed
8psi	0951	17600.0	8.8	3psi		collect samples - Br, turbidity
8psi	1043	18050	8.6	3psi		Collected samples - Br turbidity & TOC, slight vacuum
8psi	1134	18500	8.8	3psi		Collected samples - Br turbidity
8psi	1226	18950	8.6	5psi		collected samples - Br, turbidity, TOC
8psi	1323	19440	8.6	3psi		collected samples - Br, turbidity then [illegible]
8psi	1415	19850	8.6	3psi		stopped temporarily due to low water levels collected Br turbidity, TOC
10psi	1638	20300	—	5psi		Collected Br turbidity samples
—	1657	20452.6	—	—		end of day
10-11-05 —	0820	20452.6	—	—		start of day
8psi	0858	20780	8.6	3psi		collected Br turbidity, TOC
8psi	0947	21200	8.6	3.5psi		collected Br, turbidity
7psi	10.43	21,650	8.0	2psi		Collected Br Turbidity TOC.
7psi	1133	22,100	9.0	3psi		collected Br, Turbidity
8psi	1225	22550	8.6	3psi		collected Br Turbidity, TOC
8psi	1318	23000	8.5	3psi		collected Br Turbidity
7psi	1412	23450		3psi		collected Br, turbidity, TOC
8psi	1507	23900		3psi		collected Br, turbidity
	1630	23955.2				stopped pump to transfer tanks
10-12-05	0852	23955.2				start of day
8psi	0937	24350		3psi		Collected Br, turb, TOC
8psi	1030	24800		3psi		Collected Br, tub.
8psi	1127	25100		3psi		collected Br, turb TOC nearly out of oil
						Finished 1140, started flushing

Created: 2005.01.28

- @ 10 gpm sample every 30 min = 300 gal.

28 Sept 05 Carol call: sample every 1.5 hours for 5 gpm = 450 gal

PJ

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Injection Well ID: RPO-6A
Monitored By:
Mainfold No.: Single manifold

Pump pressure notes (left margin): 20 psi → (28 Sept 1330); 40 psi → (1533); closed valve pump (1544); 15 psi → (1600)

Date + Pump Pressure	Time	Mechanical / Digital Totalizer Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Ratio (%)	Comments (i.e., amount of oil remaining in tote, visual observations, note if water flush)
28 Sept	1330	~~838.1~~ 911.0	12.0	13.0	1.08	Tried to calibrate to 1.05%
	1533	970.3	~~17.0~~ 11.0	17.0	"	multiple leakevents; added Ball Valve to pump to
	1544	1061.0	5.5	10.0	1.08	prevent over pressurization
	1600	1139.0	5.75	11.0		collect sample - purge 1.26L from MW-70-08
15 psi	1615	1220.4	5.5	12.0		
15 psi	1631	1313.8	6.0	12.0		
17 psi	1653	1439.0	5.5	13.5		Collect Sample + TOC + turbidity
17 psi	1703	1492.2	5.3	14.0	1.1%	Reach 1" diff. on tote - Calculated dose ratio
19 psi	1747	1739.0	5.5	15.0		Collect Samples + TOC + turbidity
19 psi	1753	1760.2	—	15.0	"	Shut down for evening
29 Sept	700	1760.2	—	—	1.1%	Start up - generate ups & downs.
10 psi	811	1836.1	5.0	7.0	1.1%	
10 psi	842	1990.5	5.0	6.5		
11 psi	0922	2200.0	5.2	8.0		collect samples + TOC + turbidity
12 psi	947	2328.5	5.1	9.0		
14 psi	1015	2476.1	5.3	10.0		
14 psi	1045	2628.5	5.1	11.0		collect samples + turbidity
15 psi	1115	27[illegible]9.4	5.0	11.5		
15 psi	1145	2930.8	5.0	12.0		
15 psi	1217	3089.0	4.3	12.5		
16 psi	1245	3229.4	5.0	12.5		
16 psi	1315	3377.7	4.9	13.0		
14 psi	1350	3539	--	9.5		generator off from 1330 to 1335 for refueling, collect samples & TOC + turbidity
13 psi	1420	3689.8	5.0	10.5		
14 psi	1450	3836.9	4.9	11.0		

838.1 ← start of pumping oil (took a while to correct leaks - no oil lost :)
mostly water loss on pump side of dosmatic. Spiking pressures cause leaks @ hoses.

Carol Aziz / Cath Crea

Last Updated: 2005.08.22

1 of 2

②

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Attention: Carol Aziz

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Injection Well ID: RDO-6A
Monitored By: M. Bogaert/M. Duffy
Mainfold No.:

Date	Time	Mechanical / Digital Totalizer Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Ratio (%)	Comments (i.e., amount of oil remaining in tote, visual observations, note if water flush)
29 sept 15psi	1530	3986.2	4.8	11.5		
15psi	1550	4135.3	5.0	11.5		
15psi	1620	4284.4	5.0	12		
15psi	1652	4450.0	5.0	12.5		sample and turbidity collected
	1657	4497.6	—	NR		end pumping for day (collect samples + TOC + turbidity)
30 Sept	715	4497.6	—	—	1.1%	Start up. Leak detected within protective casing.
12psi	1135	4759.0	6.0	8.0	@ 6" on tote	Turn off – hear vacuum sucking. 4-inch well casing
10 psi	1156	4900.0	6.5	7.0	@	joint not threaded properly. Begin when fixed.
12psi	1226	5095.1	6.5	7.5		Volume lost ~ 20 gallons of 1.1% oil and water.
14psi	1258	5302.2	6.5	9.5		collect samples + turbidity
14psi	1311	~~5376.5~~ 5376.5	6.0	10.0	1.1%	@ 7" of oil Decreased pressure @ well head.
18psi	1345	5598.0	6.5	11.3		
21psi	1417	5800.0	6.3	12.5		collect samples + TOC + turbidity
22psi	1448	5985.0	6.0	14.5		add gas to generator
22psi	1517	6149.2	6.1	14.5		@ 8" of oil
23psi	1534	6250.0	6.0	15.0		decreased pump flow & sampled Br and Turbidity
9psi	1604	6367.5	4.1	6.5		Collect sample for Br @ Filter pre dosmatic
10psi	1634	6491.0	4.1	8.0		
11psi	1709	6631.5	4.0	9.0		
11psi	1725	6700.0	4.0	9.5		collect samples + turbidity and end for day
						next sample 7150
1 Oct 05	1000	6700.9	—	—		Startup. @ 9 inches on tote.
10psi	1013	6755.5	4.2	7.0	~1.1%	here ← · opened ~~well~~ well head valve all the way
10psi	1046	6926.0	5.0	7.5		
10psi	1118	7091.0	5.0	10		

operating @ 0.98% ∴ dose ratio a little
4,122
3848
1.05
617.5
1" = 687
0.005 = 687 / 617.5

Attn: Carol Aziz

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario ◆ N1G 5G3 ◆ Canada
Tel: (519) 822-2230 ◆ Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Injection Well ID: RDO-6A
Monitored By: H. Chuhman
Mainfold No.: ____

7000

Date	Time	Mechanical / Digital Totalizer Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Ratio (%)	Comments (i.e., amount of oil remaining in tote, visual observations, note if water flush)
12 psi	1130	7153.0	5.0	10.0		Collect Br. samples, TOC & turbidity
14 psi	1159	7293.0	5.0	11.0		~~SB~~
15 psi	1230	7452.0	5.0	12.0		
15 psi	1300	7600.0	5.0	13.0		Collect Br & turbidity sample.
16 psi	1332	7760.0	5.0	14.0		
17 psi	1358	7892.0	5.0	15.0		Decrease pressure on well head
17 psi	1431	8050.0	5.5	13.5	1.1%	Collect samples - Br, Turb, TOC.
18 psi	1500	8195.5	5.0	15.0		EOS tote down 11 inches @ 8086.0 @ 14:38
22 psi	1530	8345.0	5.0	16.0		try closing valve @ wellhead & pre-dosmatic to ↓ pres
24 psi	1603	8500.0	4.5	16.5		Adjusted ball valve on grundfos pump to ↓ pres @ well head
10 psi	1636	8629.5	4.0	6.0		
11 psi	1700	8718.0	3.5	10.0		
13 psi	1728	8817.0	3.5	11.0		
12 psi	1807	8950.0	3.5	10.0		Collect samples Br + Turbidity + TOC
12 psi	1915	9086.2		11.0		End of day shutdown.
20Oct05	800	9086.5	4.0	—	1.1%	Start up.
NR	830	9200.0	4.0	2.0		
8 psi	907	9338.0	4.0	6.5		
8 psi	924	9400.0	3.5	7.0		Collect samples Br + Turbidity + TOC
9 psi	1002	9541.5	3.5	7.0	0.98%	@ 13 inch used of EOS tote; as lean, will adjust slightly
9 psi	1030	9648.0	3.5	8.0		
10 psi	1113	9808.0	~~4.0~~ 3.7	8.5		
10 psi	1124	9850.0	4.0	8.5		Collect samples Br + Turbidity + ~~TOC~~
10 psi	1200	9978.0	3.5	8.0		
11 psi	1242	10133.2		8.5		

Last Updated: 2005.08.22

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
130 Research Lane, Suite 2
Guelph, Ontario • N1G 5G3 • Canada
Tel: (519) 822-2230 • Fax: (519) 822-3151

Project Name: Seal Beach
Project No.: HY0888.05
Site Location: Area 70

Injection Well ID: RDO-6A
Monitored By: M. Bogaart & Marlene Duffy
Mainfold No.: Single channel

