Southwest Division
Naval Facilities Engineering Command
Contracts Department
1220 Pacific Highway
San Diego, California 92132-5190

Contract No. N68711-95-D-7526

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY

CLEAN 3

FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A FORMER MARINE CORPS AIR STATION TUSTIN, CALIFORNIA

CTO-0035/0051
August 2003

Prepared by:

BECHTEL ENVIRONMENTAL, INC.
1230 Columbia Street, Suite 400
San Diego, California 92101-8502

REGISTERED GEOLOGIST
JAMES T. CALLIAN
No 6844
STATE OF CALIFORNIA

Signature: James T. Callian
James T. Callian, RG 6844, CTO Leader

Date: Aug 6 2003

RECEIVED

AUG 07 2003

DTSC
CYPRESS

EXECUTIVE SUMMARY

This report presents results of the final feasibility study (FS) for Operable Unit (OU)-1A at Former Marine Corps Air Station (MCAS) Tustin, California. Bechtel Environmental, Inc., prepared this FS Report on behalf of the United States Department of the Navy (DON), Southwest Division Naval Facilities Engineering Command (SWDIV) under the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3 Program, Contract No. N68711-95-D-7526. This FS Report incorporates comments made by the DON, regulatory agencies, the Base Realignment and Closure Cleanup Team, the city of Tustin, and the Restoration Advisory Board on the revised draft OU-1 FS Report (BNI 1999a) and the redline/strikeout version of the draft final OU-1 FS Report (BNI 2000a). In addition, relevant and appropriate comments received during preparation of the final OU-1B FS Report were reviewed to ensure consistency with this FS Report (BNI 2002a).

This FS Report was completed within the context of the DON's Installation Restoration Program (IRP). The DON has elected to implement the IRP by following remedial investigation (RI) and FS protocols prescribed by the United States Environmental Protection Agency (U.S. EPA) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Pertinent U.S. EPA regulations are provided in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The CERCLA RI/FS process is intended to characterize the nature and extent of risk posed by uncontrolled hazardous waste release sites and to evaluate potential remedial options. While this FS Report conforms to the requirements of the NCP and related U.S. EPA technical guidance (e.g., U.S. EPA 1988a), no IRP site at Former MCAS Tustin is on U.S. EPA's National Priorities List.

The draft final RI Report for Marine Corps Air Facility Tustin OU-1 and OU-2, issued in November 1997, recommended that remedial response actions be initiated to address elevated concentrations of volatile organic compounds (VOCs) in groundwater at IRP-13S (BNI 1997a). The principal VOCs of concern were trichloroethene (TCE), 1,2,3-trichloropropane (TCP), and related chlorinated organic solvents. A risk assessment originally performed during the RI concluded that VOC contamination would represent a potential human-health concern if the shallow groundwater underlying IRP-13S were to be used as a source of drinking water. The RI Report concluded that direct human contact with VOC-affected soils at IRP-13S does not pose significant health risks.

Previous documents issued by the Navy CLEAN II program and SWDIV defined OU-1 to encompass stationwide groundwater (BNI 1997b, SWDIV 1998). However, based on findings and recommendations presented in the RI Report, OU-1 was redefined as consisting of VOC-affected groundwater at and downgradient of IRP-3, IRP-12, and IRP-13S. During 2001, OU-1 was separated into OU-1A (IRP-13S) and OU-1B (IRP-3 and IRP-12) to facilitate completion of an FS at OU-1B, and to expedite a time-critical removal action at OU-1A, implemented in coordination with groundwater cleanup at adjacent underground storage tank Site 222. Vadose zone and saturated zone soils at IRP-13S also fall within the scope of this FS to the extent that such materials are continuing sources of groundwater contamination. Figure ES-1 illustrates the approximate extent of soil and groundwater contamination associated with OU-1A.

This FS Report develops and evaluates remedial action alternatives to mitigate risks to human health arising from the potential consumption of VOC-affected groundwater at OU-1A. Results of this evaluation, in conjunction with other site-specific information, will be used by the DON to select an appropriate remedy for OU-1A. A preferred remedial alternative is not identified or recommended in this FS Report. Comments made during public and regulatory agency review of this document will be considered during the remedy selection process. These comments have been addressed in this document and will be incorporated into the Proposed Plan as well as in a Record of Decision.

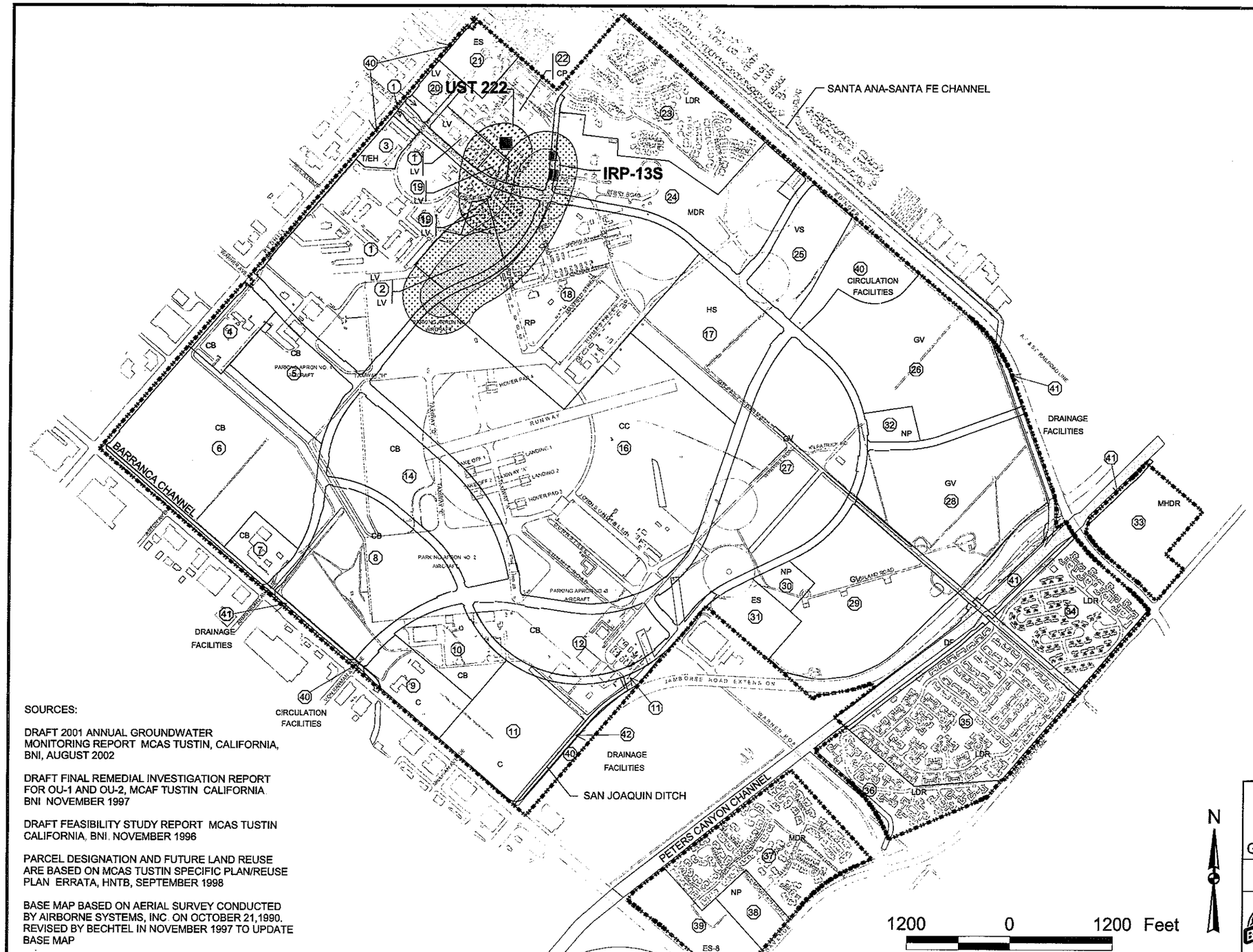
DEVELOPMENT OF THE OU-1 FEASIBILITY STUDY

Eight remedial alternatives were evaluated in the revised draft FS Report for OU-1 including no action, monitored natural attenuation, hydraulic containment, aggressive groundwater extraction with off-site soil disposal, aggressive groundwater extraction with on-site soil disposal, permeable reaction wall, vacuum-enhanced extraction (VEE) with on-site soil disposal, and VEE with off-site soil disposal. The revised draft FS Report addressed community and regulatory agency comments by evaluating VEE groundwater extraction for its potential to decrease remediation time for groundwater. A VEE pilot test was performed at a nearby site IRP-3 to support the FS at that site and assess the effectiveness of implementing this technology at other nearby sites including IRP-13S. The pilot test concluded that VEE would only be marginally more effective than standard groundwater extraction. Community and regulatory agency comments were again received and addressed, and an additional remedial alternative (Alternative 7) with potential to decrease remediation time was considered. Alternative 7, hydraulic containment with hot spot removal, is evaluated in this FS Report and includes a combination of hydraulic containment wells, groundwater extraction at selected hot spots, and excavation of VOC-contaminated hot spot soils.

STATION LOCATION, OPERATING HISTORY, AND FUTURE LAND USE

Former MCAS Tustin is located in central Orange County, California, and encompasses approximately 1,600 acres. Most of Former MCAS Tustin is located within the city of Tustin, with approximately 95 acres lying within the city of Irvine and a portion bordering the city of Santa Ana.

The DON initially established MCAS Tustin in 1942 to support observation blimps conducting antisubmarine patrols off the California coast during World War II. The facility was decommissioned in 1949 and then reactivated in 1951 for the Korean War. Since that time, it has been used exclusively for United States Marine Corps (USMC) helicopter operations. Physical improvements installed over the years to support the mission of MCAS Tustin include more than 200 buildings and structures, a 3,000-foot-long runway, aircraft parking aprons, and numerous aircraft maintenance shops. Site development, including military housing, occupies all but 530 acres of the station. Much of the undeveloped land was leased for commercial agriculture.



LEGEND

- GOVERNMENT PROPERTY LINE
- ROAD OR PAVED AREA
- RAILROAD
- BUILDING OR STRUCTURE
- DRAINAGE DITCH
- FORMER MCAS TUSTIN REUSE PARCEL BOUNDARY
- AREA OF INSTITUTIONAL CONTROLS (INCLUDING GROUNDWATER EXTRACTION)
- EXTENT OF 1,2,3-TCP GROUNDWATER CONTAMINATION FROM IRP-13S
- EXTENT OF MTBE GROUNDWATER CONTAMINATION FROM UST 222
- LOCATION OF KNOWN OR POTENTIAL SOIL CONTAMINATION

NOTE:

1,2,3-TCP AND MTBE PLUMES ARE BASED ON WINTER 2001 GROUNDWATER DATA

SYMBOL	LAND USE
1	PARCEL NUMBER
40	CIRCULATION FACILITIES
41	DRAINAGE FACILITIES
C	COMMERCIAL
CB	COMMERCIAL BUSINESS
CC	COMMUNITY CORE
CP	COMMUNITY PARK
	EASEMENTS/ROADS
ES	ELEMENTARY SCHOOL (K-6)
ES-8	ELEMENTARY SCHOOL (K-8)
GV	GOLF VILLAGE
HS	HIGH SCHOOL
LDR	LOW DENSITY RESIDENTIAL
LV	LEARNING VILLAGE
MDR	MEDIUM DENSITY RESIDENTIAL
MHDR	MEDIUM HIGH DENSITY RESIDENTIAL
NP	NEIGHBORHOOD PARK
RP	URBAN REGIONAL PARK
T/EH	TRANSITIONAL/EMERGENCY HOUSING
VS	VILLAGE SERVICES

SOURCES:

DRAFT 2001 ANNUAL GROUNDWATER MONITORING REPORT MCAS TUSTIN, CALIFORNIA, BNI, AUGUST 2002

DRAFT FINAL REMEDIAL INVESTIGATION REPORT FOR OU-1 AND OU-2, MCAF TUSTIN CALIFORNIA. BNI NOVEMBER 1997

DRAFT FEASIBILITY STUDY REPORT MCAS TUSTIN CALIFORNIA, BNI. NOVEMBER 1996

PARCEL DESIGNATION AND FUTURE LAND REUSE ARE BASED ON MCAS TUSTIN SPECIFIC PLAN/REUSE PLAN ERRATA, HNTB, SEPTEMBER 1998

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21,1990. REVISED BY BECHTEL IN NOVEMBER 1997 TO UPDATE BASE MAP

Feasibility Study Report

Figure ES-1

Approximate Extent of Contaminated Soil and Groundwater Within Scope of OU-1A Feasibility Study

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 7/21/03
File No.: 035L10339
Job No.: 23818-035
Rev No.: D

MCAS Tustin ceased active military operations in July 1999, and the Former MCAS Tustin property is being disposed in accordance with the Base Closure and Realignment Act. The property was determined to be excess to the long-term needs of the USMC, and on 13 May 2002, the DON transferred a majority of MCAS Tustin, including the property surrounding IRP-13S, under various conveyance documents to the city of Tustin. Additional property within the former housing areas at MCAS Tustin was sold through public sale in early 2003. Remaining property at the station that is under the control of the DON includes areas where environmental investigations or cleanup has yet to be conducted. According to the MCAS Tustin Specific Plan, as adopted by the Tustin City Council on 03 February 2003, future land use at the station will include commercial and residential areas, schools and child care facilities, parks, a golf course, and other recreational facilities (Figure ES-1). For the purpose of this FS Report, it was assumed that remedial actions designed to address OU-1A groundwater contamination must be adequate to support residential redevelopment, generally considered the most sensitive reuse option.

GEOLOGY AND HYDROGEOLOGY

Former MCAS Tustin overlies the Irvine Pressure Subbasin, which is the regional aquifer in central Orange County. In the vicinity of the station, the Irvine Pressure Subbasin is defined by extensive water-bearing zones (WBZs) occurring deeper than about 90 feet below ground surface (bgs), the approximate demarcation between the shallow and regional aquifers (BNI 1997a).

The Irvine Pressure Subbasin is currently used as a primary source of municipal drinking water and irrigation water. The quality of the regional aquifer is good, with an average total dissolved solids (TDS) concentration below the secondary maximum contaminant level (MCL) for drinking water established by the California Department of Health Services (DHS). The closest potable water supply well in the regional aquifer is operated by the city of Tustin at a location approximately 1.5 miles north (upgradient) of the station.

Soils shallower than approximately 90 feet bgs at in the vicinity of the site are primarily fine-grained floodplain sediments with interbedded and laterally discontinuous deposits of coarser sands and gravels. Groundwater occurs in these sand and gravel lenses. There does not appear to be a laterally continuous shallow aquifer beneath the site in the sense of a contiguous saturated permeable unit. Nevertheless, the RI data suggest that the discontinuous WBZs encountered within the alluvial materials shallower than approximately 90 feet bgs collectively constitute the uppermost hydrogeologic regime or "shallow aquifer" at the site (BNI 1997a).

For the convenience of discussion and presentation, the RI generalized the shallow saturated strata underlying the installation into three WBZs, a convention that is followed throughout this FS Report. The boundaries between WBZs vary from location to location at Former MCAS Tustin, reflecting the highly irregular distribution of coarse-grained materials. Groundwater is first encountered at depths ranging from approximately 5 to

15 feet bgs. The first, or uppermost, WBZ extends from the water table to the top of the second saturated coarse-grained zone, which occurs at approximately 20 to 50 feet bgs. The second WBZ extends from the top of the second saturated coarse-grained zone to the top of the third coarse-grained zone, which occurs from 50 to 100 feet bgs. The third WBZ extends from the top of the third saturated coarse-grained zone to the top of the regional aquifer, which is characterized by a transmissive sand zone found in most soil borings drilled to approximately 90 feet bgs and below.

Field data show that the first and second WBZs are hydraulically interconnected. The third WBZ appears to be hydraulically separated from the second WBZ across most of the installation. However, there is evidence of localized hydraulic communication between the second WBZ and the third WBZ through a lithologic discontinuity identified downgradient of the IRP-13S source area (BNI 1999c). The third WBZ is also an apparent transition zone between the shallow aquifer and the underlying regional aquifer.

All lithologic, hydraulic, and geochemical evidence to date indicates that the shallow groundwater system at Former MCAS Tustin is separated from the Irvine Pressure Subbasin. Stationwide, an aquitard comprised of a continuous stiff clay layer appears to effectively limit hydraulic communication between the shallow and regional aquifers. This clay layer ranges from 10 feet to 30 feet thick across most of the station (BNI 1997a).

In general, groundwater flows from north to south across the station. The shallow aquifer intercepts the land surface at Peters Canyon Channel, Barranca Channel, and the Santa Ana-Santa Fe Channel (Figure ES-1), with groundwater from the first two WBZs flowing into these drainages. While the OU-1A plumes have not yet reached the drainage system, it is important to note that the channels surrounding the former station act as dewatering trenches that would ultimately control the off-site migration of dissolved VOCs in the subsurface. Groundwater flow in the third WBZ and the Irvine Pressure Subbasin is not influenced by the surface drainage system (BNI 1997a).

Historically, shallow groundwater at Former MCAS Tustin has not been used for beneficial purposes due to its poor quality, low yield, and the availability of alternative high-quality municipal water supplies. This situation is not likely to change with redevelopment of the property. TDS concentrations in the first two WBZs are elevated, generally exceeding the drinking water secondary MCL as well as beneficial use guidelines established by the California Regional Water Quality Control Board, Santa Ana Region (RWQCB) and the California State Water Resources Control Board. Water quality in the shallow aquifer is also degraded as a result of natural processes and agricultural practices unrelated to USMC operations, with sulfate, nitrate, and selenium all exceeding DHS and RWQCB criteria for drinking water supply.

OPERABLE UNIT 1A

OU-1A comprises groundwater contamination at IRP-13S and is located near the northwestern corner of Former MCAS Tustin property. IRP-13S occupies a total area of approximately 0.7 acre and consists of two distinct areas, Temporary Storage Area ST-72

and Miscellaneous Wash Area MWA-18, which are separated by a distance of approximately 100 feet. ST-72, an inactive vehicle maintenance facility, includes the southern half of Building 16, former Building 50, and the surrounding paved area. Prior to 1985, cleaning solvent was reportedly used as a degreaser to wash down floors in Building 16. Spent solvent was likely released to storm drains or the ground. MWA-18 is an inactive washpad formerly used to clean small generators and other field equipment. Solvents used during these activities may have been released to the subsurface through cracks in the concrete pad.

During the RI, soil contamination at ST-72 was found to consist mostly of 1,2,3-TCP and was centered around Building 16. 1,2,3-TCP was reported at a maximum concentration of 160 micrograms per kilogram (µg/kg) in a soil sample collected above the first WBZ. TCE, the predominant soil contaminant at MWA-18, was reported at a maximum concentration of 21,000 µg/kg in vadose zone samples collected directly underneath the former washpad (BNI 1997a).

Groundwater contamination originating at IRP-13S has been identified in all three WBZs of the shallow aquifer. In the first two WBZs, contiguous plumes of contaminated groundwater containing 1,2,3-TCP extend approximately 2,400 feet to the south from the ST-72 source area adjacent to Building 16. During the RI, maximum reported concentrations of 1,2,3-TCP in the first and second WBZs were 340 micrograms per liter (µg/L) and 160 µg/L, respectively (BNI 1997a). 1,2,3-TCP extends over an area of approximately 22.8 acres in the first WBZ and about 21.3 acres in the second WBZ. VOC contamination in the third WBZ is restricted to a localized area about 1,500 feet downgradient of the ST-72 source area. During the RI, 1,2,3-TCP was reported at a maximum concentration of 34 µg/L in the third WBZ.

The second predominant groundwater contaminant at IPR-13S during the RI was TCE. TCE in groundwater originating at MWA-18 was restricted to the first WBZ and overlapped the 1,2,3-TCP plume, extending about 1,200 feet from the IRP-13S source area. During the RI, the maximum TCE concentration reported downgradient of IRP-13S was 310 µg/L (BNI 1997a).

VOC FATE AND TRANSPORT

A conceptual model of VOC distribution and transport at OU-1A was first developed using data collected during the RI. This conceptual model suggested that sources of TCE and 1,2,3-TCP originating at or near the surface originally entered groundwater through the vadose zone in dissolved form. The major VOC releases occurred more than 20 years ago and were apparently related to washing of small generators at MWA-18 and floor cleaning activities at ST-72. VOCs are typically found at very low concentrations in the vadose zone, except for one area of TCE contamination identified in unsaturated soil at MWA-18. Much of the contaminant mass at IRP-13S has been retained below the water table in the upper confining clay layer of the first WBZ.

There is no evidence suggesting the presence of VOCs as dense nonaqueous-phase liquids. Extensive plumes of dissolved VOCs have been identified in the sand layers of the first two WBZs at and downgradient of IRP-13S. Other than in one localized area downgradient of IRP-13S, VOCs have apparently not migrated into the third WBZ (BNI 1997b, 1999c, 2002b). There is no indication that the regional aquifer has been impacted by chlorinated VOCs from OU-1A.

As part of the RI, a modeling study was completed to evaluate the long-term fate and transport of site-related VOCs in vadose zone soils. Results from this analysis indicated that TCE in the vadose zone at MWA-18 may act as continuing source of groundwater contamination. The modeling analysis also indicated that TCE leached from the vadose zone at IRP-13S would be mostly retained in the upper confining clay layer of the first WBZ, and would not measurably impact water quality in the deeper and more transmissive sand layers.

Modeling was also conducted to assess VOC transport in the saturated zone. Existing groundwater contamination in the sand layers of the first and second WBZs at IPR-13S is expected to continue migrating to the south and southwest. Without remedial action, the impacted area at the Former MCAS Tustin property would expand significantly over time. VOC plumes originating at IRP-13S would eventually pass the station boundary and begin impacting Barranca Channel in about 40 years. Maximum TCE and 1,2,3-TCP concentrations of approximately 80 and 13 μg/L, respectively, would reach the drainage channel in about 70 years.

VOC contamination at OU-1A would gradually diminish over time due to natural attenuation processes. However, TCE and 1,2,3-TCP concentrations in shallow groundwater are expected to remain above the site remediation goals (discussed below) for over 100 years without remedial action.

RISK ASSESSMENT SUMMARY

A human-health risk assessment was performed during the FS for OU-1A to evaluate potential risks from exposure to contaminated soil and groundwater from the Source Area. Potential risks were evaluated under both current and future conditions after 30 years from implementing one of the remedial alternatives, hydraulic containment with hot spot removal. For the purposes of this FS, residential receptors were assumed to be living in a house on-site, using contaminated groundwater extracted from the shallow aquifer for household purposes. A separate risk assessment scenario was performed to evaluate potential risks to residential receptors in the Source Area for OU-1A, with institutional controls in place to prevent the domestic use of contaminated groundwater. Additional risk assessment scenarios were performed to evaluate potential risks to residents living in the Polynuclear Aromatic Hydrocarbon Apron Study Area and the Auto Hobby Shop Area, for construction/utility workers implementing reuse plans at OU-1A, and to evaluate risks to residents from groundwater only (as worst-case scenarios) at OU-1A. Results from residential scenarios conducted for the Source Area at

OU-1A are summarized in the following paragraphs, and other exposure scenarios are summarized in this FS Report.

The potential excess lifetime cancer risks for residents in the Source Area with beneficial groundwater use were 4.8×10^{-3} under current conditions and 4.0×10^{-4} in the future 30 years after implementing the hydraulic containment with hot spot removal alternative. Future risk is based on 1,2,3-TCP concentrations of 1 µg/L after remediation. The risk for each remedial alternative can be evaluated and compared on the basis of the time to reach this endpoint. Potential noncancer risks (hazard indexes) were estimated at 7.3 and 3.7 under current and future conditions, respectively. Results obtained under current and future conditions for the Source Area at OU-1A exceed the upper bound of U.S. EPA's generally allowable risk range (10^{-6} to 10^{-4}) and the noncancer threshold value of 1.0. Results from the risk assessment indicate that most of the cancer and noncancer risks are associated with exposure to VOCs, principally 1,2,3-TCP in contaminated shallow groundwater that has been extracted and used for domestic purposes.

An additional risk assessment scenario performed for residents in the Source Area with nonbeneficial groundwater use (i.e., institutional controls preventing extraction and use of contaminated groundwater for domestic purposes) indicates that estimated cancer risks are more than two orders of magnitude lower than with beneficial groundwater use, and fall within U.S. EPA's generally allowable risk range (10^{-6} to 10^{-4}). Noncancer risks are estimated at 1.0, which does not exceed U.S. EPA's threshold for noncancer risk (hazard index). Therefore, institutional controls would be effective in protecting human health and allow for the reuse of existing and newly constructed buildings within the site boundary for OU-1A.

REMEDIAL ACTION OBJECTIVES AND SITE CLEANUP GOALS

The following overall remedial action objectives were developed for OU-1A to focus the FS and define the scope of potential groundwater cleanup activities.

- Reduce the concentrations of VOCs in groundwater to levels consistent with site remediation goals or until the plume has stabilized, and prevent or limit VOC migration beyond current OU-1A plume boundaries.
- Protect human health by preventing extraction of VOC-impacted shallow groundwater for domestic use until site remediation goals are achieved.
- Protect potential ecological receptors in Barranca Channel by preventing the off-station migration of groundwater containing VOCs at concentrations exceeding site remediation goals.
- Implement appropriate remedial actions as necessary to facilitate transfer and reuse of those portions of the Former MCAS Tustin property actually or potentially affected by the OU-1A plumes.

While VOC-affected soils are of concern as continuing sources of groundwater contamination, the risk assessment completed for the RI showed that direct contact with

these materials is not a significant human-health threat even if future land use at the station includes redevelopment as residential areas and/or parks (BNI 1997a). These are the most sensitive uses for the Former MCAS Tustin property projected in the Specific Plan. Therefore, cleanup of contaminated soils to health-based criteria is not a remedial action objective for this FS.

Numerical remediation goals for OU-1A groundwater were developed after an analysis of applicable or relevant and appropriate requirements (ARARs). Table ES-1 lists target concentrations for TCE and 1,2,3-TCP. These groundwater remediation goals support the remedial action objective of restoring the shallow aquifer underlying the site to a potential drinking water supply, to the extent practicable. In general, the values listed in Table ES-1 are federal MCLs promulgated by U.S. EPA or California MCLs established by DHS, whichever is lowest for a given constituent. For 1,2,3-TCP, the remediation goal was based on advisories and guidance issued by U.S. EPA and the state of California, along with other technical information. According to the NCP, such information is to be considered when determining cleanup requirements for constituents that do not have promulgated regulatory standards. U.S. EPA and DHS have not established MCLs for 1,2,3-TCP in drinking water.

IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

General response actions and remedial technologies were identified to address the VOC-contaminated groundwater and soil associated with OU-1A. Following U.S. EPA technical guidance (U.S. EPA 1988a), these technologies were screened on the basis of expected effectiveness, implementability, and relative cost. Only a single technology screening step was conducted, consistent with U.S. EPA policy for VOC-contaminated sites (U.S. EPA 1993a). The objective of this screening step was to select representative process options for each applicable technology and thereby simplify the development of comprehensive remedial alternatives for the site.

DEVELOPMENT AND ANALYSIS OF REMEDIAL ALTERNATIVES

Nine comprehensive remedial alternatives were developed for OU-1A. Each alternative involved a combination of general response actions and incorporated the remedial technologies and process options retained from the screening step. The nine alternatives evaluated in this FS were as follows:

- Alternative 1 – no action
- Alternative 2 – monitored natural attenuation
- Alternative 3 – hydraulic containment
- Alternative 4 – aggressive groundwater extraction with off-site soil disposal
- Alternative 4A – aggressive groundwater extraction with on-site soil treatment
- Alternative 5 – permeable reaction wall

Table ES-1
Proposed Remediation Goals for OU-1A Groundwater
(reported in micrograms per liter)

Constituent	Remediation Goal	Basis
Trichloroethene (TCE)	5	Federal MCL*
1,2,3-Trichloropropane (1,2,3-TCP)	0.5	TBD

Note:
* Federal MCLs: 40 C.F.R. § 141.61

Acronyms/Abbreviations:
C.F.R. – *Code of Federal Regulations*
MCL – maximum contaminant level
OU – operable unit
§ – section
TBD – to be determined

- Alternative 6 – vacuum-enhanced extraction with off-site soil disposal
- Alternative 6A – vacuum-enhanced extraction with on-site soil treatment
- Alternative 7 – hydraulic containment with hot spot removal

Disposal options for treated groundwater will be reevaluated in the remedial design to determine the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, effective groundwater mounding geometries and reinjection inflow rates, substantive regulations, regulatory/public input, and total-maximum-daily-load discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated.

Groundwater modeling studies were conducted to assess the performance of each alternative over a 30-year period. Each alternative was also evaluated in detail against criteria specified in the NCP. Alternatives 4A and 6A are variations of Alternatives 4 and 6, respectively, that were added for this FS to include on-site soil treatment and disposal instead of off-site soil disposal at a landfill. The detailed evaluation of the nine remedial options is summarized in Table ES-2.

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The relative performance of the nine remedial alternatives was evaluated against NCP criteria. This analysis was intended to distinguish the advantages and disadvantages of the alternatives and identify key tradeoffs that must be balanced during remedial selection. Results of the comparative analysis are described for each of the evaluation criteria in the text below and are summarized in Table ES-3.

Short-Term Effectiveness

Considering all the factors listed in the U.S. EPA RI/FS guidance (U.S. EPA 1988a), Alternative 7, hydraulic containment with hot spot removal, would be the most effective option in the short term (Table ES-2). This alternative would involve limited-scale remedial activities unlikely to have adverse short-term impacts to workers or the surrounding community. The combination of institutional and engineering controls comprising Alternative 7 would effectively limit further migration of the OU-1A plumes and reduce potential human exposure to VOC-affected groundwater. Compared to hydraulic containment alone, risks posed by excavation and on-site treatment activities are balanced by a shorter overall remediation period and lower concentrations of VOCs in groundwater. Deed restrictions would be limited to approximately 54.1 acres. Although this option would not achieve complete aquifer restoration for many years, if ever, this disadvantage is balanced by the fact that hydraulic containment satisfies all other remedial action objectives (RAOs) established for OU-1A and can be implemented in less than 1 year with minimal construction-related impacts.

Alternative 3, hydraulic containment, would limit further migration of VOCs in groundwater but would not achieve complete aquifer restoration for many years, if ever. With no soil excavation, Alternative 3 presents fewer risks to workers and the surrounding community than Alternative 7. Deed restrictions would effectively prevent exposure to contaminated groundwater until remediation goals are met.

Alternative 2, monitored natural attenuation, would also present very few risks during field implementation. Deed restrictions and a long-term groundwater monitoring program could be implemented within a year following issuance of the Record of Decision. Human exposure to VOCs in shallow groundwater would be effectively controlled by this alternative. However, Alternative 2 would not prevent further downgradient migration of VOCs in groundwater at OU-1A and would not achieve remediation goals for over 100 years. Consequently, Alternative 2 was considered among the least effective alternatives in the short term primarily because of the length of time required to mitigate the major threats associated with OU-1A.

Alternatives 4 and 4A, aggressive groundwater extraction with off-site soil disposal and on-site soil treatment, respectively, Alternative 5, permeable reaction wall, and Alternatives 6 and 6A, VEE with off-site soil disposal and VEE with on-site soil treatment, respectively, are all rated less effective than Alternative 7 with respect to short-term effectiveness. These alternatives would combine institutional controls, groundwater extraction or *in situ* treatment, and long-term monitoring. The major components of these alternatives could be in place 9 months (Alternatives 4/4A and 6/6A) to 3 years (Alternative 5) after initial mobilization for field construction. Once implemented, these alternatives would prevent or significantly reduce further downgradient migration of the VOC plumes while controlling human exposure to VOCs in shallow groundwater. Assuming that restoration of the shallow aquifer underlying Former MCAS Tustin is technically feasible, the time required to attain site remediation

Table ES-2
Summary of Detailed Analysis[a] of OU-1A Remedial Alternatives

	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternative 4 Aggressive Groundwater Extraction With Off-Site Soil Disposal	Alternative 4A Aggressive Groundwater Extraction With On-Site Soil Treatment	Alternative 5 Permeable Reaction Wall
Major Components	No remedial action	• Groundwater monitoring • Institutional controls • Periodic reviews	• Groundwater extraction (four wells) • GAC treatment of extracted groundwater • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • Off-site disposal of excavated soil • Groundwater extraction (18 wells) • GAC treatment of extracted groundwater • Injection of treated water (18 wells) • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site treatment and backfilling of excavated soil • Groundwater extraction (18 wells) • GAC treatment of extracted groundwater • Injection of treated water (18 wells) • Institutional controls • Performance monitoring, periodic reviews	• *In situ* treatment of groundwater using permeable reaction walls • Institutional controls • Performance monitoring, periodic reviews
Short-Term Effectiveness	No short-term impacts; does not affect existing conditions; VOCs would remain above site remediation goals for over 100 years.	Minimal short-term impacts during well installation and sampling; further reduces potential for human exposure to VOCs in shallow groundwater once deed restrictions have been implemented	Short-term risks from installing wells, building treatment plant, and handling contaminated groundwater readily managed	Short-term risks to workers and community from excavation/ handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/ handling/treatment of contaminated soils; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; minimal impact on community during operational period, other than possible iron replacement at assumed 15-year intervals
Long-Term Effectiveness and Permanence	Does not meet remedial action objectives; residual risks unchanged from baseline conditions; does not prevent migration of 1,2,3-TCP to third WBZ, with possible threat to regional aquifer; allows off-station migration with eventual discharge of contaminants to Barranca Channel.	Does not meet remedial action objectives; residual risks unchanged from baseline conditions; does not prevent migration of 1,2,3-TCP to third WBZ; institutional controls prevent human exposure to VOCs; allows off-station migration with eventual discharge of contaminants to Barranca Channel; long-term success uncertain due to heterogeneity of aquifer	Prevents VOC migration beyond existing plume boundaries, eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction over 30 years; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; monitoring and periodic reviews assure effectiveness; would require long-term operation; long-term success uncertain due to heterogeneity of aquifer.	Prevents VOC migration beyond existing plume boundaries and reduces OU-1A contaminants; eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness	Prevents VOC migration beyond existing plume boundaries and reduces OU-1A contaminants; eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness.	Long-term effectiveness uncertain due to innovative technology; captures most existing VOC contamination, with minimal plume migration beyond existing boundaries; does not address threat to third WBZ and regional aquifer; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; monitoring and periodic reviews assure effectiveness; long-term success uncertain due to heterogeneity of aquifer.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction other than that attributed to natural attenuation processes; maximum VOC concentrations decrease by 55% to 72% over 30 years due to dilution, dispersion, and adsorption; no decrease in VOC mass; continued migration of VOCs increases the volume of contaminated groundwater	No reduction other than that attributed to natural attenuation processes; maximum VOC concentrations decrease by 55% to 72% over 30 years due to dilution, dispersion, and adsorption; no decrease in VOC mass; continued migration of VOCs increases the volume of contaminated groundwater	Controls contaminant mobility through containment; extraction reduces toxicity and volume of contamination; TCE and 1,2,3-TCP mass reduced by more than 40% and 60%, respectively; maximum VOC concentrations reduced by 69% to more than 99% over 30 years; adsorbed VOCs destroyed during GAC regeneration.	Controls contaminant mobility through containment; aggressive extraction reduces toxicity and volume; TCE and 1,2,3-TCP mass reduced by 95% and 74%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils placed in secure landfill; adsorbed VOCs destroyed during GAC regeneration.	Controls contaminant mobility through containment; aggressive extraction reduces toxicity and volume; TCE and 1,2,3-TCP mass reduced by 95% and 74%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils thermally treated and used as backfill; adsorbed VOCs destroyed during GAC regeneration.	Reduces toxicity, mobility, and volume due to contaminant destruction as plume migrates through reactive iron; TCE and 1,2,3-TCP mass reduced by 45% and 60%, respectively; maximum VOC concentrations reduced by 50% to more than 99% over 30 years
Implementability	Does not entail active remediation or any further response actions; readily implementable.	Readily implementable due to limited scope of action; deed restrictions compatible with redevelopment	Uses readily available components with high operational reliability; deed restrictions compatible with redevelopment.	Uses readily available, proven, highly reliable technologies; deed restrictions compatible with redevelopment	Uses readily available, proven, highly reliable technologies; deed restrictions compatible with redevelopment	Limited full-scale applications; ability to install deep (75 feet bgs) iron walls uncertain; deed restrictions could constrain redevelopment on some parcels.