11psi

Date	Time	Mechanical / Digital Totalizer Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Ratio (%)	Comments (i.e., amount of oil remaining in tote, visual observations, note if water flush)
2Oct05	1326	10300.1	3.8	10 psi	1.07%	Collect Br + Turbidity + TOC → Tote @ 14"
11psi	1421	10499.0	3.6	11 psi		
13psi	1520	10715.5	3.7	12 psi		
13psi	1535	10760.5	3.0	12 psi		Collect Br + Turbidity + TOC
13psi	1647	11024.5	3.7	12 psi	1.07%	Leak @ well head - 4-inch McMaster Carr adaptors, not well - @ 15 in. gal on
12psi	1742	11200.0 Sampled	3.2	10 psi		Tote. → Vented pressure 15 minutes ago Sample
						Collected Br, Turbidity & TOC
12psi	1820	11337.2		10 psi		End of Day
3Oct05	735	11337.2	—	—	1.07%	Start of Day
11psi	920	11621.0	5.0	8.0		Made multiple pump ball valve adjustments to control flow/pressure
13psi	952	11760.5	4.3	9.0		Collect Br, Turbidity & 16 inch on EOS Tote
13psi	1026	11932.3	5.0	10		
15psi	1056	12074.0	4.7	11		
16psi	1126	12210.0	4.5	11.5	1.07%	Collect Br + Turbidity & TOC / @ 11:51 17" on EOS Tote
22psi	1156	12356.0	4.8	12		
23psi	1226	12492.0	4.5	13		
24psi	1303	12660.0	4.5	13.5		Collect BR + Turbidity
30psi	1383	12792.0	4.4	14		
35psi	1403	12914.0	4.0	13		
37psi	1433	13038.9	4.1	14		
37psi	1452	13110.0	3.8	14.5	1.06%	Collect BR + Turbidity + TOC / 18" on EOS tote
36psi	1503	13162.5	4.1	14		
38psi	1533	13285.5	4.1	15		
48psi	1606	13414.0	3.8	15		
59psi	1647	13560.0	3.6	15.0		

Last Updated: 2005.08.22

857.3 Stop injection @ 16,911 gallons

EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants

2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location: Seal Beach; Area 70

Injection Well ID: RDO-6A
Monitored By: M. Bogart, Marlene Duffy, Henry Chapman

Attn: Carol Aziz

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
45psi 3Oct05	1710	13637.0	3.3	14psi		
—	1730	13696.7		—	—	Pump turned off. Could not restart. No alarm indicated on control box - End of Day
4Oct05	910	13696.7	~~4.0~~	~~8.0~~	—	New pump installed in tank have ~3600 gallons left in tank
11psi	1000	13890.0	3.9	5.0	1.06%	
14psi	1044	14056.5		6.0		Sample + turbidity + TOC collected at 14010.0 H_2S odor in purge water
14psi	1116	14178.9		6		
16psi	1144	14277.2		6.5		
14.5psi	1247	~~14460~~ 14464.0		5.5	1.06%	sample + turbidity collected, pump turned off temporarily to add sleeve
16psi	1314	14564.0	3.7	6.5		20" of oil
17psi	1344	14671.0	3.5	7.0		
19psi	1414	14779.8	3.6	7.5		
20psi	1445	~~14894~~ 14894.1	3.6	8.0		
20psi	1500	14947.9	3.6	8.0		Sample + turbidity + TOC collected
22psi	1547	15113.5	3.5	9.0		
23psi	1615	15210.8	3.5	10.0	1.05%	21" of oil
23psi	1644	15312.5	3.5	10.0		
23psi	1706	15390.0	3.5	10.0		collect samples + turbidity
NR	1817	15622.0	3.4	10.0		End of Day
—	714	15622.0	—	—	—	Start up
23	747	15776.0	4.7	9.0		
24	0809	15880.0	4.7	9.5		samples + turbidity + TOC collected
26psi	847	16053.2	4.7	10.0		
28psi	1010	16434.0	4.6	10.5		Samples + turbidity collected
32psi	1043	16577.6	4.3	10.3		
33psi	1112	16762.8	4.2	11		

Created: 2005.01.28

EMULSIFIED OIL INJECTION -
INJECTION FLOW MEASUREMENTS

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: RDO-6A
Monitored By: M. Bogaert, Melan Duffy

35psi

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
50.7psi	1145	16844.0	4.3	11.5		
36psi	1155	16884.0		11.5		collect samples + turbidity + TOC
NR	1210	not recorded		0psi		turned pump off to exchange
15psi	1435	16986.1	—			New pump started
21psi	1503	17016.5	3.2	1.5 psi		
23psi	1532	17105.8	[illegible]	2psi		
20psi	1603	17170.0	3.6	2psi		
35psi	1634	17300.0	3.5	8psi		Collect samples - Br, Turbidity only
47psi	1709	17402.1	3.4	8psi		
48psi	1737	17482.8		5psi		End pump for day
Gocto5						
0	718	17492.0	—	1.5psi		start pump
11psi	840	17556.5	—	8.5psi		cleaned filter
10psi	0916	17697.5	3.9	8.5psi		
10psi	0930	17755	4.1	8.2psi		Collect Samples - Br, turbidity + TOC
10psi	1004	17896.0	4.2	8.2psi		
10psi	1032	18000.7	3.7	8.2psi		
10psi	1102	18121.8	4.0	8psi		
10psi	1127	18210.0	—	7.5psi		Stopped briefly to adjust pump, collect samples - Br, turbidity
11psi	1207	18367.0	4.0	8.5psi		
11psi	1235	18467.8	3.6	9psi		
11psi	1317	18603.8	3.2	9psi		
11psi	1325	18658.0	6.7	9.5psi		Collect samples - Br, turbidity + TOC
11psi	1353	18748.0	3.2	9.5psi		
10psi	1420	18870.8		10psi		
11psi	1450	18945.0		10psi		

1506 19001.0 — end pumping - out of Water

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EMULSIFIED OIL INJECTION -
INJECTION FLOW MEASUREMENTS

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: RDO 6B
Monitored By: Marlene Duffy & M. Bryant

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
7Oct05	1447	19307.2	—	0.0	1.08%	Start injection
41psi	1507	19503.0	9.79	0.0		release vacuum just after this
43psi	1533	19750.0	9.5	0.0		collect samples - Br + turbidity
45psi	1626	20200.0	9.0	0.0		collect samples - Br + turbidity + TOC
—	1630	20238.2	—	—		End of Day
8Oct	800	20238.2	—	—		Startup.
45psi	849	20650.0	9.0	0.0		have valve open to vent vacuum - Collect Br + Turbidity
45psi	930	21100.0	11.0	0.0		Collect Br, Turb + TOC
45psi	1043	21550.0	6.2	0.0		Collect Br + Turb. - drop in flow due to ~~[illegible]~~ filter clogging *
19psi	1150	22000.0	10.5	0.0		System back on after cleaning @ 1135 Collect Br, Turb + TOC
18psi	1220	22480	16.0	0.0		Collect Br + Turb + ~~TOC~~
18psi	1247	22900	15.5	0.0		Still vacuum. Collect Br + Turbidity + TOC
20psi	1316	23350	14.5	0.0		Collect Br + Turbidity ~~+TOC~~
20psi	1346	23800	15.0	0.0		Collect Br + Turbidity + TOC - off for lunch - sys down.
15psi	1540	24450	15.0	0.0		Collect Br + Turb. slight vacuum
15psi	1609	24900	15.5	0.0		Collect Br + Turb + TOC
15psi	1638	25350	15.5	0.0		Collect Br + Turb - slight positive pressure @ well head
15psi	1707	25800	15.5	0.0		Collect Br + Turb + TOC - strange vacuum on well
20psi	1736	26250	15.5	0.0		Slight +ve pressure. Collect Br + Turb.
18psi	1805	26700	15.5	0.0		Collect Br + Turb. + TOC
—	1815	26849.5	—	—	1.08%	End of Day
10/10 —	7:47	26849.5	—	—	—	Beginning of day
19psi	8:09	27150.0	14.3	0.0	1.08%	Collect Br + Turb. samples
20psi	8:39	27600.0	15.0	0.0		Collect Br + Turb. + TOC samples. Pressure @ well head before
15psi	9:09	28050.0	15.0	0.0		Collect Br + Turb samples

* filter clogging occurring @ influent water filter pre dosmatic pump

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EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: ROD 6B
Monitored By: Duygu Tokat

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
10/10 15psi	9:34	28,500.0	18.0	0	1.08%	Collect Br + Turb + TOC samples
15psi	10:05	28,950.0	14.5	0	"	Collect Br + Turb samples.
20 psi	10:31	29,400.0	17.3	1.5	"	Collect Br + Turb + TOC.
20 psi	11:01	29,850.0	15.0	1.5	"	" " "
20 psi	11:31	30,300.0	15.0	1.1	"	" " " + TOC
20psi	12:05	30,750.0	—	1.1	"	Br + Turb
20psi	12:35	31,200.0	15.0	1.1	"	Br + Turb + TOC
20psi	13:05	31,650.0	15.0	1.1	"	Br + Turb
22psi	13:35	32,100.0	15.0	2.5	"	Br + Turb + TOC
20psi	14:05	32,550.0	15.0	0.5	"	Br + Turb
20psi	14:35	33,000.0	15.0	1.1	"	Br + Turb + TOC
20psi	15:05	33,450.0	15.0	0	"	Br + Turb
20psi	15:35	33,900.0	15.0	1.1	"	Br + Turb + TOC
20psi	16:05	34,350.0	15.0	1.1	"	Br + Turb
20psi	16:35	34,800.0	15.0	0.5	"	Br + Turb + TOC
20psi	17:05	35,250.0	15.0	~~0~~ 1.1	"	Br + Turb
20psi	17:17	35,453.9	—	1	—	— End of day.
10/11/05 —	07:58	35,453.9	—	2	—	Start of day
20psi	08:26	35,700.0	—	2	1.08%	Br + Turb + TOC samples
—	08:33	35,790.2	—	—	"	Ran out of water Stop system.
—	12:03	35,790.7	—	—	~~"~~	Start pumping.
15psi	12:31	36,150	16.1	1.4	"	Turb
15psi	13:03	36,600	14.1	"	"	Br + Turb + TOC
15psi	13:38	37,050	12.9	1.4	"	Turb
15psi	14:12	37,500	13.2	1.1	"	Br + Turb + TOC
15psi	14:46	37,950	13.2	1.2	"	Turb

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EMULSIFIED OIL INJECTION - *INJECTION FLOW MEASUREMENTS*

GeoSyntec Consultants
2100 Main Street, Suite 150
Huntington Beach, CA 92648
Tel: (714) 969-0800 w Fax: (714) 969-0820

Project Name: Site 70 Seal Beach
Project No.: HY0888
Site Location:

Injection Well ID: ROD 6B
Monitored By: Duygu Tokat, Marlene Duffy
Jame Allen

Date	Time	Mechanical Water Meter Reading (gal)	Flow Rate (gpm)	Well-Head Pressure (psi)	Emulsion Dose Rate (L/min)	Comments (i.e., amount of oil remaining in tote, visual observations)
10/11/05 15psi	15:22	38,400	12.5	1.4	1.08 %	Br + Turb + TOC
15psi	15:53	38,850	14.1	2.5	"	Turb
15psi	16:25	39,300	14.1	1.1	"	Br + Turb + TOC
—	16:28	39,356.5	—	—	—	End of day / start of day
10/12/05 15psi	0811	39,356				
14psi	0842	39750.0	12.7	2.0 psi	"	Turb. turned pump off from 910 to 920 to transfer oil
14psi	927	40290		2.0psi	"	turb + Br + TOC
—	950	40425.8	—			turned pump off switch to EOS oil
14psi	1152	42060.0		2.0psi		ended pumping oil in RDO 6B

Created: 2005.01.28

APPENDIX D-F
Groundwater Elevation Figures from BEI, 2005

Figures 2-1 through 2-4

These detailed station maps have been deleted from the Internet-accessible version of this document as per Department of the Navy Internet security regulations.