(table continues)

Table ES-2 (continued)

	Alternative 6 Vacuum-Enhanced Extraction With Off-Site Soil Disposal	Alternative 6A Vacuum-Enhanced Extraction With On-Site Soil Treatment	Alternative 7 Hydraulic Containment With Hot Spot Removal
Major Components	• Excavation of source area soils • Off-site disposal of excavated soil • Groundwater extraction by VEE in first WBZ (four wells) and conventional extraction in second WBZ (four wells) • GAC treatment of extracted groundwater and soil gas • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site thermal treatment and backfilling of excavated soil • Groundwater extraction by VEE in first WBZ (four wells) and conventional extraction in second WBZ (four wells) • GAC treatment of extracted groundwater and soil gas • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site thermal treatment and backfilling of treated soil • Groundwater extraction (five wells) • GAC treatment of extracted groundwater • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews
Short-Term Effectiveness	Short-term risks to workers and community from excavation/ handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/ handling/treatment of contaminated soils; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks from installing wells, building treatment plant, and handling contaminated groundwater readily managed with engineering controls and standard health and safety protocols
Long-Term Effectiveness and Permanence	Prevents VOC migration beyond station boundaries and reduces VOCs within OU-1A plume; eliminates future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; VEE wells may draw 1,2,3-TCP upward from lower clay to sand layer of first WBZ; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness; actual VEE performance may not match model predictions based on pilot study results	Prevents VOC migration beyond station boundaries and reduces VOCs within OU-1A plume; eliminates future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; VEE wells may draw 1,2,3-TCP upward from lower clay to sand layer of first WBZ; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness; actual VEE performance may not match model predictions based on pilot study results	Prevents VOC migration beyond existing plume boundaries, eliminating potential off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction over 30 years; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; monitoring and periodic reviews assure effectiveness; would require long-term operation; long-term success uncertain due to heterogeneity of aquifer
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduces contaminant toxicity, mobility, and volume through extraction; TCE and 1,2,3-TCP mass reduced by over 90% and 80%, respectively; maximum concentrations of VOCs reduced by 70% to over 99% during 10 to 15 year operating period; contaminated soils placed in secure landfill; adsorbed VOCs destroyed during GAC regeneration	Reduces contaminant toxicity, mobility, and volume through extraction; TCE and 1,2,3-TCP mass reduced by over 90% and 80%, respectively; maximum concentrations of VOCs reduced by 70% to over 99% during 10 to 15 year operating period; contaminated soils thermally treated and used as backfill and desorbed VOCs incinerated; adsorbed VOCs destroyed during GAC regeneration	Controls contaminant mobility through containment; extraction reduces toxicity and volume of contamination; TCE and 1,2,3-TCP mass reduced by more than 73% and 65%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils thermally treated and used as backfill; adsorbed VOCs destroyed during GAC regeneration
Implementability	Proven and reliable technologies are used; deed restrictions compatible with redevelopment	Proven and reliable technologies are used; deed restrictions compatible with redevelopment	Uses readily available components with high operational reliability; deed restrictions compatible with redevelopment

(table continues)

Table ES-2 (continued)

	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternative 4 Aggressive Groundwater Extraction With Off-Site Soil Disposal	Alternative 4A Aggressive Groundwater Extraction With On-Site Soil Treatment	Alternative 5 Permeable Reaction Wall
Cost[b]	No cost	$0.8 million	$3.8 million	$8.5 million	$7.6 million	$19.0 million
Compliance with ARARs	Not applicable. ARARs are not triggered by the no action alternative	Chemical-Specific Meets site cleanup standards, although attainment will take over 100 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; eventually attains remediation goals within OU-1A plume after many decades Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; should restore beneficial uses within all portions of shallow aquifer in 50 to 60 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, as well as all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; should restore beneficial uses within all portions of shallow aquifer in 50 to 60 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, as well as all other action-specific ARARs	Chemical-Specific Attains site remediation goals, but only after many decades Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs
Overall Protection of Human Health and the Environment	Does not protect HH/E in an overall sense; significant expansion of the OU-1A plume will occur; allows for potential discharges to Barranca Channel; does not actively address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; allows migration of VOCs beyond installation boundaries at significant concentrations; uncontrolled groundwater contamination could negatively affect site redevelopment; lack of long-term monitoring means that future risks, such as 1,2,3-TCP migration to the third WBZ or regional aquifer, would not be identified	Offers a fair degree of protection to HH/E; institutional controls limit future human consumption of VOC-affected groundwater; does not comply with all action-specific ARARs; allows for significant expansion of the OU-1A plume; allows for potential discharges to Barranca Channel; does not actively address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; allows migration of VOCs beyond installation boundaries at significant concentrations; continued migration of VOC-affected groundwater could have a negative affect on site redevelopment; deficiencies mitigated somewhat by long-term monitoring and periodic reviews to track plume migration and provide basis for additional remedial actions, if needed	Protects HH/E; uses proven technology to contain OU-1A plume, prevent off-station migration and discharge into Barranca Channel, and control threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls prevent human exposure to VOCs in shallow groundwater; eventually removes OU-1A contamination; requires long-term operations and enforcement of institutional controls; monitoring and periodic reviews assure protection of HH/E	Removal of source areas at the IRP site and remediation of plume would provide permanent solution to OU-1A contamination and thus high level of protection to HH/E; some short-term risks from handling and transport of large volumes of contaminated soil; contains OU-1A plume; prevents off-station migration and potential discharge to Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility	Removal of source areas at the IRP site and remediation of plume would provide permanent solution to OU-1A contamination and thus high level of protection to HH/E; some short-term risks from handling and treatment of large volumes of contaminated soil; contains OU-1A plume; prevents off-station migration and potential discharge to Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility	Remediation of OU-1A plume using a destructive process would provide a permanent solution and thus protect HH/E; uncertainties regarding deep construction reduce implementability rating; short-term risks due to soil excavation and off-site transport; captures most of OU-1A plume and prevents significant off-station migration; prevents potential discharge to Barranca Channel; does not address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews assure protection of HH/E

(table continues)

Table ES-2 (continued)

	Alternative 6 Vacuum-Enhanced Extraction With Off-Site Soil Disposal	Alternative 6A Vacuum-Enhanced Extraction With On-Site Soil Treatment	Alternative 7 Hydraulic Containment With Hot Spot Removal
Cost[b]	$6.4 million	$5.6 million	$4.3 million
Compliance with ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents off-station VOC migration; should restore beneficial uses to aquifer in about 50 years, except for first WBZ, which will require many additional decades Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly; complies with all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents off-station VOC migration; should restore beneficial uses to aquifer in about 50 years, except for first WBZ, which will require many additional decades Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly; complies with all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; eventually attains remediation goals within OU-1A plume a little after 30 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given limited scale of extraction; complies with all other action-specific ARARs
Overall Protection of Human Health and the Environment	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and transport of large volumes of contaminated soil; contains OU-1A; prevents off-station migration and potential discharge to Barranca Channel; VEE could induce TCE to move upward from lower clay to sand layer of first WBZ; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility (VEE and conventional wells)	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and treatment of large volumes of contaminated soil; contains OU-1A; prevents off-station migration and potential discharge to Barranca Channel; VEE could induce TCE to move upward from lower clay to sand layer of first WBZ; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility (VEE and conventional wells)	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and treatment of large volumes of contaminated soil; uses proven technology to contain OU-1A plume; prevents off-station migration and discharge into Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls prevent human exposure to VOCs in shallow groundwater; eventually removes OU-1A contamination; requires shorter time of operations than Alternative 3; enforcement of institutional controls; and monitoring and periodic reviews assure protection of HH/E

Notes:
[a] NCP criteria of state and community acceptance will be addressed after public review and comment on this document
[b] costs shown are net present values expressed in 2002 dollars; cost estimates are order-of-magnitude (+50% to -30%)

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
bgs – below ground surface
GAC – granular activated carbon
HH/E – human health and the environment
IRP – Installation Restoration Program
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
OU – operable unit
TCE – trichloroethene
TCP – trichloropropane
VEE – vacuum-enhanced extraction
VOC – volatile organic compound
WBZ – water-bearing zone

Table ES-3
Summary of Comparative Analysis of OU-1A Remedial Alternatives

Criterion	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternatives 4/4A Aggressive Groundwater Extraction	Alternative 5 Permeable Reaction Wall	Alternatives 6/6A Vacuum-Enhanced Extraction	Alternative 7 Hydraulic Containment With Hot Spot Removal
Short-term effectiveness	○	◑	◕	◔	◔	◔	●
Long-term effectiveness and permanence	○	○	◑	◕	◔	◑	●
Reduction of toxicity, mobility, or volume through treatment	○	○	◑	◕	◑	◕	◕
Implementability	●	●	◕	◑	○	◑	◕
Cost	●	●	◕	◑	○	◑	◕
Compliance with ARARs	Not applicable	Complies	Complies	Complies	Complies	Complies	Complies
Overall protection of human health and the environment	Not Protective	Not Protective	Protective	Protective	Protective	Protective	Protective

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
OU – operable unit

Relative Performance in Satisfying NCP Criteria

○	◔	◑	◕	●
Low	Low to Moderate	Moderate	Moderate to High	High

goals is estimated to range from 50 to 60 years for Alternatives 4 and 4A, and several decades longer for Alternatives 5, 6, and 6A. In addition, each of these alternatives would involve relatively large-scale soil excavation projects.

Alternative 1, no action, is the least desirable alternative from the standpoint of short-term effectiveness. The VOC plumes would continue to expand in a downgradient direction, further downward migration of 1,2,3-TCP to the third WBZ would still be possible, and VOC concentrations in the first and second WBZs would exceed site remediation goals for more than 100 years. The NCP and CERCLA require consideration of a no action alternative as a basis for comparison with other remedial alternatives developed during the FS. The no action alternative is not considered a viable alternative for OU-1A because it would not be protective of human health and/or the environment.

Long-Term Effectiveness and Permanence

For each alternative, long-term effectiveness and permanence were evaluated using model-based predictions of groundwater quality. The modeling results presented in this FS suggest that several alternatives could achieve site remediation goals given sufficient time. However, it should be noted that the shallow aquifer system underlying Former MCAS Tustin is heterogeneous, with potentially significant quantities of VOCs adsorbed to fine-grained, low-permeability clay layers. These VOCs, especially those adsorbed to the lower confining layer of the first WBZ, cannot easily be remediated and may serve as a continuing source of contamination to the more transmissive sand layers. It is difficult to accurately model the long-term effect that VOCs released from the clay layers could have on groundwater quality in the first and second WBZs. Thus, complete aquifer restoration by groundwater extraction or *in situ* treatment (included in all alternatives excluding Alternatives 1 and 2) may not be technically practicable within a reasonable period of time, despite model predictions indicating otherwise.

With this qualification, Alternative 7 was determined to provide the best overall long-term performance among the remedial options evaluated in this FS (Table ES-3). Alternative 7 would also use proven and reliable technologies to excavate contaminated soils and extract and treat VOC-affected groundwater. Alternative 7 would prevent significant migration of VOCs beyond existing plume boundaries by extracting a significant amount of contaminated groundwater from near-source, relatively elevated concentration portions of the plumes before VOCs would be allowed to migrate to hydraulic containment wells located at the downgradient margins of the plumes. Alternative 7 would also prevent future discharges of contaminated groundwater to Barranca Channel.

Alternatives 4 and 4A were the next best options in terms of long-term effectiveness and permanence as they include the use of proven and reliable technologies to excavate contaminated soils and extract and treat VOC-affected groundwater, prevent significant VOC migration beyond existing plume boundaries, and prevent future discharges of contaminated groundwater to Barranca Channel. Although heterogeneities in the shallow aquifer system may ultimately preclude complete groundwater restoration, Alternatives 4

and 4A would, at the very least, contain the OU-1A plumes through extraction and prevent human exposure to VOCs through institutional controls.

Alternatives 6 and 6A were rated less technically effective over the long-term than Alternatives 4 and 4A. While these options would have many of the same advantages as Alternatives 4 and 4A, a recent field test at IRP-3 suggests that model-based predictions of high groundwater extraction rates for a VEE system may not be realized in practice (BNI 1999a).

Alternative 3, hydraulic containment, was also rated less favorably than Alternatives 4, 4A, and 7 with respect to long-term effectiveness and permanence. The major advantages of Alternative 3 include preventing both human exposure to VOCs in shallow groundwater (through institutional controls) and further migration of contaminated groundwater (through groundwater extraction at the downgradient plume margins). The major disadvantage of Alternative 3 is that it would potentially require continuing operation and maintenance for the groundwater extraction and treatment system for many decades beyond the 30-year period considered in this FS.

The long-term effectiveness and permanence of Alternative 5, permeable reaction wall, were considered to be lower than those of Alternatives 3, 4/4A, and 7. Permeable reaction walls employ innovative technology, and the performance of this option over several decades is uncertain. Alternative 5 would significantly reduce maximum 1,2,3-TCP and TCE concentrations, and therefore risk as well. However, residual contaminant concentrations after 30 years would generally be greater than several other alternatives, primarily because Alternative 5 would rely on natural groundwater flow to transport VOCs to the reactive iron.

Alternative 1, no action, and Alternative 2, monitored natural attenuation, are the least attractive options from the standpoint of long-term effectiveness and permanence. Neither alternative would meet RAOs established for the site. Existing permitting processes in Orange County would potentially prevent human exposure to VOCs in shallow groundwater; deed restrictions under Alternative 2 would provide for enforcement of institutional controls by the DON and California Environmental Protection Agency Department of Toxic Substances Control.

Reduction of Toxicity, Mobility, or Volume Through Treatment

On the basis of computer modeling results, Alternatives 6 and 6A (VEE) would achieve the greatest reductions in contaminant mass, reducing the overall mass of TCE and 1,2,3-TCP by more than 97 and 80 percent, respectively, over the 30-year period considered in this FS. However, the predictions assumed that high groundwater extraction rates can be attained with VEE, and pilot test results showed that VEE rates were only marginally higher than standard pumping. Thus, the contaminant mass reductions actually achievable with Alternatives 6/6A are likely to be equivalent to those of Alternatives 4/4A.

Alternatives 4 and 4A (aggressive groundwater extraction) and Alternative 7 (hydraulic containment with hot spot removal) were rated slightly less effective than Alternatives 6 and 6A in reducing contaminant toxicity, mobility, or volume through treatment over 30 years. Under Alternatives 4 and 4A, residual TCE and 1,2,3-TCP mass would be reduced by 95 and 74 percent, respectively; under Alternative 7, residual TCE and 1,2,3-TCP mass would be reduced by approximately 73 and 65 percent, respectively.

Alternative 3, hydraulic containment, and Alternative 5, permeable reaction wall, were rated similarly with respect to reduction of contaminant toxicity, mobility, or volume through treatment. Both alternatives would reduce the mass of TCE and 1,2,3-TCP by approximately 30 and 60 percent, respectively. Alternative 3 would control VOC mobility through hydraulic containment, whereby the toxicity and volume of contaminated groundwater would gradually be reduced through extraction at the downgradient plume margins. VOCs in the extracted groundwater under Alternative 3 would be adsorbed onto granular activated carbon (GAC) and destroyed when the spent GAC is thermally regenerated at an off-site facility. Alternative 5 would reduce contaminant toxicity, mobility, and volume through *in situ* reductive dehalogenation of VOCs as the VOC plumes pass through the reactive iron walls.

Alternative 1, no action, and Alternative 2, monitored natural attenuation, would result in no reduction in contaminant toxicity, mobility, or volume other than that attributable to natural processes. Maximum VOC concentrations in groundwater would be reduced by 60 to 75 percent over 30 years due to dilution, dispersion, and adsorption. However, there would be no decrease in the mass of TCE or 1,2,3-TCP since VOC biodegradation is assumed to be negligible under the prevailing aerobic conditions of the shallow aquifer. The VOC plumes would continue to migrate into areas currently unaffected by VOCs, increasing the overall volume of contaminated groundwater over time.

Implementability

The best alternatives from an implementability perspective were Alternative 1, no action, and Alternative 2, monitored natural attenuation. The absence of field construction or other remedial activities under Alternative 1 and the limited scope of groundwater monitoring under Alternative 2 make each of these alternatives readily implementable from a technical viewpoint. The lack of regulatory agency and community support for Alternatives 1 and 2 would make each of these options less implementable from an administrative viewpoint; however, execution of the long-term groundwater monitoring program under Alternative 2 should present no unusual concerns administratively.

Alternative 3, hydraulic containment, and Alternative 7, hydraulic containment with hot spot removal, were rated slightly less implementable than Alternatives 1 and 2, as both would employ reliable, widely available technologies and would be implemented using conventional equipment and construction methods. No difficulties are anticipated with regard to reliability or scheduling.

For technical reasons, Alternatives 6 and 6A (VEE), and 4 and 4A were considered less implementable than Alternative 3 or 7. The benefits of using VEE to enhance

groundwater capture in the first WBZ are uncertain based on the results of pilot testing (BNI 1999b). Otherwise, Alternatives 6 and 6A would use proven and reliable technologies and construction methods. The VEE options were also determined to be administratively implementable.

Alternative 5 was the least implementable remedial option considered in this FS Report. Permeable reaction wall technology is considered innovative, and there are very few full-scale applications as large as what would be required at OU-1A. Conditions at the site, specifically the hardness of the shallow groundwater, raise concerns about possible chemical precipitation on the surface of the reactive iron that could adversely affect the long-term reliability of this technology. In addition, the constructability of permeable reaction walls to remediate the second WBZ is uncertain. Further reducing the administrative implementability of Alternative 5 is the fact that only one process vendor markets the technology.

Cost

Table ES-2 presents the net present value cost estimates developed for the nine remedial alternatives. In terms of net present value, the alternatives were grouped into four relatively low-cost options (under $5 million), four moderate-cost options (under $10 million), and one high-cost option (approximately $19 million).

The least expensive among the relatively low-cost options are Alternative 1 (no action), which has no associated costs, and Alternative 2 (monitored natural attenuation), with a net present value of $0.8 million. Alternative 3 (hydraulic containment) and Alternative 7 (hydraulic containment with hot spot removal) are somewhat more expensive, with estimated net present values of $3.8 and $4.3 million, respectively.

Net present values for the moderate-cost options, Alternatives 4 and 4A (aggressive groundwater extraction) and Alternatives 6 and 6A (VEE), are estimated to range from $5.6 to $8.5 million. As noted in Section 5.8.2.5, the estimated net present cost of Alternative 6 could increase by $0.5 million to approximately $6.1 million if additional VEE wells were required to contain the OU-1A plumes and obtain the desired groundwater extraction rates in the first WBZ. A similar increase would also apply to Alternative 6A. Given the accuracy of the cost-estimation procedures used in this FS (-30 percent to +50 percent), the $2.1 million to $2.0 million cost difference between Alternative 4 and Alternative 6, and Alternative 4A and Alternative 6A, is not significant. For purposes of this comparative analysis, the costs of aggressive groundwater extraction and VEE should be considered equivalent.

The most expensive remedial option considered in this FS is Alternative 5 (permeable reaction wall), at an estimated net present cost of $19.0 million. The high capital costs associated with this alternative are primarily due to installation of the reactive iron walls, transportation and off-site disposal of contaminated soils removed during the initial construction, the assumed need to replace the reactive iron after 15 years, and the licensing fee paid to the process vendor.

Compliance With ARARs

Alternative 2 (monitored natural attenuation), Alternative 3 (hydraulic containment), Alternatives 4 and 4A (aggressive groundwater extraction), Alternative 5 (permeable reaction wall), Alternatives 6 and 6A (VEE), and Alternative 7 (hydraulic containment with hot spot removal) would comply with all chemical-, location-, and action-specific ARARs for OU-1A identified in Appendix A.

Alternatives 4 and 4A, 6 and 6A, and 7 are intended to restore groundwater within OU-1A to the site remediation goals established in Section 2.5, to the extent practicable. With one notable exception, Alternatives 4 and 4A and 6 and 6A are expected to achieve the site remediation goals throughout the first and second WBZs within about 50 to 60 years. Alternatives 6 and 6A would require many additional decades to reduce 1,2,3-TCP in the first WBZ to the remediation goal of 0.5 μg/L. Alternative 7 essentially achieves the site remediation goals established for shallow groundwater at OU-1A (5 μg/L TCE) in approximately 15 years, although the modeled 1,2,3-TCP concentrations are predicted to slightly exceed the remediation goal.

Alternative 2 (monitored natural attenuation) would eventually satisfy the chemical-specific ARARs identified for the shallow aquifer system, which are driven by RWQCB's classification of the underlying Irvine Pressure Subbasin (regional aquifer) as a potential source of drinking water supply. However, in the absence of an action remedy, the time to achieve these ARARs for Alternative 2 is expected to be longer than for Alternatives 3 through 7. Monitored natural attenuation does not entail any active measures to prevent downgradient migration of the VOC plumes within the first and second WBZs, nor does it address the potential for further downward migration of 1,2,3-TCP into the third WBZ.

ARARs are not triggered by Alternative 1 (no action).

Overall Protection of Human Health and the Environment

Alternative 3 (hydraulic containment), Alternatives 4 and 4A (aggressive groundwater extraction), Alternatives 6 and 6A (VEE), and Alternative 7 are considered protective of human health and the environment. All six alternatives would satisfy the RAOs established in Section 2 by accomplishing the following:

- preventing human exposure to VOCs in shallow groundwater through institutional controls
- containing the VOC plumes within their existing boundaries
- preventing the off-station migration of contaminated groundwater and eliminating the potential for future VOC discharges to Barranca Channel
- controlling threats to water quality in the third WBZ and deeper regional aquifer by controlling the potential for further downward migration of 1,2,3-TCP from the second to the third WBZ
- substantially reducing TCE and 1,2,3-TCP mass and concentrations over 30 years, thereby reducing potential risk to human health and the environment

- complying with all identified ARARs and eventually achieving site remediation goals throughout the areas currently affected by the VOC plumes
- tracking and verifying the progress of groundwater remediation through a systematic program of long-term monitoring and periodic site reviews
- limiting the area covered by deed restrictions to 54.1 acres; in all cases, the required deed restrictions should be compatible with redevelopment of the Former MCAS Tustin property

In addition to these benefits, Alternatives 4 and 4A, 6 and 6A, and 7 would remove VOC-affected soils from the source areas at OU-1A.

Alternative 5 (permeable reaction wall) would provide many of the same advantages as those listed above for Alternatives 3, 4 and 4A, 6 and 6A, and 7 and is protective of human health and the environment. However, Alternative 5 is rated slightly less protective of overall human health and the environment for three reasons. First, the long-term performance of the technology is uncertain, since the hardness in shallow groundwater at OU-1A would increase the potential for chemical precipitates to foul the reactive iron. Second, the deep iron wall installations required to remediate the plume in the second WBZ may be difficult to construct. Finally, because it is a passive process, Alternative 5 would not actively reverse the potential for further downward migration of 1,2,3-TCP into the third WBZ.

Alternative 2 (monitored natural attenuation) would be slightly more protective than Alternative 1 (no action), but would offer decidedly less protection to human health and the environment than would the other remedial alternatives. Alternative 2 would prevent human exposure to VOCs in shallow groundwater through institutional controls. However, monitored natural attenuation would not prevent plume migration to off-station areas, resulting in the eventual discharge of VOCs to Barranca Channel. Alternative 2 would allow significant expansion of the VOC plumes on the Former MCAS Tustin property as well as the further downward migration of 1,2,3-TCP into the third WBZ. The continued migration of VOC-affected groundwater could have a negative effect on site redevelopment. The deficiencies identified for Alternative 2 would be mitigated somewhat by long-term monitoring and periodic reviews, which would track plume movement and provide a basis for additional remedial actions.

Alternative 1 would not protect human health and the environment as it would not reduce contaminant mass in the subsurface. It has the same deficiencies noted above for Alternative 2 without the benefits of either deed restrictions or long-term monitoring. Although there is no current human exposure to VOCs in shallow groundwater at OU-1A, redevelopment of the property may change this situation over time. No action would not provide the engineering or strengthened institutional controls included with the other alternatives to mitigate future risks. Therefore, overall protection of human health and the environment is considered unacceptable under Alternative 1.

This page left blank intentionally

TABLE OF CONTENTS

Section | Page

ACRONYMS/ABBREVIATIONS xvii

EXECUTIVE SUMMARY ES-1

1 INTRODUCTION

1.1 Purpose and Methodology 1-2

1.2 Report Organization 1-3

1.3 Base Location and Operating History 1-4

1.3.1 Base Location 1-4
1.3.2 Operational History 1-5
1.3.3 Hazardous Waste Generation and Management 1-11
1.3.4 Proposed Future Land Use 1-11

1.4 Physical Setting and Climate 1-12

1.4.1 Topography 1-17
1.4.2 Surface Water Hydrology 1-17
1.4.3 Climate and Meteorology 1-18

1.5 Geology and Hydrogeology 1-18

1.5.1 Regional Geology and Hydrogeology 1-18
1.5.2 Shallow Groundwater System at Former MCAS Tustin 1-27

1.6 Background Information for IRP-13S 1-37

1.6.1 History of Operations and Waste Management at IRP-13S 1-38
1.6.2 Soil and Groundwater Investigations at IRP-13S 1-43
1.6.3 Time-Critical Removal Action at IRP-13S 1-59
1.6.4 Future Land Use at IRP-13S 1-59

1.7 VOC Distribution and Transport 1-60

1.7.1 Subsurface VOC Contamination 1-60
1.7.2 Long-Term VOC Fate and Transport 1-62

1.8 Summary of Baseline Risk Assessment 1-69

1.8.1 Incorporation of 1,2,3-TCP and MTBE Into Baseline Risk Assessment 1-70
1.8.2 Incorporation of AOC Soil Data Into Baseline Risk Assessment 1-71
1.8.3 Groundwater Data 1-71
1.8.4 Source Area Residential Scenarios 1-72

Section

Page

1.8.4.1 Residential Risk Under Current Conditions With Beneficial Use 1-72
1.8.4.2 Residential Risk Under Future Conditions With Beneficial Use 1-72
1.8.4.3 Residential Risk Under Current Conditions With Nonbeneficial Use 1-74
1.8.5 PAH Apron Study and Auto Hobby Shop Areas Residential Scenarios 1-74
1.8.6 Additional Scenarios 1-76
1.8.6.1 Construction/Utility Worker Risks Under Current Conditions OU-Wide 1-76
1.8.6.2 Residential Risk Under Current Conditions With Beneficial and Nonbeneficial Use (Groundwater Only) 1-76
1.8.7 Summary of Baseline Risk Assessment Results 1-77

2 REMEDIAL ACTION OBJECTIVES

2.1 Affected Media and Contaminants of Concern 2-1
2.2 Potential Receptors/Exposure Pathways 2-3
2.3 Applicable or Relevant and Appropriate Requirements 2-5
2.4 ARARs Affecting OU-1A Remediation (Cleanup) Goals 2-7
2.4.1 Water Quality Control Plan for the Santa Ana River Basin 2-8
2.4.2 Federal Drinking Water Standards 2-9
2.4.3 California Drinking Water Standards 2-10
2.4.4 RCRA Groundwater Protection Standards 2-10
2.4.5 Cleanup to Background Levels 2-13
2.5 Remediation Goals for OU-1A Groundwater 2-15
2.5.1 Remediation Approach 2-15
2.5.2 Establishing Remediation Goals and Cleanup Levels 2-16
2.6 Restoration Time Frame 2-18
2.6.1 Current Use and Value of the Aquifer 2-18
2.6.2 Ability to Monitor and Control Contaminant Migration 2-18
2.6.3 Technical Considerations 2-19
2.6.4 Conclusions 2-19
2.7 Area of Attainment 2-20

Table of Contents

Section Page

3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

3.1 General Response Actions 3-1

3.2 Identification of Remedial Technologies 3-3

3.3 Screening of Remedial Technologies 3-4

3.3.1 Screening Criteria 3-5
3.3.2 Groundwater 3-6

3.3.2.1 No Action 3-6
3.3.2.2 Institutional Controls 3-6
3.3.2.3 Monitored Natural Attenuation 3-21
3.3.2.4 Containment 3-21
3.3.2.5 *In Situ* Groundwater Treatment 3-24
3.3.2.6 Groundwater Extraction 3-29
3.3.2.7 *Ex Situ* Groundwater Treatment 3-35
3.3.2.8 Groundwater Discharge (Disposal) 3-37
3.3.2.9 Screening Results for Groundwater 3-38

3.3.3 Soil (Source Material) 3-39

3.3.3.1 No Action 3-40
3.3.3.2 Institutional Controls 3-40
3.3.3.3 Containment 3-40
3.3.3.4 Soil Excavation 3-40
3.3.3.5 *Ex Situ* Soil Treatment 3-41
3.3.3.6 Soil Disposal 3-41
3.3.3.7 *In Situ* Soil Treatment 3-42
3.3.3.8 Screening Results for Soil 3-44

4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

4.1 Remedial Alternatives Development Process 4-1

4.2 Remedial Alternatives for IRP-13S 4-2

4.2.1 No Action 4-2
4.2.2 Monitored Natural Attenuation 4-7
4.2.3 Hydraulic Containment 4-9
4.2.4 Aggressive Groundwater Extraction 4-11
4.2.5 Permeable Reaction Wall 4-15
4.2.6 Vacuum-Enhanced Extraction 4-16
4.2.7 Hydraulic Containment with Hot Spot Removal 4-19

4.3 Alternatives Screening 4-21

Section

Page

5 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

5.1 Evaluation Criteria 5-1

5.1.1 Overall Protection of Human Health and the Environment 5-1
5.1.2 Compliance With ARARs 5-2
5.1.3 Long-Term Effectiveness and Permanence 5-2
5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-11
5.1.5 Short-Term Effectiveness 5-11
5.1.6 Implementability 5-12
5.1.7 Cost 5-12
5.1.8 State Acceptance 5-14
5.1.9 Community Acceptance 5-14

5.2 Alternative 1 – No Action 5-14

5.2.1 Description 5-14
5.2.2 Detailed Analysis 5-16

5.2.2.1 Short-Term Effectiveness 5-16
5.2.2.2 Long-Term Effectiveness and Permanence 5-16
5.2.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-21
5.2.2.4 Implementability 5-22
5.2.2.5 Cost 5-22
5.2.2.6 Compliance With ARARs 5-22
5.2.2.7 Overall Protection of Human Health and the Environment 5-22

5.3 Alternative 2 – Monitored Natural Attenuation 5-23

5.3.1 Description 5-23

5.3.1.1 Institutional Controls 5-24
5.3.1.2 Groundwater Monitoring 5-29
5.3.1.3 Periodic Reviews 5-31

5.3.2 Detailed Analysis 5-31

5.3.2.1 Short-Term Effectiveness 5-32
5.3.2.2 Long-Term Effectiveness and Permanence 5-32
5.3.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-35
5.3.2.4 Implementability 5-35
5.3.2.5 Cost 5-36

Table of Contents

Section Page

5.3.2.6 Compliance With ARARs 5-36
5.3.2.7 Overall Protection of Human Health and the Environment 5-39

5.4 Alternative 3 – Hydraulic Containment 5-41

5.4.1 Description 5-41

5.4.1.1 Groundwater Extraction 5-41
5.4.1.2 Groundwater Conveyance and Treatment 5-42
5.4.1.3 Groundwater Disposal 5-47
5.4.1.4 Performance Monitoring 5-49
5.4.1.5 Institutional Controls 5-51
5.4.1.6 Periodic Reviews 5-53

5.4.2 Detailed Analysis 5-53

5.4.2.1 Short-Term Effectiveness 5-53
5.4.2.2 Long-Term Effectiveness and Permanence 5-54
5.4.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-60
5.4.2.4 Implementability 5-60
5.4.2.5 Cost 5-61
5.4.2.6 Compliance With ARARs 5-61
5.4.2.7 Overall Protection of Human Health and the Environment 5-65

5.5 Alternative 4 – Aggressive Groundwater Extraction With Off-Site Soil Disposal 5-66

5.5.1 Description 5-66

5.5.1.1 Excavation of Source Material 5-66
5.5.1.2 Building Demolition 5-70
5.5.1.3 Backfilling of Excavations 5-70
5.5.1.4 Effects of Backfill With Low Levels of VOCs 5-73
5.5.1.5 Off-Site Disposal of Source Materials 5-75
5.5.1.6 Groundwater Extraction 5-77
5.5.1.7 Groundwater Conveyance and Treatment 5-78
5.5.1.8 Injection of Treated Groundwater 5-81
5.5.1.9 Performance Monitoring 5-83
5.5.1.10 Institutional Controls 5-85
5.5.1.11 Periodic Reviews 5-86

5.5.2 Detailed Analysis 5-87

5.5.2.1 Short-Term Effectiveness 5-87
5.5.2.2 Long-Term Effectiveness and Permanence 5-88

Section | Page

5.5.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-95
5.5.2.4 Implementability 5-96
5.5.2.5 Cost 5-96
5.5.2.6 Compliance With ARARs 5-98
5.5.2.7 Overall Protection of Human Health and the Environment 5-101

5.6 Alternative 4A – Aggressive Groundwater Extraction With On-Site Soil Treatment 5-102

5.6.1 Description 5-103

5.6.1.1 Excavation of Source Material 5-103
5.6.1.2 Treatment of Source Material 5-103
5.6.1.3 Building Demolition 5-105
5.6.1.4 Backfilling of Excavations 5-105
5.6.1.5 Effects of Backfill With Low Levels of VOCs 5-105
5.6.1.6 Disposition of Treated Source Materials 5-105
5.6.1.7 Groundwater Extraction 5-107
5.6.1.8 Groundwater Conveyance and Treatment 5-107
5.6.1.9 Injection of Treated Groundwater 5-107
5.6.1.10 Performance Monitoring 5-107
5.6.1.11 Institutional Controls 5-107
5.6.1.12 Periodic Reviews 5-107

5.6.2 Detailed Analysis 5-108

5.6.2.1 Short-Term Effectiveness 5-108
5.6.2.2 Long-Term Effectiveness and Permanence 5-108
5.6.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-108
5.6.2.4 Implementability 5-109
5.6.2.5 Cost 5-109
5.6.2.6 Compliance With ARARs 5-110
5.6.2.7 Overall Protection of Human Health and the Environment 5-111

5.7 Alternative 5 – Permeable Reaction Wall 5-111

5.7.1 Description 5-111

5.7.1.1 Permeable Reaction Wall System 5-112
5.7.1.2 Performance Monitoring 5-118
5.7.1.3 Institutional Controls 5-120
5.7.1.4 Periodic Reviews 5-121

Table of Contents

Section Page

5.7.2 Detailed Analysis 5-121

5.7.2.1 Short-Term Effectiveness 5-121
5.7.2.2 Long-Term Effectiveness and Permanence 5-122
5.7.2.3 Reduction of Toxicity, Mobility or Volume Through Treatment 5-124
5.7.2.4 Implementability 5-130
5.7.2.5 Cost 5-131
5.7.2.6 Compliance With ARARs 5-133
5.7.2.7 Overall Protection of Human Health and the Environment 5-135

5.8 Alternative 6 – Vacuum-Enhanced Extraction With Off-Site Soil Disposal 5-137

5.8.1 Description 5-137

5.8.1.1 Excavation of Source Material 5-138
5.8.1.2 Building Demolition 5-141
5.8.1.3 Backfilling of Excavations 5-141
5.8.1.4 Effects of Backfill With Low Levels of VOCs 5-141
5.8.1.5 Off-Site Disposal of Source Materials 5-141
5.8.1.6 Groundwater Extraction 5-142
5.8.1.7 Groundwater Conveyance and Treatment 5-143
5.8.1.8 Groundwater Disposal 5-147
5.8.1.9 Performance Monitoring 5-147
5.8.1.10 Institutional Controls 5-150
5.8.1.11 Periodic Reviews 5-151

5.8.2 Detailed Analysis 5-151

5.8.2.1 Short-Term Effectiveness 5-151
5.8.2.2 Long-Term Effectiveness and Permanence 5-153
5.8.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-156
5.8.2.4 Implementability 5-157
5.8.2.5 Cost 5-158
5.8.2.6 Compliance With ARARs 5-158
5.8.2.7 Overall Protection of Human Health and the Environment 5-163

5.9 Alternative 6A – Vacuum-Enhanced Extraction With On-Site Soil Treatment 5-164

5.9.1 Description 5-165

5.9.1.1 Excavation of Source Material 5-165
5.9.1.2 Treatment of Source Material 5-165

Section | Page

5.9.1.3 Building Demolition 5-167
5.9.1.4 Backfilling of Excavations 5-167
5.9.1.5 Effects of Backfill With Low Levels of VOCs 5-167
5.9.1.6 Disposition of Treated Source Materials 5-168
5.9.1.7 Groundwater Extraction 5-168
5.9.1.8 Groundwater Conveyance and Treatment 5-168
5.9.1.9 Groundwater Disposal 5-168
5.9.1.10 Performance Monitoring 5-168
5.9.1.11 Institutional Controls 5-169
5.9.1.12 Periodic Reviews 5-169

5.9.2 Detailed Analysis 5-169

5.9.2.1 Short-Term Effectiveness 5-169
5.9.2.2 Long-Term Effectiveness and Permanence 5-170
5.9.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-170
5.9.2.4 Implementability 5-170
5.9.2.5 Cost 5-170
5.9.2.6 Compliance With ARARs 5-172
5.9.2.7 Overall Protection of Human Health and the Environment 5-173

5.10 Alternative 7 – Hydraulic Containment With Hot Spot Removal 5-173

5.10.1 Description 5-174

5.10.1.1 Soil Hot Spot Excavation 5-174
5.10.1.2 Treatment of Source Material 5-180
5.10.1.3 Building Demolition 5-181
5.10.1.4 Backfilling of Excavations 5-181
5.10.1.5 Effect of Backfill With Low Levels of VOCs 5-181
5.10.1.6 Disposal of Treated Source Materials 5-182
5.10.1.7 Groundwater Extraction 5-182
5.10.1.8 Groundwater Conveyance and Treatment 5-184
5.10.1.9 Groundwater Disposal 5-190
5.10.1.10 Performance Monitoring 5-190
5.10.1.11 Institutional Controls 5-192
5.10.1.12 Periodic Reviews 5-192

5.10.2 Detailed Analysis 5-192

5.10.2.1 Short-Term Effectiveness 5-192
5.10.2.2 Long-Term Effectiveness and Permanence 5-193
5.10.2.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-194

Table of Contents

Section Page

5.10.2.4 Implementability 5-196
5.10.2.5 Cost 5-196
5.10.2.6 Compliance With ARARs 5-198
5.10.2.7 Overall Protection of Human Health and the Environment 5-201

6 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

6.1 Short-Term Effectiveness 6-3
6.2 Long-Term Effectiveness and Permanence 6-5
6.3 Reduction of Toxicity, Mobility, or Volume Through Treatment 6-8
6.4 Implementability 6-11
6.5 Cost 6-12
6.6 Compliance With ARARs 6-14
6.7 Overall Protection of Human Health and the Environment 6-15

7 REFERENCES

APPENDICES
(ON COMPACT DISK INSIDE BACK COVER)

Appendix

A APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B GROUNDWATER MODELING RESULTS

C ZERO-VALENT IRON TREATMENT WALL TECHNOLOGY

D COST DEVELOPMENT SUMMARIES

E SOIL EXCAVATION VOLUME

F HUMAN-HEALTH RISK ASSESSMENT

FIGURES

Figure | Page

ES-1 Approximate Extent of Contaminated Soil and Groundwater Within Scope of OU-1A Feasibility Study ES-3

1-1 Former MCAS Tustin Location Map 1-6

1-2 Existing Site Layout at Former MCAS Tustin 1-7

1-3 Adjacent Land Use Within 2000 Feet of Former MCAS Tustin 1-9

1-4 Current Land Use at Former MCAS Tustin 1-13

1-5 Proposed Future Land Use at Former MCAS Tustin 1-15

1-6 Regional Topography and Location Map 1-19

1-7 MCAS Tustin Topography, Surface Drainage, Wetlands, and Former Agricultural Areas 1-21

1-8 Hydrogeologic Basin Boundary 1-23

1-9 Groundwater Contour Map (Regional Aquifer) November 1999 1-25

1-10 Former MCAS Tustin Conceptual Hydrogeologic Model 1-29

1-11 Cross Section A-A′ 1-31

1-12 Basewide Water-Level Elevations in the First WBZ (Winter 2001) 1-33

1-13 Basewide Water-Level Elevations in the Second WBZ (Winter 2001) 1-35

1-14 Source Area and Contaminated Groundwater Within Scope of OU-1A Feasibility Study 1-39

1-15 IRP-13S: ST-72 and MWA-18 Site Layout 1-41

1-16 Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, ST-72 Source Area 1-47

1-17 Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, MWA-18 Source Area 1-49

1-18 Vertical Extent of 1,2,3-TCP in Groundwater at IRP-13S and UST Site 222 1-51

Table of Contents

Figure		Page
1-19	2001 Groundwater Monitoring Results, IRP-13S and UST Site 222 – First WBZ	1-53
1-20	2001 Groundwater Monitoring Results, IRP-13S and UST Site 222 – Second WBZ	1-55
1-21	2001 Groundwater Monitoring Results, IRP-13S and UST Site 222 – Third WBZ	1-57
1-22	Estimated Current TCE and 1,2,3-TCP Concentrations at IRP-13S	1-65
1-23	Simulated TCE and 1,2,3-TCP Concentrations After 30 Years at IRP-13S	1-67
2-1	TCE Concentration Versus Time for Groundwater Extraction	2-14
3-1	Vertical Barriers for Containment	3-22
3-2	Containment Using Groundwater Extraction Wells	3-24
3-3	Air Sparging for Groundwater Remediation	3-25
3-4	Permeable Reaction Wall for Groundwater Remediation	3-27
3-5	Groundwater Extraction Using French Drains	3-29
3-6	Groundwater Extraction Using Wells	3-30
3-7	Vacuum-Enhanced Extraction Using Wells	3-32
3-8	Soil Vapor Extraction Using Wells	3-34
4-1	Conceptual Model of the Hydraulic Containment Alternative	4-10
4-2	Contaminant Flux From Upper Confining Layer	4-12
4-3	Conceptual Model of the Aggressive Groundwater Extraction Alternative	4-14
4-4	Conceptual Model of Vacuum-Enhanced Extraction Alternative	4-18
4-5	Conceptual Model of Hydraulic Containment With Hot Spot Removal Alternative	4-20
5-1	Alternative 1: No Action – Simulated TCE and 1,2,3-TCP Concentrations in the 1st WBZ at IRP-13S	5-17
5-2	Alternative 1: No Action – Simulated 1,2,3-TCP Concentrations in the 2nd WBZ at IRP-13S	5-19

Figure | Page

5-3 Predicted 1,2,3-TCP Concentrations in First WBZ and Second WBZs at Barranca Channel Under No Action 5-21

5-3A Approximate Extent of Contaminated Soil and Groundwater Within Scope of OU-1A Feasibility Study 5-25

5-4 Predicted Maximum TCE Concentrations Under Monitored Natural Attenuation 5-28

5-5 Predicted Maximum 1,2,3-TCP Concentrations Under Monitored Natural Attenuation 5-28

5-6 Groundwater Monitoring Approach for Monitored Natural Attenuation 5-29

5-7 Alternative 2: Monitored Natural Attenuation – Predicted VOC Migration Pathways Over Time 5-33

5-8 Alternative 3: Hydraulic Containment Site Layout 5-43

5-9 Typical Extraction Well 5-46

5-10 Predicted TCE Concentrations in Hydraulic Containment Wells Under Alternative 3 5-48

5-11 Predicted 1,2,3-TCP Concentrations in Hydraulic Containment Wells Under Alternative 3 5-48

5-12 Alternative 3: Hydraulic Containment – Simulated TCE and 1,2,3-TCP Concentrations in the First WBZ at IRP-13S 5-55

5-13 Alternative 3: Hydraulic Containment – Simulated 1,2,3-TCP Concentrations in the Second WBZ at IRP-13S 5-57

5-14 Predicted Maximum TCE Concentrations Under Hydraulic Containment 5-59

5-15 Predicted Maximum 1,2,3-TCP Concentrations Under Hydraulic Containment 5-59

5-16 Alternative 4/4A: Aggressive Groundwater Extraction Site Layout 5-67

5-17 Extent of TCE and 1,2,3-TCP Soil Contamination and Excavation Areas at IRP-13S 5-71

5-18 Volume of Soil to Be Excavated Under Alternative 4 5-73

5-19 Backfilling of Excavation Following Source Removal 5-74

Table of Contents

Figure Page

5-20 Predicted TCE Concentrations in Aggressive Groundwater Extraction Wells 5-79

5-21 Predicted 1,2,3-TCP Concentrations in IRP-13S Aggressive Groundwater Extraction Wells 5-79

5-22 Typical Injection Well 5-82

5-23 Alternative 4/4A: Aggressive Groundwater Extraction – Simulated TCE and 1,2,3-TCP Concentrations in the First WBZ at IRP-13S 5-89

5-24 Alternative 4/4A: Aggressive Groundwater Extraction – Simulated 1,2,3-TCP Concentrations in the Second WBZ at IRP-13S 5-91

5-25 Predicted Maximum TCE Concentrations Under Aggressive Groundwater Extraction 5-94

5-26 Predicted Maximum 1,2,3-TCP Concentrations Under Aggressive Groundwater Extraction 5-94

5-27 Alternative 5: Permeable Reaction Wall Site Layout 5-113

5-28 Schematic Diagram of Reactive Wall (Gate) Components 5-115

5-29 Predicted TCE Concentrations Entering Reactive Wall 5-117

5-30 Predicted 1,2,3-TCP Concentrations Entering Reactive Wall 5-117

5-31 Alternative 5: Permeable Reaction Wall – Simulated TCE and 1,2,3-TCP Concentrations in the First WBZ at IRP-13S 5-125

5-32 Alternative 5: Permeable Reaction Wall – Simulated 1,2,3-TCP Concentrations in the Second WBZ at IRP-13S 5-127

5-33 Predicted Maximum TCE Concentrations Under Alternative 5 5-129

5-34 Predicted Maximum 1,2,3-TCP Concentrations Under Alternative 5 5-129

5-35 Alternative 6/6A: Vacuum-Enhanced Extraction Site Layout 5-139

5-36 Typical Vacuum-Enhanced Extraction Well 5-144

5-37 Predicted TCE Concentrations in Vacuum-Enhanced Extraction Wells 5-145

5-38 Predicted 1,2,3-TCP Concentrations in Vacuum-Enhanced Extraction Wells 5-145

Figure | Page

5-39 Predicted Maximum TCE Concentrations Under Vacuum-Enhanced Extraction 5-154

5-40 Predicted Maximum 1,2,3-TCP Concentrations Under Vacuum-Enhanced Extraction 5-154

5-41 Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Site Layout 5-175

5-42 Alternative 7: Extent of TCE Soil Contamination > 400 µg/kg and Excavation Areas at IRP-13S 5-177

5-43 Volume of Soil to Be Excavated Under Alternative 7 5-179

5-44 Backfilling of Excavation Following Hot Spot Source Removal 5-181

5-45 Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Simulated TCE and 1,2,3-TCP Concentrations in the First WBZ at IRP-13S 5-185

5-46 Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Simulated 1,2,3-TCP Concentrations in the Second WBZ at IRP-13S 5-187

5-47 Predicted TCE Concentrations in Extraction Wells Under Alternative 7 5-189

5-48 Predicted 1,2,3-TCP Concentrations in Extraction Wells Under Alternative 7 5-189

5-49 Predicted Maximum TCE Concentrations Under Alternative 7 5-195

5-50 Predicted Maximum 1,2,3-TCP Concentrations Under Alternative 7 5-195

6-1 Maximum TCE Concentrations in the First WBZ at IRP-13S 6-6

6-2 Maximum 1,2,3-TCP Concentrations in the First WBZ at IRP-13S 6-6

6-3 Maximum 1,2,3-TCP Concentrations in the Second WBZ at IRP-13S 6-7

6-4 Residual TCE Mass After 30 Years 6-9

6-5 Residual 1,2,3-TCP Mass After 30 Years 6-9

TABLES

Table | Page

ES-1 Proposed Remediation Goals for OU-1A Groundwater ES-11

ES-2 Summary of Detailed Analysis of OU-1A Remedial Alternatives ES-13

ES-3 Summary of Comparative Analysis of OU-1A Remedial Alternatives ES-21

1-1 Total Cancer and Noncancer Risk Estimates for Source Area Residential Scenarios 1-73

1-2 Total Cancer and Noncancer Risk Estimates for Additional Residential Scenarios.... 1-75

1-3 Summary of Lifetime Cancer Risks and Hazard Indexes 1-78

2-1 Chemicals of Concern in Groundwater 2-2

2-2 Estimated Plume Dimensions, Maximum VOC Concentrations, and VOC Mass 2-2

2-3 Federal MCLs and MCLGs for Chemicals of Concern 2-11

2-4 California MCLs for Chemicals of Concern 2-11

2-5 Proposed Remediation Goals for Groundwater 2-16

3-1 Screening of Remedial Technologies and Process Options for Groundwater 3-7

3-2 Screening of Remedial Technologies and Process Options for Soil (Source Material) 3-15

3-3 Summary of Retained Remedial Technologies and Process Options for OU-1A Groundwater 3-39

3-4 Summary of Retained Remedial Technologies and Process Options for OU-1A Soil (Source Material) 3-44

4-1 Summary of Remedial Alternatives for IRP-13S 4-3

5-1 Summary of Detailed Analysis of OU-1A Remedial Alternatives 5-3

5-2 Groundwater Monitoring for Monitored Natural Attenuation 5-31

5-3 Summary of Cost Estimate for Alternative 2 5-37

Table | Page

5-4 Extraction Well Details for Hydraulic Containment 5-45

5-5 Performance Monitoring for Hydraulic Containment 5-50

5-6 Summary of Cost Estimate for Alternative 3 5-62

5-7 Predicted VOC Concentrations in Groundwater From Backfilled Soils 5-76

5-8 Extraction Well Details for Aggressive Groundwater Extraction 5-78

5-9 Performance Monitoring for Aggressive Groundwater Extraction 5-84

5-10 Summary of Cost Estimate for Alternative 4 5-97

5-11 Summary of Cost Estimate for Alternative 4A 5-106

5-12 Performance Monitoring for Permeable Reaction Walls 5-119

5-13 Summary of Cost Estimate for Alternative 5 5-132

5-14 Extraction Well Details for Vacuum-Enhanced Extraction 5-143

5-15 Performance Monitoring for Vacuum-Enhanced Extraction 5-148

5-16 Summary of Cost Estimate for Alternative 6 5-159

5-17 Summary of Cost Estimate for Alternative 6A 5-171

5-18 Extraction Well Details for Hydraulic Containment With Hot Spot Removal 5-183

5-19 Performance Monitoring for Hydraulic Containment With Hot Spot Removal 5-191

5-20 Summary of Cost Estimate for Alternative 7 5-197

6-1 Summary of Comparative Analysis of OU-1A Remedial Alternatives 6-2

6-2 Summary of Cost Estimates for OU-1A Remedial Alternatives 6-13

ACRONYMS/ABBREVIATIONS

ACM	asbestos-containing material
AFCEE	(United States) Air Force Center for Environmental Excellence
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BCT	BRAC Cleanup Team
BEI	Bechtel Environmental, Inc.
bgs	below ground surface
BNI	Bechtel National, Inc.
BRAC	Base Realignment and Closure
Brown and Caldwell	Brown and Caldwell Consulting Engineers
CAA	Clean Air Act
Cal. Civ. Code	*California Civil Code*
Cal. Code Regs.	*California Code of Regulations*
Cal/EPA	California Environmental Protection Agency
Cal. Health & Safety Code	*California Health and Safety Code*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
C.F.R.	*Code of Federal Regulations*
ch.	chapter
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CTO	contract task order
CWA	Clean Water Act
DCE	dichloroethene
DHS	(California) Department of Health Services
div.	division
DNAPL	dense nonaqueous-phase liquid
DOE	(United States) Department of Energy
DON	(United States) Department of the Navy
DOT	(United States) Department of Transportation
DTSC	(California Environmental Protection Agency) Department of Toxic Substances Control
DWR	(California) Department of Water Resources

EIR	environmental impact report
EIS	environmental impact statement
EPC	exposure-point concentration
ETI	EnviroMetal Technologies Incorporated
°F	degrees Fahrenheit
Freon 112	1,1,2,2-tetrachloro-1,2-difluoroethane
Freon 113	1,1,2-trichloro-1,2,2-trifluoroethane
FS	feasibility study
GAC	granular activated carbon
gal	gallon
gpd	gallons per day
gpm	gallons per minute
GSE	ground support equipment
HHRA	human-health risk assessment
in/yr	inches per year
IRP	Installation Restoration Program
IRP-13S	IRP-13 South
JEG	Jacobs Engineering Group Inc.
LDR	land-disposal restriction
LRA	Local Redevelopment Authority
LTA	lighter-than-air
LUCICP	land-use control implementation and certification plan
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
MCAS	Marine Corps Air Station
MCAF	Marine Corps Air Facility
MCL	maximum contaminant level
MCLG	MCL goal
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MPE	multiphase extraction
MSL	mean sea level
MTBE	methyl tert-butyl ether
MWA	miscellaneous wash area

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OCHCA	Orange County Health Care Agency
OHM	OHM Remediation Services Corp.
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
O/W	oil/water
PAH	polynuclear aromatic hydrocarbon
PCAP	Petroleum Corrective Action Program
POTW	publicly owned treatment works
PP	proposed plan
PR	preliminary review
PRG	preliminary remediation goal
PTES	Pacific Treatment Environmental Services
QA	quality assurance
QC	quality control
RAB	Restoration Advisory Board
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
redox	oxidation-reduction
RFA	RCRA facility assessment
RG	registered geologist
RI	remedial investigation
ROD	record of decision
RWQCB	(California) Regional Water Quality Control Board (Santa Ana Region)
§	section
SCAQMD	South Coast Air Quality Management District
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
SP	specific plan
SPSH	six-phase soil heating
SVE	soil vapor extraction
SWDIV	Southwest Division Naval Facilities Engineering Command
SWRCB	(California) State Water Resources Control Board

TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCP	trichloropropane
TCRA	time-critical removal action
TDS	total dissolved solids
TDU	thermal desorption unit
tit.	title
TMDL	total maximum daily load
TPH	total petroleum hydrocarbons
UIC	underground injection control
U.S.C	*United States Code*
U.S. EPA	United States Environmental Protection Agency
USMC	United States Marine Corps
UST	underground storage tank
VC	vinyl chloride
VEE	vacuum-enhanced extraction
VLEACH	Vadose Zone Leaching Model
VOC	volatile organic compound
VSI	visual site inspection
WBZ	water-bearing zone
WQCP	water quality control plan
WQO	water quality objective

Section 1
INTRODUCTION

This report presents results of the feasibility study (FS) for Operable Unit (OU)-1A at Former Marine Corps Air Station (MCAS) Tustin, California. Bechtel Environmental, Inc. (BEI), prepared this FS Report on behalf of the United States Department of the Navy (DON), Southwest Division Naval Facilities Engineering Command (SWDIV), under the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3 Program, Contract No. N68711-95-D-7526. This FS Report incorporates comments made by the DON, regulatory agencies, the Base Realignment and Closure Cleanup Team (BCT), the city of Tustin, and the Restoration Advisory Board (RAB) on the revised draft OU-1 FS Report (BNI 1999a) and the redline/strikeout version of the draft final OU-1 FS Report (BNI 2000a). In addition, relevant and appropriate comments received during preparation of the final OU-1B FS Report were reviewed to ensure consistency with this FS Report (BNI 2002a).

This FS Report was completed within the context of the DON's Installation Restoration Program (IRP). The DON has elected to implement the IRP by following remedial investigation (RI) and FS protocols prescribed by the United States Environmental Protection Agency (U.S. EPA) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Pertinent U.S. EPA regulations are provided in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This FS Report was also prepared in accordance with applicable state laws, particularly the *California Health and Safety Code* (Cal. Health & Safety Code). The CERCLA RI/FS process is intended to characterize the nature and extent of risk posed by uncontrolled hazardous waste release sites and to evaluate potential remedial options. While this FS Report conforms to the requirements of the NCP and related U.S. EPA technical guidance (e.g., U.S. EPA 1988a), no IRP site at Former MCAS Tustin is on U.S. EPA's National Priorities List.

IRP-13 South (IRP-13S) is one of three sites at Former MCAS Tustin that were originally defined as OU-1: IRP-3 (Paint Stripper Disposal Area), IRP-12 (Drum Storage Area No. 2), and IRP-13S (Temporary Storage Area No. 72 [ST-72] and Miscellaneous Wash Area No. 18 [MWA-18]). IRP-13S is being addressed separately as OU-1A to implement a time-critical removal action (TCRA) for 1,2,3-trichloropropane (TCP) in groundwater in coordination with a cleanup action for methyl tert-butyl ether (MTBE) at an adjacent site. IRP-3 and IRP-12 are designated as OU-1B. The following paragraphs present a brief summary of evaluations conducted for IRP-13S prior to this FS Report.

The draft final RI Report for OU-1 and OU-2 at Former MCAS Tustin recommended that a remedial response action be initiated to address groundwater contamination at IRP-13S. Elevated concentrations of volatile organic compounds (VOCs) including 1,2,3-TCP, trichloroethene (TCE), and related chlorinated organic solvents were identified in groundwater plumes originating at the site (BNI 1997a). A risk assessment originally performed during the RI concluded that this VOC contamination would present a potential human-health concern if the shallow groundwater underlying IRP-13S were to be used as a source of drinking water. The RI Report concluded that direct human contact with VOC-affected soils at IRP-13S does not pose significant health risks.

The final RI Report recommended that an FS be prepared to develop and evaluate remedial alternatives for groundwater contamination associated with IRP-13S (BNI 1997a). VOCs, principally chlorinated organic solvents and related breakdown products, were reported at concentrations that could result in adverse effects on human health if shallow groundwater at IRP-13S were to be used as a drinking water source. Although the draft final RI Report recommended no further action for soil, the final RI Report recommended that vadose zone soil at IRP-13S be remediated because it may be a continuing source of groundwater contamination. IRP-13S was included in the revised draft FS Report for OU-1 (BNI 1999a).

Eight remedial alternatives were evaluated in the revised draft FS Report for OU-1 including no action, monitored natural attenuation, hydraulic containment, aggressive groundwater extraction with off-site soil disposal, aggressive groundwater extraction with on-site soil disposal, permeable reaction wall, vacuum-enhanced extraction (VEE) with on-site soil disposal, and VEE with off-site soil disposal. The revised draft FS Report addressed community and regulatory agency comments by evaluating VEE groundwater extraction for its potential to decrease groundwater remediation time. A VEE pilot test was performed at a nearby site, IRP-3, to support the FS at that site and assess the effectiveness of implementing this technology at Former MCAS Tustin. The pilot test concluded that VEE would only be marginally more effective than standard groundwater extraction (BNI 1999b). Community and regulatory agency comments were again received and addressed, and an additional remedial alternative, with potential to decrease remediation time, was considered. Alternative 7, hydraulic containment with hot spot removal, includes a combination of hydraulic containment wells, groundwater extraction at selected hot spots, and excavation of VOC-contaminated hot spots. This alternative is evaluated in this FS Report.

1.1 PURPOSE AND METHODOLOGY

The purpose of this FS Report is to develop and evaluate remedial action alternatives to mitigate risks to human health associated with exposure to VOC-contaminated groundwater originating at IRP-13S. The results of this evaluation, in conjunction with other site-specific information, will be used by the DON to select an appropriate remedy for OU-1A groundwater. Nine remedial alternatives considered in this FS include monitored natural attenuation (Alternative 2), hydraulic containment (Alternative 3), aggressive groundwater extraction with off-site soil disposal/on-site soil treatment (Alternatives 4 and 4A), permeable reaction wall (Alternative 5), VEE with off-site soil disposal/on-site soil treatment (Alternatives 6 and 6A), and hydraulic containment with hot spot removal (Alternative 7). A no action alternative (Alternative 1) is also evaluated, as required by the NCP, although it is not considered a remedial action.

The FS methodology is summarized below and further detailed in subsequent sections of this report. It includes the following steps (U.S. EPA 1988a).

1. Establish remedial action objectives (RAOs).
2. Identify applicable or relevant and appropriate requirements (ARARs).

3. Establish response objectives for all environmental media of concern (e.g., soil, groundwater, surface water, and air), considering contaminant exposure pathways, receptors, and appropriate cleanup levels.
4. Identify general response actions, including no action, to meet RAOs for each medium of concern.
5. Identify volumes or areas of environmental media for which remedial response actions may be needed.
6. Identify remedial technologies and representative process options under each general response action, based on technical considerations.
7. Screen remedial technologies and process options based on effectiveness, implementability, and cost.
8. Assemble the retained technologies and process options into remedial alternatives representing a range of treatment and containment combinations.
9. Evaluate remedial alternatives in detail against the following nine criteria, which are specified in the NCP:
   a. overall protection of human health and the environment
   b. compliance with ARARs
   c. long-term effectiveness and permanence
   d. reduction of toxicity, mobility, or volume through treatment
   e. short-term effectiveness
   f. implementability
   g. cost
   h. state acceptance
   i. community acceptance
10. Perform a comparative evaluation of remedial alternatives.

This FS Report does not identify or recommend a preferred remedial alternative for OU-1A. A preferred remedial alternative will be identified and published for public comment in the Proposed Plan (PP), as required by CERCLA and the NCP. Public comments on the RI and FS Reports, as well as on the PP, will be addressed in the Record of Decision (ROD) for OU-1A. It should be noted that the remedial action alternatives developed in this FS are conceptual in nature. The actual details for implementation of the selected remedial alternative will be developed in the remedial design phase of this project.

1.2 REPORT ORGANIZATION

This FS Report is divided into an executive summary, seven main sections, and six appendices as follows.

- Section 1 provides an overview of the CERCLA FS process and summarizes significant findings from the RI completed for IRP-13S (BNI 1997a,b).

- Section 2 outlines RAOs and chemical-specific ARARs for OU-1A.
- Section 3 identifies and screens various remedial technologies and process options for source area soils and contaminated groundwater at OU-1A.
- Section 4 presents the development of nine remedial alternatives that address groundwater contamination associated with OU-1A.
- Section 5 provides a detailed description of each of the nine remedial alternatives developed in the previous section and analyzes these alternatives using criteria provided in the NCP.
- Section 6 compares the nine remedial alternatives to each other relative to the criteria listed in the NCP.
- Section 7 lists the references used throughout this FS Report.
- Appendix A documents ARARs for OU-1A.
- Appendix B presents the results of groundwater modeling studies used to evaluate various remedial alternatives.
- Appendix C provides background information on permeable reaction walls that use zero-valent iron to reductively dehalogenate chlorinated VOCs. This appendix also summarizes the results of a bench-scale treatability test of this technology using samples of VOC-affected groundwater from Former MCAS Tustin.
- Appendix D describes the development of cost estimates for remedial alternatives considered in this FS Report and provides detailed costs for each alternative analyzed in Section 5.
- Appendix E estimates the volume of source area soil that will be excavated at IRP-13S under certain remedial options.
- Appendix F addresses the risks to human health associated with potential inhalation exposure to VOCs that may be emitted from soil and shallow groundwater *in situ* into enclosed spaces (i.e., homes) and from free-standing shallow groundwater during potential construction activities (e.g., installation of underground utilities). Appendix F also addresses Resource Conservation and Recovery Act (RCRA) areas of concern (AOCs) and two other IRP sites (IRP-9A and IRP-9B) located within the OU-1A boundary.

1.3 BASE LOCATION AND OPERATING HISTORY

The following subsections of this report provide general information regarding the location and operational history of Former MCAS Tustin, including hazardous waste generation, past waste disposal practices, and proposed future land use. Specific details regarding IRP-13S are presented in Section 1.6.

1.3.1 Base Location

Former MCAS Tustin encompasses about 1,600 acres within central Orange County, California (Figure 1-1). The station is located approximately 40 miles south of downtown Los Angeles and 95 miles north of the United States/Mexico border. Most of

the former station is located within the city of Tustin, with approximately 95 acres lying within the city of Irvine and a portion bordering the city of Santa Ana.

As shown on Figure 1-2, Former MCAS Tustin is bounded by Red Hill Avenue on the west, Barranca Parkway on the south, Edinger Avenue and a railroad right-of-way on the north, and Harvard Avenue on the east. Over the last several decades, the area surrounding the station has been transformed from primarily agricultural land to a fully developed urban community consisting of residences, public institutions, light manufacturing facilities, and business and commercial establishments. Figure 1-3 illustrates current land use on adjoining properties as of late 1995.

1.3.2 Operational History

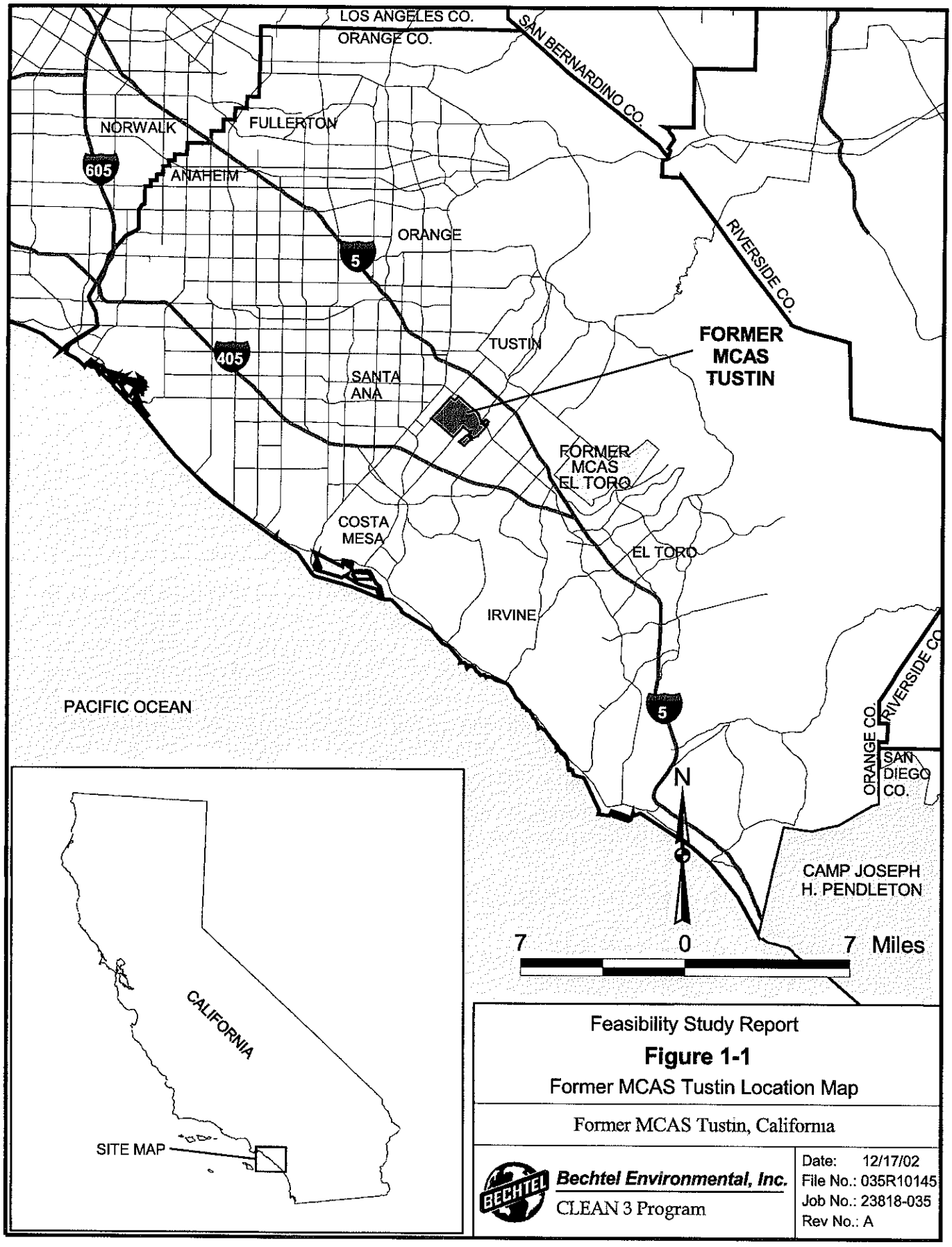
Former MCAS Tustin was initially established by the DON as a lighter-than-air (LTA) base to support observation blimps and personnel conducting antisubmarine patrols off the California coast during World War II. The facility was commissioned in late 1942 upon completion of two timber-framed blimp hangars, buildings that still exist and are currently listed on the National Register of Historic Places. The site served as an LTA base until 1949, at which time it was decommissioned as an active military installation.

In 1951, the facility was reactivated for the Korean War and used exclusively to support helicopter operations. It was officially designated as the Santa Ana Marine Corps Air Facility (MCAF). The name of the station was changed several times over the ensuing years. In 1978, the base was renamed Marine Corps Air Station (MCAS) Tustin to reflect its annexation by the city of Tustin, redesignated as MCAS Tustin in 1986 and as MCAF Tustin in October 1997. Beginning in 2000, the station was again referred to as MCAS Tustin.

During its operational life, MCAS Tustin served as a major center for United States Marine Corps (USMC) helicopter aviation on the Pacific Coast. The station was specifically tasked to provide operational training facilities for the USMC as well as the following:

- operation of helicopter-confined area landing sites in and around the Santa Ana Mountains
- operational, logistic, and administrative support as required
- operation of an air traffic control facility covering assigned air space
- shore facilities and services for assigned activities

Approximately 4,000 active duty military and civilian personnel were assigned to MCAS Tustin to operate and maintain 12 helicopter squadrons, totaling 170 rotary-wing aircraft. All military units were transferred from MCAS Tustin to other USMC installations effective November 1998. MCAS Tustin ceased active military operations in July 1999 and closed in accordance with the Base Closure and Realignment Act.



Feasibility Study Report

Figure 1-1

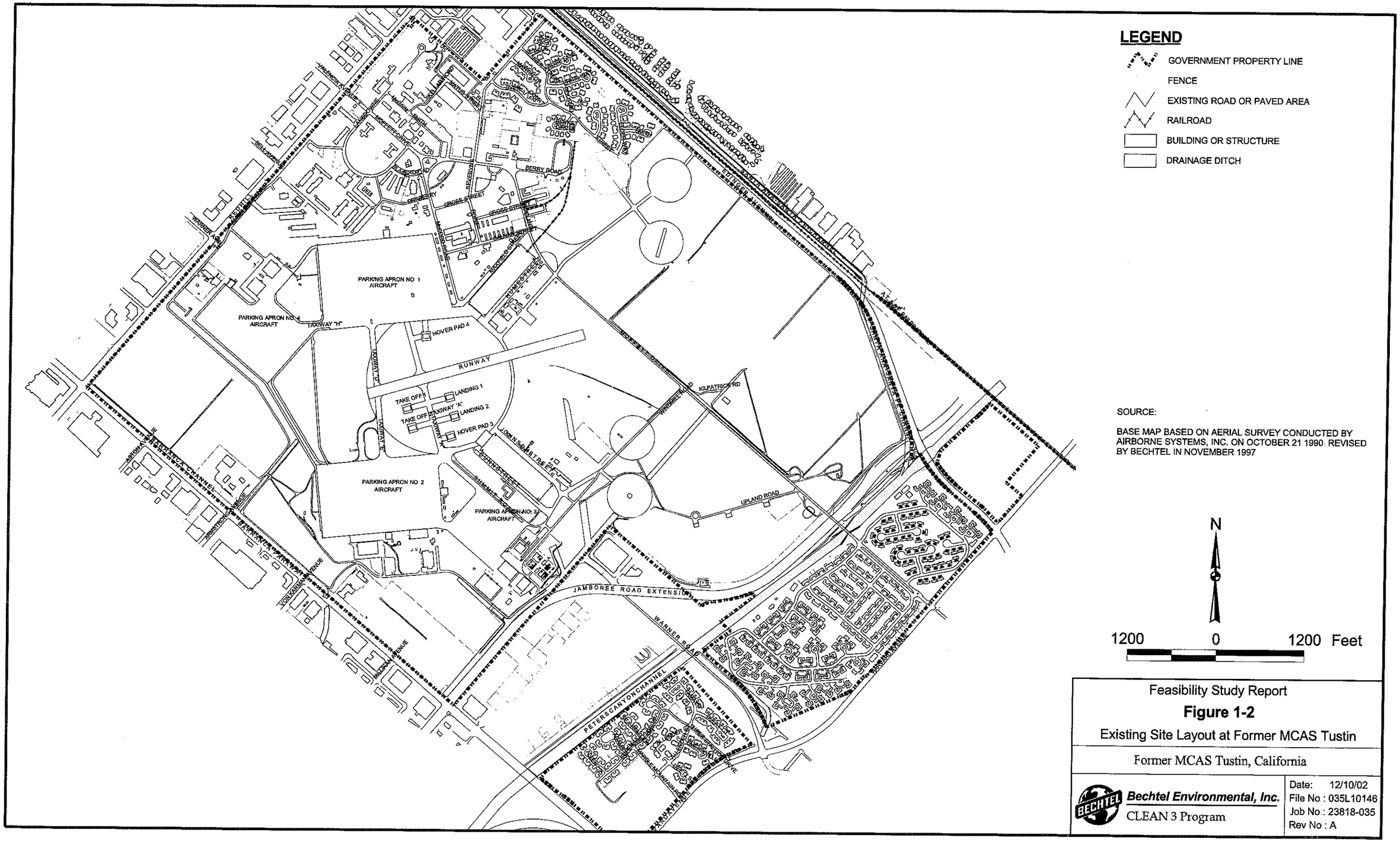
Former MCAS Tustin Location Map

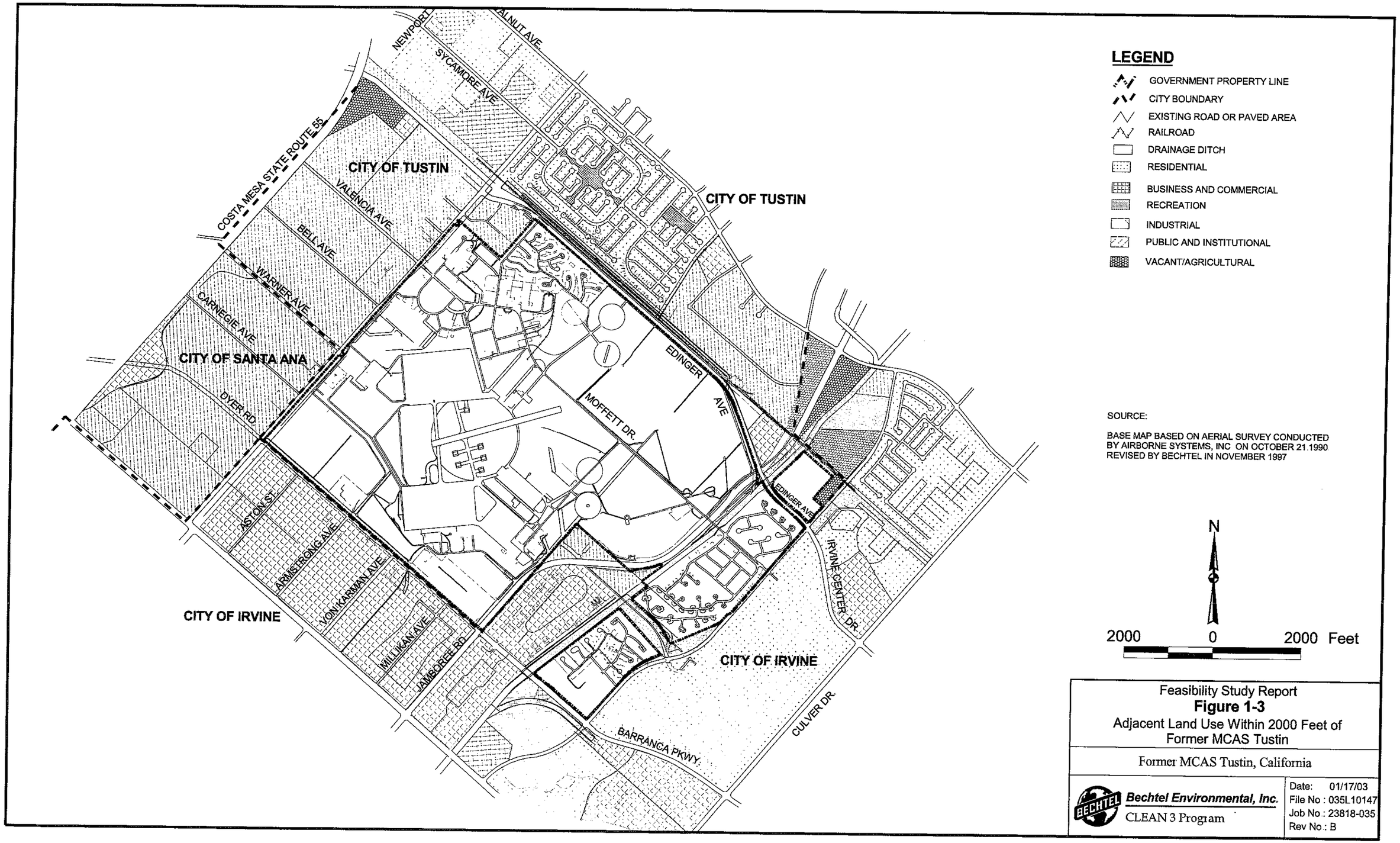
Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 12/17/02
File No.: 035R10145
Job No.: 23818-035
Rev No.: A


LEGEND
GOVERNMENT PROPERTY LINE
FENCE
EXISTING ROAD OR PAVED AREA
RAILROAD
BUILDING OR STRUCTURE
DRAINAGE DITCH
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21 1990. REVISED BY BECHTEL IN NOVEMBER 1997
N
1200 0 1200 Feet
PARKING APRON NO 1 AIRCRAFT
PARKING APRON NO 4 AIRCRAFT
TAXIWAY "H"
HOVER PAD 4
RUNWAY
TAKE OFF 1
LANDING 1
TAKE OFF 2
TAXIWAY "A"
LANDING 2
HOVER PAD 3
PARKING APRON NO 2 AIRCRAFT
PARKING APRON NO 3 AIRCRAFT
KILPATRICK RD
UPLAND ROAD
JAMBOREE ROAD EXTENSION
WARNER ROAD
PETERS CANYON CHANNEL
BERRY ROAD
CROSS STREET
HOOPER ROAD
HUNTER STREET
BURNS STREET
LOGAN STREET
SEVERANCE
MACARTHUR BOULEVARD
JAMBOREE ROAD
VON KARMAN AVENUE
JEFFREY ROAD
SANTA ANA FREEWAY
SOUTHERN PACIFIC RAILROAD
ATCHISON TOPEKA AND SANTA FE RAILROAD
SANTA ANA CHANNEL
JOHNSTON AVENUE
BARRANCA PARKWAY
VOLUNTEER AVENUE
HALEDON AVENUE
MAINTAINER AVENUE
Feasibility Study Report
Figure 1-2
Existing Site Layout at Former MCAS Tustin
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/10/02
File No : 035L10146
Job No : 23818-035
Rev No : A



Feasibility Study Report
Figure 1-3
Adjacent Land Use Within 2000 Feet of Former MCAS Tustin

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/17/03
File No : 035L10147
Job No : 23818-035
Rev No : B

Physical improvements installed over the years to support the mission of MCAS Tustin include more than 200 buildings and structures, a 3,000-foot-long runway, aircraft parking aprons, and numerous aircraft maintenance shops. Site development, including military housing, occupies all but 530 acres of the 1,600-acre facility. Much of the undeveloped land was previously leased for agriculture, producing crops for market that typically included strawberries, corn, beans, cabbage, celery, melons, and squash. Agricultural production ended in 2000. Current land use at Former MCAS Tustin is illustrated on Figure 1-4.

1.3.3 Hazardous Waste Generation and Management

In addition to nonhazardous household and office trash, Former MCAS Tustin generated hazardous waste in the course of routine maintenance of helicopters, ground support equipment, and vehicle engines. Spent materials included waste solvents from parts cleaning and degreasing, jet fuel and hydraulic fluid samples, and waste rags contaminated with oils and solvents. Absorbents were used to contain and clean up small spills of oil, hydraulic fluid, jet fuel, and solvents, with the spent absorbents swept up and managed as hazardous waste. Other waste-generating operations included paint removal, draining of antifreeze from engines, use of paint thinner, use of aerosol paint cans, and cleaning of metallic fuel filters in jet fuel.

Beginning in the mid-1980s, MCAS Tustin segregated these types of spent materials for disposal in permitted hazardous waste management facilities. However, some hazardous waste liquids were disposed of directly to the ground prior to the time stringent waste management procedures were implemented by the USMC. Unintended releases to the subsurface may also have occurred from aboveground oil/water (O/W) separator tanks, hazardous materials storage areas, or equipment wash-down areas. Section 1.6 describes past management of hazardous waste and hazardous materials at IRP-13S in more detail.

1.3.4 Proposed Future Land Use

The Former MCAS Tustin property was determined to be excess to the long-term needs of the USMC. It was therefore decided to transfer the property to other federal agencies and/or nonfederal interests for redevelopment and reuse.

In November 1993, the DON organized the BCT to manage and coordinate facilitywide cleanup and closure activities for the purpose of expediting land transfer at Former MCAS Tustin. California Environmental Protection Agency Department of Toxic Substances Control (DTSC) is the lead regulatory agency overseeing environmental restoration at the station. U.S. EPA and the California Regional Water Quality Control Board (RWQCB) Santa Ana Region are also participating members of the BCT.

The city of Tustin has been recognized by the United States Department of Defense as the Local Redevelopment Authority (LRA) responsible for reuse planning at Former MCAS Tustin. In September 1998, the LRA prepared a Specific Plan (SP) errata updating the 1996 SP, which designates the preferred reuse and transfer mechanism for each parcel at

the station (The Planning Center 1996, 1998). The SP was approved by the United States Department of Housing and Urban Development on 24 March 1998.

The LRA and the USMC prepared a joint federal Environmental Impact Statement (EIS) and state Environmental Impact Report (EIR) to address potential environmental issues associated with the planned reuse of Former MCAS Tustin. The EIS/EIR was developed in accordance with the National Environmental Policy Act and the California Environmental Quality Act. The final EIS/EIR was issued in December 1999 (DON 1999).

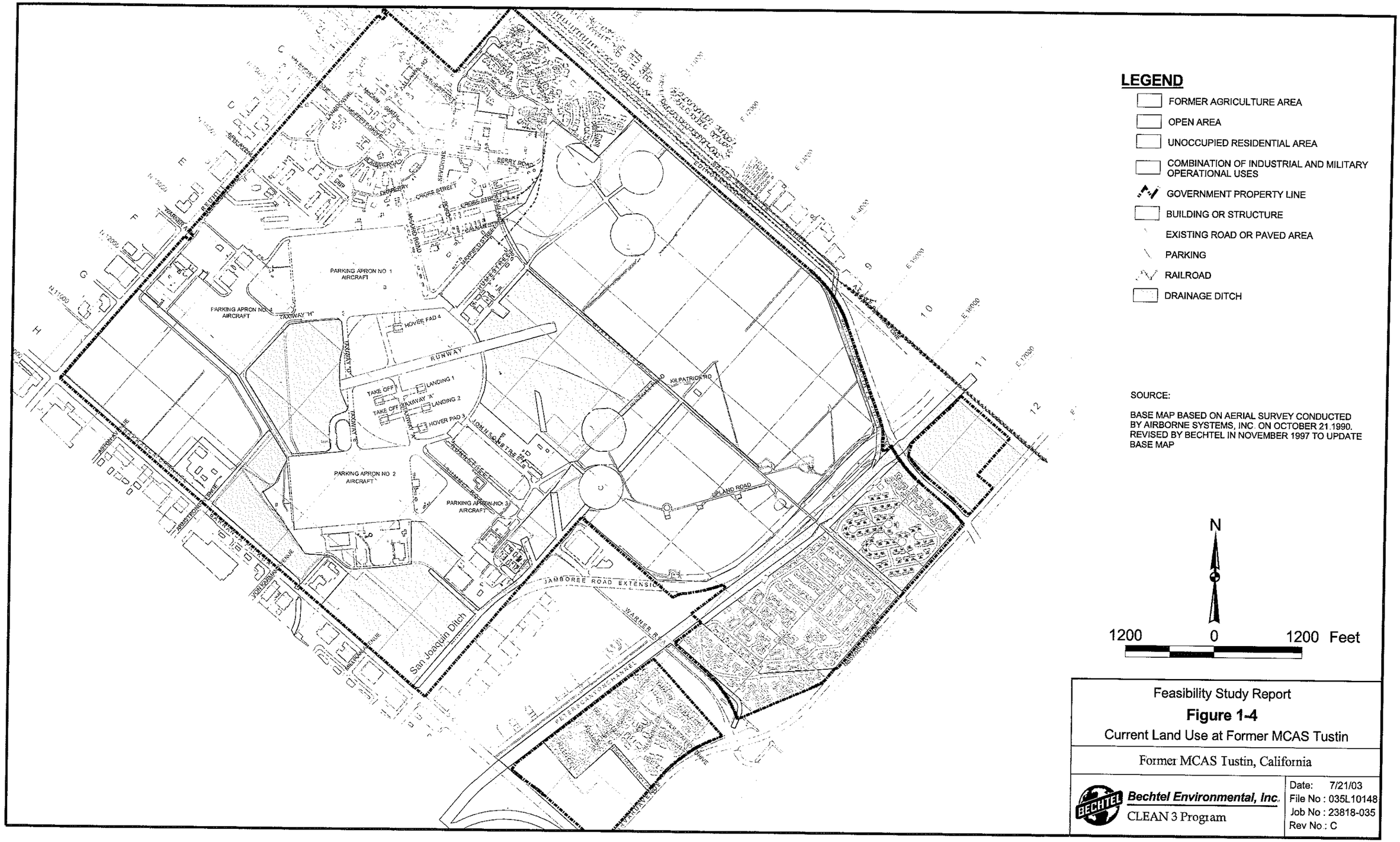
On 13 May 2002, the DON transferred the majority of Former MCAS Tustin property, including the property surrounding IRP-13S, under various conveyance documents to the city of Tustin. Additional property within the former housing areas at MCAS Tustin was sold through public sale in early 2003. Remaining property at the station that is under the control of the DON includes areas where environmental investigations are ongoing or cleanup has yet to be initiated.