APPENDIX D-G
Groundwater Monitoring Well Survey Data

10-1099-08

Geosyntec \ SEAL BEACH NAVAL WEAPONS STATION Well locations

Horizontal Datum = NAD83 CCS, Zone 6, 2004.0 Epoch

Vertical Datum = NAVD88, 1995 Adj. ORANGE COUNTY SURVEYOR

Values shown are in feet.

NUMBER	NORTHING (ft) NAD83	EASTING (ft) NAD83	ELEV (ft) NAVD88 1995 OCS Adj.	DESCRIPTION
103	2223799.666	6006296.180	10.41	N'LY RIM RD0-1
104	2223624.661	6006182.538	9.53	N'LY RIM RD0-2
105	2223540.131	6006123.613	9.28	N'LY RIM RD0-3A
106	2223534.611	6006114.891	9.21	N'LY RIM RD0-3B
107	2223451.966	6006074.304	9.11	N'LY RIM RD0-4
108	2223284.037	6005966.573	8.62	N'LY RIM RD0-5
109	2223059.080	6006257.726	10.60	N'LY RIM RD0-6B
110	2223071.595	6006285.178	11.30	N'LY RIM RD0-6A
201	2223523.445	6006118.619	n/a	MW-70-38
202	2223529.112	6006127.333	n/a	MW-70-01
203	2223518.148	6006126.935	n/a	MW-70-07
204	2223199.931	6006275.158	n/a	MW-70-32
205	2223188.855	6006284.093	n/a	MW-70-33
206	2223059.523	6006287.773	n/a	MW-70-08
207	2223050.739	6006281.723	n/a	MW-70-09
208	2223038.205	6006273.905	n/a	MW-70-03
209	2223024.851	6006266.135	n/a	MW-70-34
210	2223046.906	6006260.926	n/a	MW-70-31

10-1099-08

Geosyntec \ SEAL BEACH NAVAL WEAPONS STATION Well locations

Horizontal Datum = NAD83 CCS, Zone 6, 2004.0 Epoch

Vertical Datum = NAVD88, 1995 Adj. ORANGE COUNTY SURVEYOR

Values shown are in feet.

NUMBER	NORTHING (ft) NAD83	EASTING (ft) NAD83	ELEV (ft) NAVD88 1995 OCS Adj.	DESCRIPTION
Control				
101	2223739.230	6006403.010	11.55	CONTROL POINT
102	2222493.235	6005660.836	11.48	CONTROL POINT

JASON R. KINNIE, PLS 7090

PROFESSIONAL LAND SURVEYOR
JASON R. KINNIE
NO. 7090
EXP. 12/31/2006
STATE OF CALIFORNIA

SURVEYED BY ______ DATE ______

ORANGE COUNTY SURVEYOR

HUITT-ZOLLARS
430 EXCHANGE SUITE 200 IRVINE, CA 92602-1315 714/734-5100

Project No. 10 - 1099 -08 Date 9/22/05 Page 1 of 6

Surveyed By: G. BARNWARD Equipment: TRIMBLE GPS

Crew: C BROWN 1724, 9834, 1937

TYPE OF SURVEY: MONITORING WELL LOCS

LOCATION OF SURVEY: SEAL BEACH NAVAL WEAPONS STATION

REFERENCES

BENCH MARKS: ELEV PER CORS SITE.

TIE NOTES: NONE

RECORD MAPS: NONE

CALC. MAPS:

OTHER DATA:

CLIENT: GEOSYNTEC

SURVEY REQUESTED BY: JASON KINNIE

SURVEY OF ________ INDEX ________ PAGE 2/6

SURVEYED BY ________ DATE ________ ORANGE COUNTY SURVEYOR

HUITT-ZOLLARS

430 EXCHANGE SUITE 200 IRVINE, CA 92602-1315 714 / 734-5100

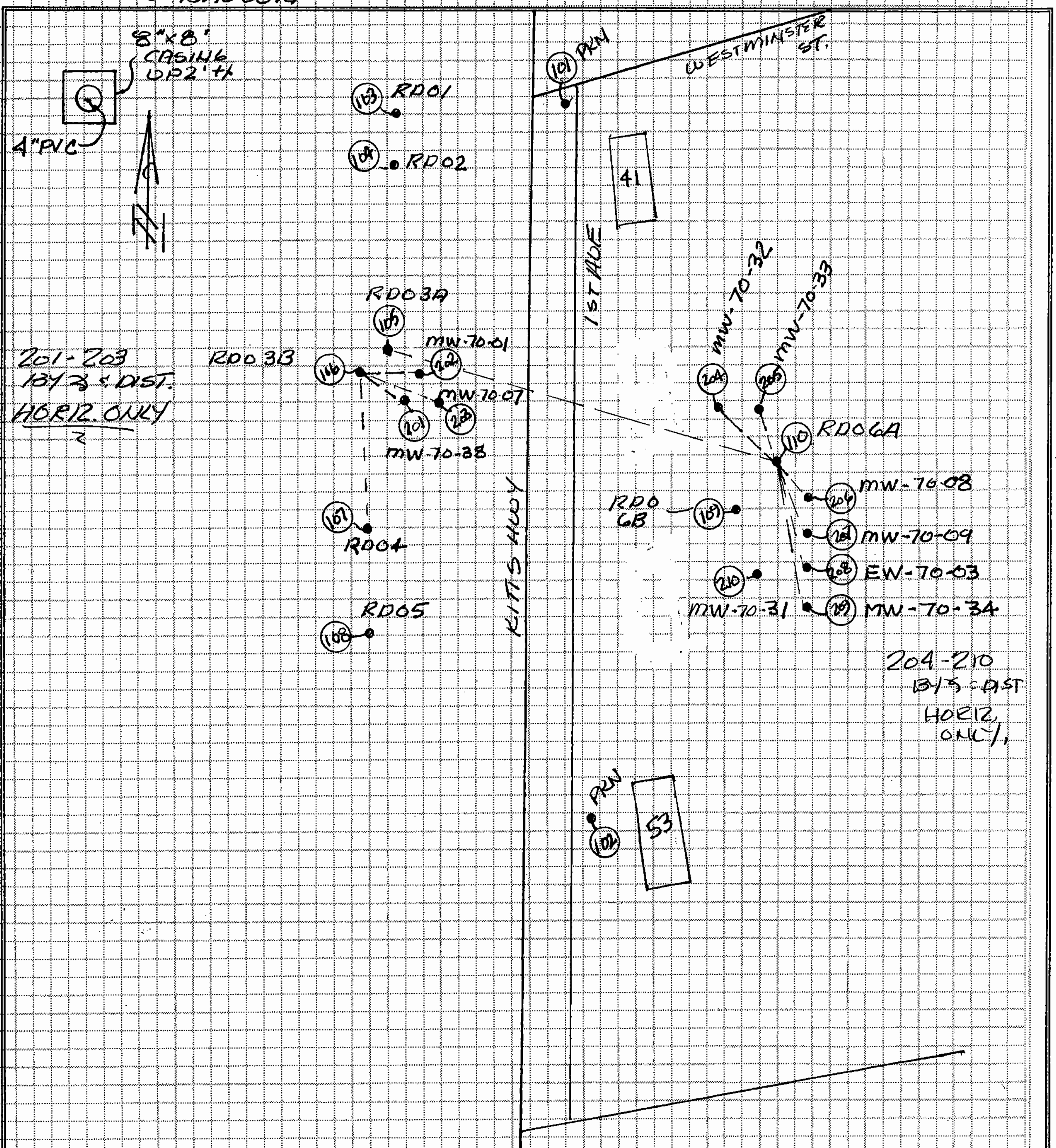
Project: GEOSYNTEC SEAL BEACH

Sheet: 2 of ____

Survey Crew: B-BARNARD / C-BROWN

Date: 9 / 22 / 05

Project No.: 10 - 1099 - 08



HUITT-ZOLLARS - GPS Static Setup Sheet

Field Crew: B BARNARD	Job # 10 - 1099 - 08	Project: GEOSINTEC SEALBEACH
C BROWN	Date: 9 /22 /05	Client: GEO SINTEC.
	Julian Day:	Processed by: / Date:

Ant Type: 1 = 5800 2 = 4800 3 = Zeph 4 = Zeph Geod
Inst. Serial #: A = 1724 B = 9834 C = 1937 D = Other

SESSION #	POINT #	START TIME	STOP TIME	H.I.	Ant Type / Serial # / Desc.	Aerial Target	is Up	Down
0	101	7:27	11:02	5.11 ft / 1.555 m	Ant Type: (4) Serial #: (B) — Desc. SET PKN NEAR INT. 1ST AVE & WESTMINSTER ST. E/o KITTS HWY	NO	O	O
0	102	7:37	10:49	4.78 ft / 1.456 m	Ant Type: (3) Serial #: (C) — Desc. SET PKN 50'+/- W/O BLD #53 E. SIDE 1ST AVE	NO	O	O
0	103	8:00	8:15	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N. RIM 4" PVC RD01	NO	O	O
1	104	8:18	8:33	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N. RIM 4" PVC RD02	NO	O	O
2	105	8:36	8:51	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. S. RIM 4" PVC RD03A	NO	O	O
3	106	8:54	9:09	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N. RIM 4" PVC RD0 3B	NO	O	O
4	107	9:12	9:27	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N RIM 4" PVC RD0-4	NO	O	O
5	108	9:33	9:48	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N. RIM 4" PVC RD0-5	NO	O	O
6	109	9:56	10:14	3.42 ft / 1.042 m	Ant Type: (1) Serial #: (A) — Desc. N RIM 4" PVC RD0-6B			

HUITT-ZOLLARS - GPS Static Setup Sheet

Field Crew: B. Barnard, C Brown	Job # 10 - 1090 - 08	Project: Geosyntec Seal Beach
	Date: 9 / 22 / 05	Client: Geosyntec
	Julian Day:	Processed by: / Date:

SESSION #	POINT #	START TIME	STOP TIME	H.I.	Ant Type: 1 = 5800 2 = 4800 3 = Zeph 4 = Zeph Geod; Inst. Serial #: A = 1724 B = 9834 C = 1937 D = Other	Aerial Target	is Up	Down
7	110	10 : 19	10 : 34	3.42 ft / 1.042 m	Ant Type: (1) 2 3 4 Serial #: (A) B C D; Desc. N. Rim 4" PVC RDO-6A	No	0	0
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			
		:	:	ft / m	Ant Type: 1 2 3 4 Serial #: A B C D; Desc.			

STAR*NET-PRO Version 6.0.18

Run Date: Wed Oct 05 2005 09:59:19

Summary of Files Used and Option Settings

Project Folder and Data Files

Project Name	109908
Project Folder	R:\10109908\GPS109908\STARNET
Data File List	109908.dat
	109908.gps
	109901VFTR01.dat

Project Option Settings

STAR*NET Run Mode	: Adjust with Error Propagation
Type of Adjustment	: 3D
Project Units	: FeetUS; DMS
Coordinate System	: Lambert NAD83; CA Zone 6 0406
Geoid Height Model	: GEOID99.GHT
Vertical Deflection	: N=0.00 E=0.00 (Defaults, Seconds)
Longitude Sign Convention	: Positive West
Input/Output Coordinate Order	: North-East
Angle Data Station Order	: At-From-To
Distance/Vertical Data Type	: Slope/Zenith
Convergence Limit; Max Iterations	: 0.0100; 10
Default Coefficient of Refraction	: 0.0700
Create Coordinate File	: Yes
Create Geodetic Position File	: No
Create Ground Scale Coordinate File	: No
Create Dump File	: No
GPS Vector Standard Error Factors	: None
GPS Vector Centering (Meters)	: 0.00200
GPS Vector Transformations	: None

Instrument Standard Error Settings

Project Default Instrument			
Distances (Constant)	:	0.03000	FeetUS
Distances (PPM)	:	5.00000	
Angles	:	3.00000	Seconds
Directions	:	3.00000	Seconds
Azimuths & Bearings	:	4.00000	Seconds
Zeniths	:	10.00000	Seconds
Elevation Differences (Constant)	:	0.05000	FeetUS
Elevation Differences (PPM)	:	0.00000	
Centering Error Instrument	:	0.00500	FeetUS
Centering Error Target	:	0.00500	FeetUS
Centering Error Vertical	:	0.00500	FeetUS

Summary of Unadjusted Input Observations

Number of Entered Stations (FeetUS) = 4
(Elevations Marked with (*) are Ellipsoid Heights)

Fixed Stations	Latitude	Longitude	Elev	Description
BLSA	33-47-58.338894	118-01-43.183357	43.1720	CORS PT.

Partially Fixed	Latitude	Longitude	Elev	Description
	N-StdErr	E-StdErr	StdErr	
LBCH	33-47-15.954705	118-12-11.982891	-88.1600*	CORS PT.
	FIXED	FIXED	FREE	

Free Stations	Latitude	Longitude	Elev	Description
FVPK	33-39-44.359569	117-56-08.517720	-35.4300*	CORS PT.
SACY	33-44-35.665458	117-53-44.026736	-34.4300*	CORS PT.

Number of Measured Geodetic Angle Observations (DMS) = 10

At	From	To	Angle	StdErr	t-T
106	107	201	315-23-10.00	119.22	0.00
106	107	202	267-41-23.00	108.75	0.00
106	107	203	297-39-20.00	69.62	0.00
110	105	204	14-33-40.00	10.67	0.01
110	105	205	18-29-44.00	11.73	0.01
110	105	206	186-53-43.00	119.65	0.01
110	105	207	208-26-01.00	70.40	0.01
110	105	208	217-40-52.00	42.74	0.01
110	105	209	221-11-30.00	30.28	0.01
110	105	210	243-30-50.00	43.00	0.01

Number of Measured Distance Observations (FeetUS) = 10

From	To	Distance	StdErr	HI	HT	Comb Grid	Type
106	201	11.9800	0.0309	0.000	99.000	0.9999888	S
106	202	13.8200	0.0309	0.000	99.000	0.9999887	S
106	203	20.5200	0.0309	0.000	99.000	0.9999887	S
110	204	128.7497	0.0314	0.000	99.000	0.9999885	S
110	205	117.2898	0.0314	0.000	99.000	0.9999885	S
110	206	12.4300	0.0309	0.000	99.000	0.9999885	S
110	207	21.2000	0.0309	0.000	99.000	0.9999885	S
110	208	35.2799	0.0310	0.000	99.000	0.9999885	S
110	209	50.4899	0.0311	0.000	99.000	0.9999885	S
110	210	34.6999	0.0310	0.000	99.000	0.9999885	S

Number of Zenith Observations (DMS) = 10

From	To	Zenith	StdErr	HI	HT
106	201	100-41-33.00	122.16	0.000	99.000
106	202	100-10-43.00	106.01	0.000	99.000
106	203	96-14-36.00	71.78	0.000	99.000
110	204	91-02-40.00	15.11	0.000	99.000
110	205	91-08-23.00	15.96	0.000	99.000
110	206	96-35-25.00	117.77	0.000	99.000

110	207	94-16-51.00	69.52	0.000	99.000
110	208	92-39-02.00	42.53	0.000	99.000
110	209	91-23-52.00	30.57	0.000	99.000
110	210	94-09-11.00	43.21	0.000	99.000

Number of GPS Vector Observations (FeetUS) = 33

From To	DeltaX DeltaY DeltaZ	StdErrX StdErrY StdErrZ	CorrelXY CorrelXZ CorrelYZ
(V1 Postprocessed 22-SEP-2005 15:00:17.0 109908.asc)			
101	-79.4193	0.0100	0.1236
103	80.3095	0.0105	-0.0889
	48.0482	0.0101	-0.0997
(V2 Postprocessed 22-SEP-2005 16:13:32.0 109908.asc)			
101	-361.2145	0.0097	0.0849
107	10.4598	0.0102	-0.0334
	-244.9563	0.0100	-0.0895
(V3 Postprocessed 22-SEP-2005 15:55:02.0 109908.asc)			
101	-304.9241	0.0096	0.0966
106	32.8316	0.0103	-0.0482
	-175.5933	0.0097	-0.0904
(V4 Postprocessed 22-SEP-2005 15:37:47.0 109908.asc)			
101	-295.8589	0.0101	0.1951
105	31.5054	0.0113	-0.0980
	-170.8398	0.0099	-0.1480
(V5 Postprocessed 22-SEP-2005 15:19:17.0 109908.asc)			
101	-222.9036	0.0100	0.1619
104	46.2316	0.0109	-0.0879
	-99.5721	0.0099	-0.1192
(V6 Postprocessed 22-SEP-2005 16:32:47.0 109908.asc)			
101	-497.8632	0.0096	0.0457
108	-23.1004	0.0099	-0.0056
	-386.3835	0.0101	-0.0690
(V7 Postprocessed 22-SEP-2005 17:19:17.0 109908.asc)			
101	-268.6524	0.0098	0.0841
110	-278.1591	0.0100	-0.0820
	-556.8562	0.0100	-0.0933
(V8 Postprocessed 22-SEP-2005 16:56:32.0 109908.asc)			
101	-295.8051	0.0096	0.0537
109	-271.2054	0.0100	-0.0304
	-568.0418	0.0103	-0.0880
(V9 Postprocessed 22-SEP-2005 17:19:17.0 109908.asc)			
110	-696.0045	0.0098	0.0794
102	0.0573	0.0100	-0.0783
	-489.8001	0.0100	-0.0868
(V10 Postprocessed 22-SEP-2005 16:56:32.0 109908.asc)			
109	-668.8488	0.0096	0.0538
102	-6.8959	0.0100	-0.0304
	-478.6188	0.0103	-0.0880
(V11 Postprocessed 22-SEP-2005 16:13:32.0 109908.asc)			
107	-603.4405	0.0096	0.0771
102	-288.5612	0.0101	-0.0304
	-801.7002	0.0099	-0.0834
(V12 Postprocessed 22-SEP-2005 15:55:02.0 109908.asc)			
106	-659.7259	0.0097	0.1203