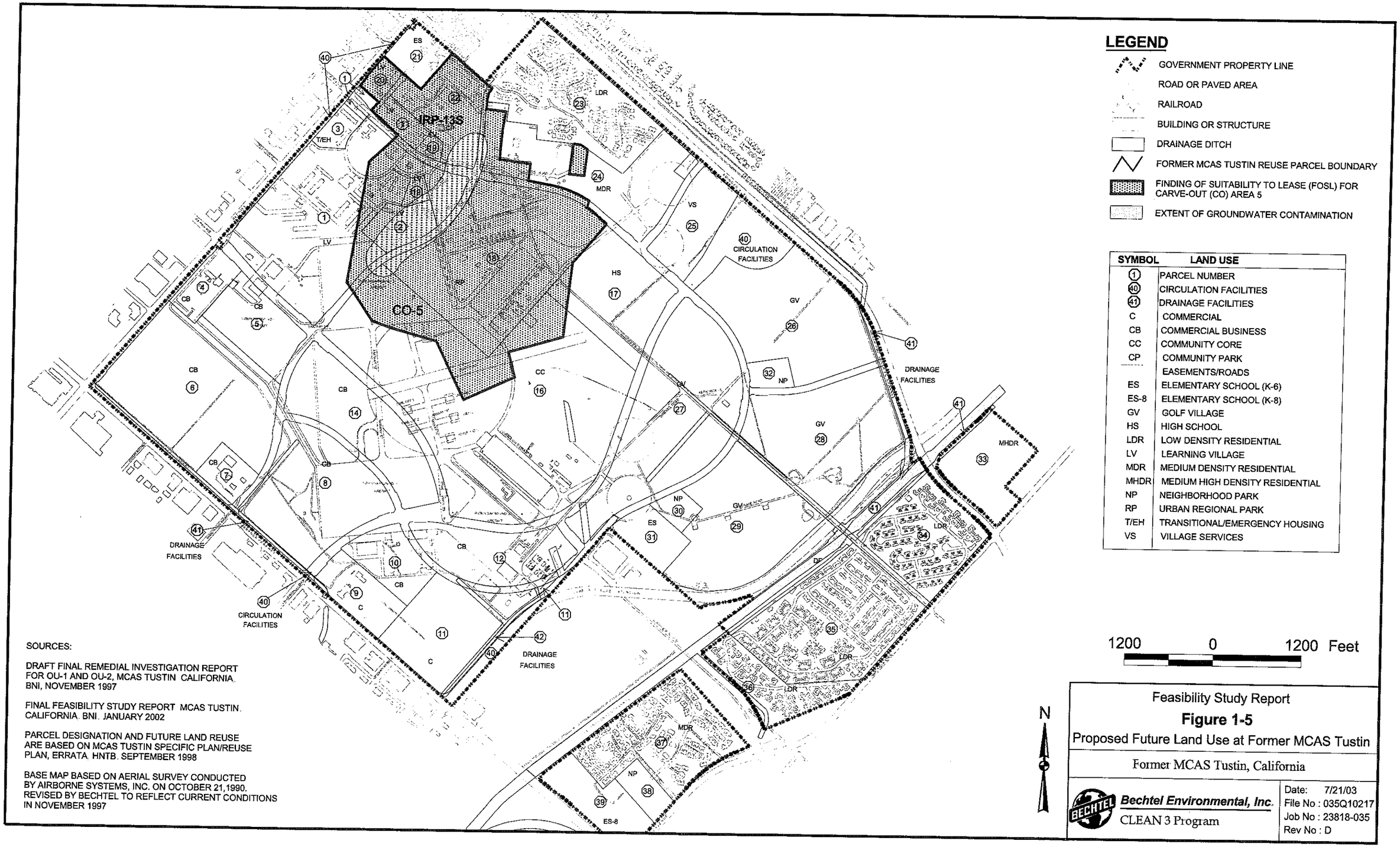
As noted in the Base Realignment and Closure (BRAC) Cleanup Plan (SWDIV 1998), the SP/RP is the cornerstone of the environmental restoration strategy at Former MCAS Tustin. Figure 1-5 shows carve-out Area 5, which surrounds OU-1A including the VOC groundwater plume. Portions of this area are, or will be, leased while cleanup activities are occurring. Reuse designations at Former MCAS Tustin include commercial, light industrial, and residential areas, schools and child care facilities, parks, a golf course, and recreational facilities. Future land use for areas defined as "community core" by the city of Tustin may include residential, commercial, and/or other uses identified within the approved SP/RP errata.

The city's reuse plan for Former MCAS Tustin formed the basis for the human-health risk assessment (HHRA) completed to support the RI (BNI 1997a). Future land use was also a key consideration throughout this FS in the development and analysis of OU-1A remedial alternatives. For areas designated as "community core," it was assumed that remediation would have to be adequate to support residential redevelopment, generally considered the most sensitive reuse option.

1.4 PHYSICAL SETTING AND CLIMATE

This section describes topographical features and surface water hydrology in the vicinity of Former MCAS Tustin, as well as the regional climate. The relationship between surface water and groundwater is an important consideration when evaluating potential VOC migration pathways in the subsurface. Regional climate, particularly rainfall, evapotranspiration, and net recharge, have a direct bearing on groundwater movement at the site. The information in the following subsections was condensed from the RI Report (BNI 1997a).


LEGEND
FORMER AGRICULTURE AREA
OPEN AREA
UNOCCUPIED RESIDENTIAL AREA
COMBINATION OF INDUSTRIAL AND MILITARY OPERATIONAL USES
GOVERNMENT PROPERTY LINE
BUILDING OR STRUCTURE
EXISTING ROAD OR PAVED AREA
PARKING
RAILROAD
DRAINAGE DITCH
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21,1990. REVISED BY BECHTEL IN NOVEMBER 1997 TO UPDATE BASE MAP
N
1200
0
1200 Feet
PARKING APRON NO 1 AIRCRAFT
PARKING APRON NO 4 AIRCRAFT
PARKING APRON NO 2 AIRCRAFT
PARKING APRON NO 3 AIRCRAFT
TAXIWAY "H"
HOVER PAD 4
HOVER PAD 3
RUNWAY
TAKE OFF 1
LANDING 1
TAXIWAY "A"
TAKE OFF 2
LANDING 2
TAXIWAY "B"
TAXIWAY "E"
JOHNSON STREET
CROSS STREET
BERRY ROAD
MOFFETT DRIVE
MOFFETT STREET
KILPATRICK RD
UPLAND ROAD
JAMBOREE ROAD EXTENSION
WARNER AVENUE
San Joaquin Ditch
PEA BREECH CANYON CHANNEL
JOHNSON AVENUE
ARMSTRONG AVENUE
MILTON AVENUE
EDINGER AVENUE
MAIN STREET
E 12000
E 14000
E 16000
E 17000
E 19000
N 11000
N 12000
N 13000
N 14000
N 15000
N 16000
N 17000
N 18000
N 19000
N 20000
N 21000
N 22000
N 23000
N 24000
N 25000
N 26000
N 27000
N 28000
N 29000
N 30000
N


LEGEND
GOVERNMENT PROPERTY LINE
ROAD OR PAVED AREA
RAILROAD
BUILDING OR STRUCTURE
DRAINAGE DITCH
FORMER MCAS TUSTIN REUSE PARCEL BOUNDARY
FINDING OF SUITABILITY TO LEASE (FOSL) FOR CARVE-OUT (CO) AREA 5
EXTENT OF GROUNDWATER CONTAMINATION
SYMBOL LAND USE
1 PARCEL NUMBER
40 CIRCULATION FACILITIES
41 DRAINAGE FACILITIES
C COMMERCIAL
CB COMMERCIAL BUSINESS
CC COMMUNITY CORE
CP COMMUNITY PARK
EASEMENTS/ROADS
ES ELEMENTARY SCHOOL (K-6)
ES-8 ELEMENTARY SCHOOL (K-8)
GV GOLF VILLAGE
HS HIGH SCHOOL
LDR LOW DENSITY RESIDENTIAL
LV LEARNING VILLAGE
MDR MEDIUM DENSITY RESIDENTIAL
MHDR MEDIUM HIGH DENSITY RESIDENTIAL
NP NEIGHBORHOOD PARK
RP URBAN REGIONAL PARK
T/EH TRANSITIONAL/EMERGENCY HOUSING
VS VILLAGE SERVICES
IRP-13S
CO-5
1200 0 1200 Feet
N
SOURCES:
DRAFT FINAL REMEDIAL INVESTIGATION REPORT FOR OU-1 AND OU-2, MCAS TUSTIN CALIFORNIA. BNI, NOVEMBER 1997
FINAL FEASIBILITY STUDY REPORT MCAS TUSTIN. CALIFORNIA. BNI. JANUARY 2002
PARCEL DESIGNATION AND FUTURE LAND REUSE ARE BASED ON MCAS TUSTIN SPECIFIC PLAN/REUSE PLAN, ERRATA. HNTB. SEPTEMBER 1998
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21,1990. REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS IN NOVEMBER 1997
Feasibility Study Report
Figure 1-5
Proposed Future Land Use at Former MCAS Tustin
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 7/21/03
File No : 035Q10217
Job No : 23818-035
Rev No : D

1.4.1 Topography

Former MCAS Tustin is situated at the eastern edge of a broad coastal plain, an essentially planar alluvial flatland bounded on the east-northeast by the foothills of the Santa Ana Mountains and on the south by the San Joaquin Hills. The coastal plain slopes gently toward the Pacific Ocean in a southwesterly direction. The topographic surroundings of Former MCAS Tustin are shown on Figure 1-6.

The topography at the former station is essentially flat, with a mean elevation of approximately 54 feet above mean sea level (MSL). The ground surface ranges in elevation from about 75 feet above MSL at the northwest corner to about 45 feet above MSL in the southeast portion of the station, sloping approximately 20 feet per mile.

1.4.2 Surface Water Hydrology

The land comprising Former MCAS Tustin was fairly marshy before it was first developed in 1942, with a main drainage channel located in what is now the middle of the station. The station was regraded with backfill, and an extensive surface and subsurface drainage system was installed that is still in use today. The primary drainages surrounding the station include Peters Canyon Channel, Santa Ana-Santa Fe Channel, Barranca Channel, and San Joaquin Channel. Only Peters Canyon Channel, Barranca Channel, and San Joaquin Channel receive drainage from the station. The drainage system, surface drainage patterns, boundaries of former agricultural areas, and potential as well as jurisdictional wetlands on the station are shown on Figure 1-7.

The three major drainage channels that surround Former MCAS Tustin (Peters Canyon Channel, Santa Ana-Santa Fe Channel, and Barranca Channel) are incised about 10 to 20 feet below the surrounding land surface and typically contain water year-round. The channels are unlined, permitting flow between groundwater and surface water. The channels act as dewatering trenches that partially control the movement of shallow groundwater. Data obtained during the RI (BNI 1997a) indicate that both Barranca Channel and Peters Canyon Channel gain flow from the shallow groundwater system in the vicinity of the station. The Santa Ana-Santa Fe Channel loses water to the subsurface in its western reach and gains flow from groundwater in its eastern reach.

Surface water runoff at the station is controlled by local topography and the drainage system. Surface water at the station originates almost entirely on-site as stormwater or landscape irrigation runoff, flowing away from the station to the south and southeast. Surface water flowing toward the station is intercepted by the Santa Ana-Santa Fe Channel or Peters Canyon Channel and routed around the station (Figure 1-7). San Joaquin Channel is the main on-site drainage channel, collecting runoff from the central and eastern portions of the station and discharging to Peters Canyon Channel through a conduit beneath Barranca Parkway. Runoff from the station also enters Peters Canyon Channel via Barranca Channel.

Peters Canyon Channel carries all the runoff from Former MCAS Tustin to San Diego Creek, approximately 1 mile to the southwest. San Diego Creek eventually empties into Upper Newport Bay about 5 miles southwest of the station.

1.4.3 Climate and Meteorology

The climate of the Tustin area is Mediterranean, with hot, dry summers and cool, wet winters. The mean daily temperature is approximately 64 degrees Fahrenheit (°F), with occasional low temperatures around 30 °F and high temperatures near 100 °F.

The average annual precipitation is 12.5 inches, with most rainstorms occurring between November and April. Precipitation averages only 0.12 inch from May through October. The average annual potential evaporation rate is about 60 inches. The average stationwide net groundwater infiltration rate under current land-use conditions is estimated to be from 0 inches per year (in/yr) to 0.5 in/yr (BNI 1997a). This very low infiltration rate can be explained by the combined effects of low precipitation, high evaporation, extensive areas of pavement (which prevent groundwater recharge), and the drainage network (which routes stormwater and irrigation runoff away from the facility before it can enter the shallow groundwater system).

1.5 GEOLOGY AND HYDROGEOLOGY

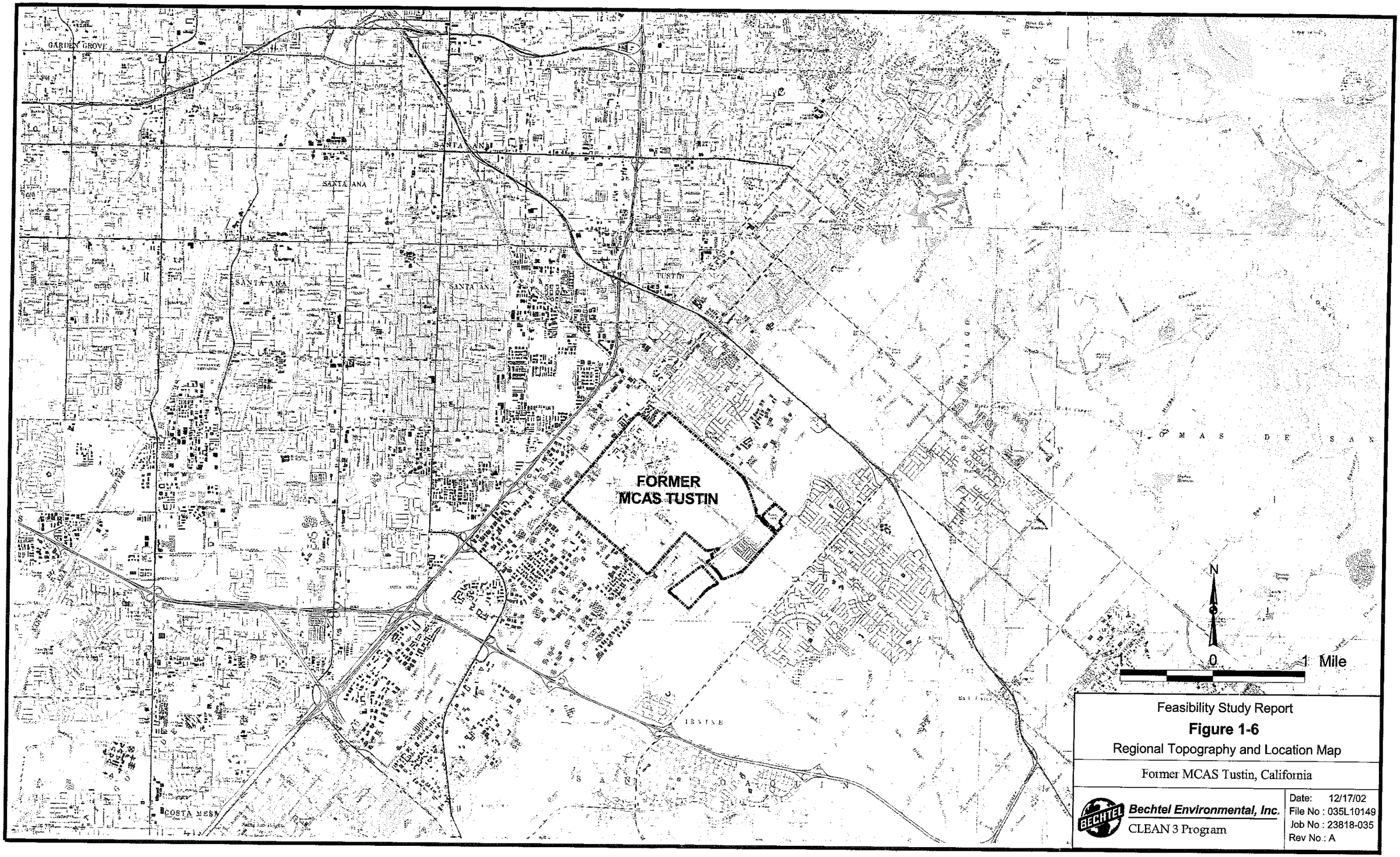
Provided below is a brief summary of the geology and hydrogeology of Former MCAS Tustin. The geology and hydrogeology are described in detail in the RI Report (BNI 1997a) and in related documents issued by the Navy CLEAN II Program (BNI 1998a, 2002b). The conceptual hydrogeologic model developed for Former MCAS Tustin provides the framework for evaluating remedial alternatives in subsequent sections of this FS Report.

1.5.1 Regional Geology and Hydrogeology

Former MCAS Tustin is located on the Tustin Plain, which resulted from the disposition of an alluvial fan formed by San Diego Creek and other smaller fans sourced from the southern part of the Santa Ana Mountains. Approximately 1,300 feet of unconsolidated sediments were deposited in the vicinity of the station. These include Quaternary floodplain deposits near the ground surface to approximately 150 feet below ground surface (bgs), Pleistocene stream terrace and alluvial deposits to about 300 feet bgs, and the Pleistocene sand, gravel, silt, and clay of the San Pedro Formation to approximately 1,300 feet bgs.

Floodplain sediments found at ground surface to depths from about 90 to 150 feet bgs consist of massive silt, clayey silt, clay, and silty clay deposits, with discontinuous sand and gravel lenses. Sand and gravel lenses are interpreted to have been deposited by relatively narrow stream (fluvial) channels that incised finer, predominantly silt/clay floodplain sediments. The uppermost floodplain deposits at the station consist of silt and clay and can be up to 50 feet thick and laterally continuous. The fluvial, coarser-grained deposits are relatively thin (1 foot to 10 feet thick) and laterally discontinuous.

Former MCAS Tustin is located near the center of the Irvine Groundwater Subbasin (Subbasin), which has been designated by RWQCB as a public water supply source (RWQCB 1995) (Figure 1-8). In the Forebay Area at the fringes of the Subbasin, the



Feasibility Study Report

Figure 1-6

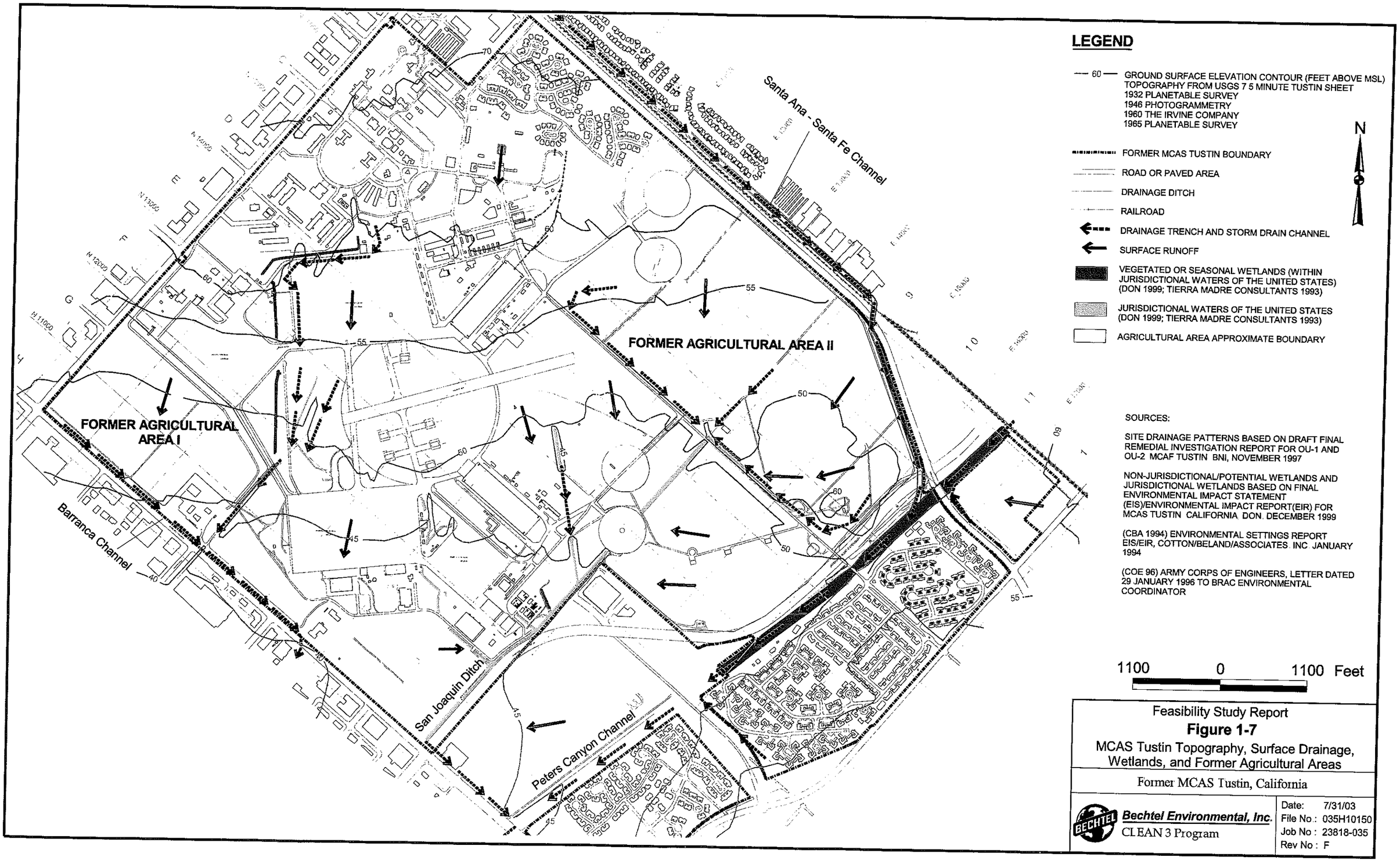
Regional Topography and Location Map

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 12/17/02
File No : 035L10149
Job No : 23818-035
Rev No : A



Feasibility Study Report

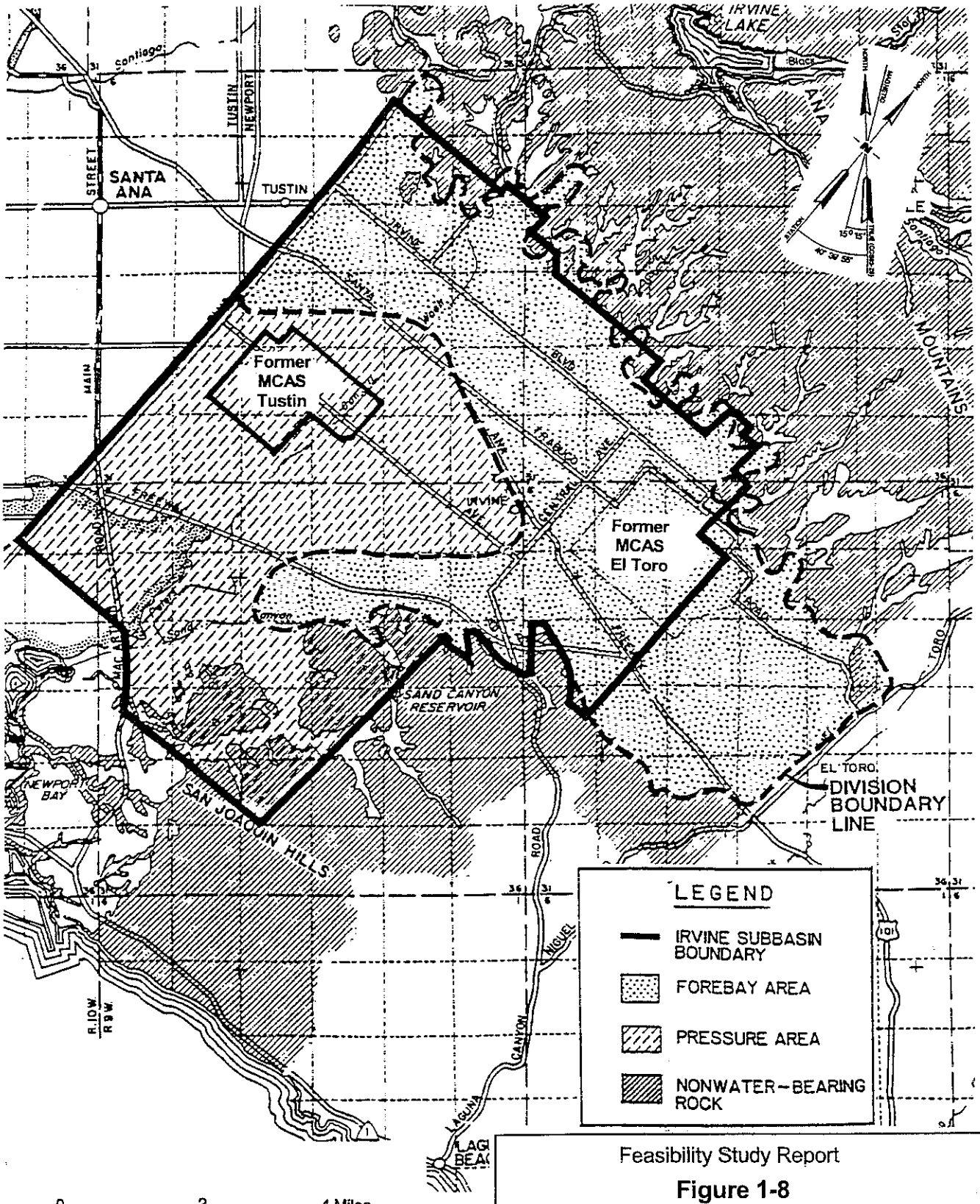
Figure 1-7

MCAS Tustin Topography, Surface Drainage, Wetlands, and Former Agricultural Areas

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 7/31/03
File No.: 035H10150
Job No.: 23818-035
Rev No.: F



0 2 4 Miles
GRAPHIC SCALE
SCALE 1:125,000

Source: Brown and Caldwell 1985

Source: California Department of Water Resources 1967

Feasibility Study Report

Figure 1-8

Hydrogeologic Basin Boundary

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 12/10/02
File No.: 035H10151
Job No.: 23818-035
Rev No.: A

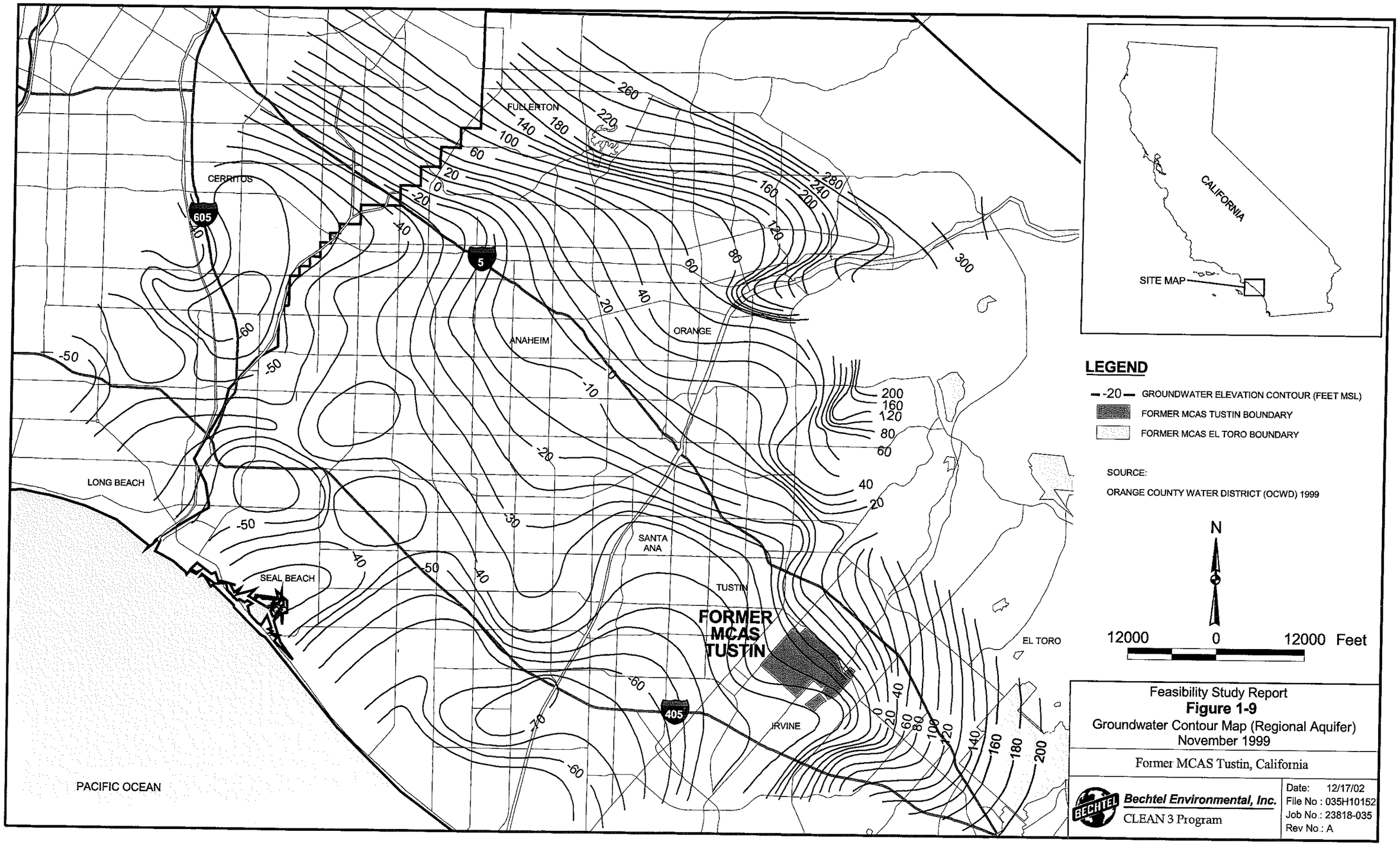
overlying alluvial sediments abut essentially non-water-bearing, consolidated sedimentary, metasedimentary, and igneous bedrock of the San Joaquin Hills and the foothills of the Santa Ana Mountains. These are recharge areas where water infiltrates into unconfined aquifers along alluvial fans. Infiltrated groundwater then flows toward the center of the Subbasin, known as the "Pressure Area," where the regional aquifer becomes artesian, confined by overlying low-permeability materials. The boundary between the Forebay Area and the Pressure Area varies seasonally and annually according to the relative amounts of groundwater withdrawal and recharge in the areas. From the Pressure Area, groundwater in the regional aquifer flows generally southwesterly toward the Pacific Ocean, with local pumping depressions nested around several municipal and agricultural extraction well fields. A groundwater-level contour map for the regional aquifer is provided on Figure 1-9.

In the vicinity of the station, the regional aquifer occurs as an extensive, well-developed water-bearing sand zone at approximately 90 to 150 feet bgs, or between 40 feet below MSL to 100 feet below MSL. This sand, probably a beach deposit, constitutes the uppermost part of the Subbasin Pressure Area within the older (Pleistocene) alluvial sediments. Lithologic, hydraulic, and geochemical data are provided in the RI Report to support 40 feet below MSL as the approximate demarcation between the shallow and regional aquifers under the station (BNI 1997a).

The regional aquifer is currently used as a primary source of municipal drinking water and irrigation water. Water quality varies both laterally and vertically, with total dissolved solids (TDS) concentrations ranging from 250 to 1,700 milligrams per liter (mg/L), averaging about 800 mg/L. The average TDS concentration in the regional aquifer is below the 1,000 mg/L maximum secondary drinking water standard established by the California Department of Health Services (DHS) and promulgated in the *California Code of Regulations* (Cal. Code Regs.) at Cal. Code Regs. Title (tit.) 22, Section (§) 64449. However, the average TDS concentration is above the 700 mg/L water quality objective recommended by RWQCB for most irrigation uses (RWQCB 1995). Groundwater in the regional aquifer generally contains sodium and calcium as the dominant cations and either sulfate or carbonate as the dominant anion (BNI 1997a).

The RI Report identified 28 production wells in the regional aquifer within a 3.5-mile radius of Former MCAS Tustin, most screened between 200 feet below MSL to 300 feet below MSL (BNI 1997a). The closest potable water supply well, operated by the city of Tustin, is located 1.5 miles north (upgradient) of the station. There are six agricultural water supply wells within 1 mile of the Former MCAS Tustin perimeter.

Osumi Farms operated the only on-station production well, designated as OSUM-T. This well, used exclusively for agricultural purposes, is located in the southern portion of the station. OSUM-T operated on demand and had an estimated pumping capacity of 2,000 to 3,000 gallons per minute (gpm). This well drew water from regional aquifer zones between approximately 103 feet below MSL to 263 feet below MSL and 301 feet below MSL to 790 feet below MSL (148 to 308 feet bgs and 346 to 835 feet bgs, respectively).


FULLERTON
CERRITOS
605
5
ANAHEIM
ORANGE
LONG BEACH
SEAL BEACH
SANTA ANA
TUSTIN
FORMER MCAS TUSTIN
EL TORO
IRVINE
405
PACIFIC OCEAN
CALIFORNIA
SITE MAP
LEGEND
-20 GROUNDWATER ELEVATION CONTOUR (FEET MSL)
FORMER MCAS TUSTIN BOUNDARY
FORMER MCAS EL TORO BOUNDARY
SOURCE:
ORANGE COUNTY WATER DISTRICT (OCWD) 1999
N
12000 0 12000 Feet
Feasibility Study Report
Figure 1-9
Groundwater Contour Map (Regional Aquifer)
November 1999
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/17/02
File No : 035H10152
Job No : 23818-035
Rev No.: A

Between 1980 and 2000, production at OSUM-T averaged approximately 715 acre-feet per year (233 million gallons per year). OSUM-T was shut down in December 2000.

1.5.2 Shallow Groundwater System at Former MCAS Tustin

Shallow groundwater occurs mainly in relatively coarser-grained discontinuous lenses of sand and gravel of varying thickness and extent within primarily fine-grained floodplain deposits. There does not appear to be a laterally continuous shallow aquifer beneath the station in the sense of a contiguous saturated permeable unit. Nevertheless, consistent water-level readings in cluster wells completed at various depth intervals indicate that discontinuous water-bearing zones (WBZs) encountered within the alluvial materials from approximately 20 feet bgs to approximately 90 feet bgs collectively constitute the uppermost hydrogeologic regime, or "shallow aquifer," at Former MCAS Tustin (BNI 1997a).

The primary sources of local recharge to the shallow aquifer include infiltration of rainfall and water used locally for landscape irrigation. Regional recharge in the Forebay Area and artificial recharge along portions of the Santa Ana River may also contribute water to the deeper portion of the shallow aquifer (BNI 1997a).

All lithologic, hydraulic, and geochemical evidence to date indicates that the shallow aquifer system at Former MCAS Tustin is separated from the regional aquifer by a stationwide aquitard consisting of a continuous stiff clay layer with a thickness of 10 to 30 feet (BNI 1997a). Based on a review of the OSUM-T well, groundwater quality data, and water-level data collected stationwide, this aquitard appears to effectively impede hydraulic communication between the shallow and regional aquifers.

The shallow saturated strata at the station (to approximately 90 feet bgs) were generalized into three WBZs (BNI 1997a), a convention that is followed throughout this FS Report. The conceptual hydrogeologic model for Former MCAS Tustin illustrates the general relationship between the three WBZs comprising the shallow aquifer, the continuous clay aquitard at the bottom of the third WBZ, and the regional aquifer underlying the station (Figure 1-10).

Groundwater is first encountered at the station at depths from approximately 5 to 15 feet bgs (60 feet above MSL to 30 feet above MSL). The first, or uppermost, WBZ extends from the water table to the top of the second saturated coarse-grained zone, which occurs at approximately 20 to 50 feet bgs. The second WBZ extends from the top of the second saturated coarse-grained zone to the top of the third coarse-grained zone, which occurs from 50 to 100 feet bgs. The third WBZ extends from the top of the third saturated coarse-grained zone to the top of the regional aquifer, which is characterized by a transmissive sand zone found in most soil borings drilled to approximately 90 feet bgs and deeper.

The boundaries between WBZs vary from location to location at the station, reflecting the highly irregular lateral and vertical distribution of coarse-grained materials (sand, silty sand, and gravels) within the shallow groundwater regime. In general, each WBZ

contains some fine-grained sediments (clay, silt, or sandy clay). However, subsurface studies indicate that coarse-grained materials may be absent from a specific WBZ at some locations, while relatively thick sequences of permeable fluvial channel deposits can overlap WBZs elsewhere. A detailed cross section provided on Figure 1-11 further illustrates the complexity of shallow hydrogeologic conditions beneath the station (BNI 1997a).

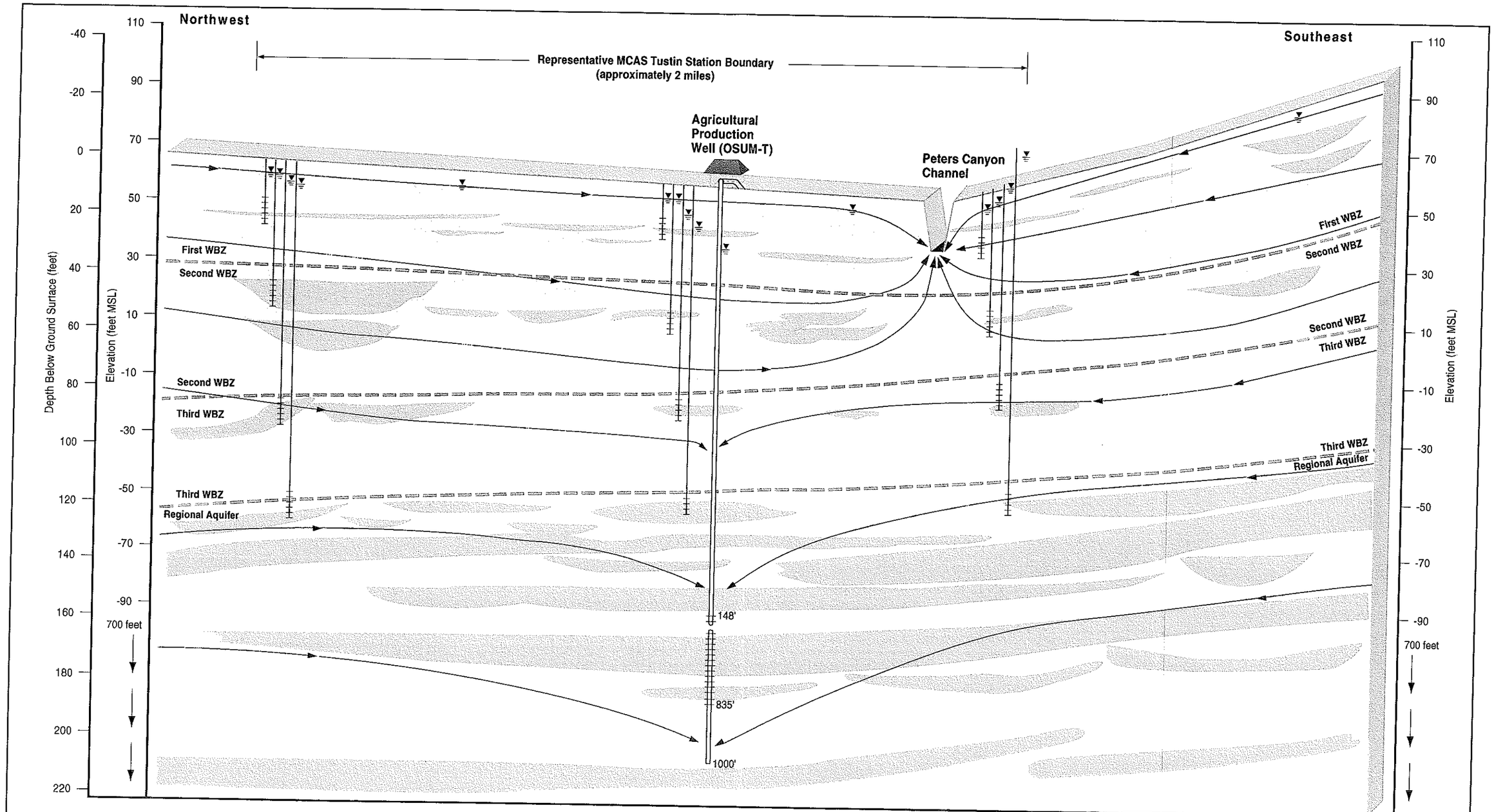
Groundwater in the first WBZ at the site and throughout the station occurs mostly in sand intervals. Hydraulic testing completed during the RI indicated that groundwater in the uppermost sand zone within the first WBZ is pressurized, indicating semiconfined conditions. Fine-grained materials or confining layers within the first WBZ are also saturated, and at some locations first encountered groundwater actually occurs within clays and silts. Groundwater within the second and third WBZs is also generally confined or semiconfined. There are no indications of perched or semiperched groundwater at the station (BNI 1997a).