102	-310.9289	0.0106	-0.0606
	-871.0694	0.0098	-0.1118
(V13 Postprocessed 22-SEP-2005 15:37:47.0 109908.asc)			
105	-668.7909	0.0100	0.1816
102	-309.6019	0.0111	-0.0905
	-875.8225	0.0099	-0.1381
(V14 Postprocessed 22-SEP-2005 15:19:17.0 109908.asc)			
104	-741.7523	0.0100	0.1714
102	-324.3354	0.0110	-0.0935
	-947.0866	0.0100	-0.1254
(V15 Postprocessed 22-SEP-2005 15:00:17.0 109908.asc)			
103	-885.2325	0.0100	0.1303
102	-358.4067	0.0106	-0.0933
	-1094.7134	0.0101	-0.1055
(V16 Postprocessed 22-SEP-2005 14:37:02.0 109908.asc)			
101	-964.6521	0.0094	0.0559
102	-278.0968	0.0098	-0.0438
	-1046.6623	0.0096	-0.0788
(V17 Postprocessed 22-SEP-2005 16:32:47.0 109908.asc)			
108	-466.7891	0.0095	0.0436
102	-255.0063	0.0098	-0.0056
	-660.2603	0.0101	-0.0662
(V18 Postprocessed 22-SEP-2005 17:19:17.0 109908.asc)			
BLSA	-17288.4877	0.0132	0.3748
110	-1056.5235	0.0137	-0.3472
	-13607.5772	0.0139	-0.3142
(V19 Postprocessed 22-SEP-2005 16:56:32.0 109908.asc)			
BLSA	-17315.6225	0.0108	0.1901
109	-1049.5531	0.0120	-0.1014
	-13618.7965	0.0135	-0.2016
(V20 Postprocessed 22-SEP-2005 16:13:32.0 109908.asc)			
BLSA	-17381.0275	0.0119	0.3649
107	-767.8728	0.0149	-0.1798
	-13295.6391	0.0135	-0.3186
(V21 Postprocessed 22-SEP-2005 15:55:02.0 109908.asc)			
BLSA	-17324.7515	0.0118	0.4144
106	-745.5128	0.0152	-0.2547
	-13226.3327	0.0121	-0.3680
(V22 Postprocessed 22-SEP-2005 15:37:47.0 109908.asc)			
BLSA	-17315.6947	0.0135	0.5517
105	-746.8633	0.0179	-0.3729
	-13221.5660	0.0128	-0.4532
(V23 Postprocessed 22-SEP-2005 15:19:17.0 109908.asc)			
BLSA	-17242.7677	0.0146	0.5560
104	-732.1582	0.0193	-0.3903
	-13150.2909	0.0143	-0.4335
(V24 Postprocessed 22-SEP-2005 15:00:17.0 109908.asc)			
BLSA	-17099.2574	0.0128	0.3910
103	-698.0377	0.0156	-0.2807
	-13002.6693	0.0136	-0.3059
(V25 Postprocessed 22-SEP-2005 14:37:02.0 109908.asc)			
102	17984.4793	0.0102	0.2574
BLSA	1056.4404	0.0121	-0.2151
	14097.3950	0.0112	-0.3338
(V26 Postprocessed 22-SEP-2005 16:32:47.0 109908.asc)			
BLSA	-17517.7072	0.0105	0.1838

108	-801.4889	0.0118	-0.0582
	-13437.0969	0.0126	-0.1865
(V27 Postprocessed 22-SEP-2005 14:27:17.0 109908.asc)			
101	17019.8382	0.0103	0.2662
BLSA	778.3544	0.0122	-0.2259
	13050.7327	0.0113	-0.3451
(V28 Postprocessed 22-SEP-2005 14:37:02.0 109908.asc)			
102	48356.9864	0.0137	0.6189
SACY	-27997.5769	0.0205	-0.5628
	-2911.0329	0.0174	-0.7118
(V29 Postprocessed 22-SEP-2005 14:27:17.0 109908.asc)			
101	47392.3487	0.0138	0.6219
SACY	-28275.6525	0.0205	-0.5686
	-3957.7041	0.0176	-0.7139
(V30 Postprocessed 22-SEP-2005 14:37:02.0 109908.asc)			
LBCH	29939.1720	0.0105	0.3096
102	-23974.4256	0.0129	-0.2656
	-10528.7582	0.0118	-0.4037
(V31 Postprocessed 22-SEP-2005 14:27:17.0 109908.asc)			
LBCH	30903.8105	0.0105	0.2963
101	-23696.3413	0.0126	-0.2556
	-9482.0970	0.0117	-0.3875
(V32 Postprocessed 22-SEP-2005 14:37:02.0 109908.asc)			
102	29920.8673	0.0101	0.2298
FVPK	-36719.5732	0.0117	-0.1900
	-27408.6343	0.0109	-0.3015
(V33 Postprocessed 22-SEP-2005 14:27:17.0 109908.asc)			
101	28956.2300	0.0101	0.2171
FVPK	-36997.6529	0.0115	-0.1823
	-28455.3003	0.0109	-0.2870

Adjustment Statistical Summary

Convergence Iterations = 4

Number of Stations = 24

Number of Observations = 129
Number of Unknowns = 67
Number of Redundant Obs = 62

Observation	Count	Sum Squares of StdRes	Error Factor
Angles	10	0.00	0.00
Distances	10	0.00	0.00
Zeniths	10	0.00	0.00
GPS Deltas	99	47.04	0.99
Total	129	47.04	0.87

Adjustment Passed the Chi Square Test at 5% Level

Adjusted Station Information

Adjusted Coordinates (FeetUS)

Station	N	E	Elev	Description
BLSA	2239163.1209	6021325.9440	43.1720	CORS PT.
FVPK	2188768.2086	6048757.3679	80.4265	CORS PT.
LBCH	2235829.1532	5968189.5718	29.4330	CORS PT.
SACY	2218014.8802	6061433.3618	80.8486	CORS PT.
101	2223739.2298	6006403.0096	11.5452	CONTROL POINT
102	2222493.2350	6005660.8363	11.4825	CONTROL POINT
103	2223799.6662	6006296.1801	10.4123	N'LY RIM RD0-1
104	2223624.6614	6006182.5381	9.5313	N'LY RIM RD0-2
105	2223540.1310	6006123.6133	9.2837	N'LY RIM RD0-3A
106	2223534.6109	6006114.8914	9.2124	N'LY RIM RD0-3B
107	2223451.9658	6006074.3040	9.1091	N'LY RIM RD0-4
108	2223284.0365	6005966.5729	8.6226	N'LY RIM RD0-5
109	2223059.0801	6006257.7261	10.6023	N'LY RIM RD0-6B
110	2223071.5950	6006285.1782	11.2986	N'LY RIM RD0-6A
201	2223523.4447	6006118.6185	-92.0105	MW-70-38
202	2223529.1119	6006127.3326	-92.2301	MW-70-01
203	2223518.1481	6006126.9353	-92.0196	MW-70-07
204	2223199.9309	6006275.1578	-90.0467	MW-70-32
205	2223188.8550	6006284.0932	-90.0331	MW-70-33
206	2223059.5230	6006287.7729	-89.1281	MW-70-08
207	2223050.7388	6006281.7225	-89.2840	MW-70-09
208	2223038.2050	6006273.9052	-89.3330	MW-70-03
209	2223024.8511	6006266.1347	-88.9331	MW-70-34
210	2223046.9056	6006260.9260	-90.2142	MW-70-31

Adjusted Positions and Ellipsoid Heights (FeetUS)

Station	Latitude	Longitude	Ellip Ht	Geoid Ht
BLSA	33-47-58.338894	118-01-43.183357	-73.3631	-116.5351
FVPK	33-39-44.359566	117-56-08.517635	-35.2810	-115.7074
LBCH	33-47-15.954705	118-12-11.982891	-87.9499	-117.3829
SACY	33-44-35.665213	117-53-44.026833	-34.2478	-115.0964
101	33-45-23.222925	118-04-36.786238	-105.2504	-116.7955
102	33-45-10.769563	118-04-45.316169	-105.3145	-116.7971
103	33-45-23.802206	118-04-38.063857	-106.3855	-116.7978
104	33-45-22.051460	118-04-39.373280	-107.2669	-116.7982
105	33-45-21.205119	118-04-40.053516	-107.5147	-116.7984
106	33-45-21.149005	118-04-40.155654	-107.5862	-116.7985
107	33-45-20.324490	118-04-40.619129	-107.6894	-116.7985
108	33-45-18.644748	118-04-41.859996	-108.1762	-116.7988
109	33-45-16.470104	118-04-38.365514	-106.1898	-116.7921
110	33-45-16.598654	118-04-38.043031	-105.4932	-116.7918
201	33-45-21.039201	118-04-40.109200	-208.8089	-116.7984
202	33-45-21.096769	118-04-40.007185	-209.0284	-116.7983
203	33-45-20.988253	118-04-40.009613	-208.8177	-116.7982
204	33-45-17.866339	118-04-38.188327	-206.8397	-116.7930
205	33-45-17.758332	118-04-38.080216	-206.8259	-116.7928
206	33-45-16.479695	118-04-38.009800	-205.9198	-116.7916
207	33-45-16.391758	118-04-38.079624	-206.0756	-116.7916
208	33-45-16.266425	118-04-38.169593	-206.1247	-116.7917
209	33-45-16.132990	118-04-38.258837	-205.7247	-116.7917
210	33-45-16.350237	118-04-38.325096	-207.0062	-116.7920
			Average:	-116.6928

Convergence Angles (DMS) and Grid Factors at Stations
(Grid Azimuth = Geodetic Azimuth - Convergence)
(Elevation Factor Includes a Geoid Height Correction at Each Station))