Field data suggest that the first and second WBZs are hydraulically interconnected. However, the third WBZ appears to be hydraulically separated from the second WBZ across most of the station. The third WBZ is also an apparent transition zone between the shallow aquifer and the underlying regional aquifer.

Cluster well locations throughout the station are used to monitor groundwater flow within the three WBZs in the shallow aquifer. With the exception of localized, relatively minor variations, the first and second WBZs flow in the same direction, toward the south and southwest, under nearly identical gradients. As noted in Section 1.4.2, the shallow aquifer intercepts the land surface at Peters Canyon Channel, Barranca Channel, and Santa Ana-Santa Fe Channel, with groundwater discharging to the drainages. Thus, the three main drainage channels surrounding the station ultimately control the off-station migration of dissolved VOCs in the subsurface. Groundwater elevation contours and flow directions in the first and second WBZs (shown on Figures 1-12 and 1-13, respectively) indicate that shallow groundwater at OU-1A would eventually migrate to and intercept Barranca Channel (BNI 2002b). Groundwater flow in the third WBZ is interpreted to be generally toward the southwest and is not influenced by the surface drainage system at the station (BNI 1997a).

Because of poor quality and low yield, groundwater from the shallow aquifer at the site (i.e., shallower than 40 feet below MSL) has not been extracted for beneficial use. Naturally occurring background salt concentrations are elevated, especially in the first two WBZs. Salts, measured as TDS, tend to decrease with depth (BNI 1997a, 2002b). Water quality ranges from saline in samples collected shallower than 10 feet above MSL, to brackish at depths between 10 feet above MSL to 30 feet below MSL, to fresh at depths deeper than 30 feet below MSL.

The California State Water Resources Control Board (SWRCB) determined that groundwater with TDS concentrations exceeding 3,000 mg/L is generally not expected to be used for public drinking water supply (SWRCB 1968, RWQCB 1995). As noted in



Legend

Clayey Silt and Clay

Silty Sand and Sand

Water Level

Monitoring Well

Production Well

Acronyms/Abbreviations:

MSL mean sea level

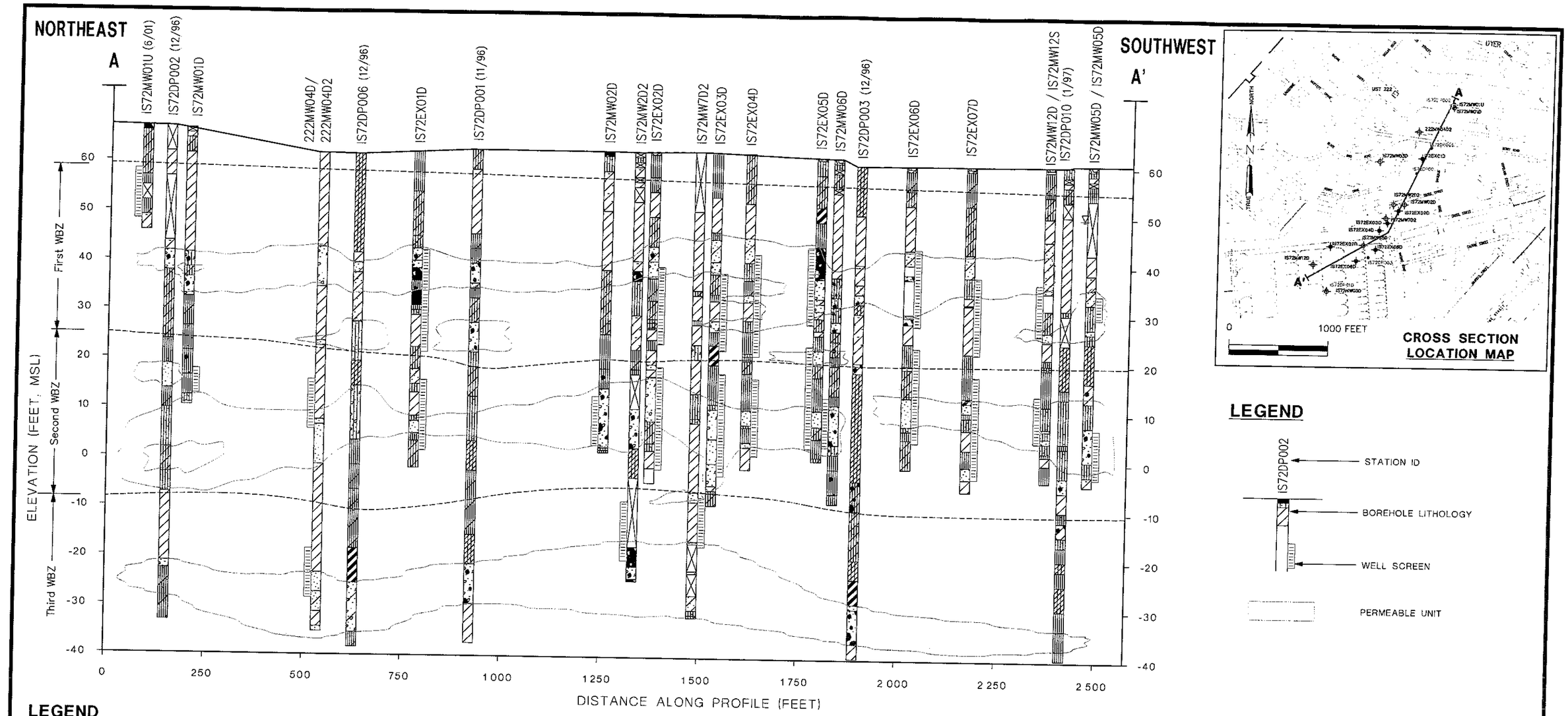
WBZ water-bearing zone

Feasibility Study Report
Figure 1-10
Former MCAS Tustin
Conceptual Hydrogeologic Model

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 6/11/03
File No 035X10191
Job No 23818-035
Rev No C



Feasibility Study Report

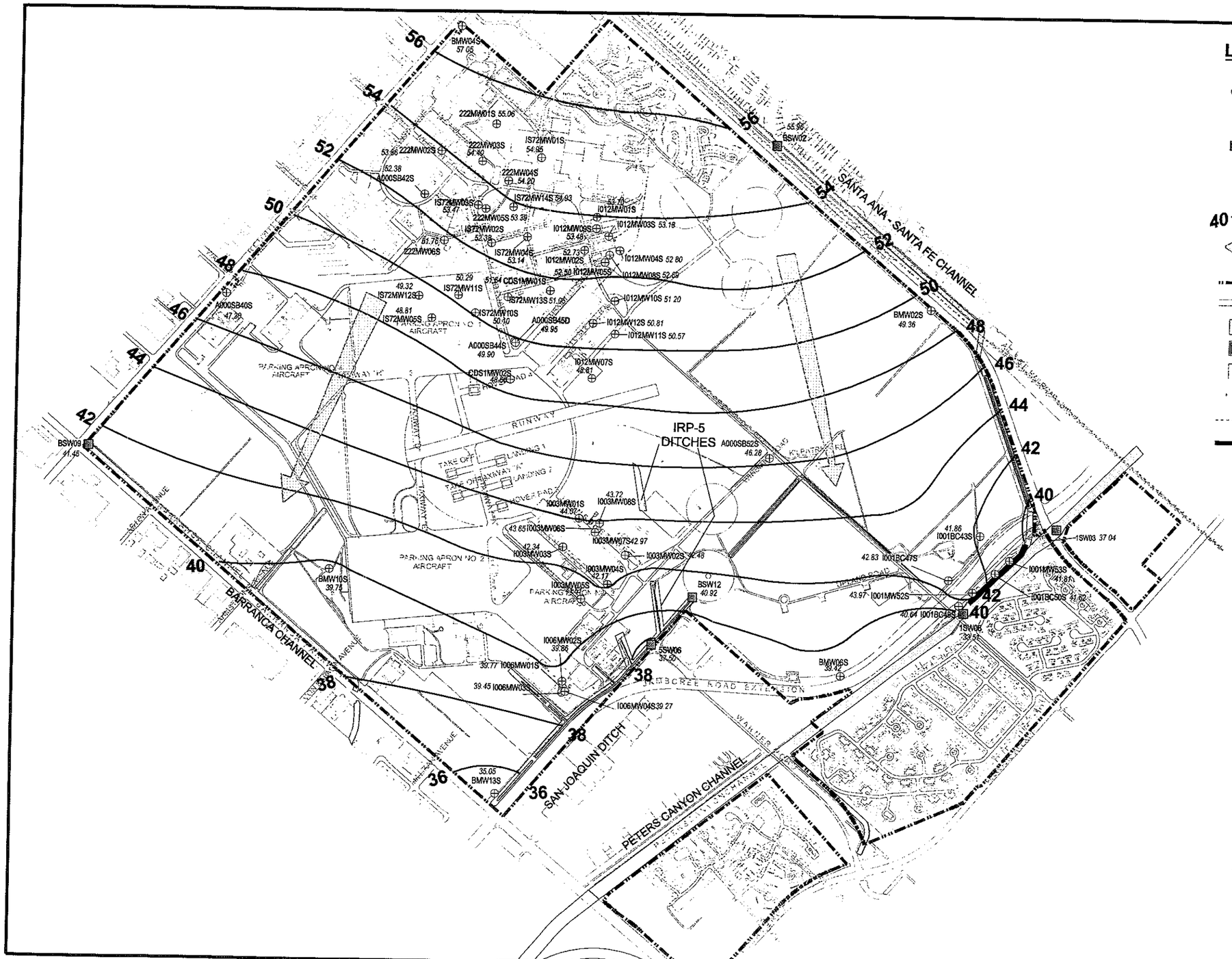
Figure 1-11

Cross Section A-A'

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/17/03
File No: 035X10306
Job No: 23818-035
Rev No: A



LEGEND

⊕ BMW10S	WELL INSTALLED IN 1st PERMEABLE WATER-BEARING ZONE (WBZ) OR IN OVERLYING FINER GRAINED ZONE CROSSING WATER TABLE (SHALLOW)
■ BSW11	SURFACE-WATER GAUGING LOCATION
42.60	WATER-LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (MSL) (ELEVATIONS REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1988)
40	GROUNDWATER EQUIPOTENTIAL LINE IN FEET ABOVE MSL
	GENERALIZED GROUNDWATER FLOW DIRECTION (DIRECTION OF GROUNDWATER FLOW IS PERPENDICULAR TO WATER LEVEL CONTOURS)
	GOVERNMENT PROPERTY LINE
	EXISTING ROAD OR PAVED AREA
	SURFACE CHANNEL
	CONCRETE-LINED CHANNEL STRUCTURE
	BUILDING OR STRUCTURE
	RAILROAD
	FENCE
	IRP-1 CONTAINMENT WALL

N

NOTE:

GROUNDWATER ELEVATIONS BASED ON WATER-LEVEL MEASUREMENTS TAKEN BETWEEN 3 DECEMBER AND 11 DECEMBER 2001

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON 21 OCTOBER 1990 REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS, NOVEMBER 1997

1200 0 1200 Feet

Feasibility Study Report

Figure 1-12

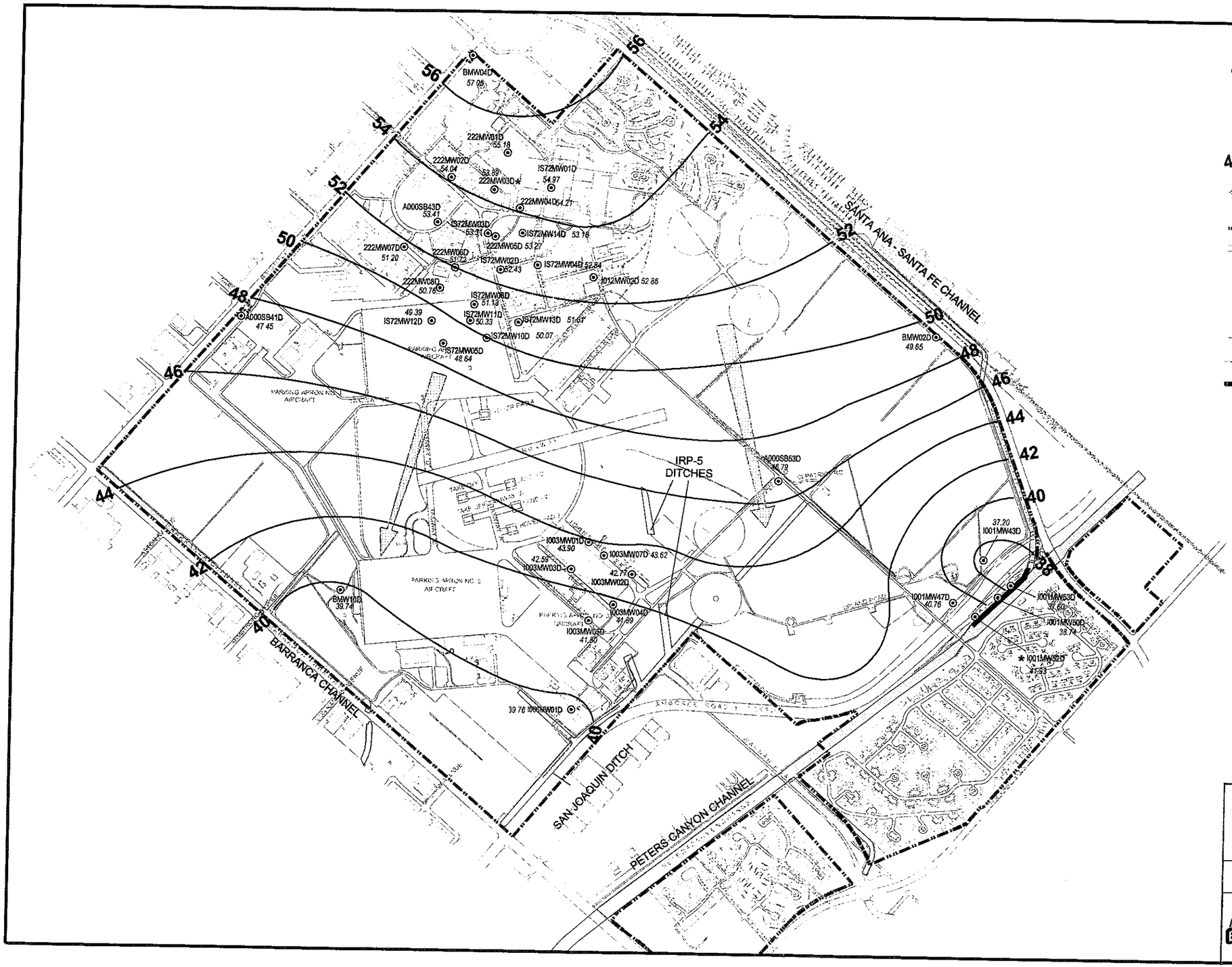
Basewide Water-Level Elevations in the First WBZ (Winter 2001)

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 01/16/03
File No : 035Q10153
Job No : 23818-035
Rev No : B



LEGEND

⊙ BMW02D	WELL INSTALLED IN 2nd PERMEABLE WATER-BEARING ZONE (WBZ) (DEEP)
52 20	WATER-LEVEL ELEVATION IN FEET ABOVE MEAN SEA LEVEL (MSL) (ELEVATIONS REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1988)
40	GROUNDWATER EQUIPOTENTIAL LINE (DECEMBER 2001) IN FEET ABOVE MSL
	GENERALIZED GROUNDWATER FLOW DIRECTION (DIRECTION OF GROUNDWATER FLOW IS PERPENDICULAR TO WATER-LEVEL CONTOURS)
	GOVERNMENT PROPERTY LINE
	EXISTING ROAD OR PAVED AREA
	SURFACE CHANNEL
	CONCRETE-LINED CHANNEL STRUCTURE
	BUILDING OR STRUCTURE
	RAILROAD
	FENCE
	IRP-1 CONTAINMENT WALL
*	WATER-LEVEL DATA FOR THIS MONITORING WELL IS NOT CONSISTENT WITH OTHER DATA AND THEREFORE WAS NOT USED FOR GROUNDWATER CONTOURS

NOTE:

GROUNDWATER ELEVATIONS BASED ON WATER-LEVEL MEASUREMENTS TAKEN BETWEEN 3 DECEMBER AND 11 DECEMBER 2001

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON 21 OCTOBER 1990. REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS, NOVEMBER 1997

N

1200 0 1200 Feet

Feasibility Study Report

Figure 1-13

Basewide Water-Level Elevations in the Second WBZ (Winter 2001)

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 0116/03
File No : 035Q10154
Job No : 23818-035
Rev No : B

Section 1.5.1, DHS established the maximum secondary drinking water standard for TDS at 1,000 mg/L, and the RWQCB recommends an upper concentration of 700 mg/L TDS for most irrigation uses (RWQCB 1995). By way of comparison, TDS concentrations at the station average approximately 6,000 mg/L in the first WBZ and exceed 10,000 mg/L in the downgradient lowland areas of the station along Peters Canyon Channel. The maximum reported TDS concentration in groundwater from the first WBZ was 40,000 mg/L. TDS concentrations average 2,400 mg/L and 660 mg/L in the second and third WBZs, respectively.

Groundwater monitoring conducted during the RI and subsequent groundwater monitoring events have shown that the shallow aquifer at Former MCAS Tustin is degraded as a result of natural processes (e.g., leaching of selenium-bearing soils) and former agricultural practices unrelated to USMC operations (BNI 1997b, 1998a, 1999d, 2000b, 2001a, 2002b). Background concentrations of sulfate, selenium, and nitrate in the first and second WBZs exceed DHS and U.S. EPA criteria for drinking water supply by approximately 10 times, 10 times, and 2 times, respectively. However, groundwater in strata deeper than about 100 feet bgs is of good quality and is generally suitable for public drinking water and irrigation (BNI 1997a).

Stationwide, including OU-1A, sodium and calcium are the major cations, and sulfate and chloride are the predominant anions in shallow groundwater (BNI 1997a). The primary causes of elevated background TDS concentrations on-site include the cyclic downward leaching of salts by infiltrating water from precipitation and irrigation, salt concentration through direct evaporation of moisture from the vadose zone and shallow water table, and the weathering of naturally occurring caliche and gypsum deposits in the alluvium (BNI 1997a, 2002b).

Elevated TDS concentrations are also correlated with elevated nitrate concentrations in the shallow aquifer especially in the first and second WBZs, which are likely derived from applied fertilizers. Former agricultural activities in the site vicinity, including irrigation and application of fertilizers, could have resulted in elevated TDS and nitrate concentrations. The correlation between elevated TDS and nitrate concentrations supports the interpretation that irrigation return water containing sulfate- and nitrogen-based fertilizers caused elevated TDS concentrations in the shallow aquifer at Former MCAS Tustin (BNI 1997a).

1.6 BACKGROUND INFORMATION FOR IRP-13S

IRP-13S is located adjacent to Severyns Street, north of Copeland Street, in the northwest corner of the Former MCAS Tustin property, occupying an area of approximately 0.7 acre (Figure 1-14). Residual contamination in soils of the source area that resulted in VOC-contaminated groundwater associated with OU-1A is located at ST-72 and MWA-18 (Figure 1-14). ST-72 and MWA-18 are separated by a distance of approximately 100 feet (Figure 1-15). ST-72 contains two buildings (part of Building 16 and the former Building 50) used for vehicle maintenance in the former Ground Support

Equipment (GSE) Yard. MWA-18 is a former washpad used for cleaning small generators and other field equipment.

The following subsections provide background information for IRP-13S, including operational history, significant findings from the RI and other investigations, and expected future land uses. These descriptions were excerpted primarily from the RI Report (BNI 1997a) and supplemented with information from other key documents issued under the Navy CLEAN II Program (BNI 1996a, 1996b, 1997b, 1998a, 2002b).

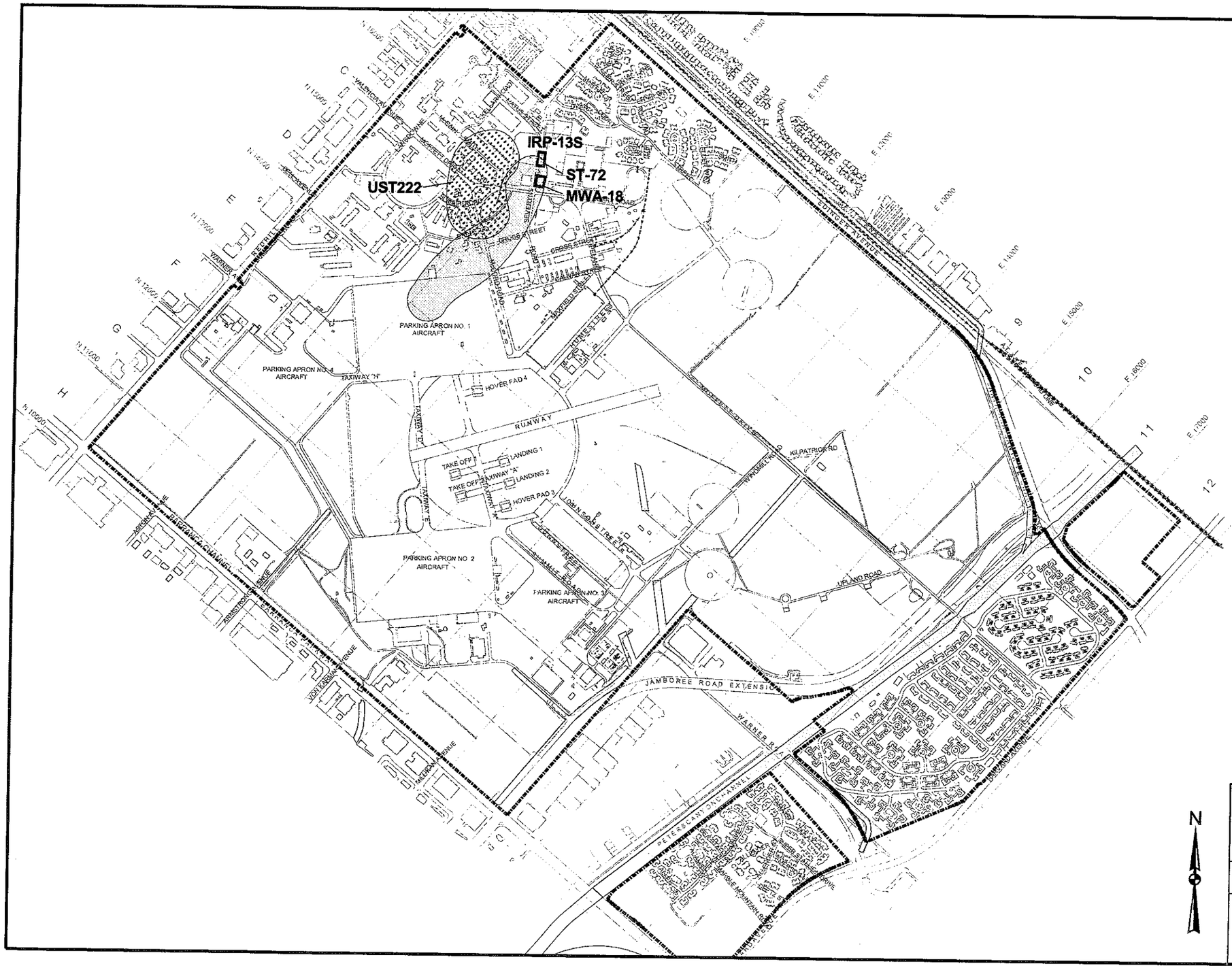
1.6.1 History of Operations and Waste Management at IRP-13S

Vehicle maintenance activities were formerly conducted at ST-72, located in the northern portion of IRP-13S. ST-72 consists of the southern half of Building 16, the former Building 50, and the paved area surrounding the buildings. This area was part of the former GSE Yard, originally constructed in 1942 (Brown and Caldwell 1985, JEG 1992).

The southern half of Building 16 operated as a GSE maintenance garage from 1942 through 1993 and then, until recently, it housed administrative functions (BNI 1998a). A hoist lift with a below-grade waste oil collection sump is still present. Cleaning solvents were reportedly used as degreasers to wash down floors in the building, and waste solvent was likely released to storm drains or to the ground outside the building (Brown and Caldwell 1985). By 1985, biodegradable soaps were being used for this purpose instead of solvents (BNI 1997a).

Building 50 was demolished in 1982, and the area was then used as a parking lot before the station's closure (JEG 1992). Before its demolition, Building 50 was used as a vehicle lubrication facility within the former GSE Yard from the mid-1960s until the mid-1970s. A steam-cleaning wash rack reportedly existed on the south side of the building (Brown and Caldwell 1985). Currently, the footprint of former Building 50 consists of a concrete pad with the remains of a hydraulic lift in the middle. Jacobs Engineering Group Inc. (JEG) (1992) reported that the sumps below the former lift were filled with sediment that appeared to be stained. However, no visible evidence of the sumps associated with former Building 50 has been found, and there are no records available to indicate whether the sumps were excavated or left in place (BNI 1997b).

MWA-18 is an inactive washpad located west of Building 47 within the former GSE Yard that comprises the southern portion of IRP-13S. Installed in the 1940s, it was formerly used for washing small generators and other field equipment, and consists of a concrete pad (50 feet by 56 feet) sloped to a drain. No O/W separator was connected to MWA-18. JEG (1992) reported numerous cracks in the concrete pad and stated that its overall integrity appeared to be poor. During the RCRA facility assessment (RFA), wash water from USMC equipment-cleaning activities several hundred feet north of MWA-18 was observed to drain across an asphalt-covered parking lot toward MWA-18 (BNI 1997b).



LEGEND

- GOVERNMENT PROPERTY LINE
- EXISTING ROAD OR PAVED AREA
- BUILDING OR STRUCTURE
- RAILROAD
- IRP-13S: TEMPORARY STORAGE AREA NO. ST-72 AND MISCELLANEOUS WASH AREA NO 18
- APPROXIMATE AREAL EXTENT OF 1,2,3-TCP IN GROUNDWATER AT CONCENTRATIONS EXCEEDING 1 ug/L IN THE FIRST WATER-BEARING ZONE
- APPROXIMATE AREAL EXTENT OF MTBE IN GROUNDWATER AT CONCENTRATIONS EXCEEDING 10 ug/L IN THE FIRST WATER-BEARING ZONE

NOTES:

LOCATIONS INDICATED ARE APPROXIMATE INVESTIGATION BOUNDARIES

1,2,3-TCP AND MTBE PLUMES ARE BASED ON WINTER 2001 GROUNDWATER DATA

ug/L - MICROGRAMS PER LITER
1 2,3-TCP - 1,2,3-TRICHLOROPROPANE

SOURCES:

DRAFT 2001 ANNUAL GROUNDWATER MONITORING REPORT MCAS TUSTIN CALIFORNIA, BNI AUGUST 2001.

IRP13S AND FORMER UST SITE 222 LOCATION BASED ON: DRAFT FINAL REMEDIAL INVESTIGATION REPORT FOR OU-1 AND OU-2, MCAF TUSTIN CALIFORNIA, BNI NOVEMBER 1997

FINAL EXPANDED SITE INPECTION REPORT, MCAS TUSTIN, CALIFORNIA, BNI, MARCH 1997;
FINAL RCRA FACILITY ASSESSMENT REPORT. MCAS TUSTIN. BNI JUNE 1997

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS

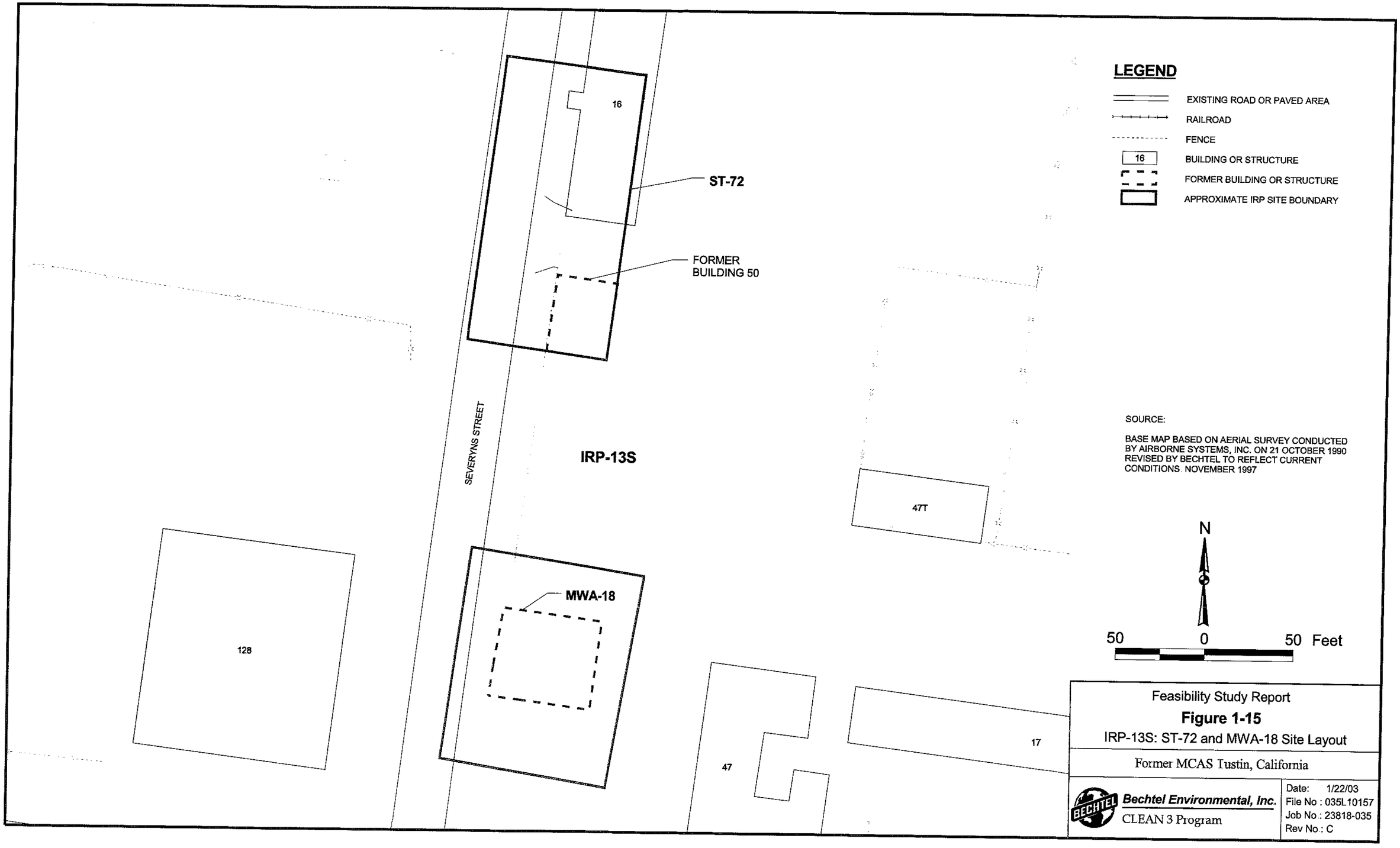
1200 0 1200 Feet

Feasibility Study Report
Figure 1-14
Source Area and Contaminated Groundwater Within Scope of OU-1A Feasibility Study

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/22/03
File No.: 035L10155
Job No.: 23818-035
Rev No.: C


16
ST-72
FORMER
BUILDING 50
SEVERYNS STREET
IRP-13S
47T
MWA-18
128
47
17
LEGEND
EXISTING ROAD OR PAVED AREA
RAILROAD
FENCE
16
BUILDING OR STRUCTURE
FORMER BUILDING OR STRUCTURE
APPROXIMATE IRP SITE BOUNDARY
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON 21 OCTOBER 1990 REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS. NOVEMBER 1997
N
50
0
50 Feet
Feasibility Study Report
Figure 1-15
IRP-13S: ST-72 and MWA-18 Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 1/22/03
File No : 035L10157
Job No : 23818-035
Rev No : C

1.6.2 Soil and Groundwater Investigations at IRP-13S

The potential for subsurface contamination at ST-72 was first identified under the Navy Assessment and Control of Installation Pollutants program (Brown and Caldwell 1985) and was named as an area to be investigated under an RFA. A preliminary review (PR) and a visual site inspection (VSI) conducted at ST-72 indicated that hazardous substances may have been stored, handled, disposed of, or released at this site (JEG 1992, BNI 1997a). Two RFA sampling visits were conducted at ST-72 in 1995 and 1996 that involved collection of limited field data to address uncertainties remaining from the PR and VSI regarding the extent of soil and groundwater contamination. A screening-level risk assessment and a preliminary analysis of contaminant fate and transport were also performed.

The first RFA sampling visit (Event 1) at ST-72 was completed between October 1995 and May 1996. Two temporary well points installed in the first WBZ confirmed the presence of VOCs including TCE, 1,2,3-TCP, 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), and 1,1,2,2-tetrachloro-1,2-difluoroethane (Freon 112) in groundwater. 1,2,3-TCP was identified as presenting the greatest human-health risk of the VOCs encountered at ST-72. Only trace concentrations (less than 5 micrograms per kilogram [µg/kg]) of VOCs were reported in soil samples collected between the ground surface and 15 feet bgs (BNI 1997b).

In September 1996, a second step-out RFA sampling visit (Event 2) was conducted to confirm the presence of 1,2,3-TCP in groundwater at ST-72 and to estimate its areal extent in the first WBZ. Based on results from Event 2, the presence of 1,2,3-TCP, TCE, and Freon 113 in groundwater at ST-72 was confirmed. The extent of 1,2,3-TCP in groundwater was larger than previously interpreted and was not fully delineated (BNI 1997b).

On the basis of the two RFA sampling visits, the DON determined that VOC contamination in the groundwater plume originating at ST-72 extended beyond the site's boundaries and would therefore be more appropriately managed under the CERCLA program. An RI for ST-72, now known as IRP-13S, was conducted between October 1996 and February 1997. The scope of the RI was expanded to include MWA-18, another suspected source of VOCs released to groundwater (BNI 1997b).

The RI conducted for ST-72 and MWA-18 was intended to confirm results obtained from previous RFA sampling visits, characterize geologic and hydrogeologic conditions at and downgradient of IRP-13S, determine the vertical and lateral extent of groundwater contamination, and characterize soil contamination in likely VOC source areas (BNI 1997b). Results from the RI were presented as Appendix M in the RFA Report (BNI 1997b) and were also incorporated by reference into the draft final RI Report for OU-1 and OU-2 (BNI 1997a).

Quarterly groundwater monitoring has been conducted at IRP-13S since completion of the RI Report in 1997. 1,2,3-TCP was first reported in groundwater samples from the

third WBZ during the September and December 1997 monitoring rounds. In 1998, a limited deep HydroPunch® investigation was conducted to evaluate potential mechanisms for downward migration of 1,2,3-TCP into the third WBZ and to determine the direction of groundwater flow and the extent of 1,2,3-TCP in the third WBZ at IRP-13S (BNI 1999c). As a part of this investigation, three new monitoring wells were installed in crossgradient and downgradient limits of the 1,2,3-TCP plume in the third WBZ.

Based on data from previous RFA sampling visits, soil was excavated at MWA-18 and ST-72. MWA-18 consisted of a 50- by 56-foot concrete pad sloped to a drain. The concrete pad was removed and soil was excavated to a maximum depth of 3 feet bgs to remove total petroleum hydrocarbons (TPH) contamination. Four confirmation samples were taken from the bottom of the excavation and TPH concentrations were reported to be below target cleanup levels; however, TCE was reported in one sample collected at 3 feet bgs at a concentration of 11,000 µg/kg. Based on these results, TCE-contaminated soil was found to exist at MWA-18 and was interpreted to be a potential source of TCE in groundwater. The site was, therefore, identified for CERCLA closure in association with IRP-13S (OHM 2001a).

Based on limited soil sampling performed adjacent to Building 16 during the RI, ST-72 was identified as the probable source of 1,2,3-TCP in groundwater. ST-72 was subsequently split into ST-72A and ST-72B. ST-72A consisted of a 40- by 47-foot concrete pad with a hydraulic lift. Based on further soil sampling results that indicated no reportable concentrations of 1,2,3-TCP in soil at the site, no excavation was required, and the DON recommended ST-72A for no further action (OHM 2001b).

Three stages of soil excavation were performed at ST-72B, which consisted of a 40- by 47-foot concrete pad with the remains of a hydraulic lift in the middle. Following the third stage of excavation, confirmation samples were collected from the sidewalls and bottom floor of the excavation. TPH as diesel was reported in soil samples collected at 12 feet bgs at concentrations exceeding target cleanup values. Further excavation typically would have been conducted; however, TCE was reported at concentrations of 30 and 76 µg/kg in samples collected at 12 and 10 feet bgs, respectively. TCE was not reported in any soil samples collected above 10 feet bgs and, therefore, it was assumed that TCE contamination could be attributed to lateral migration from nearby site IRP-13S. Given the presence of TCE, the DON determined that ST-72B would undergo CERCLA closure in association with OU-1A (OHM 2001c).

In January 2002, a TCRA for 1,2,3-TCP in groundwater was implemented at IRP-13S. The purpose of the TCRA was to initiate hydraulic containment of 1,2,3-TCP within the current boundaries of the plumes in the first and second WBZs to prevent further vertical and horizontal migration until the final remedy is installed at the site or until plume migration is stabilized. Seven extraction wells and ten groundwater monitoring wells were installed in the first and second WBZs as a part of this system. The operation and effectiveness of this system is not considered in this FS Report, but is briefly described here and in subsections below.

Soil Contamination

On the basis of data collected during the RI, soil contamination was interpreted to exist in the following two distinct areas at IRP-13S.

- **ST-72.** At ST-72, 1,2,3-TCP was the predominant soil contaminant (Figure 1-16). The lateral extent of 1,2,3-TCP in soil at ST-72 is encompassed by a roughly circular area, approximately 35 feet in diameter at 5 to 7 feet bgs. In deeper soil samples (10 to 15 feet bgs), the area of contamination extends horizontally to about 110 feet south of Building 16. The presence of 1,2,3-TCP in soil at ST-72, reported at concentrations up to 160 µg/kg, was attributed to past releases of cleaning solvents to the ground outside Building 16 (BNI 1997b).
- **MWA-18.** At MWA-18, TCE was the predominant soil contaminant (Figure 1-17). Elevated concentrations of 1,2,3-TCP were only encountered at depths consistent with groundwater transport in the first WBZ from the upgradient ST-72 source area. The lateral extent of TCE reported in soil is defined by an approximate circular area centered on the former washpad, approximately 100 feet in diameter at 1 to 7 feet bgs and at 10 to 15 feet bgs. TCE was reported at a maximum concentration of 21,000 µg/kg in shallow soil samples collected directly beneath MWA-18 (BNI 1997b).