Station	Convergence Angle	------- Factors ------- Scale	x Elevation	= Combined
BLSA	-0-58-38.66	0.99998707	1.00000351	0.99999058
FVPK	-0-55-34.76	0.99997051	1.00000169	0.99997220
LBCH	-1-04-24.20	0.99998542	1.00000421	0.99998963
SACY	-0-54-15.36	0.99997958	1.00000164	0.99998122
101	-1-00-14.06	0.99998125	1.00000504	0.99998629
102	-1-00-18.75	0.99998081	1.00000504	0.99998585
103	-1-00-14.76	0.99998127	1.00000509	0.99998636
104	-1-00-15.48	0.99998121	1.00000513	0.99998634
105	-1-00-15.86	0.99998118	1.00000514	0.99998632
106	-1-00-15.91	0.99998118	1.00000515	0.99998632
107	-1-00-16.17	0.99998115	1.00000515	0.99998630
108	-1-00-16.85	0.99998109	1.00000518	0.99998626
109	-1-00-14.93	0.99998101	1.00000508	0.99998609
110	-1-00-14.75	0.99998102	1.00000505	0.99998606
201	-1-00-15.89	0.99998117	1.00000999	0.99999116
202	-1-00-15.83	0.99998118	1.00001000	0.99999118
203	-1-00-15.83	0.99998117	1.00000999	0.99999116
204	-1-00-14.83	0.99998106	1.00000990	0.99999096
205	-1-00-14.77	0.99998106	1.00000990	0.99999095
206	-1-00-14.73	0.99998101	1.00000985	0.99999086
207	-1-00-14.77	0.99998101	1.00000986	0.99999087
208	-1-00-14.82	0.99998100	1.00000986	0.99999087
209	-1-00-14.87	0.99998100	1.00000984	0.99999084

210	-1-00-14.91	0.99998101	1.00000991	0.99999091
Project Averages:	-0-59-55.07	0.99998102	1.00000672	0.99998773

Coordinate Changes from Entered Provisionals (FeetUS)

(Elevations Marked with (*) are Ellipsoid Heights)

Station	dN	dE	dZ
BLSA	0.0000	0.0000	0.0000
FVPK	-0.0004	0.0071	0.1490*
LBCH	0.0000	0.0000	0.2101*
SACY	-0.0246	-0.0086	0.1822*

Adjusted Observations and Residuals

Adjusted Measured Geodetic Angle Observations (DMS)

At	From	To	Angle	Residual	StdErr	StdRes
110	105	207	208-26-01.00	-0-00-00.00	70.40	0.0
110	105	206	186-53-43.00	-0-00-00.00	119.65	0.0
106	107	203	297-39-20.00	0-00-00.00	69.62	0.0
110	105	208	217-40-52.00	-0-00-00.00	42.74	0.0
106	107	201	315-23-10.00	-0-00-00.00	119.22	0.0
110	105	209	221-11-30.00	-0-00-00.00	30.28	0.0
110	105	205	18-29-44.00	0-00-00.00	11.73	0.0
110	105	210	243-30-50.00	-0-00-00.00	43.00	0.0
106	107	202	267-41-23.00	-0-00-00.00	108.75	0.0
110	105	204	14-33-40.00	-0-00-00.00	10.67	0.0

Adjusted Measured Distance Observations (FeetUS)

From	To	Distance	Residual	StdErr	StdRes
110	207	21.2000	0.0000	0.0309	0.0
110	205	117.2898	-0.0000	0.0314	0.0
110	209	50.4899	0.0000	0.0311	0.0
110	208	35.2799	0.0000	0.0310	0.0
110	204	128.7497	-0.0000	0.0314	0.0
106	201	11.9800	-0.0000	0.0309	0.0
110	210	34.6999	0.0000	0.0310	0.0
106	203	20.5200	0.0000	0.0309	0.0
110	206	12.4300	0.0000	0.0309	0.0
106	202	13.8200	0.0000	0.0309	0.0

Adjusted Zenith Observations (DMS)

From	To	Zenith	Residual	StdErr	StdRes
106	202	100-10-43.00	-0-00-00.00	106.01	0.0
106	201	100-41-33.00	0-00-00.00	122.16	0.0
110	206	96-35-25.00	-0-00-00.00	117.77	0.0
110	208	92-39-02.00	-0-00-00.00	42.53	0.0
106	203	96-14-36.00	-0-00-00.00	71.78	0.0
110	209	91-23-52.00	-0-00-00.00	30.57	0.0
110	207	94-16-51.00	0-00-00.00	69.52	0.0
110	205	91-08-23.00	0-00-00.00	15.96	0.0
110	204	91-02-40.00	-0-00-00.00	15.11	0.0
110	210	94-09-11.00	0-00-00.00	43.21	0.0

Adjusted GPS Vector Observations (FeetUS)

From To	Component	Adj Value	Residual	StdErr	StdRes
(V1 Postprocessed 22-SEP-2005 15:00:17.0 109908.asc)					
101	Delta-N	58.5561	0.0053	0.0097	0.5
103	Delta-E	-107.8734	-0.0023	0.0095	0.2
	Delta-U	-1.1355	0.0008	0.0112	0.1
	Length	122.7468			
(V2 Postprocessed 22-SEP-2005 16:13:32.0 109908.asc)					

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101                Delta-N         -292.9830        0.0144   0.0097   1.5
107                Delta-E         -323.6266        0.0020   0.0094   0.2
                   Delta-U           -2.4436       -0.0029   0.0107   0.3
                   Length           436.5537
(V3 Postprocessed 22-SEP-2005 15:55:02.0 109908.asc)
101                Delta-N         -209.6384        0.0005   0.0095   0.1
106                Delta-E         -284.4928       -0.0007   0.0094   0.1
                   Delta-U           -2.3388       -0.0027   0.0107   0.3
                   Length           353.3976
(V4 Postprocessed 22-SEP-2005 15:37:47.0 109908.asc)
101                Delta-N         -203.9662       -0.0001   0.0097   0.0
105                Delta-E         -275.8688        0.0007   0.0094   0.1
                   Delta-U           -2.2671        0.0020   0.0120   0.2
                   Length           343.0903
(V5 Postprocessed 22-SEP-2005 15:19:17.0 109908.asc)
101                Delta-N         -118.4153       -0.0012   0.0097   0.1
104                Delta-E         -218.4333       -0.0026   0.0095   0.3
                   Delta-U           -2.0180        0.0008   0.0116   0.1
                   Length           248.4741
(V6 Postprocessed 22-SEP-2005 16:32:47.0 109908.asc)
101                Delta-N         -462.7764       -0.0045   0.0098   0.5
108                Delta-E         -428.4004        0.0004   0.0094   0.0
                   Delta-U           -2.9354        0.0011   0.0103   0.1
                   Length           630.6326
(V7 Postprocessed 22-SEP-2005 17:19:17.0 109908.asc)
101                Delta-N         -669.6061        0.0013   0.0095   0.1
110                Delta-E         -106.1175        0.0018   0.0095   0.2
                   Delta-U           -0.2538       -0.0021   0.0108   0.2
                   Length           677.9626
(V8 Postprocessed 22-SEP-2005 16:56:32.0 109908.asc)
101                Delta-N         -682.6002       -0.0011   0.0098   0.1
109                Delta-E         -133.3464        0.0030   0.0095   0.3
                   Delta-U           -0.9511       -0.0079   0.0106   0.7
                   Length           695.5036
(V9 Postprocessed 22-SEP-2005 17:19:17.0 109908.asc)
110                Delta-N         -589.2203        0.0006   0.0095   0.1
102                Delta-E         -614.1196        0.0019   0.0095   0.2
                   Delta-U            0.1613       -0.0057   0.0107   0.5
                   Length           851.0719
(V10 Postprocessed 22-SEP-2005 16:56:32.0 109908.asc)
109                Delta-N         -576.2266        0.0055   0.0098   0.6
102                Delta-E         -586.8902       -0.0017   0.0095   0.2
                   Delta-U            0.8591        0.0041   0.0106   0.4
                   Length           822.4827
(V11 Postprocessed 22-SEP-2005 16:13:32.0 109908.asc)
107                Delta-N         -965.8454       -0.0131   0.0096   1.4
102                Delta-E         -396.6025        0.0002   0.0094   0.0
                   Delta-U            2.3487       -0.0037   0.0106   0.3
                   Length          1044.1055
(V12 Postprocessed 22-SEP-2005 15:55:02.0 109908.asc)
106                Delta-N        -1049.1899        0.0027   0.0096   0.3
102                Delta-E         -435.7367        0.0005   0.0094   0.0
                   Delta-U            2.2407        0.0045   0.0111   0.4
                   Length          1136.0770
(V13 Postprocessed 22-SEP-2005 15:37:47.0 109908.asc)
105                Delta-N        -1054.8620        0.0025   0.0096   0.3
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102	Delta-E	-444.3609	-0.0008	0.0094	0.1
	Delta-U	2.1688	0.0002	0.0118	0.0
	Length	1144.6375			
(V14 Postprocessed	22-SEP-2005 15:19:17.0 109908.asc)				
104	Delta-N	-1140.4125	0.0058	0.0097	0.6
102	Delta-E	-501.7977	0.0044	0.0095	0.5
	Delta-U	1.9152	-0.0083	0.0117	0.7
	Length	1245.9315			
(V15 Postprocessed	22-SEP-2005 15:00:17.0 109908.asc)				
103	Delta-N	-1317.3826	0.0004	0.0097	0.0
102	Delta-E	-612.3611	0.0037	0.0096	0.4
	Delta-U	1.0204	0.0018	0.0113	0.2
	Length	1452.7505			
(V16 Postprocessed	22-SEP-2005 14:37:02.0 109908.asc)				
101	Delta-N	-1258.8243	0.0032	0.0093	0.3
102	Delta-E	-720.2390	0.0018	0.0093	0.2
	Delta-U	-0.1146	0.0011	0.0102	0.1
	Length	1450.3044			
(V17 Postprocessed	22-SEP-2005 16:32:47.0 109908.asc)				
108	Delta-N	-796.0518	-0.0028	0.0098	0.3
102	Delta-E	-291.8277	-0.0030	0.0094	0.3
	Delta-U	2.8445	-0.0176	0.0103	1.7
	Length	847.8620			
(V18 Postprocessed	22-SEP-2005 17:19:17.0 109908.asc)				
BLSA	Delta-N	-16345.8868	-0.0013	0.0115	0.1
110	Delta-E	-14764.2908	0.0013	0.0110	0.1
	Delta-U	-43.7406	-0.0098	0.0174	0.6
	Length	22026.6704			
(V19 Postprocessed	22-SEP-2005 16:56:32.0 109908.asc)				
BLSA	Delta-N	-16358.8676	0.0114	0.0119	1.0
109	Delta-E	-14791.5253	-0.0055	0.0101	0.5
	Delta-U	-44.4667	0.0224	0.0141	1.6
	Length	22054.5630			
(V20 Postprocessed	22-SEP-2005 16:13:32.0 109908.asc)				
BLSA	Delta-N	-15969.1604	-0.0414	0.0119	3.5*
107	Delta-E	-14981.6222	-0.0032	0.0103	0.3
	Delta-U	-45.7992	0.0002	0.0173	0.0
	Length	21896.6934			
(V21 Postprocessed	22-SEP-2005 15:55:02.0 109908.asc)				
BLSA	Delta-N	-15885.8341	0.0013	0.0107	0.1
106	Delta-E	-14942.4495	0.0012	0.0099	0.1
	Delta-U	-45.6044	0.0176	0.0175	1.0
	Length	21809.1403			
(V22 Postprocessed	22-SEP-2005 15:37:47.0 109908.asc)				
BLSA	Delta-N	-15880.1661	0.0039	0.0112	0.3
105	Delta-E	-14933.8229	-0.0014	0.0101	0.1
	Delta-U	-45.5224	-0.0061	0.0210	0.3
	Length	21799.1012			
(V23 Postprocessed	22-SEP-2005 15:19:17.0 109908.asc)				
BLSA	Delta-N	-15794.6423	0.0144	0.0124	1.2
104	Delta-E	-14876.3476	0.0104	0.0109	1.0
	Delta-U	-45.1688	-0.0380	0.0228	1.7
	Length	21697.4303			
(V24 Postprocessed	22-SEP-2005 15:00:17.0 109908.asc)				
BLSA	Delta-N	-15617.7233	-0.0079	0.0120	0.7
103	Delta-E	-14765.7056	0.0077	0.0108	0.7

	Delta-U	-44.0758	0.0027	0.0182	0.1
	Length	21492.8194			
(V25 Postprocessed	22-SEP-2005 14:37:02.0 109908.asc)				
102	Delta-N	16942.3908	0.0021	0.0095	0.2
BLSA	Delta-E	15370.3960	-0.0039	0.0094	0.4
	Delta-U	19.4288	-0.0184	0.0141	1.3
	Length	22875.6214			
(V26 Postprocessed	22-SEP-2005 16:32:47.0 109908.asc)				
BLSA	Delta-N	-16138.9043	0.0006	0.0115	0.1
108	Delta-E	-15086.4750	-0.0038	0.0099	0.4
	Delta-U	-46.4920	-0.0319	0.0134	2.4
	Length	22092.2638			
(V27 Postprocessed	22-SEP-2005 14:27:17.0 109908.asc)				
101	Delta-N	15683.2121	-0.0030	0.0095	0.3
BLSA	Delta-E	14650.5456	-0.0067	0.0094	0.7
	Delta-U	20.8656	-0.0050	0.0143	0.4
	Length	21461.6416			
(V28 Postprocessed	22-SEP-2005 14:37:02.0 109908.asc)				
102	Delta-N	-3498.7504	0.0018	0.0101	0.2
SACY	Delta-E	55843.4896	0.0004	0.0098	0.0
	Delta-U	-3.6640	-0.0136	0.0268	0.5
	Length	55952.9856			
(V29 Postprocessed	22-SEP-2005 14:27:17.0 109908.asc)				
101	Delta-N	-4758.8577	-0.0018	0.0102	0.2
SACY	Delta-E	55123.1702	-0.0005	0.0098	0.0
	Delta-U	-2.0698	0.0136	0.0269	0.5
	Length	55328.2082			
(V30 Postprocessed	22-SEP-2005 14:37:02.0 109908.asc)				
LBCH	Delta-N	-12631.5058	0.0024	0.0095	0.2
102	Delta-E	37715.0254	-0.0089	0.0094	1.0
	Delta-U	-55.1436	0.0080	0.0154	0.5
	Length	39774.1262			
(V31 Postprocessed	22-SEP-2005 14:27:17.0 109908.asc)				
LBCH	Delta-N	-11371.7988	0.0098	0.0095	1.0
101	Delta-E	38433.7192	-0.0047	0.0094	0.5
	Delta-U	-55.6606	-0.0070	0.0151	0.5
	Length	40080.8143			
(V32 Postprocessed	22-SEP-2005 14:37:02.0 109908.asc)				
102	Delta-N	-32964.1877	0.0030	0.0094	0.3
FVPK	Delta-E	43682.7295	0.0016	0.0093	0.2
	Delta-U	-1.5726	-0.0110	0.0135	0.8
	Length	54724.9352			
(V33 Postprocessed	22-SEP-2005 14:27:17.0 109908.asc)				
101	Delta-N	-34224.0156	-0.0030	0.0094	0.3
FVPK	Delta-E	42961.7331	-0.0016	0.0093	0.2
	Delta-U	-2.1755	0.0105	0.0133	0.8
	Length	54927.1678			

Adjusted Bearings (DMS) and Horizontal Distances (FeetUS)
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(Relative Confidence of Bearing is in Seconds)

From	To	Grid Bearing	Grid Dist / Grnd Dist	95% RelConfidence Brg	Dist	PPM
101	102	S30-46-48.08W	1450.2842 1450.3044	1.25	0.0089	6.1023
101	103	N60-30-07.13W	122.7399 122.7416	25.49	0.0151	122.7374
101	104	S62-32-28.53W	248.4625 248.4659	12.72	0.0148	59.7657
101	105	S54-31-34.25W	343.0781 343.0828	8.92	0.0147	42.8259
101	106	S54-37-04.70W	353.3850 353.3899	8.54	0.0146	41.1801
101	107	S48-50-56.33W	436.5409 436.5469	7.02	0.0150	34.4366
101	108	S43-47-41.57W	630.6172 630.6258	4.79	0.0151	23.9496
101	109	S12-03-26.88W	695.4933 695.5029	4.32	0.0155	22.2397
101	110	S10-00-32.77W	677.9532 677.9625	4.52	0.0150	22.1408
101	BLSA	N44-03-15.35E	21461.3696 21461.6179	0.09	0.0091	0.4262
101	FVPK	S50-27-15.46E	54925.9865 54927.1232	0.06	0.0168	0.3063
101	LBCH	N72-26-37.43W	40080.3328 40080.8106	0.05	0.0090	0.2237
101	SACY	S84-03-40.88E	55327.2793 55328.1627	0.07	0.0174	0.3150
102	103	N25-56-04.52E	1452.7299 1452.7501	2.13	0.0152	10.4697
102	104	N24-45-16.10E	1245.9127 1245.9300	2.47	0.0153	12.2492
102	105	N23-50-51.62E	1144.6195 1144.6354	2.62	0.0150	13.0752
102	106	N23-33-28.46E	1136.0589 1136.0747	2.62	0.0148	13.0012
102	107	N23-19-43.96E	1044.0883 1044.1028	2.88	0.0153	14.6401
102	108	N21-08-14.30E	847.8454 847.8572	3.50	0.0153	18.0797
102	109	N46-31-45.91E	822.4707 822.4823	3.74	0.0151	18.3788
102	110	N47-11-22.11E	851.0600 851.0719	3.64	0.0148	17.4178
102	BLSA	N43-13-12.59E	22875.3294 22875.5991	0.08	0.0091	0.4000
102	FVPK	S51-57-18.64E	54723.7466 54724.8903	0.06	0.0168	0.3073
102	LBCH	N70-24-34.19W	39773.6393 39774.1224	0.05	0.0090	0.2256
102	SACY	S85-24-33.06E	55952.0353	0.07	0.0174	0.3115

			55952.9404			
103	BLSA	N44-22-15.48E	21492.5462	0.15	0.0154	0.7143
			21492.7941			
104	BLSA	N44-15-44.32E	21697.1534	0.15	0.0154	0.7098
			21697.4039			
105	110	S19-01-32.46E	495.6099	8.13	0.0201	40.4835
			495.6167			
105	BLSA	N44-13-05.37E	21798.8227	0.14	0.0150	0.6900
			21799.0745			
106	107	S26-09-21.26W	92.0736	43.21	0.0200	217.7318
			92.0749			
106	201	S18-27-28.74E	11.7718	295.00	0.0743	6315.5358
			11.7720			
106	202	S66-09-15.74E	13.6023	269.67	0.0745	5475.7778
			13.6025			
106	203	S36-11-18.74E	20.3980	175.81	0.0753	3689.8162
			20.3982			
106	BLSA	N44-13-28.08E	21808.8616	0.14	0.0149	0.6816
			21809.1135			
107	BLSA	N44-08-59.07E	21896.4133	0.14	0.0154	0.7054
			21896.6665			
108	BLSA	N44-02-48.69E	22091.9805	0.14	0.0154	0.6958
			22092.2364			
109	BLSA	N43-05-48.55E	22054.2812	0.14	0.0155	0.7019
			22054.5386			
110	204	N04-27-52.45W	128.7265	27.34	0.0770	597.9236
			128.7280			
110	205	N00-31-48.45W	117.2650	29.85	0.0768	655.1801
			117.2663			
110	206	S12-07-49.45E	12.3477	292.98	0.0751	6083.7682
			12.3478			
110	207	S09-24-28.55W	21.1406	172.51	0.0755	3571.2522
			21.1408			
110	208	S18-39-19.55W	35.2417	104.94	0.0758	2150.5594
			35.2421			
110	209	S22-09-57.55W	50.4742	74.55	0.0760	1506.2345
			50.4748			
110	210	S44-29-17.54W	34.6083	105.57	0.0757	2186.4964
			34.6087			
110	BLSA	N43-04-00.91E	22026.3897	0.14	0.0152	0.6887
			22026.6470			

Error Propagation

Station Coordinate Standard Deviations (FeetUS)