Other VOCs reported in soil at trace concentrations included Freon 113 and several other chlorofluorocarbon (CFC) compounds, chloroform, 1,1,1-trichloroethane (TCA), toluene, and benzene. 1,2-dichloroethene (DCE), a common TCE degradation product, was also reported in soil at concentrations up to 140 µg/kg. Phenanthrene, a polynuclear aromatic hydrocarbon (PAH) compound, was reported in four soil samples at concentrations below 10 µg/kg. Mercury was the only metal reported in soil samples at concentrations exceeding background values. Mercury was reported at concentrations from 0.16 to 1.8 milligrams per kilogram (mg/kg) in soil samples collected from both source areas at ST-72 and MWA-18 (BNI 1997b).

Groundwater Contamination

On the basis of quarterly groundwater monitoring conducted from 1997 through 2001 and summarized in the 2001 Annual Groundwater Monitoring Report for Former MCAS Tustin, VOCs in groundwater originating at IRP-13S have been identified in all three WBZs (Figures 1-18, 1-19, 1-20, and 1-21) (BNI 2002b). Monitoring results indicate that the VOC plume at OU-1A commingles with the adjacent MTBE plume. Groundwater monitoring results in the shallow aquifer underlying OU-1A are briefly summarized below based on quarterly monitoring data obtained during 2001.

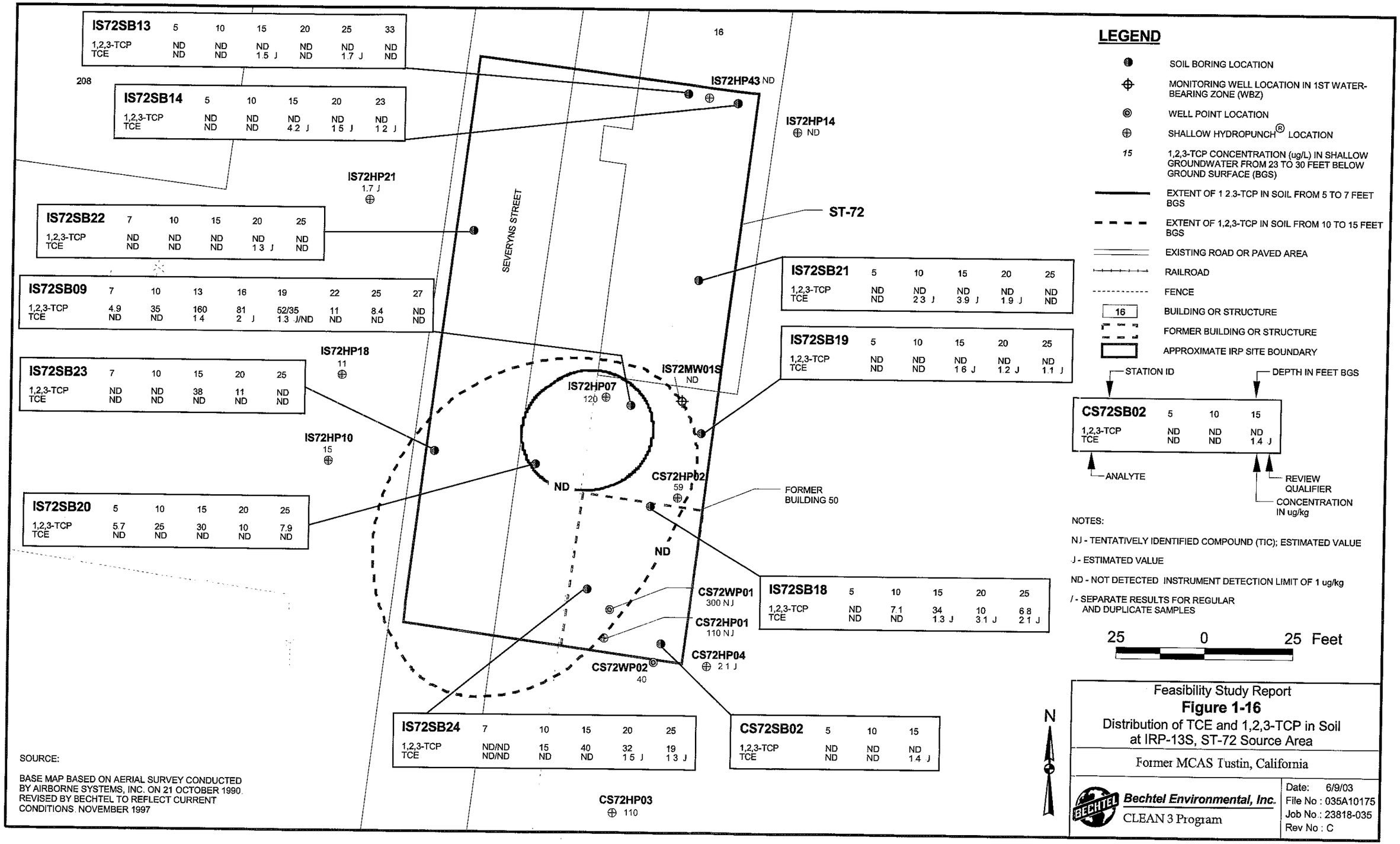
Figure 1-19 shows the lateral extent of the 1,2,3-TCP plume in the first WBZ at concentrations exceeding 1.0 microgram per liter (µg/L) based on quarterly groundwater monitoring data collected during 2001. The 1,2,3-TCP plume extends approximately 2,400 feet south-southwest from the source area at IRP-13S and is about 600 feet across at its widest point. The maximum reported concentration of 1,2,3-TCP (85 µg/L) in

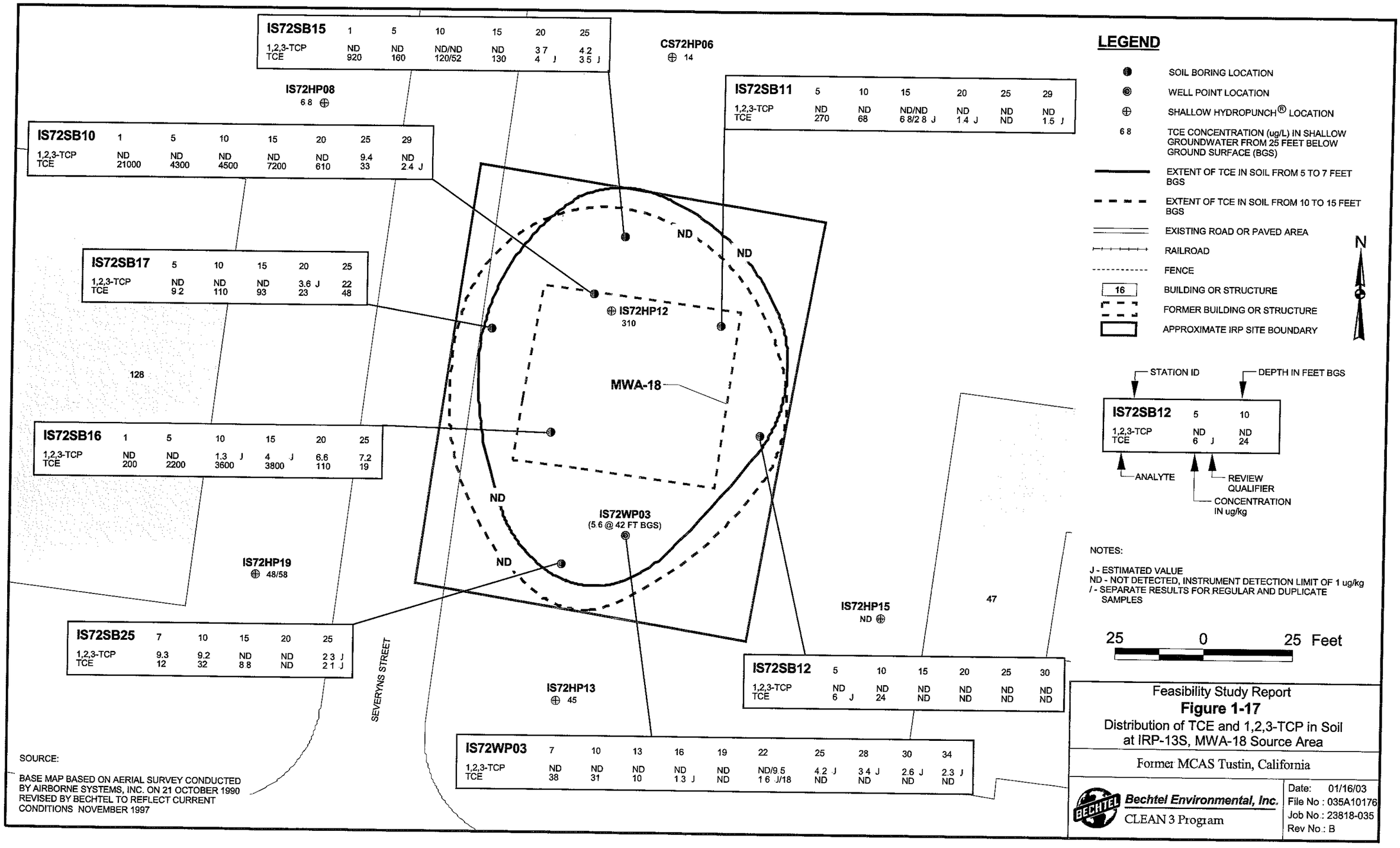
groundwater from the sand layer of the first WBZ was collected during the fall 2001 monitoring round from a well located approximately 700 feet downgradient from Building 16 (BNI 2002b). From 1997 through 2001, the extent of 1,2,3-TCP in the first WBZ has remained relatively stable based on quarterly monitoring results (BNI 2002b).

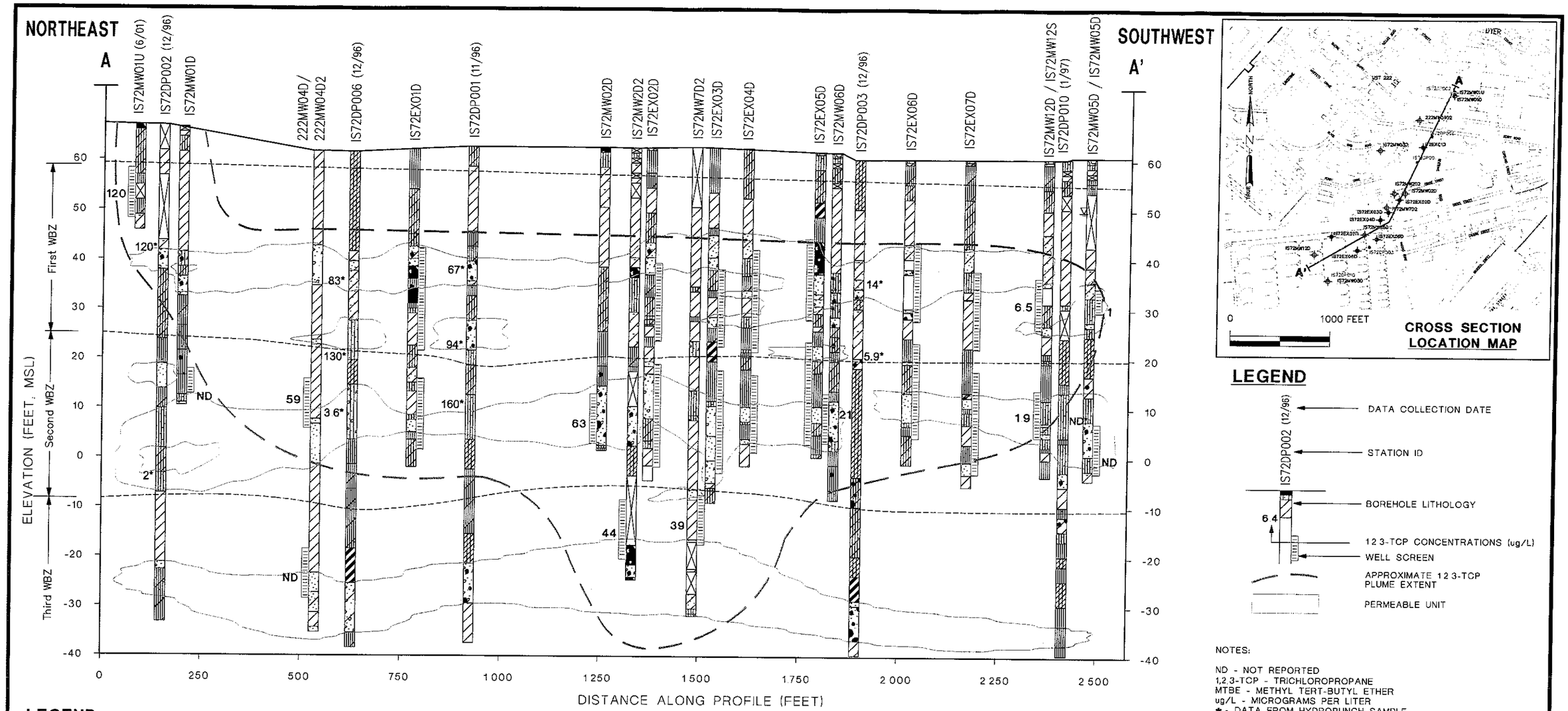
Figure 1-20 shows the lateral extent of 1,2,3-TCP in the second WBZ at concentrations exceeding 1.0 µg/L. The 1,2,3-TCP plume extends approximately 2,100 feet downgradient from the source area at ST-72 and is approximately 650 feet wide. 1,2,3-TCP in the second WBZ underlies the footprint of the 1,2,3-TCP plume in the first WBZ (BNI 1997a). The maximum reported concentration of 1,2,3-TCP in groundwater from the second WBZ (160 µg/L) was collected during late 1996 in a deep HydroPunch groundwater sample located approximately 700 feet downgradient from Building 16. From 1997 through 2001, the extent of 1,2,3-TCP in the second WBZ remained relatively stable based on monitoring results (BNI 2002b).

In the third WBZ, 1,2,3-TCP is interpreted to exist in a localized area near the intersection of Cross Street and McCord Road, approximately 1,500 feet downgradient from the source area at Building 16 (Figure 1-21). The maximum reported concentration of 1,2,3-TCP in the third WBZ (50 µg/L) was reported in a groundwater sample from well IS72MW7D2 during the spring 2001 monitoring round. TCE in groundwater originating from MWA-18 occurs with 1,2,3-TCP in the first WBZ. 1,2-DCE, a breakdown product of TCE, was also reported at trace concentrations in groundwater underlying MWA-18. Other VOCs reported in groundwater at IRP-13S include 1,1,1-TCA, chloroform, acetone, methyl ethyl ketone, CFCs, and toluene, all generally at low concentrations (BNI 1997a, 2002b). Based on RI monitoring data, hexavalent chromium in groundwater was the only metal reported at concentrations (3 to 5 µg/L) exceeding background values (BNI 1997a).

MTBE, a gasoline additive, was first identified in groundwater samples collected at IRP-13S in 1997. Based on data presented in the 2001 Annual Groundwater Monitoring Report, MTBE from adjacent Underground Storage Tank (UST) Site 222 commingles with 1,2,3-TCP in the first and second WBZs at IRP-13S (BNI 2002b). MTBE was reported at a maximum concentration of 62,000 µg/L in groundwater samples collected from wells located on the western boundary of the IRP-13S plumes in the first and second WBZs (BNI 2002b). Further fieldwork to delineate the source and extent of MTBE contamination was conducted under the Petroleum Corrective Action Program (PCAP). This work suggested that UST Site 222 is the MTBE source area. This UST is located west of IRP-13S at a former service station. Remedial activities to address the contamination originating at UST Site 222 are being managed by the DON under the PCAP and closely coordinated with activities associated with the TCRA groundwater treatment system currently operating at IRP-13S. The remedy for IRP-13S will require integration of the MTBE cleanup activities into aspects of the overall design.


IS72SB13 5 10 15 20 25 33
1,2,3-TCP ND ND ND ND ND ND
TCE ND ND 1.5 J ND 1.7 J ND
IS72SB14 5 10 15 20 23
1,2,3-TCP ND ND ND ND ND
TCE ND ND 4.2 J 1.5 J 1.2 J
IS72SB22 7 10 15 20 25
1,2,3-TCP ND ND ND ND ND
TCE ND ND ND 1.3 J ND
IS72SB09 7 10 13 16 19 22 25 27
1,2,3-TCP 4.9 35 160 81 52/35 11 8.4 ND
TCE ND ND 1.4 2 J 1.3 J/ND ND ND ND
IS72SB23 7 10 15 20 25
1,2,3-TCP ND ND 38 11 ND
TCE ND ND ND ND ND
IS72SB20 5 10 15 20 25
1,2,3-TCP 5.7 25 30 10 7.9
TCE ND ND ND ND ND
IS72SB21 5 10 15 20 25
1,2,3-TCP ND ND ND ND ND
TCE ND 2.3 J 3.9 J 1.9 J ND
IS72SB19 5 10 15 20 25
1,2,3-TCP ND ND ND ND ND
TCE ND ND 1.6 J 1.2 J 1.1 J
IS72SB18 5 10 15 20 25
1,2,3-TCP ND 7.1 34 10 6.8
TCE ND ND 1.3 J 3.1 J 2.1 J
IS72SB24 7 10 15 20 25
1,2,3-TCP ND/ND 15 40 32 19
TCE ND/ND ND ND 1.5 J 1.3 J
CS72SB02 5 10 15
1,2,3-TCP ND ND ND
TCE ND ND 1.4 J
IS72HP43 ND
IS72HP14 ND
IS72HP21 1.7 J
IS72HP18 11
IS72HP10 15
IS72HP07 120
IS72MW01S ND
CS72HP02 59
CS72WP01 300 NJ
CS72HP01 110 NJ
CS72HP04 2.1 J
CS72WP02 40
CS72HP03 110
ND
ND
ND
16
208
SEVERYNS STREET
ST-72
FORMER BUILDING 50
N
LEGEND
SOIL BORING LOCATION
MONITORING WELL LOCATION IN 1ST WATER-BEARING ZONE (WBZ)
WELL POINT LOCATION
SHALLOW HYDROPUNCH® LOCATION
15 1,2,3-TCP CONCENTRATION (ug/L) IN SHALLOW GROUNDWATER FROM 23 TO 30 FEET BELOW GROUND SURFACE (BGS)
EXTENT OF 1,2,3-TCP IN SOIL FROM 5 TO 7 FEET BGS
EXTENT OF 1,2,3-TCP IN SOIL FROM 10 TO 15 FEET BGS
EXISTING ROAD OR PAVED AREA
RAILROAD
FENCE
16 BUILDING OR STRUCTURE
FORMER BUILDING OR STRUCTURE
APPROXIMATE IRP SITE BOUNDARY
STATION ID
DEPTH IN FEET BGS
CS72SB02 5 10 15
1,2,3-TCP ND ND ND
TCE ND ND 1.4 J
ANALYTE
REVIEW QUALIFIER
CONCENTRATION IN ug/kg
NOTES:
NJ - TENTATIVELY IDENTIFIED COMPOUND (TIC); ESTIMATED VALUE
J - ESTIMATED VALUE
ND - NOT DETECTED INSTRUMENT DETECTION LIMIT OF 1 ug/kg
/ - SEPARATE RESULTS FOR REGULAR AND DUPLICATE SAMPLES
25 0 25 Feet
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON 21 OCTOBER 1990. REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS. NOVEMBER 1997
Feasibility Study Report
Figure 1-16
Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, ST-72 Source Area
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 6/9/03
File No : 035A10175
Job No : 23818-035
Rev No : C


IS72SB15 1 5 10 15 20 25
1,2,3-TCP ND ND ND/ND ND 3 7 4 2
TCE 920 160 120/52 130 4 J 3 5 J
CS72HP06
14
IS72HP08
6 8
IS72SB11 5 10 15 20 25 29
1,2,3-TCP ND ND ND/ND ND ND ND
TCE 270 68 6 8/2 8 J 1.4 J ND 1.5 J
IS72SB10 1 5 10 15 20 25 29
1,2,3-TCP ND ND ND ND ND 9.4 ND
TCE 21000 4300 4500 7200 610 33 2.4 J
IS72SB17 5 10 15 20 25
1,2,3-TCP ND ND ND 3.6 J 22
TCE 9 2 110 93 23 48
ND
ND
IS72HP12
310
MWA-18
128
IS72SB16 1 5 10 15 20 25
1,2,3-TCP ND ND 1.3 J 4 J 6.6 7.2
TCE 200 2200 3600 3800 110 19
ND
IS72WP03
(5.6 @ 42 FT BGS)
ND
IS72HP19
48/58
IS72HP15
ND
47
IS72SB25 7 10 15 20 25
1,2,3-TCP 9.3 9.2 ND ND 2 3 J
TCE 12 32 8 8 ND 2 1 J
SEVERYNS STREET
IS72SB12 5 10 15 20 25 30
1,2,3-TCP ND ND ND ND ND ND
TCE 6 J 24 ND ND ND ND
IS72HP13
45
IS72WP03 7 10 13 16 19 22 25 28 30 34
1,2,3-TCP ND ND ND ND ND ND/9.5 4.2 J 3 4 J 2.6 J 2.3 J
TCE 38 31 10 1 3 J ND 1 6 J/18 ND ND ND ND
LEGEND
SOIL BORING LOCATION
WELL POINT LOCATION
SHALLOW HYDROPUNCH® LOCATION
6 8 TCE CONCENTRATION (ug/L) IN SHALLOW GROUNDWATER FROM 25 FEET BELOW GROUND SURFACE (BGS)
EXTENT OF TCE IN SOIL FROM 5 TO 7 FEET BGS
EXTENT OF TCE IN SOIL FROM 10 TO 15 FEET BGS
EXISTING ROAD OR PAVED AREA
RAILROAD
FENCE
16 BUILDING OR STRUCTURE
FORMER BUILDING OR STRUCTURE
APPROXIMATE IRP SITE BOUNDARY
N
STATION ID
DEPTH IN FEET BGS
IS72SB12 5 10
1,2,3-TCP ND ND
TCE 6 J 24
ANALYTE
REVIEW QUALIFIER
CONCENTRATION IN ug/kg
NOTES:
J - ESTIMATED VALUE
ND - NOT DETECTED, INSTRUMENT DETECTION LIMIT OF 1 ug/kg
/ - SEPARATE RESULTS FOR REGULAR AND DUPLICATE SAMPLES
25 0 25 Feet
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON 21 OCTOBER 1990 REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS NOVEMBER 1997
Feasibility Study Report
Figure 1-17
Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, MWA-18 Source Area
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 01/16/03
File No : 035A10176
Job No : 23818-035
Rev No.: B



NOTES:

ND - NOT REPORTED
1,2,3-TCP - TRICHLOROPROPANE
MTBE - METHYL TERT-BUTYL ETHER
ug/L - MICROGRAMS PER LITER
* - DATA FROM HYDROPUNCH SAMPLE

1,2,3-TCP AND MTBE CONCENTRATIONS FROM WINTER 2001 GROUNDWATER MONITORING ROUND UNLESS NOTED OTHERWISE

Feasibility Study Report

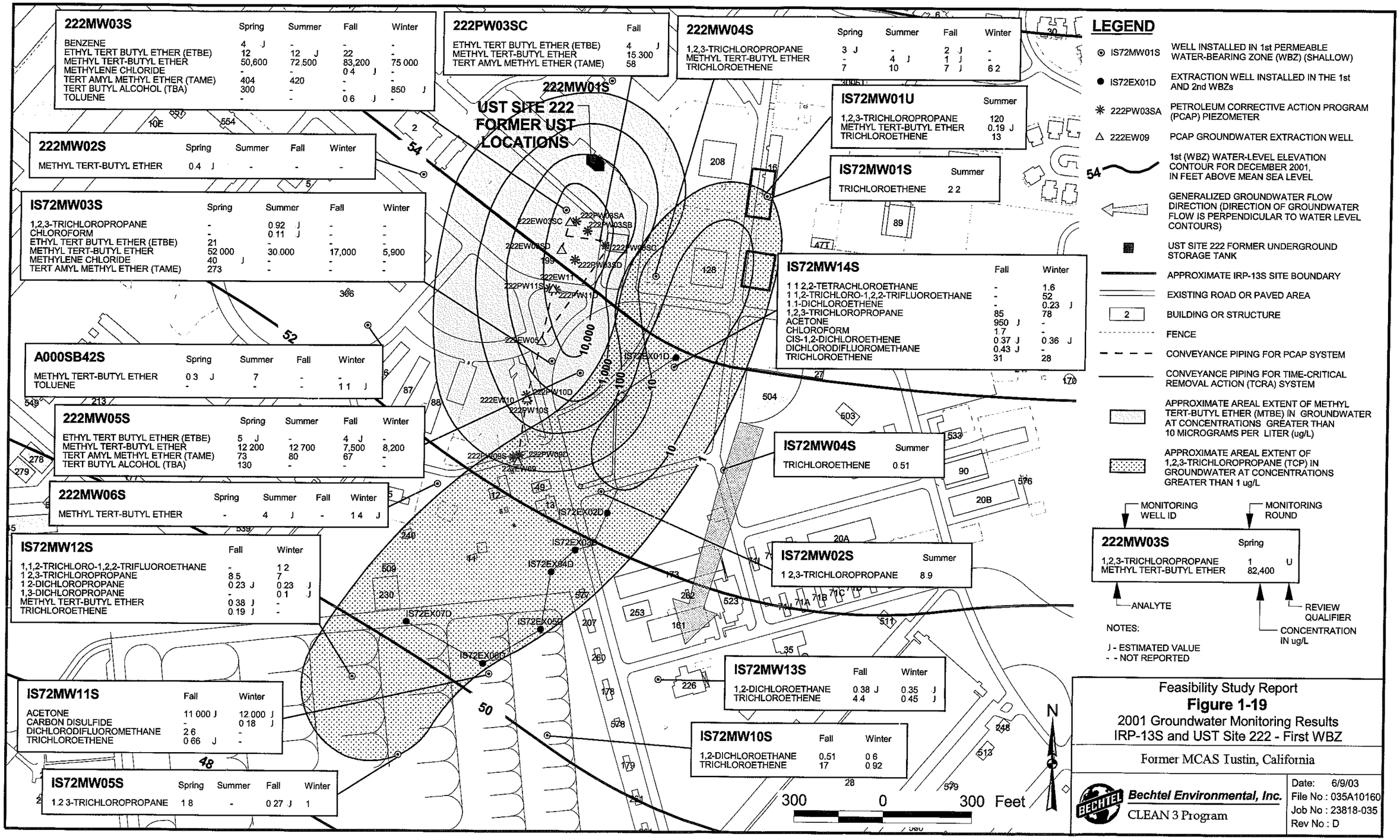
Figure 1-18

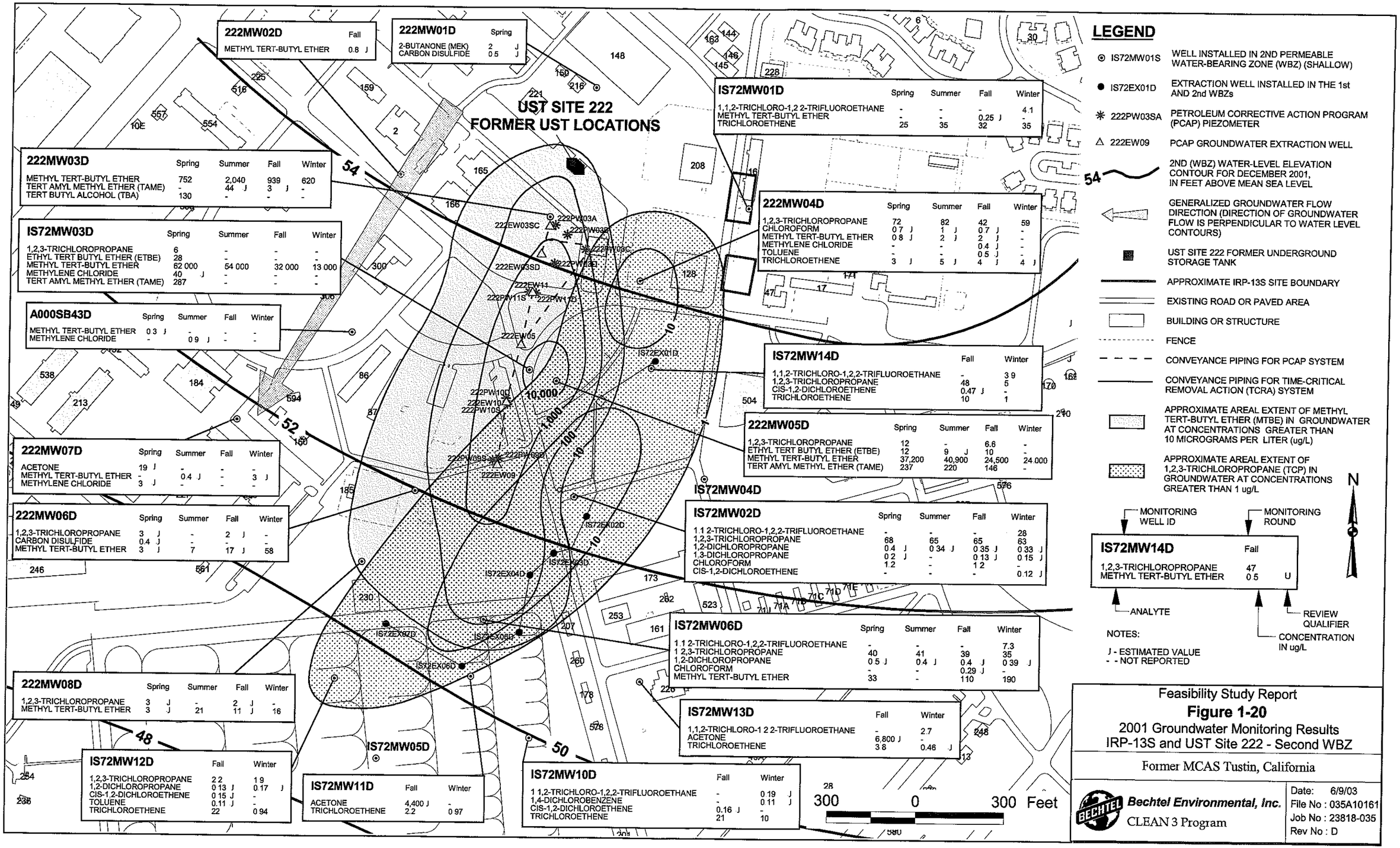
Vertical Extent of 1,2,3-TCP in Groundwater at IRP-13S and UST Site 222

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/23/02
File No: 035X10190
Job No: 23818-035
Rev No: C


222MW03S
Spring Summer Fall Winter
BENZENE 4 J - - -
ETHYL TERT BUTYL ETHER (ETBE) 12 12 J 22 -
METHYL TERT-BUTYL ETHER 50,600 72,500 83,200 75 000
METHYLENE CHLORIDE - - 0 4 J -
TERT AMYL METHYL ETHER (TAME) 404 420 - -
TERT BUTYL ALCOHOL (TBA) 300 - - 850 J
TOLUENE - - 0 6 J -
222PW03SC
Fall
ETHYL TERT BUTYL ETHER (ETBE) 4 J
METHYL TERT-BUTYL ETHER 15 300
TERT AMYL METHYL ETHER (TAME) 58
222MW04S
Spring Summer Fall Winter
1,2,3-TRICHLOROPROPANE 3 J - 2 J -
METHYL TERT-BUTYL ETHER - 4 J 1 J -
TRICHLOROETHENE 7 10 7 J 6 2
222MW02S
Spring Summer Fall Winter
METHYL TERT-BUTYL ETHER 0.4 J - - -
IS72MW01U
Summer
1,2,3-TRICHLOROPROPANE 120
METHYL TERT-BUTYL ETHER 0.19 J
TRICHLOROETHENE 13
IS72MW01S
Summer
TRICHLOROETHENE 2 2
IS72MW03S
Spring Summer Fall Winter
1,2,3-TRICHLOROPROPANE - 0 92 J - -
CHLOROFORM - 0 11 J - -
ETHYL TERT BUTYL ETHER (ETBE) 21 - - -
METHYL TERT-BUTYL ETHER 52 000 30.000 17,000 5,900
METHYLENE CHLORIDE 40 J - - -
TERT AMYL METHYL ETHER (TAME) 273 - - -
IS72MW14S
Fall Winter
1 1 2,2-TETRACHLOROETHANE - 1.6
1 1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE - 52
1 1-DICHLOROETHENE - 0.23 J
1,2,3-TRICHLOROPROPANE 85 78
ACETONE 950 J -
CHLOROFORM 1.7 -
CIS-1,2-DICHLOROETHENE 0.37 J 0.36 J
DICHLORODIFLUOROMETHANE 0.43 J -
TRICHLOROETHENE 31 28
A000SB42S
Spring Summer Fall Winter
METHYL TERT-BUTYL ETHER 0 3 J 7 - -
TOLUENE - - - 1 1 J
222MW05S
Spring Summer Fall Winter
ETHYL TERT BUTYL ETHER (ETBE) 5 J - 4 J -
METHYL TERT-BUTYL ETHER 12 200 12 700 7,500 8,200
TERT AMYL METHYL ETHER (TAME) 73 80 67 -
TERT BUTYL ALCOHOL (TBA) 130 - - -
IS72MW04S
Summer
TRICHLOROETHENE 0.51
222MW06S
Spring Summer Fall Winter
METHYL TERT-BUTYL ETHER - 4 J - 1 4 J
IS72MW12S
Fall Winter
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE - 1 2
1 2,3-TRICHLOROPROPANE 8 5 7
1 2-DICHLOROPROPANE 0 23 J 0.23 J
1,3-DICHLOROPROPANE - 0 1 J
METHYL TERT-BUTYL ETHER 0 38 J -
TRICHLOROETHENE 0.19 J -
IS72MW02S
Summer
1 2,3-TRICHLOROPROPANE 8 9
IS72MW13S
Fall Winter
1,2-DICHLOROETHANE 0.38 J 0.35 J
TRICHLOROETHENE 4.4 0 45 J
IS72MW11S
Fall Winter
ACETONE 11 000 J 12.000 J
CARBON DISULFIDE - 0 18 J
DICHLORODIFLUOROMETHANE 2 6 -
TRICHLOROETHENE 0 66 J -
IS72MW10S
Fall Winter
1,2-DICHLOROETHANE 0.51 0 6
TRICHLOROETHENE 17 0 92
IS72MW05S
Spring Summer Fall Winter
1 2 3-TRICHLOROPROPANE 1 8 - 0 27 J 1
UST SITE 222
FORMER UST
LOCATIONS
222MW01S
222EW03SC
222PW03SA
222PW03SB
222EW03SD
222PW03SC
222PW03SD
222EW11
222PW11S
222PW11D
222EW05
IS72EX01D
222EW10
222PW10D
222PW10S
222PW09S
222PW09D
222EW09
IS72EX02D
IS72EX03D
IS72EX04D
IS72EX07D
IS72EX05D
IS72EX06D
10,000
1,000
100
10
1
54
52
50
48
N
300 0 300 Feet
LEGEND
IS72MW01S WELL INSTALLED IN 1st PERMEABLE WATER-BEARING ZONE (WBZ) (SHALLOW)
IS72EX01D EXTRACTION WELL INSTALLED IN THE 1st AND 2nd WBZs
222PW03SA PETROLEUM CORRECTIVE ACTION PROGRAM (PCAP) PIEZOMETER
222EW09 PCAP GROUNDWATER EXTRACTION WELL
1st (WBZ) WATER-LEVEL ELEVATION CONTOUR FOR DECEMBER 2001, IN FEET ABOVE MEAN SEA LEVEL
GENERALIZED GROUNDWATER FLOW DIRECTION (DIRECTION OF GROUNDWATER FLOW IS PERPENDICULAR TO WATER LEVEL CONTOURS)
UST SITE 222 FORMER UNDERGROUND STORAGE TANK
APPROXIMATE IRP-13S SITE BOUNDARY
EXISTING ROAD OR PAVED AREA
BUILDING OR STRUCTURE
FENCE
CONVEYANCE PIPING FOR PCAP SYSTEM
CONVEYANCE PIPING FOR TIME-CRITICAL REMOVAL ACTION (TCRA) SYSTEM
APPROXIMATE AREAL EXTENT OF METHYL TERT-BUTYL ETHER (MTBE) IN GROUNDWATER AT CONCENTRATIONS GREATER THAN 10 MICROGRAMS PER LITER (ug/L)
APPROXIMATE AREAL EXTENT OF 1,2,3-TRICHLOROPROPANE (TCP) IN GROUNDWATER AT CONCENTRATIONS GREATER THAN 1 ug/L
MONITORING WELL ID
MONITORING ROUND
222MW03S Spring
1,2,3-TRICHLOROPROPANE 1 U
METHYL TERT-BUTYL ETHER 82,400
ANALYTE
REVIEW QUALIFIER
CONCENTRATION IN ug/L
NOTES:
J - ESTIMATED VALUE
- - NOT REPORTED
Feasibility Study Report
Figure 1-19
2001 Groundwater Monitoring Results
IRP-13S and UST Site 222 - First WBZ
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 6/9/03
File No : 035A10160
Job No : 23818-035
Rev No : D

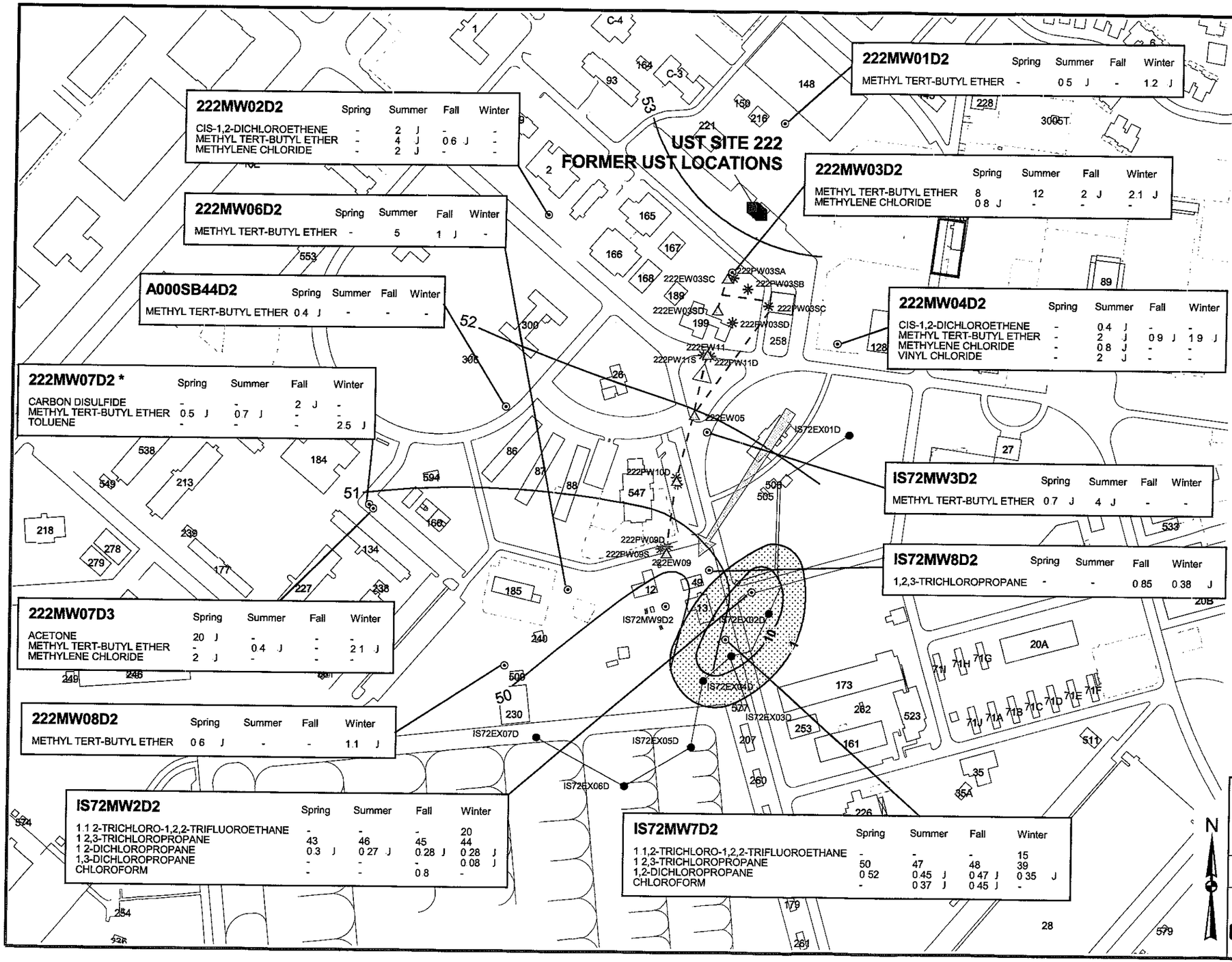


Feasibility Study Report
Figure 1-20
2001 Groundwater Monitoring Results
IRP-13S and UST Site 222 - Second WBZ

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 6/9/03
File No : 035A10161
Job No : 23818-035
Rev No : D



222MW01D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	-	0 5 J	-	1 2 J

222MW02D2	Spring	Summer	Fall	Winter
CIS-1,2-DICHLOROETHENE	-	2 J	-	-
METHYL TERT-BUTYL ETHER	-	4 J	0 6 J	-
METHYLENE CHLORIDE	-	2 J	-	-

222MW03D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	8	12	2 J	2.1 J
METHYLENE CHLORIDE	0 8 J	-	-	-

222MW06D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	-	5	1 J	-

A000SB44D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	0 4 J	-	-	-

222MW04D2	Spring	Summer	Fall	Winter
CIS-1,2-DICHLOROETHENE	-	0.4 J	-	-
METHYL TERT-BUTYL ETHER	-	2 J	0 9 J	1 9 J
METHYLENE CHLORIDE	-	0 8 J	-	-
VINYL CHLORIDE	-	2 J	-	-

222MW07D2 *	Spring	Summer	Fall	Winter
CARBON DISULFIDE	-	-	2 J	-
METHYL TERT-BUTYL ETHER	0 5 J	0 7 J	-	-
TOLUENE	-	-	-	2 5 J

IS72MW3D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	0 7 J	4 J	-	-

IS72MW8D2	Spring	Summer	Fall	Winter
1,2,3-TRICHLOROPROPANE	-	-	0 85	0 38 J

222MW07D3	Spring	Summer	Fall	Winter
ACETONE	20 J	-	-	-
METHYL TERT-BUTYL ETHER	-	0 4 J	-	2 1 J
METHYLENE CHLORIDE	2 J	-	-	-

222MW08D2	Spring	Summer	Fall	Winter
METHYL TERT-BUTYL ETHER	0 6 J	-	-	1.1 J

IS72MW2D2	Spring	Summer	Fall	Winter
1 1 2-TRICHLORO-1,2,2-TRIFLUOROETHANE	-	-	-	20
1 2,3-TRICHLOROPROPANE	43	46	45	44
1 2-DICHLOROPROPANE	0.3 J	0 27 J	0.28 J	0 28 J
1,3-DICHLOROPROPANE	-	-	-	0 08 J
CHLOROFORM	-	-	0 8	-

IS72MW7D2	Spring	Summer	Fall	Winter
1 1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	-	-	-	15
1 2,3-TRICHLOROPROPANE	50	47	48	39
1,2-DICHLOROPROPANE	0 52	0 45 J	0 47 J	0 35 J
CHLOROFORM	-	0 37 J	0 45 J	-

LEGEND

- IS72MW2D2 — WELL INSTALLED IN 3rd PERMEABLE WATER-BEARING ZONE (WBZ) (SHALLOW)
- IS72EX01D — EXTRACTION WELL INSTALLED IN THE 1st AND 2nd WBZs
- 222PW03A — PETROLEUM CORRECTIVE ACTION PROGRAM (PCAP) PIEZOMETER
- 222EW09 — PCAP GROUNDWATER EXTRACTION WELL INSTALLED IN THE 1ST OR 2ND WBZ
- 54 — 3rd WBZ WATER-LEVEL ELEVATION CONTOUR FOR DECEMBER 2001, IN FEET ABOVE MEAN SEA LEVEL
- GENERALIZED GROUNDWATER FLOW DIRECTION (DIRECTION OF GROUNDWATER FLOW IS PERPENDICULAR TO WATER LEVEL CONTOURS)
- UST SITE 222 FORMER UNDERGROUND STORAGE TANKS
- APPROXIMATE IRP-13S SITE BOUNDARY
- EXISTING ROAD OR PAVED AREA
- BUILDING OR STRUCTURE
- FENCE
- CONVEYANCE PIPING FOR PCAP SYSTEM
- CONVEYANCE PIPING FOR TIME-CRITICAL REMOVAL ACTION (TCRA) SYSTEM
- APPROXIMATE AREAL EXTENT OF 1,2,3-TRICHLOROPROPANE (TCP) IN GROUNDWATER AT CONCENTRATIONS GREATER THAN 1 ug/L

MONITORING WELL ID — MONITORING ROUND

IS72MW3D2	Summer
METHYL TERT-BUTYL ETHER	4 U

ANALYTE — REVIEW QUALIFIER — CONCENTRATION IN ug/L

NOTES:

J - ESTIMATED VALUE
- - NOT REPORTED
*- NOT USED FOR CONTOURING PURPOSES

300 0 300 Feet

Feasibility Study Report

Figure 1-21

2001 Groundwater Monitoring Results
IRP-13S and UST Site 222 - Third WBZ

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 7/31/03
File No : 035A10289
Job No : 23818-035
Rev No : D

In a 09 March 2001 letter to the BCT, the DON indicated that MTBE contamination from UST Site 222 would be addressed under the PCAP, a separate compliance program, and a TCRA would be implemented at IRP-13S to address 1,2,3-TCP in groundwater.

1.6.3 Time-Critical Removal Action at IRP-13S

Interim removal of groundwater under a TCRA system installed at IRP-13S began in January 2002. The purpose of the TCRA system was to initiate hydraulic containment of groundwater contaminated with 1,2,3-TCP within present plume boundaries in the first and second WBZs to prevent further vertical and/or horizontal migration until the final remedy is implemented or plume migration is stabilized. Bechtel National, Inc. (BNI), and other contractors operating the TCRA system worked closely with Shaw Environmental, Inc., who is operating a treatment system for remediation of groundwater contaminated with MTBE from UST Site 222 under the PCAP. Close coordination is necessary to ensure that groundwater extraction is balanced and not resulting in crossgradient migration and further commingling of the two plumes. Changes in water level elevations are also monitored over time to evaluate the impact of pumping on shallow groundwater in the vicinity of the commingled plumes.

A total of seven extraction and ten groundwater monitoring wells were installed in both the first and second WBZs. The system was designed to extract groundwater at approximately 35 gpm. Extracted groundwater is pumped to the treatment system via buried and aboveground pipelines and is treated using a dual-stage granular activated carbon (GAC) adsorption system. Influent water is prefiltered using bag filters to remove entrained sediments and other materials that could cause fouling, prior to being pumped through two (in-series) 2,000-pound GAC filters. Clean, treated water is then discharged to a nearby storm drain located at the corner of Cross Street and McCord Road. Clean effluent water is sampled weekly to ensure compliance with the substantive provisions of National Pollutant Discharge Elimination System (NPDES) Permit No. CAG918001.

Results from quarterly groundwater monitoring conducted during summer 2002 indicate the TCRA system is effectively containing the VOC plumes (PTES 2002). Components (e.g., extraction wells) may be incorporated into the final remedy depending on the compatibility of the components with the selected remedy. Several of the alternatives evaluated in this FS are not compatible with the TCRA system (i.e., Alternative 1, no action, Alternative 5, permeable reaction wall, and Alternative 2, monitored natural attenuation, do not require groundwater extraction as part of the remedy and would not require compatibility with the TCRA system). Therefore, the TCRA system is not included in the evaluation of the alternatives. If components of the TCRA system were incorporated into the final remedy, they would likely enhance the effectiveness of the remedy.

1.6.4 Future Land Use at IRP-13S

The IRP-13S source area is situated on land identified in the SP/RP as Parcel No. 24, which has been designated by the city of Tustin for residential redevelopment

(The Planning Center 1998) (Figure 1-5). The groundwater plumes originating at IRP-13S extend downgradient from the source area under several other redevelopment parcels. These downgradient parcels and their respective reuse designations are as follows (The Planning Center 1996):

Parcel	Redevelopment Plan
1A	Learning Village
2	Community Park
18,19	Commercial Business
22	Community Park

In addition, much of the IRP-13S plume in the first WBZ lies directly under the right-of-way for the planned extension of Armstrong Avenue, Valencia Loop Road, and Severyns Street. A number of below-grade utility improvements are anticipated to be constructed along this corridor, including a sanitary sewer; storm sewer; supply lines for domestic water, gas, and electricity; and telephone, cable television, and other telecommunications infrastructure. The LRA has initiated discussions with the DON regarding the roadway extension and proposed methods to prevent any negative impacts to the existing plume conditions at OU-1A during construction activities.

1.7 VOC DISTRIBUTION AND TRANSPORT

Data obtained during the RI form the basis for the conceptual model of subsurface VOC distribution and transport at OU-1A and have been used to support a numerical model that simulates long-term VOC migration in the subsurface without active remediation. Conceptual and numerical models of site-related soil and groundwater contamination are presented in the following subsections. Supporting information was taken primarily from the RI Report (BNI 1997a); the Limited Deep HydroPunch Investigation at IRP-13S (BNI 1999c); and the 1997, 1998, and 2001 Annual Groundwater Monitoring Reports (BNI 1998b, 1999d, 2002b).

Uncontrolled releases of VOCs (mainly 1,2,3-TCP and TCE), associated with activities at two sites, MWA-18 and ST-72, migrated through the soil to groundwater in the first WBZ. Over the years, VOC contaminants have migrated horizontally and vertically via hydraulic connections between the first and second WBZs. VOCs have also migrated from the second to the third WBZ in a localized hydraulic connection approximately 1,500 feet downgradient from where the uncontrolled releases of VOCs occurred. Figure 1-18 presents a graphical representation of the nature and extent of groundwater contamination at IRP-13S.

1.7.1 Subsurface VOC Contamination

TCE and 1,2,3-TCP are the predominant VOCs reported in groundwater and soil at IRP-13S (BNI 1997a). VOCs are typically reported at very low concentrations in vadose zone soils at the site. Results from previous soil sampling for VOCs in the vadose zone are presented in Section 1.6.2 (Figures 1-16 and 1-17). Maximum reported VOC

concentrations were identified below the top of the water table in a relatively thick, low permeability, silty clay layer, referred to as the upper confining layer of the first WBZ. This silty clay layer retards vertical contaminant migration in the subsurface. It is approximately 20 feet thick and lies immediately above a more permeable silty sand layer in the first WBZ at IRP-13S.

Relatively elevated contaminant concentrations remain bound in the fine-grained soil of the upper confining layer of the first WBZ due to the tendency of clays to adsorb chlorinated VOCs. The presence of residual sorbed and dissolved VOCs in the upper clay layer provides a potential long-term source of contamination to the deeper portions of the shallow aquifer system (BNI 1997a).

Net groundwater infiltration rates at Former MCAS Tustin are generally low, typically less than 0.5 in/yr. Therefore, there is no large driving force to promote the downward migration of VOCs in the shallow aquifer system. However, infiltration rates on the order of 10 in/yr in localized areas at IRP-13S may have been responsible for the vertical migration of TCE and 1,2,3-TCP to maximum depths of approximately 60 feet bgs (BNI 1997a). A potential explanation for higher localized groundwater infiltration rates is the former routine disposal of wash water outside of Building 16 at ST-72 and on the washpad at MWA-18.

It was recognized that groundwater remediation would be much more difficult if TCE and 1,2,3-TCP were present in the subsurface as dense nonaqueous-phase liquids (DNAPLs). Site characterization data were, therefore, evaluated to assess the potential for the existence of DNAPLs at the site. Data from the site were compared against criteria developed by U.S. EPA as generic DNAPL indicators in soil and groundwater (U.S. EPA 1991) including:

- concentrations of potential DNAPL chemicals in groundwater exceeding 1 percent of pure-phase solubility; the aqueous solubilities of pure-phase TCE and 1,2,3-TCP were estimated at 1,100 mg/L and 4,000 mg/L, respectively (BNI 1997a);
- concentrations of potential DNAPL chemicals in soils exceeding 10,000 mg/kg;
- concentrations of potential DNAPL chemicals in groundwater calculated from water/soil partitioning relationships to be greater than the pure-phase or effective solubility;
- concentrations of potential DNAPL chemicals increasing with depth in a pattern that cannot be explained by advective transport;
- concentrations of potential DNAPL chemicals increasing up the hydraulic gradient from the contaminant release area;
- presence of dissolved DNAPL chemicals in groundwater that are older than potential contaminant releases; and
- erratic patterns of dissolved concentrations of potential DNAPL chemicals in groundwater.

A review of data presented in the RI Report indicates that TCE and 1,2,3-TCP do not exhibit any of the DNAPL indicators described above (BNI 1997a). Rather, site data support a general conclusion that these contaminants are not present as separate DNAPL phases in the subsurface. Both chemicals are either sorbed to the soil matrix (in both the vadose zone and saturated zone) or are dissolved in groundwater at and downgradient from the site.

In summary, the conceptual model developed during the RI for IRP-13S suggests that VOC contamination originating at or near the surface entered groundwater through the vadose zone in dissolved form. The major releases of VOCs at IRP-13S occurred more than 10 years ago and were apparently related to the washing of small generators and other field equipment at MWA-18 and floor cleaning activities at ST-72. Much of the contaminant mass remaining in the subsurface has been retained in the upper confining layer of the first WBZ, although dissolved VOCs have migrated vertically into the sand layer of the first WBZ as well as into the second WBZ. Other than one localized area downgradient of IRP-13S, there is no evidence suggesting a pathway for the contaminant plumes at Former MCAS Tustin to migrate into the third WBZ or into the deeper regional aquifer (BNI 1997a, 1999c). This conceptual model of the VOC contamination pattern at OU-1A underlies the development and analysis of remedial alternatives presented in subsequent sections of this FS Report.

1.7.2 Long-Term VOC Fate and Transport

As part of the RI, a numerical modeling study was completed to evaluate the long-term fate and transport of site-related VOCs in vadose zone soils as well as in the first two WBZs at and downgradient of IRP-13S. The primary transport mechanisms considered in this analysis were the leaching of VOCs into groundwater from vadose zone soils and the subsequent advection, dispersion, and adsorption of these VOCs within the shallow aquifer system. Groundwater modeling simulations were based on the conservative assumption that TCE and 1,2,3-TCP would not undergo any biodegradation or chemical transformation in the subsurface. This is consistent with data from the RI, which did not indicate the presence of significant concentrations of VOC degradation products in groundwater (BNI 1997a).

A two-step fate and transport evaluation was completed.

1. A vadose zone transport model (VLEACH) was used to estimate the potential for VOCs currently found in unsaturated soil at two source areas to impact groundwater in the future.
2. A groundwater transport model (MODFLOW/MT3D) was used to evaluate the long-term migration of VOCs downgradient of IRP-13S.

Details of this analysis are presented in the RI Report (BNI 1997a).

The VLEACH model constructed for IRP-13S was used to evaluate adsorption, dissolution, and volatilization of contaminants within the vadose zone. Time-varying rates of VOC migration to the water table were calculated. Results of VLEACH

analysis indicated that VOC leaching from vadose zone soils could result in elevated concentrations of TCE (at approximately 200 µg/L) and 1,2,3-TCP (at approximately 1 µg/L) in the sand layer of the first WBZ over time. The leachate TCE concentrations were considered significant compared to existing groundwater quality at this IRP site. It was concluded that TCE in vadose zone soil at MWA-18 might act as a continuing source of future groundwater contamination. For this reason, the output from the VLEACH analysis was included as a source term in the fate and transport modeling of the IRP-13S plumes (BNI 1997a).

Upon completion of the VLEACH modeling, the MODFLOW and MT3D computer codes were used to evaluate the time-dependent migration potential of the VOC plumes originating at IRP-13S. Results were presented in the RI Report (BNI 1997a). Additional model sensitivity analyses were completed after the RI Report was issued (BNI 1998a). It is important to note that one factor related to the model assumptions resulted in a conservative estimate for plume migration. The model assumed that no biodegradation occurred that would have acted to attenuate the plumes, so that by setting this parameter to zero, the plume was allowed to migrate farther downgradient, thereby producing a conservative estimate of migration over the time evaluated in the model analysis.

The baseline analysis of VOC fate and transport assumed that engineered remedial alternatives would not be implemented to address stationwide groundwater contamination at Former MCAS Tustin. With this assumption, the groundwater modeling showed that the OU-1A plumes have high migration potential. The inputs for the model were conservative (i.e., no biodegradation) to allow risk managers to evaluate future conditions considering maximum VOC concentrations and plume dimensions. Modeling predictions for 100 years indicated that existing groundwater contamination at and downgradient of IRP-13S would remain at elevated concentrations, potentially expanding to cover areas much larger than the existing plumes (BNI 1997a). After several decades, some of these plumes would potentially reach Barranca Channel, the surface drainage located on the southern boundary of the station.

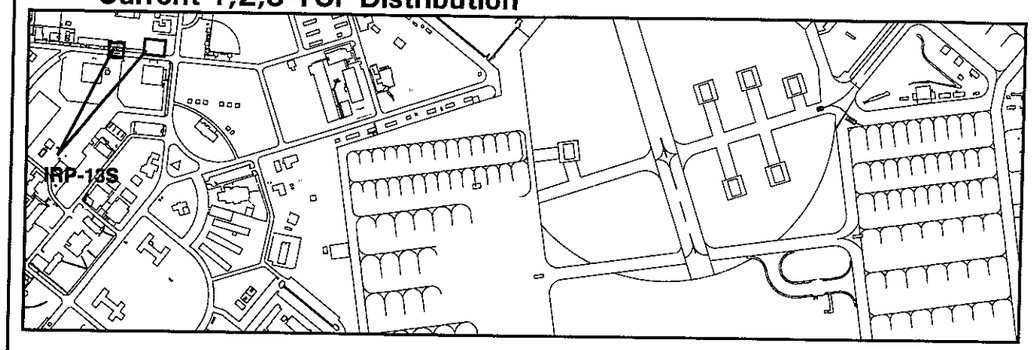
Representative outputs from the baseline groundwater modeling simulations are shown on Figures 1-22 and 1-23. Further details are provided in the RI Report (BNI 1997a). Key findings and predictions from the groundwater fate and transport analysis are as follows.

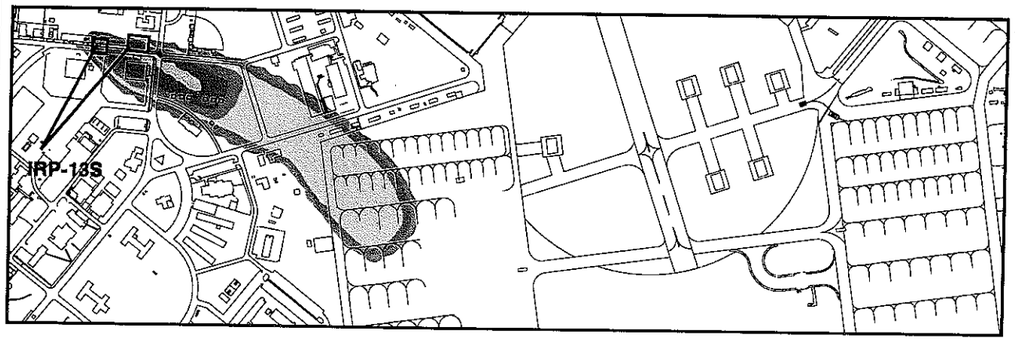
- At IRP-13S, TCE and 1,2,3-TCP within the upper confining layer of the first WBZ is predicted to be essentially stationary due to the low hydraulic conductivity of the silty clay. Over 30 years, small reductions in maximum 1,2,3-TCP concentrations are expected in this layer due to dispersion (Figures 1-22 and 1-23). Downgradient of the main body of the OU-1A plume, the model predicts low 1,2,3-TCP concentrations (on the order of 1 µg/L to 5 µg/L) caused by molecular diffusion into the clay from the sand layer of the first WBZ.
- TCE contamination within the upper confining layer at IRP-13S may increase significantly over the next 30 years due to leaching from vadose zone soils in

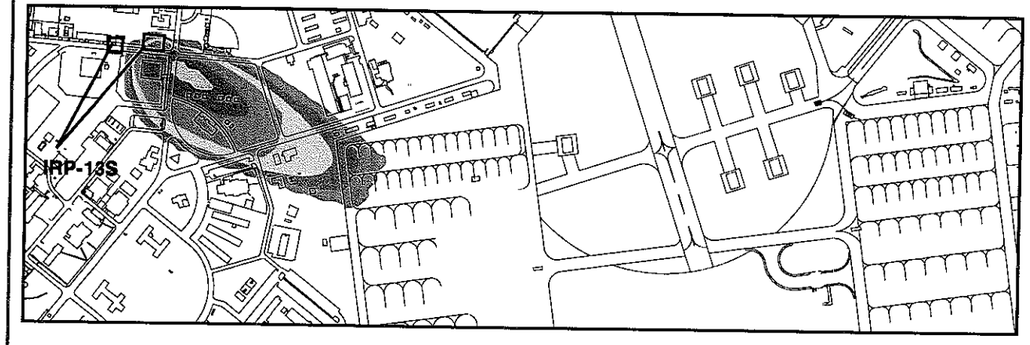
the vicinity of MWA-18. The maximum TCE concentration in the upper clay layer (2,700 µg/L) is predicted to occur in approximately 30 years.

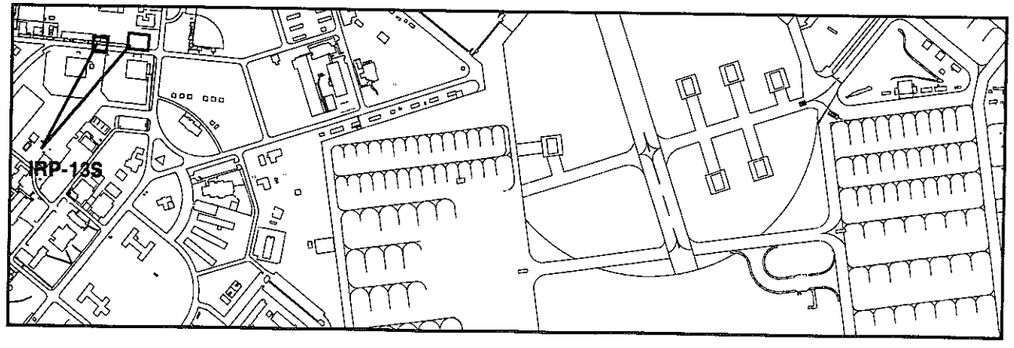
- Over the next 30 years, the 1,2,3-TCP plume originating at IRP-13S may travel an additional 2,900 feet downgradient in the sand layer of the first WBZ (Figures 1-22 and 1-23). At approximately 100 feet/year, the 1,2,3-TCP migration rate exceeds that of TCE because the former contaminant does not adsorb as readily to aquifer materials. The maximum 1,2,3-TCP concentrations predicted after 30 years in this layer range from 20 µg/L to 50 µg/L. There appears to be little migration of 1,2,3-TCP from the upper clay layer into the sand layer of the first WBZ, based on the low concentrations predicted in the sand below the IRP-13S source area after 30 years. In about 50 years, the 1,2,3-TCP plume in the sand layer of the first WBZ may reach Barranca Channel at a concentration of 0.2 µg/L, attaining a maximum of approximately 4 µg/L in 90 years (BNI 1997a).
- The TCE plume at IRP-13S is predicted to travel approximately 2,000 feet in the sand layer of the first WBZ over a period of 30 years. The maximum TCE concentrations after 30 years may also be on the order of 20 µg/L to 50 µg/L. Although the center of the TCE plume is predicted to migrate downgradient of the IRP-13S source area, a persistent plume tail may be observed in the sand layer of the first WBZ due to continuous leaching of contaminants from the upper confining layer and the vadose zone. The TCE plume originating at IRP-13S may reach Barranca Channel at a concentration of approximately 1 µg/L in about 100 years.
- At IRP-13S, the downgradient edge of 1,2,3-TCP in the lower confining layer of the first WBZ is predicted to migrate approximately 900 feet over 30 years (Figure 1-23). However, similar to the prediction for the upper clay, the 1,2,3-TCP distribution in the core of the affected lower clay layer may change little over time.
- Trace TCE concentrations are predicted in the lower confining layer at IRP-13S, on the order of 3 µg/L, caused by molecular diffusion from the overlying sand layer of the first WBZ. However, in general, the model predicts very limited TCE contamination in the lower clay at IRP-13S.
- The 1,2,3-TCP plume in the sand layer of the second WBZ is predicted to travel approximately 3,200 feet downgradient from IRP-13S over a period of 30 years (Figure 1-23). The maximum 1,2,3-TCP concentrations predicted in this layer after 30 years are on the order of 20 µg/L to 50 µg/L. The leading edge of the 1,2,3-TCP plume in the second WBZ is projected to pass underneath the station boundary in about 40 years. Figure 1-21 shows that the center of the plume in the second WBZ sand layer has already moved downgradient of the IRP-13S source area. The plume is predicted to continue migrating in this direction, as illustrated on Figure 1-23, with the plume core predicted to reach Barranca Channel at a maximum 1,2,3-TCP concentration of 13 µg/L in about 70 years.

Current 1,2,3-TCP Distribution

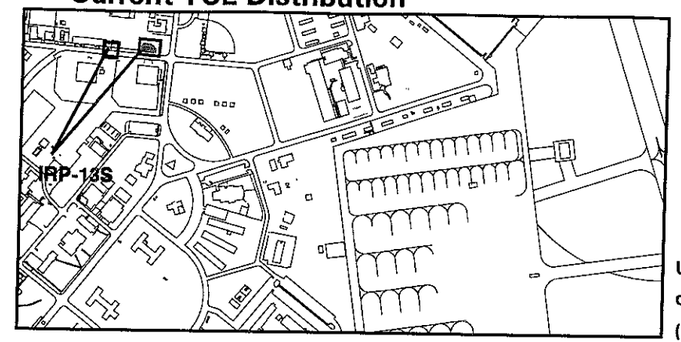




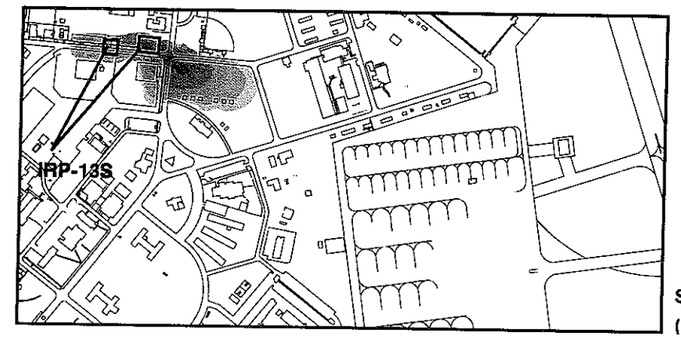




Current TCE Distribution



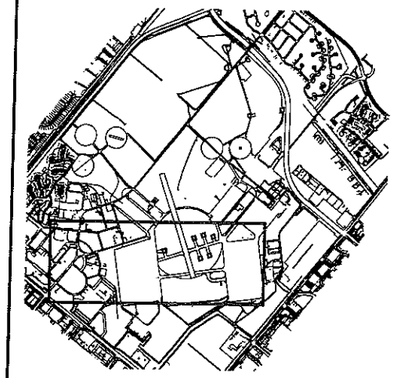
Upper Confining Layer of 1st WBZ (Model Layer 1)



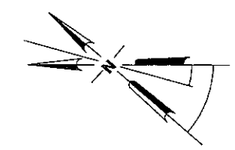
Sand Layer of 1st WBZ (Model Layer 2)

Lower Confining Layer of 1st WBZ (Model Layer 3)

Sand Layer of 2nd WBZ (Model Layer 4)



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report

Figure 1-22

Estimated Current TCE and 1,2,3-TCP Concentrations at IRP-13S

Former MCAS Tustin, California

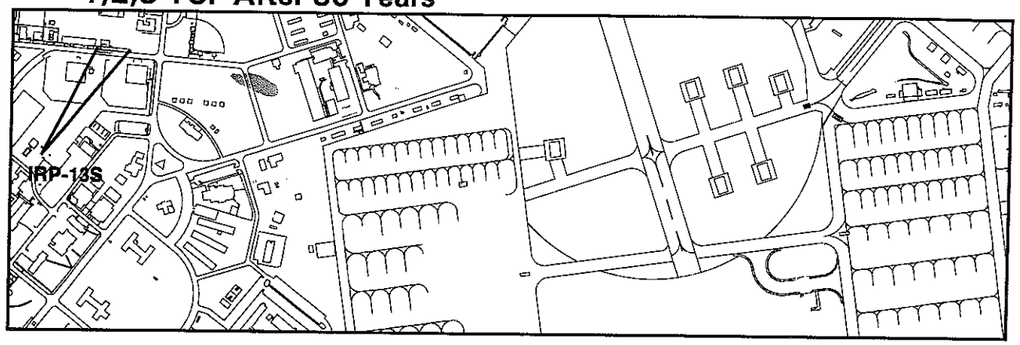
Bechtel Environmental, Inc.

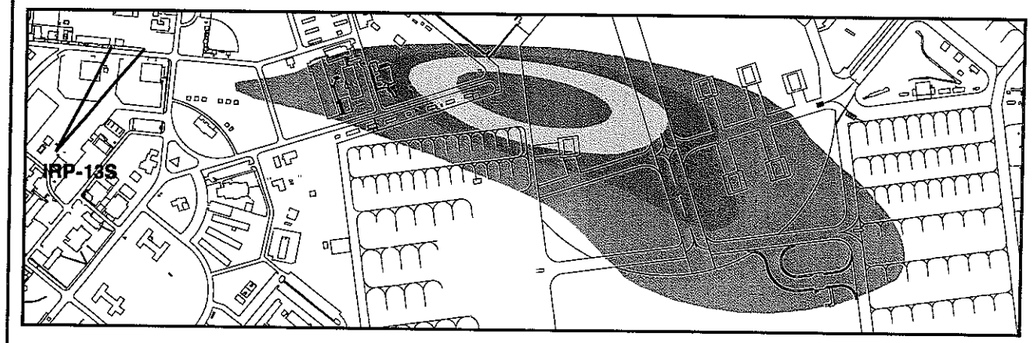
CLEAN 3 Program

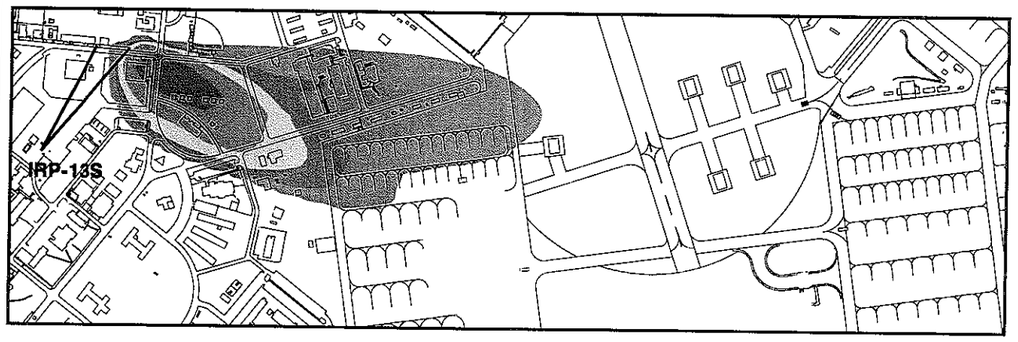
Date: 01/24/03
File No 035A10162
Job No :23818-035

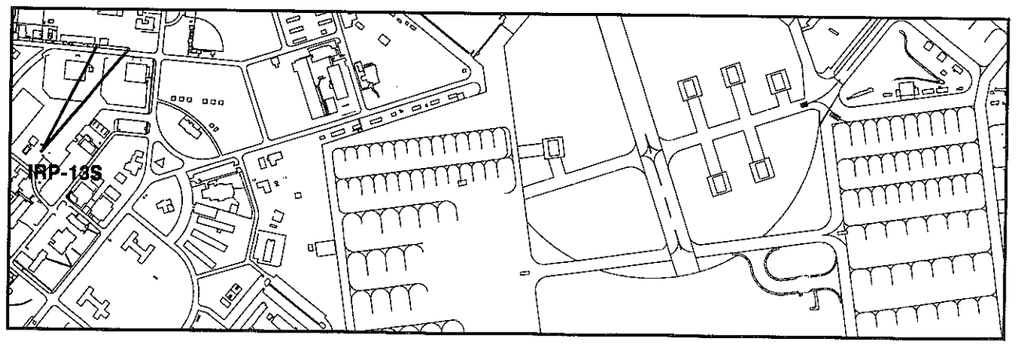
gwm72inixfs 01/24/03 /f/tustin/tustinsun

1,2,3-TCP After 30 Years

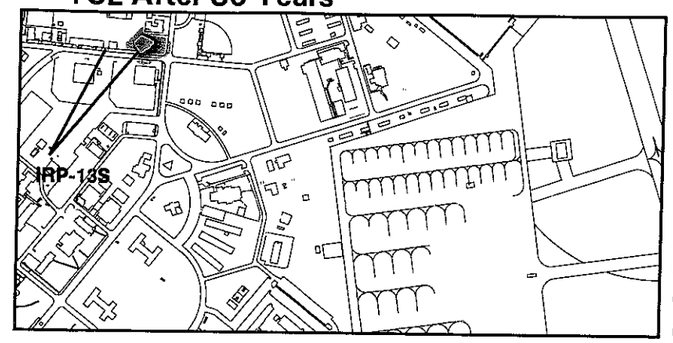




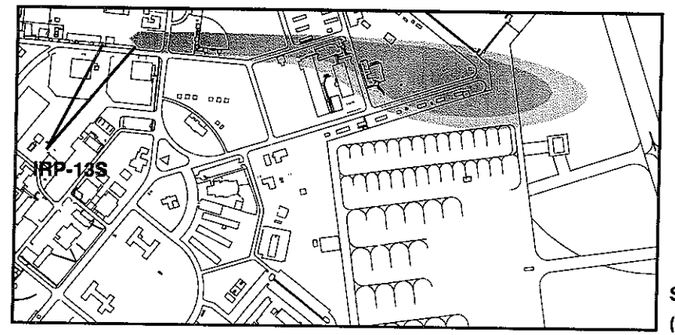




TCE After 30 Years



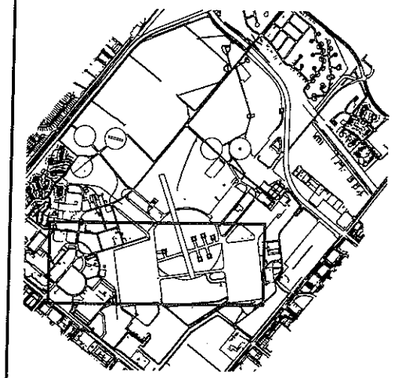
Upper Confining Layer of 1st WBZ (Model Layer 1)



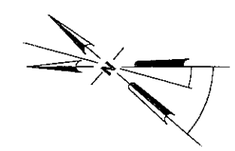
Sand Layer of 1st WBZ (Model Layer 2)

Lower Confining Layer of 1st WBZ (Model Layer 3)

Sand Layer of 2nd WBZ (Model Layer 4)



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report

Figure 1-23

Simulated TCE and 1,2,3-TCP Concentrations After 30 Years at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 01/22/03
File No 035A10163
Job No.:23818-035

gwm7230yrxfs 01/22/03 /f/tustin/tustinsun

The groundwater transport model assumed temporally and spatially varying infiltration rates at the source areas between 0 in/yr and 0.5 in/yr (BNI 1997a) based on future land uses specified in the SP/RP (The Planning Center 1996). Depending on land use during site redevelopment, actual surface infiltration in the future may be significantly different from the assumptions of the groundwater model. Model sensitivity analyses were conducted to address this issue during and after completion of the RI (BNI 1997a, 1998a). These results showed that increasing net infiltration rates by up to a factor of five had little effect on predicted plume distributions or maximum VOC concentrations in the permeable sand layers of the first and second WBZs.

Transport of 1,2,3-TCP from the second to the third WBZ may be attributed to two factors. First, a thick gravel zone underlain by a thin clay layer has been identified in a localized area at IRP-13S that permits hydraulic communication between the second and third WBZs (BNI 1999c). Second, the vertical hydraulic gradient between the second and third WBZs is seasonally reversible. While this gradient is generally oriented upward at IRP-13S, it may reverse direction during the summer months when groundwater extraction from the regional aquifer is significant. At these times, downward vertical gradients in the vicinity of the lithologic discontinuity permit 1,2,3-TCP to migrate to the third WBZ. Further details on local geologic and hydrogeologic conditions responsible for 1,2,3-TCP transport to the third WBZ are presented in a report on the 1998 field investigation at Former MCAS Tustin (BNI 1999c).

1.8 SUMMARY OF BASELINE RISK ASSESSMENT

A baseline HHRA was performed during this FS to evaluate the total combined risks (i.e., cumulative risk) to residents from exposure to all affected media under the site's current conditions and after a period of 30 years following implementation of proposed Alternative 7, hydraulic containment with hot spot removal. Cumulative risk under current conditions was evaluated for soil under three general areas identified as the Source Area, PAH Apron Study Area, and Auto Hobby Shop Area (Section 1.8.2). A previous risk assessment performed during the RI also evaluated risks to residents under current conditions but did not incorporate risks from affected soils within the VOC plume boundaries (BNI 1997a).

The focus of this FS is evaluation of risks to residents under current and future conditions with beneficial use of groundwater and under current conditions with nonbeneficial use of groundwater (i.e., no domestic use). Section 1.8.4 presents the results from these three residential scenarios performed for the Source Area. The results will provide the basis for developing RAOs, evaluating the effectiveness of remedial alternatives, and determining the reduction in risk from implementation of institutional controls to prevent domestic groundwater use.

Current conditions with beneficial use of groundwater were also evaluated at two areas where existing soil conditions pose a risk in excess of 10^{-6}. Other areas where investigations were previously conducted were also evaluated, and the risk in these areas was determined to be at an acceptable level. The PAH Apron Study Area and the Auto

Hobby Shop Area were evaluated to determine whether the cumulative impact of soil and groundwater contamination has had a significant effect on the overall risk. The results will be compared with the risk results from the Source Area to evaluate the relative risks within these areas.

Additional risk assessment scenarios (under current conditions) were conducted to address questions on institutional controls/construction provisions and to address site-specific groundwater contamination (1,2,3-TCP and MTBE). These additional scenarios include a construction/utility worker scenario (assuming worker exposure to contaminated groundwater and/or soil in open trenches) and residential groundwater-only scenarios (assuming maximum concentrations of contaminants in the mingled 1,2,3-TCP and MTBE plume area). Note that MTBE is being addressed under a separate program, the PCAP, and is not considered part of this CERCLA action. These additional risk assessment scenarios are briefly summarized in Section 1.8.6 and are fully described in Appendix F.

1.8.1 Incorporation of 1,2,3-TCP and MTBE Into Baseline Risk Assessment

California Environmental Protection Agency (Cal/EPA) toxicity values were used in addition to the U.S. EPA cancer slope factors (CSFs) in dual-tracking cancer risks, which provides cancer risk estimates using only U.S. EPA toxicity values and separate estimates using California toxicity values. Initial results from the calculation of U.S. EPA and Cal/EPA cancer risks indicate that 1,2,3-TCP is the main contributor to risk. However, since Cal/EPA does not currently have a CSF for 1,2,3-TCP, Cal/EPA risk calculations did not include all chemicals of potential concern (COPCs). The Cal/EPA cancer risk estimate was revised by using the U.S. EPA CSF for 1,2,3-TCP to calculate a revised Cal/EPA cancer risk estimate to allow for a realistic comparison of U.S. EPA and Cal/EPA risk estimates. The revised Cal/EPA risk results for current conditions with beneficial use and current conditions with nonbeneficial use indicate that the Cal/EPA cancer risk estimates are comparable to the U.S. EPA cancer risk estimates, with the U.S. EPA cancer risk being slightly higher than the revised Cal/EPA cancer risk. A discussion of the revised Cal/EPA cancer risk estimates is presented in Appendix F, Section FI4.7.

MTBE's contribution to the overall risk was evaluated for the Source Area using the U.S. EPA Region 9 CSF factor for MTBE. Based on the results of the evaluation, the addition of the MTBE CSF to the previously calculated risk estimate in the Source Area is considered negligible based on the high toxicity of 1,2,3-TCP in groundwater. MTBE was also evaluated for potential risks to residents from exposure to MTBE only in groundwater. The evaluation of MTBE in groundwater is discussed further in Appendix F, Section FI4.7.