Station	N	E	Elev
BLSA	0.00000	0.00000	0.00000
FVPK	0.00746	0.00734	0.01095
LBCH	0.00000	0.00000	0.01211
SACY	0.00792	0.00760	0.01974
101	0.00380	0.00365	0.00593
102	0.00380	0.00365	0.00593
103	0.00647	0.00616	0.00864
104	0.00649	0.00614	0.00914
105	0.00627	0.00598	0.00914
106	0.00617	0.00593	0.00842
107	0.00643	0.00603	0.00832
108	0.00640	0.00595	0.00768
109	0.00648	0.00602	0.00788
110	0.00632	0.00616	0.00832
201	0.02956	0.01279	0.01234
202	0.01541	0.02855	0.01223
203	0.02598	0.01970	0.01152
204	0.03198	0.00873	0.01259
205	0.03202	0.00845	0.01233
206	0.03070	0.01141	0.01147
207	0.03110	0.01080	0.01120
208	0.03009	0.01372	0.01114
209	0.02957	0.01512	0.01122
210	0.02347	0.02317	0.01126

Station Coordinate Error Ellipses (FeetUS)
Confidence Region = 95%

Station	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Elev
BLSA	0.00000	0.00000	0-00	0.00000
FVPK	0.01826	0.01796	0-07	0.02146
LBCH	0.00000	0.00000	0-00	0.02374
SACY	0.01939	0.01859	5-58	0.03869
101	0.00931	0.00894	1-48	0.01163
102	0.00931	0.00894	1-48	0.01162
103	0.01587	0.01507	170-39	0.01693
104	0.01589	0.01502	175-10	0.01791
105	0.01535	0.01463	2-37	0.01791
106	0.01510	0.01451	4-27	0.01650
107	0.01577	0.01474	9-19	0.01630
108	0.01572	0.01452	11-09	0.01504
109	0.01589	0.01472	6-30	0.01544
110	0.01550	0.01504	164-53	0.01631
201	0.07585	0.02154	161-47	0.02419
202	0.07590	0.02336	114-12	0.02397
203	0.07672	0.02200	144-17	0.02257
204	0.07851	0.02049	175-23	0.02468
205	0.07837	0.02067	179-17	0.02416

206	0.07670	0.02331	167-52	0.02248
207	0.07706	0.02358	9-24	0.02195
208	0.07733	0.02396	18-41	0.02184
209	0.07756	0.02438	22-14	0.02198
210	0.07717	0.02372	44-33	0.02208

Relative Error Ellipses (FeetUS)
Confidence Region = 95%

Stations From	To	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Vertical
101	102	0.00888	0.00872	4-52	0.00868
101	103	0.01542	0.01481	169-25	0.01505
101	104	0.01542	0.01475	175-11	0.01583
101	105	0.01505	0.01447	2-39	0.01603
101	106	0.01480	0.01437	4-36	0.01457
101	107	0.01533	0.01454	10-35	0.01435
101	108	0.01536	0.01439	12-43	0.01349
101	109	0.01547	0.01455	7-43	0.01387
101	110	0.01508	0.01478	161-03	0.01438
101	BLSA	0.00931	0.00894	1-48	0.01163
101	FVPK	0.01692	0.01675	178-58	0.01904
101	LBCH	0.00931	0.00894	1-48	0.02157
101	SACY	0.01813	0.01743	6-58	0.03741
102	103	0.01542	0.01482	169-29	0.01507
102	104	0.01542	0.01475	175-10	0.01585
102	105	0.01504	0.01447	2-39	0.01599
102	106	0.01482	0.01438	4-35	0.01464
102	107	0.01532	0.01454	10-36	0.01432
102	108	0.01535	0.01439	12-43	0.01348
102	109	0.01547	0.01455	7-42	0.01387
102	110	0.01508	0.01477	160-55	0.01436
102	BLSA	0.00931	0.00894	1-48	0.01162
102	FVPK	0.01692	0.01675	179-25	0.01908
102	LBCH	0.00931	0.00894	1-48	0.02161
102	SACY	0.01812	0.01743	7-09	0.03741
103	BLSA	0.01587	0.01507	170-39	0.01693
104	BLSA	0.01589	0.01502	175-10	0.01791
105	110	0.02009	0.01949	174-06	0.02049
105	BLSA	0.01535	0.01463	2-37	0.01791
106	107	0.02013	0.01921	8-44	0.01937
106	201	0.07435	0.01684	161-33	0.01769
106	202	0.07448	0.01778	113-51	0.01739
106	203	0.07526	0.01739	143-49	0.01540
106	BLSA	0.01510	0.01451	4-27	0.01650
107	BLSA	0.01577	0.01474	9-19	0.01630
108	BLSA	0.01572	0.01452	11-09	0.01504
109	BLSA	0.01589	0.01472	6-30	0.01544
110	204	0.07697	0.01706	175-32	0.01852
110	205	0.07683	0.01697	179-28	0.01782
110	206	0.07512	0.01754	167-52	0.01547
110	207	0.07550	0.01768	9-24	0.01468
110	208	0.07579	0.01793	18-39	0.01452
110	209	0.07603	0.01824	22-10	0.01474
110	210	0.07567	0.01771	44-29	0.01487
110	BLSA	0.01550	0.01504	164-53	0.01631

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01 00000000 Top of File
01 00000006 Summary of Files Used and Option Settings
02 00000009 Project Folder and Data Files
02 00000017 Project Option Settings
02 00000039 Instrument Standard Error Settings
03 00000041 Project Default Instrument
01 00000054 Summary of Unadjusted Input Observations
02 00000057 Entered Stations
03 00000060 Fixed Positions
03 00000063 Partially Fixed Positions
03 00000068 Free Positions
02 00000072 Measured Geodetic Angle Observations
02 00000086 Measured Distance Observations
02 00000100 Zenith Observations
02 00000114 GPS Vector Observations
01 00000252 Adjustment Statistical Summary
01 00000274 Adjusted Station Information
02 00000277 Adjusted Coordinates
02 00000305 Adjusted Positions and Ellipsoid Heights
02 00000334 Convergence Angles and Grid Factors at Stations
01 00000366 Coordinate Changes from Entered Provisionals
01 00000376 Adjusted Observations and Residuals
02 00000379 Adjusted Measured Geodetic Angle Observations
02 00000393 Adjusted Measured Distance Observations
02 00000407 Adjusted Zenith Observations
02 00000421 Adjusted GPS Vector Observations
01 00000591 Adjusted Bearings and Horizontal Distances
01 00000688 Error Propagation
02 00000691 Station Coordinate Standard Deviations
02 00000719 Station Coordinate Error Ellipses
02 00000749 Relative Error Ellipses
01 00000799 End of File
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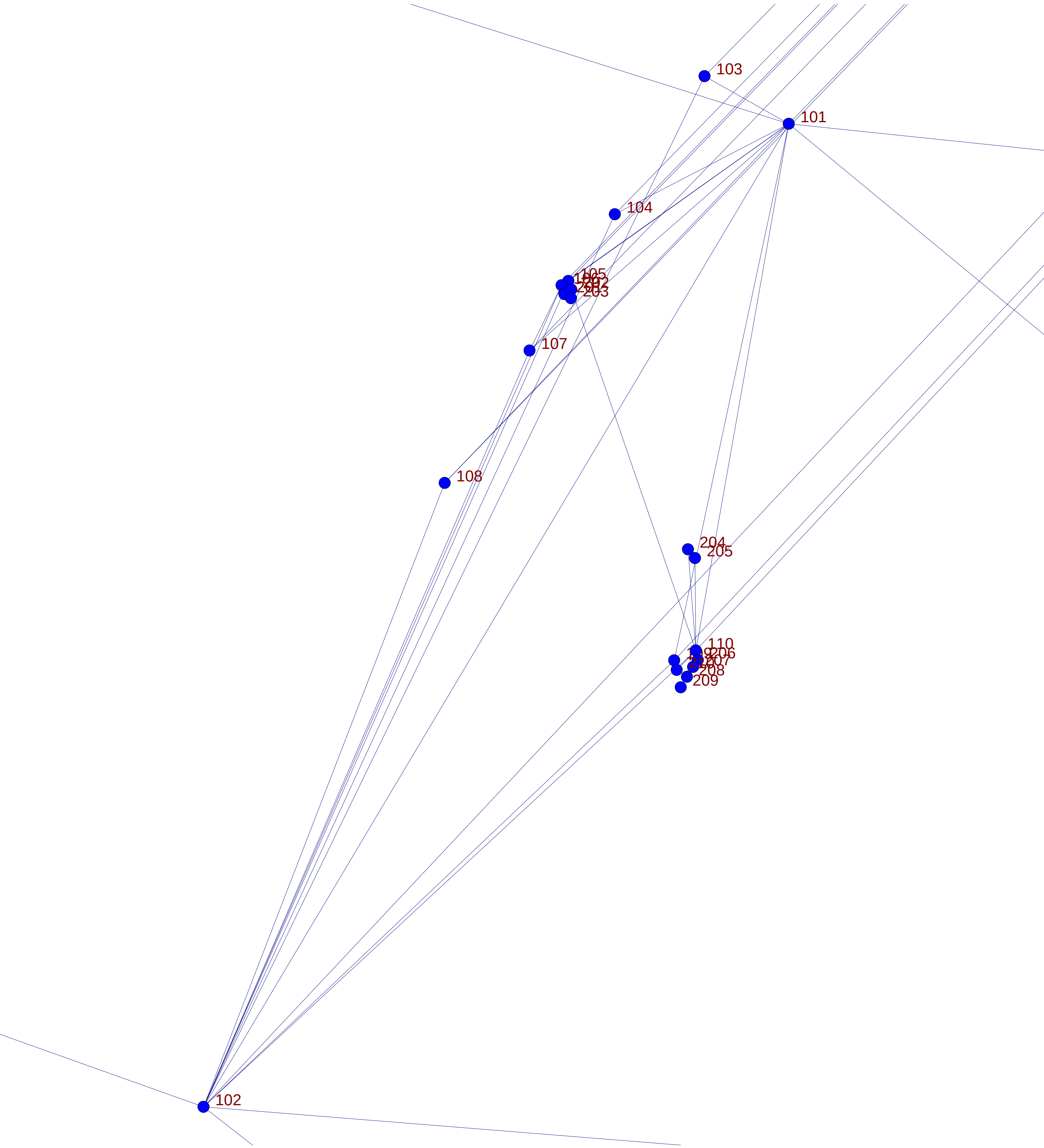
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