Although both U.S. EPA and revised Cal/EPA cancer risk estimates are presented in summary tables in this section and in detail in Appendix F, only cancer risk estimates using U.S. EPA criteria are discussed in this section since the revised Cal/EPA cancer

risk estimates are comparable to the U.S. EPA cancer risk estimates. In addition, although estimates for cancer and noncancer risks under residential scenarios are presented in the summary tables, only the more conservative cancer risk estimates calculated for an adult resident and the noncancer risk estimates calculated for a child resident are presented. Under a residential scenario, cancer risks are greater for adult receptors and noncancer risks are greater for child receptors. The discussions presented in the following paragraphs for cancer and noncancer risks are, therefore, for the most conservative estimates.

1.8.2 Incorporation of AOC Soil Data Into Baseline Risk Assessment

RCRA AOC investigations were conducted to evaluate the risk to human health (i.e., screening-level risk assessments) due to residential exposure to soil at several AOCs within OU-1A (OHM 2000, 2001a,b). For this FS, screening-level risk assessments were conducted for the AOCs within OU-1A to evaluate risks to human health due to exposure to soil under a residential scenario. Appendix F summarizes screening-level residential cancer risk estimates for soil at all AOCs located within the OU-1A boundary.

In most cases, the soil cancer risk for a resident receptor is reported to be below the U.S. EPA point of departure (10^{-6}) for health protectiveness. However, six AOCs were identified with soil risk estimates in excess of 10^{-6} in the following three general areas: the Source Area (ST-72B and MWA-18), the PAH Apron Study Area (IRP-9A, IRP-9B, and ST-47), and the Auto Hobby Shop Area (TOW-18). Baseline residential risk from soil under current conditions in these three general areas is, therefore, evaluated in this FS Report.

1.8.3 Groundwater Data

Groundwater data for the risk assessments under current and future conditions were compiled into two data sets, both delimited by the boundaries of the 1,2,3-TCP plumes in the first and second WBZs. One groundwater data set was used to estimate risks to residents in the Source Area under current and future conditions. A second groundwater data set was compiled for the remainder of the risk scenarios, including the PAH Apron Study Area and Auto Hobby Shop Area.

The first groundwater data set was used to determine the need for remedial action due to Source Area contamination. The second data set was used for further evaluation of the overall cumulative risk at the site. DTSC requested this information for risk managers to use for assessing worst-case scenario health risks, assuming residential exposure to maximum reported concentrations of MTBE and other VOCs in groundwater. The compilation of groundwater data used in the risk assessment scenarios completed during this FS is fully described in Appendix F.

1.8.4 Source Area Residential Scenarios

Three residential scenarios were conducted for the Source Area: one under current conditions (with beneficial use of groundwater), one under future conditions (with beneficial use of groundwater), and one under current conditions (with nonbeneficial use of groundwater).

1.8.4.1 RESIDENTIAL RISK UNDER CURRENT CONDITIONS WITH BENEFICIAL USE

Total cancer and noncancer risk estimates (using U.S. EPA criteria) for the Source Area exceed the upper limit of the generally acceptable risk range for cancer risk established by U.S. EPA (10^{-6} to 10^{-4}), and the noncancer threshold value or hazard index of 1.0 (which indicates the potential for development of adverse health effects) (Table 1-1). Total cancer risks at the Source Area are estimated to be 4.8×10^{-3} and are primarily associated with exposure to 1,2,3-TCP in groundwater. Noncancer risk, or the hazard index calculated for a resident child at the Source Area, is estimated to be 7.3 and is principally related to 1,2,3-TCP and selenium in groundwater.

Selenium was not identified as a site-related chemical at OU-1A. Furthermore, the background threshold concentration for selenium in the first WBZ at Former MCAS Tustin is 0.33 mg/L, while the exposure-point concentration (EPC) for selenium in groundwater at OU-1A is 0.15 mg/L. This indicates that selenium concentrations in groundwater at OU-1A do not exceed background concentrations and, therefore, the risks are related to selenium as a naturally occurring chemical in groundwater at the site.

1.8.4.2 RESIDENTIAL RISK UNDER FUTURE CONDITIONS WITH BENEFICIAL USE

The total future cancer risk estimated under the residential scenario at the Source Area is 4.0×10^{-4}, which exceeds the NCP's generally acceptable risk range of 10^{-6} to 10^{-4} (Table 1-1). The principal cancer risk driver is 1,2,3-TCP in groundwater. This risk value represents an approximately 92 percent reduction in the U.S. EPA-derived risk estimate at current conditions. The hazard index for a resident child under future conditions at the Source Area is estimated to be 3.7 and is associated with 1,2,3-TCP and selenium in groundwater and manganese in soil. This represents an approximately 49 percent reduction in noncancer risk at current conditions. The reduction in cancer and noncancer risk is principally related to the removal of 1,2,3-TCP in groundwater.

It should be noted that current and future risk assessment results presented herein were based on groundwater modeling using conservative assumptions and were prepared for very conservative residential scenarios in which the domestic use of groundwater (drinking, bathing, and other domestic uses) was assumed to occur over a period of 30 years. Domestic use of groundwater from the shallow aquifer is unlikely due to the poor quality of the water (e.g., elevated concentrations of TDS, nitrates, and salinity). The actual risks posed to residents under future conditions are expected to be less

Table 1-1
Total Cancer and Noncancer Risk Estimates for Source Area Residential Scenarios

Exposure Scenario	Risk Description	Source Area Risk[a,b,c]	Pathway/ Risk Driver/ Risk Percentage
Current conditions, residential, with beneficial groundwater use	Total cancer risk	**4.8E-3**	Groundwater: 1,2,3-TCP (96%)
	Hazard index	**7.3**	Groundwater: 1,2,3-TCP (38%) Selenium (26%) Soil: Manganese and compounds (14%)
Future conditions, residential, with beneficial groundwater use	Total cancer risk	**4.0E-4**	Groundwater: 1,2,3-TCP (95%)
	Hazard index	**3.7**	Groundwater: 1,2,3-TCP (51%) Selenium (26%) Soil: Manganese and compounds (30%)
Current conditions, residential, with nonbeneficial groundwater use (vapor intrusion only for groundwater)	Total cancer risk	1.0E-5	Air volatiles from soil: TCE (63%) 1,2,3-TCP (27%) Air volatiles from groundwater: 1,2,3-TCP (10%)
	Hazard index	1.0	Soil: Manganese and compounds (>99%)

Notes:
[a] estimate of total cancer risk based on U.S. EPA cancer slope factors since U.S. EPA cancer risk estimates are comparable to the revised Cal/EPA risk estimates
[b] values in **bold** indicate cancer risk or hazard index exceeds the generally acceptable thresholds established by U.S. EPA in the NCP at 40 C.F.R. § 300.430(e)(2)(i)(A)(2); the threshold for carcinogenic effects is a lifetime incremental cancer risk in the range of 10^{-6} to 10^{-4}
[c] soil areas evaluated in the Source Area for this risk assessment include ST-72B and MWA-18

Acronyms/Abbreviations:
Cal/EPA – California Environmental Protection Agency
C.F.R. – *Code of Federal Regulations*
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
§ – section
TCE – trichloroethene
TCP – trichloropropane
U.S. EPA – United States Environmental Protection Agency

and will be lowered based on the following: the effectiveness of institutional controls in preventing the exposure to and domestic use of shallow groundwater; the effectiveness of the proposed containment and treatment system in reducing the mass, extent, and concentrations of VOCs in shallow groundwater; and other factors such as the extent and effectiveness of natural attenuation. (Note: As a conservative assumption, groundwater modeling assumed no natural attenuation.)

1.8.4.3 RESIDENTIAL RISK UNDER CURRENT CONDITIONS WITH NONBENEFICIAL USE

An additional, more realistic residential scenario was used to estimate risks to human health assuming nonbeneficial use of groundwater (i.e., institutional controls in place that prevent groundwater use). Information from this scenario may be used to determine whether institutional controls and/or restrictions would be required for indoor occupancy of existing and/or newly constructed buildings at the site. This scenario uses all reported VOCs with EPCs calculated at 95 percent UCL of the mean value of their respective reported concentrations.

Total cancer and noncancer risk estimates (using U.S. EPA criteria) for the Source Area fall within the generally acceptable risk range for cancer risk established by U.S. EPA (10^{-6} to 10^{-4}) and do not exceed the noncancer threshold value or a hazard index of 1.0 (which indicates the potential for development of adverse health effects) (Table 1-1). Total cancer risks at the Source Area are estimated to be 1.0×10^{-5} and are primarily associated with exposure to TCE and 1,2,3-TCP in soil vapor. Noncancer risk, or hazard index, calculated for a resident child at the Source Area is estimated to be 1.0. These results indicate that with institutional controls in place to prevent domestic use of groundwater, cancer risk is reduced by more than two orders of magnitude to fall within the generally acceptable risk range established by U.S. EPA (10^{-6} to 10^{-4}).

1.8.5 PAH Apron Study and Auto Hobby Shop Areas Residential Scenarios

Total cancer and noncancer risk estimates for a resident (with beneficial use of groundwater) in the PAH Apron Study Area and the Auto Hobby Shop Area exceed the generally acceptable risk range for cancer risk and the noncancer threshold value, or hazard index, of 1.0 (Table 1-2). Total cancer risk estimates are at 4.7×10^{-3} for both the PAH Apron Study Area and the Auto Hobby Shop Area, primarily due to 1,2,3-TCP in groundwater. Noncancer risks, indicated as hazard indexes, were calculated for a resident child at the PAH Apron Study Area and the Auto Hobby Shop Area and were estimated to be 6.3 and 6.9, respectively. These noncancer risks are principally related to 1,2,3-TCP and selenium in groundwater.

Table 1-2
Total Cancer and Noncancer Risk Estimates for Additional Residential Scenarios

Exposure Scenario	Risk Description	Risk[a,b]	Pathway/ Risk Driver/ Risk Percentage
Residential PAH Apron Study Area[c] with beneficial use	Total cancer risk	**4.7E-3**	Groundwater: 1,2,3-TCP (98%)
	Hazard index	**6.3**	Groundwater: 1,2,3-TCP (44%) Selenium (30%)
Residential Auto Hobby Shop Area[c] with beneficial use	Total cancer risk	**4.7E-3**	Groundwater: 1,2,3-TCP (98%)
	Hazard index	**6.9**	Groundwater: 1,2,3-TCP (41%) Selenium (28%)

Notes:
[a] estimate of total cancer risk based on U.S. EPA cancer slope factors since U.S. EPA cancer risk estimates are comparable to the revised Cal/EPA risk estimates
[b] values in **bold** indicate cancer risk or hazard index exceeds the generally acceptable thresholds established by U.S. EPA in the NCP at 40 C.F.R. § 300.430(e)(2)(i)(A)(2); the threshold for carcinogenic effects is a lifetime incremental cancer risk in the range of 10^{-6} to 10^{-4}; for noncarcinogenic effects, the threshold is a hazard index value less than 1.0
[c] soil areas evaluated in the risk assessment include:
1) the PAH Apron Study Area including IRP-9A, IRP-9B, and ST-47
2) the Auto Hobby Shop Area including TOW-18

Acronyms/Abbreviations:
Cal/EPA – California Environmental Protection Agency
C.F.R. – *Code of Federal Regulations*
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
PAH – polynuclear aromatic hydrocarbon
§ – section
TCP – trichloropropane
U.S. EPA – United States Environmental Protection Agency

It should be noted that both cancer and noncancer risk results for these two beneficial-use residential scenarios are almost identical to those estimated for the Source Area because 1,2,3-TCP is by far the dominant risk driver for all three areas. Exposure to contaminated soil contributes less than 1 percent of the total cancer and noncancer risks for these three residential scenarios. Complete descriptions of results for the risk assessment scenarios are presented in Appendix F.

1.8.6 Additional Scenarios

Risk was also calculated for two additional scenarios under current conditions: risk to the construction/utility worker OU-wide and risk to a resident with beneficial and nonbeneficial use (groundwater only).

1.8.6.1 CONSTRUCTION/UTILITY WORKER RISKS UNDER CURRENT CONDITIONS OU-WIDE

Cancer risk under an additional construction/utility worker scenario was estimated to support land-use decisions and management of risks to construction/utility contractors implementing reuse plans throughout OU-1A. This scenario describes a construction/utility worker who would potentially be exposed to contaminated groundwater and/or soil (using maximum reported concentrations and therefore worst-case exposure) in excavations and trenches for constructing buildings, roadways, and utilities. The construction/utility worker would potentially be exposed to COPCs in shallow soil at 0 foot to 10 feet bgs and from groundwater accumulating in trenches/excavations.

Total cancer risk from a construction/utility worker exposure scenario exceeds the NCP's upper bound of the acceptable risk range of 10^{-6} to 10^{-4} for health protectiveness, and the HI exceeds the systemic toxicity threshold of 1.0. The cancer risk and HI are primarily attributable to the concentrations of TCE in soil and inhalation of soil vapors.

Based on the risk results for a construction/utility worker, it may be necessary to implement engineering controls to prevent exposure to soil vapors prior to conducting activities within the OU-1A site boundary. However, additional evaluations of site conditions should be conducted prior to initiating construction/utility activities within the OU-1A site boundary to determine appropriate safety measures to protect workers. A complete description of the results for this risk assessment scenario is presented in Appendix F.

1.8.6.2 RESIDENTIAL RISK UNDER CURRENT CONDITIONS WITH BENEFICIAL AND NONBENEFICIAL USE (GROUNDWATER ONLY)

Cancer risk under two additional groundwater-only scenarios (using maximum reported concentrations) was estimated to obtain risk information from the central portion of the commingled MTBE and 1,2,3-TCP plumes from UST Site 222 and IRP-13S, respectively. DTSC requested this information for risk managers to use for assessing worst-case-scenario health risks to potential future property users from MTBE and other VOCs in groundwater.

Using U.S. EPA criteria, the total lifetime cancer risk for a hypothetical adult resident exposed to groundwater COPCs under a beneficial-use scenario is approximately 4.8×10^{-3} (Table 1-3). Total lifetime cancer risks for an adult resident with nonbeneficial use is approximately 1.0×10^{-5}, falling within the NCP's acceptable risk range. Assuming beneficial use of groundwater, inhalation of groundwater vapors during household water use was the dominant risk pathway. Assuming nonbeneficial use of groundwater, inhalation of air volatiles from groundwater intruding into indoor air was the dominant risk pathway.

Results from these two scenarios indicate that total lifetime excess cancer risks from exposure to contaminated groundwater (calculated using maximum concentrations [i.e., the worst case]) may be reduced to within the acceptable risk range by implementing institutional controls that would prevent contact with contaminated groundwater, including preventing domestic use. Complete descriptions of results for these risk assessment scenarios are presented in Appendix F.

1.8.7 Summary of Baseline Risk Assessment Results

The baseline risk assessment conducted for this FS evaluated the total combined risk (i.e., cumulative risk) to human health from exposure to all affected media, including soil and groundwater within the OU-1A boundaries, under both current and future conditions (Table 1-3) (Appendix F). Results from this baseline risk assessment indicate that the majority of cancer and noncancer risks are associated with exposure to VOCs (principally 1,2,3-TCP) in shallow groundwater. Chemicals reported in soil were found to contribute less than 1 percent of the combined total cancer risk at OU-1A.

The baseline risk assessment indicated that lifetime cancer risks for the resident in the Source Area exceed the upper bound of the NCP's generally acceptable risk range (10^{-6} to 10^{-4}) (Table 1-3) and would, therefore, require remedial action to reduce the risks and to achieve the RAOs described in Section 2. The risk assessment for the Source Area concluded that cancer risk under residential scenarios arises primarily from exposure to shallow groundwater and that inhalation of groundwater vapors during domestic use was the dominant risk pathway (Appendix F).

The evaluation of future risk under a residential scenario (with beneficial use of groundwater) at the Source Area 30 years after remediation under proposed Alternative 7, hydraulic containment with hot spot removal, indicates that risk would be reduced by more than an order of magnitude from current conditions but would still exceed NCP's generally acceptable risk range (10^{-6} to 10^{-4}).

Estimates of risk under a residential scenario with nonbeneficial use of groundwater (i.e., institutional controls to prevent groundwater use) at current conditions would fall within the NCP's generally acceptable risk range (10^{-4} to 10^{-6}). Therefore, institutional controls would be effective in protecting human health and allow for the reuse of existing and newly constructed buildings within the site boundary for OU-1A. The variance

Table 1-3
Summary of Lifetime Cancer Risks and Hazard Indexes

Exposure Route	Cancer Risk U.S. EPA[a,b]	Cancer Risk State[c,d,e]	Hazard Index[d,e]
Resident with beneficial use of groundwater:			
Source Area (current conditions)			
Soil total[f]	9.3E-06	7.1E-07	1.0
Groundwater total[g] **(indoor vapor inhalation)**	4.7E-03	4.6E-03	6.3
Total	**4.8E-03**	**4.6E-03**	**7.3**
Resident with beneficial use of groundwater:			
Source Area (future conditions)			
Soil total[f]	5.0E-06	1.0E-07	1.0E-09
Groundwater total[g] **(indoor vapor inhalation)**	4.0E-04	3.9E-04	2.6
Total	**4.0E-04**	**3.9E-04**	**3.7**
Resident with nonbeneficial use of groundwater:			
Source Area (current conditions)			
Soil total[f]	9.3E-06	7.1E-07	1.0
Groundwater total[g] **(indoor vapor intrusion)**	1.1E-06	1.7E-06	0.00093
Total	**1.0E-05**	2.4E-06	**1.0**
Resident with beneficial use of groundwater:			
PAH Apron Study Area (current conditions)			
Soil total[f]	1.2E-06	2.4E-07	4.1E-02
Groundwater total[g] **(indoor vapor inhalation)**	4.7E-03	4.6E-03	6.2
Total	**4.7E-03**	**4.6E-03**	**6.3**
Resident with beneficial use of groundwater:			
Auto Hobby Shop Area (current conditions)			
Soil total[f]	1.1E-06	1.3E-06	6.7E-01
Groundwater total[g] **(indoor vapor inhalation)**	4.7E-03	4.6E-03	6.2
Total	**4.7E-03**	**4.6E-03**	**6.9**

Notes:
[a] risk was calculated using U.S. EPA toxicity values
[b] the risk is higher for the resident adult; therefore, only the resident adult risk results are shown
[c] risk was calculated using Cal/EPA toxicity values except for 1,2,3-TCP; U.S. EPA toxicity value for 1,2,3-TCP was used in calculation of Cal/EPA cancer risk estimates since Cal/EPA does not have a toxicity value for 1,2,3-TCP
[d] the index is higher for the resident child; therefore, only the resident child index is shown
[e] based on use of child reference doses (RfDs)
[f] soil areas evaluated in the risk assessment include:
1) the Source Area including ST-72B and MWA-18
2) the PAH Apron Study Area including IRP-9A, IRP-9B, and ST-47
3) the Auto Hobby Shop Area including TOW-18
[g] household water use – indoor vapor inhalation for groundwater refers to released groundwater vapors that accumulate in buildings during all uses of household water

(table continues)

Table 1-3 (continued)

Acronyms/Abbreviations:
IRP – Installation Restoration Program
NA – not assessed
PAH – polynuclear aromatic hydrocarbon
TCP – trichloropropane
U.S. EPA – United States Environmental Protection Agency

between the cancer risk estimates for U.S. EPA and Cal/EPA in Table 1-3 is due to different CSFs for TCE in air volatiles of a residence. The main COPC under this scenario is TCE, because exposure to 1,2,3-TCP in groundwater is prevented through institutional controls.

The U.S. EPA and revised Cal/EPA cancer risk estimates shown in Table 1-3 both use the U.S. EPA CSF for 1,2,3-TCP. Since 1,2,3-TCP in groundwater is the main risk driver (contributing over 95 percent of total risk) for OU-1A, both cancer risk estimates are comparable, with the U.S. EPA cancer risk estimate being slightly higher than the Cal/EPA estimate.

This page left blank intentionally

Section 2
REMEDIAL ACTION OBJECTIVES

U.S. EPA guidance (U.S. EPA 1988a) defines "remedial action objectives" as media-specific or OU-specific goals for protecting human health and the environment. These objectives focus the FS and define the scope of potential cleanup activities, thereby guiding the development and evaluation of remedial alternatives.

This section presents the RAOs proposed for VOC-contaminated groundwater associated with Former MCAS Tustin OU-1A. Issues addressed include affected media and chemicals of concern (COCs), existing and potential receptors and exposure pathways, ARARs, and site remediation (cleanup) goals. Because this FS concerns remediation of contaminated groundwater, this section also discusses restoration time frames and areas of attainment within the context of RAOs.

The overall RAOs for the groundwater plumes originating at IRP-13S are as follows.

- Reduce the concentrations of VOCs in groundwater to levels consistent with remediation goals or until the plume has stabilized, and prevent or limit VOC migration beyond the current OU-1A plume boundaries.
- Protect human health by preventing extraction of VOC-impacted shallow groundwater for domestic use until remediation goals are achieved.
- Protect potential ecological receptors in Barranca Channel by preventing the off-station migration of groundwater containing VOCs at concentrations exceeding remediation goals.
- Implement appropriate remedial actions as necessary to facilitate transfer and reuse of those portions of the Former MCAS Tustin property actually or potentially affected by the OU-1A plumes.

Groundwater modeling conducted for this site indicated that VOCs retained in the upper confining clay layer of the first WBZ would act as a long-term residual source of groundwater contamination to the more permeable sand layers below (BNI 1997a). Contaminated soils are therefore of concern in this FS as continuing sources of VOCs to groundwater. It is important to note, however, that direct human contact with soil at IRP-13S is not a significant human-health risk (BNI 1997a). Therefore, cleanup of contaminated soils to health-based criteria is not an RAO for this site.

2.1 AFFECTED MEDIA AND CONTAMINANTS OF CONCERN

Sampling results obtained during the RI and during other subsurface investigations conducted at Former MCAS Tustin indicate that shallow groundwater has been impacted by VOCs at and downgradient of IRP-13S. The HHRA determined that potential human exposure to this contaminated groundwater under a future residential land-use scenario would present the primary source risk to human health at this site. Therefore, VOC-affected groundwater is the primary medium of concern for this FS. As noted above, contaminated soil at IRP-13S is a secondary medium of concern and is addressed solely because of its role as a source of ongoing groundwater contamination.

COCs identified for groundwater (Table 2-1) based on source area contamination and evaluated in this FS were developed from information presented in the RI Report (BNI 1997a). Two COCs were identified: TCE and 1,2,3-TCP. In identifying these chemicals as COCs, it was assumed that background concentrations of chlorinated VOCs in groundwater at the site were below the detection limits of available U.S. EPA analytical methods. The frequency of detection and reported concentration ranges for these COCs are presented in Table 2-1. The estimated areal extent, maximum reported concentrations, and estimated mass of TCE and 1,2,3-TCP used in groundwater modeling conducted for IRP-13S is presented in Table 2-2. Groundwater modeling results are presented in Appendix B of this report.

Table 2-1
Chemicals of Concern in Groundwater

Chemical	Detection Frequency[a]	Concentration Range[b] (µg/L)
1,2,3-Trichloropropane (1,2,3-TCP)	62/120	1.7–340
Trichloroethene (TCE)	56/120	1.3–310

Notes:
[a] number of samples in which the contaminant was reported as detected/total number of groundwater samples collected during the RI (BNI 1997a)
[b] range of concentrations for samples with detectable levels of the contaminant

Acronyms/Abbreviations:
µg/L – micrograms per liter
RI – remedial investigation

Table 2-2
Estimated Plume Dimensions, Maximum VOC Concentrations, and VOC Mass

WBZ	Area (square feet)	Maximum TCE Concentration* (µg/L)	TCE Mass (pounds)	Maximum 1,2,3-TCP Concentration* (µg/L)	1,2,3-TCP Mass (pounds)
First	996,000	310	3.1	340	13.5
Second	932,000	ND	NA	160	6.4
	Subtotal Mass		**3.1**		**19.9**

Note:
* maximum reported concentrations in the sand layers of the first and second WBZs

Acronyms/Abbreviations:
µg/L – micrograms per liter
NA – not applicable
ND – not detected
TCE – trichloroethene
TCP – trichloropropane
VOC – volatile organic compound
WBZ – water-bearing zone

Based on RI data, COPCs, including three metals (cadmium, chromium, and molybdenum) and four VOCs (acetone, chloroform, methyl ethyl ketone, and toluene), were also identified for groundwater (BNI 1997a). These COPCs were reported at concentrations above background values in at least 5 percent of the samples collected at IRP-13S. Because the HHRA indicated that these COPCs did not contribute significantly to the health risk estimates for groundwater at IRP-13S, they were not identified as groundwater COCs for this FS (BNI 1997a).

2.2 POTENTIAL RECEPTORS/EXPOSURE PATHWAYS

Currently, no human population is exposed to VOC-contaminated groundwater in the shallow WBZs at Former MCAS Tustin. However, as the station is redeveloped for civilian use, potential future receptors and exposure pathways must be considered.

The HHRA conducted for this FS included residential scenarios to evaluate the potential additive risk under current and future conditions from exposure to COPCs in groundwater and soil at two AOCs (ST-72 and MWA-18), located in the Source Area identified for OU-1A. Cancer and noncancer risk estimate results for two Source Area residential scenarios, which assume beneficial use of groundwater for domestic purposes under current and future conditions, were used to evaluate the effectiveness of Alternative 7, hydraulic containment and hot spot removal. An additional Source Area residential scenario was conducted to evaluate risks under current, more reasonable conditions, including institutional controls that prevent human exposure to contaminated groundwater (mainly preventing extraction and use of groundwater for domestic purposes). Results from these three residential scenarios conducted for the Source Area are the focus of this section.

Results from other risk assessment scenarios conducted during this FS, including residential scenarios for the PAH Apron Study Area (including IRP-9A, IRP-9B, and ST-47) and the Hobby Shop Area (including TOW-18), a construction/utility worker scenario, and two groundwater-only residential scenarios, are briefly discussed in Section 1.8 and are fully presented in Appendix F. These additional risk assessment scenarios were performed to evaluate worst-case conditions for residents under current conditions and to assist in risk management decisions for land reuse operations (e.g., construction/utility work) that may be conducted within the footprint of the VOC plumes at OU-1A.

Under the three residential scenarios evaluated for the Source Area, cancer and noncancer risks to human health were highest from potential exposure to contaminated groundwater under a residential land-use scenario at current conditions with beneficial groundwater use (Table 1-1). Under this scenario, it was assumed that contaminated groundwater would be extracted from the shallow WBZs and used by residents for potable water supply without treatment. Cancer and noncancer risks were estimated based on exposures to COPCs in groundwater at concentrations at current conditions determined by the 95 percent upper confidence limit of mean concentrations reported during the last four monitoring rounds (through winter 2001) in monitoring wells and from

HydroPunch groundwater data collected during the RI. Risk estimates at future conditions were based on projected concentrations of VOCs from groundwater modeling after 30 years of remediation under Alternative 7, hydraulic containment with hot spot removal (Appendix B).

Although Alternative 7 would reduce the current residential cancer risk (with beneficial groundwater use) by an order of magnitude at completion, the future cancer risk estimate exceeds U.S. EPA thresholds established in the NCP. Noncancer risk estimates (hazard indexes) for current and future conditions also exceed the threshold value of 1.0 established in the NCP. Therefore, exposure to COPCs in groundwater and soil at OU-1A represent a potential health concern if the shallow WBZs were to be used as a potable water source by potential residents. Protection of such potential residential receptors would be achieved by satisfying the first two RAOs presented at the beginning of this section. With institutional controls to prevent exposure to contaminated groundwater, residential cancer risks would be reduced from current conditions by more than two orders of magnitude to within U.S. EPA's generally acceptable risk range, and the noncancer hazard index would not exceed the threshold value.

Under the residential scenario that assumes no domestic groundwater use, total cancer risk is estimated to be within U.S. EPA's generally acceptable risk range, since the primary exposure pathway would be from vapor intrusion via volatilization from soil and/or groundwater into indoor air (Table 1-1). Previous soil gas investigations conducted at Former MCAS Tustin, however, have not detected appreciable levels of vapor contamination in areas known to have VOC-impacted soils and groundwater (JEG 1992). The absence of soil vapor contamination was attributed to the generally low permeability of the vadose zone soils and the presence of a fine-grained confining layer at or near the water table. These conditions significantly impede the migration of vapor-phase contaminants and, therefore, inhalation exposures resulting in adverse risks to human health are expected to be less than those estimated under this residential scenario.

It is unlikely that residential exposure to contaminated groundwater at the Former MCAS Tustin property will be of the type assumed in the HHRA calculations. The shallow WBZs at Former MCAS Tustin are not expected to be used for future water resource development primarily due to:

- low yield (1 to 3 gpm per well in most areas);
- high salinity (average TDS concentrations of 6,000 mg/L and 2,400 mg/L in the first and second WBZs, respectively); and
- naturally occurring background concentrations of sulfate, nitrate, and selenium that exceed drinking water criteria established by DHS and the RWQCB.

Furthermore, Former MCAS Tustin is located in an urban area and alternative high-quality municipal water supplies would be available to future residents. In this situation, it is unlikely that homeowners would want to bear the expense and inconvenience of replacing municipally supplied water with potable supplies from their own private wells,

nor would local water purveyors be willing to export groundwater from the shallow WBZs for such purposes.

The third RAO presented at the beginning of this section has been developed to address ecological uncertainties regarding future groundwater discharges to surface water at Former MCAS Tustin. Possible future impacts on receptors in Barranca Channel would be completely avoided by implementing an OU-1A remedial alternative that prevents the off-site migration of VOC-contaminated groundwater.

Surface water surrounding Former MCAS Tustin is not currently affected by VOCs in the shallow WBZs, and a complete exposure pathway does not exist between the VOCs in the OU-1A plumes and potential ecological receptors. However, a groundwater model presented in the RI Report showed that these plumes would eventually migrate beyond the boundaries of the Former MCAS Tustin property in the absence of engineered controls (BNI 1997a). Ecological impacts could possibly result from the long-term seepage of VOC-contaminated groundwater into Barranca Channel. This drainage channel flows into San Diego Creek and ultimately into ecologically sensitive areas within Upper Newport Bay. The VOC plumes originating at IRP-13S would be expected to begin discharging to Barranca Channel in about 40 years, attaining a maximum 1,2,3-TCP concentration of 13 μg/L in approximately 70 years.

Because these discharges are not expected to begin for almost 40 years, it is difficult to predict potential impacts to ecological resources that could occur in the off-site drainage channels or downstream areas. Any environmental effects are likely to be subtle, since relatively low VOC concentrations are anticipated to exist in contaminated groundwater that would discharge to Barranca Channel. Furthermore, the potential ecological impacts of the discharges would undoubtedly be mitigated by VOC dilution and volatilization that would take place as groundwater seeps into and is mixed with the existing drainage flows. In addition, the nature of the potentially affected receiving water ecosystems could change significantly over the next 70 years. Therefore, it would be highly speculative to predict future ecological effects based on current conditions.

2.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA Section 121(d) requires that final remedial actions must attain (or the ROD 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. A preliminary identification of ARARs for IRP-13S has been issued previously by the DON (BNI 1995). This subsection provides an overview of the methodology for identifying the site-specific ARARs that will govern response actions for contaminated groundwater at IRP-13S. Those ARARs determined to be principal drivers in the development of remediation (cleanup) goals for OU-1A groundwater are summarized in the following section. A complete and detailed analysis of ARARs for OU-1A is included as Appendix A.

As the lead federal agency for environmental cleanup activities at Former MCAS Tustin, the DON has primary responsibility for identification of federal ARARs. Identification of potential state ARARs for this FS Report was initiated through DON requests to DTSC. In turn, DTSC solicited and submitted to the DON the ARARs listed by several state agencies, including the RWQCB, the South Coast Air Quality Management District (SCAQMD), the California Integrated Waste Management Board, and the California Department of Transportation. As discussed in Attachment A to Appendix A, input was also obtained from local (i.e., Orange County) agencies. In addition, regulatory agency comments were received on the ARARs presented in the draft and revised draft FS Reports for OU-1. These comments were incorporated into this FS Report as appropriate.

According to 40 *Code of Federal Regulations* (C.F.R.) § 300.5, "applicable requirements" are those standards of cleanup or control and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site. A requirement is applicable if the prerequisites of the standard show a direct correspondence to site conditions. An applicable requirement is an ARAR.

If a requirement is not specifically applicable, it must then be determined if the requirement is relevant and appropriate to the site. "Relevant and appropriate requirements" are those standards, criteria, or limitations promulgated under federal or state environmental or facility citing law that, while not "applicable," nevertheless address problems or situations sufficiently similar to those encountered at a CERCLA site to make their use well-suited to that particular facility. A requirement must be determined to be both relevant *and* appropriate in order to be considered an ARAR. If a requirement satisfies both of these tests, it must be complied with in the same manner as an applicable requirement (U.S. EPA 1988a).

Criteria for determining the relevance and appropriateness of environmental regulatory and legal requirements are listed in 40 C.F.R. § 300.400(g)(2) and include the following:

- purpose of the requirement and the purpose of the CERCLA action
- substances regulated by the requirement and the substances found at the CERCLA site
- variances or exemptions to, or waivers of, the requirement and their availability for the circumstances at the CERCLA site
- type of place regulated and the type of place affected by the release or CERCLA action
- type and size of the structure or facility regulated and the type and size of the structure or facility affected by the release or CERCLA action
- 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

Nonpromulgated advisories or guidance issued by federal or state agencies are not ARARs (40 C.F.R. § 300.400[g][3]), but are "to be considered" (TBC) requirements. TBC standards may be useful in determining the necessary level of cleanup for protection of human health and the environment when promulgated regulatory standards are not available. U.S. EPA Region 9 preliminary remediation goals (PRGs) are examples of TBCs that could be used in the absence of a regulatory standard.

In determining the extent to which on-site response actions must comply with other laws and regulations, substantive requirements must be distinguished from administrative requirements. Substantive requirements may be ARARs if they pertain directly to conditions or activities conducted entirely on-site. Procedural or administrative requirements, such as permits and reporting requirements, are not ARARs for response activities conducted on-site. Consistent with the NCP at 40 C.F.R. § 300.5, the term "on-site" as used in this FS Report is defined as the areal extent of soil and groundwater contamination associated with OU-1A as well as all suitable areas in close proximity to the contamination necessary for implementation of a remedial alternative.

ARARs can be separated into three categories. These include chemical-specific, location-specific, and action-specific ARARs. Chemical-specific ARARs are numerical standards that establish acceptable levels of risk for individual COCs in affected environmental media. Such ARARs may be derived from the application of health- or risk-based methodologies to site-specific conditions. Federal and state drinking water standards are examples of chemical-specific ARARs. Location-specific ARARs restrict remedial activities on the basis of site locations or conditions. Development restrictions imposed in environmentally sensitive areas such as wetlands are one example. Action-specific ARARs are technology- or activity-based requirements or limitations on remedial actions. Action-specific ARARs depend on the remedial technology used for site cleanup. Solid and hazardous waste management regulations pertaining to the residuals from treatment of extracted groundwater would be an example of an action-specific ARAR.

2.4 ARARs AFFECTING OU-1A REMEDIATION (CLEANUP) GOALS

The OU-1A groundwater COCs, as listed on Table 2-1, are limited to VOCs reported during the RI and previous subsurface investigations at Former MCAS Tustin. These COCs include TCE and 1,2,3-TCP, the principal risk drivers at the site, as well as other related chlorinated compounds. The RAOs listed at the beginning of this section are aimed at mitigating potential exposures to and further migration of these groundwater COCs. In addition to these narrative objectives, remedial response actions at OU-1A will be driven by state and federal ARARs that provide criteria establishing numerical groundwater remediation goals.

The substantive provisions of the following requirements constitute ARARs for this response action:

- Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) (RWQCB 1995), which establishes water quality standards applicable to groundwater at Former MCAS Tustin, including the designation of beneficial

uses of the Irvine Pressure Subbasin and water quality objectives to protect these uses

- federal maximum contaminant levels (MCLs) and MCL goals (MCLGs) for VOCs in drinking water as promulgated by U.S. EPA under the Safe Drinking Water Act (SDWA) at 40 C.F.R. § 141.61 and 40 C.F.R. § 141.50, respectively
- RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94

These are the key ARARs used to develop numerical remediation goals for OU-1A groundwater. Relevant portions of each ARAR are summarized below.

2.4.1 Water Quality Control Plan for the Santa Ana River Basin

The Basin Plan (RWQCB 1995) establishes applicable water quality standards for VOC-affected groundwater at Former MCAS Tustin. These standards comprise beneficial use designations and water quality objectives to protect those uses, including concentration levels for certain chemicals. The RWQCB has adopted the Basin Plan and is responsible for its implementation in accordance with the Porter-Cologne Water Quality Control Act, as amended.

The Basin Plan assigns the following actual or potential beneficial uses to groundwater within the regional aquifer underlying Former MCAS Tustin (Irvine Pressure Subbasin):

- domestic and municipal supply, including drinking water supply
- agricultural supply
- industrial service supply
- industrial process supply

Currently, only groundwater in the regional aquifer (deeper than approximately 40 feet below MSL) is used or likely to be used for drinking water supply or for other assigned beneficial uses.

The Basin Plan does not specifically designate beneficial uses and water quality objectives for the shallow aquifer in the vicinity of Former MCAS Tustin. Arguably, shallow groundwater is distinct from the regional aquifer and would not support the same beneficial uses because of naturally occurring conditions. The shallow WBZs contained within the shallow aquifer are separated from the deeper Irvine Pressure Subbasin by a laterally extensive clay horizon that effectively restricts flow between the two aquifers. Shallow groundwater at Former MCAS Tustin typically contains much higher concentrations of TDS and other inorganic constituents than does the regional aquifer and could not be used for most beneficial uses without treatment. Moreover, since yields from the shallow aquifer system are quite low, it is unlikely to be regarded as a potential target for development of water supplies.

However, the Basin Plan does not differentiate groundwater beneficial uses on the basis of depth. That is, there are no separate listings in the Basin Plan for the shallow and regional aquifers in the vicinity of Former MCAS Tustin. Although a technical argument

could be made that these two aquifers are separate units, a general provision of the Basin Plan clearly states that undesignated groundwater in the Santa Ana Region has the same beneficial-use designations as the groundwater basin or subbasin which it overlies. For purposes of this FS Report, therefore, the Basin Plan has been interpreted to require that the shallow groundwater system at Former MCAS Tustin support the same beneficial uses and attain the same water quality objectives as the Irvine Pressure Subbasin. Generally, the most stringent water quality objectives are those related to protection of drinking water resources.

The water quality objectives for the Irvine Pressure Subbasin, as presented in the Basin Plan, are applicable requirements for remediation of OU-1A groundwater. These objectives include both narrative and numerical criteria that are of use in defining groundwater contamination and identifying potential remediation goals for the shallow aquifer at Former MCAS Tustin. While the Basin Plan does not provide numerical water quality objectives for OU-1A COCs, it does include the following narrative objective for toxic substances, which is applicable:

> All of the waters of the region shall be maintained free of substances in concentrations which are toxic, or produce detrimental physiological responses in human, plant, animal, or aquatic life.

For this FS, it was assumed that this narrative objective for toxic substances would be satisfied when VOC concentrations in OU-1A groundwater were below health- or environmentally based criteria (i.e., below the thresholds at which toxic or detrimental physiological responses in humans or environmental receptors would be expected to occur).

2.4.2 Federal Drinking Water Standards

MCLs developed by U.S. EPA under the SDWA are directly applicable to the quality of drinking water at the tap for public water supply systems as defined in 40 C.F.R. § 141. However, the MCLs promulgated at 40 C.F.R. § 141.61 are generally considered to be relevant and appropriate as remediation goals for organic contaminants in current or potential drinking water sources and, thus, are commonly identified as ARARs for groundwater response actions under CERCLA. Although MCLs are developed using cost and technical considerations, U.S. EPA considers them to be protective of human health as well.

U.S. EPA has also developed MCLGs that serve as guidance for establishing MCLs. MCLGs for organic contaminants are promulgated at 40 C.F.R. § 141.50. An MCLG is set at a level at which no adverse health effects may arise, with a margin of safety. An MCL is required to be set as close as possible to its corresponding MCLG, taking into consideration the best technology, treatment techniques, and other factors, including cost.

CERCLA Section 121(d)(2)(A) states that MCLGs should be attained as remediation goals "where relevant and appropriate under the circumstances of the release." U.S. EPA has stated that when the MCLG is zero, it is not an appropriate groundwater remediation

goal at a CERCLA site (55 *Federal Register* 8751, 08 March 1990). Because carcinogens have MCLGs of zero, the MCL is the appropriate value to select as a remediation goal for these constituents. For noncarcinogens, the MCL in most cases is equal to the MCLG. Thus, potential groundwater remediation goals for a CERCLA site based on federal drinking water standards would generally be set at MCLs or nonzero MCLGs.

According to the Basin Plan, shallow groundwater at Former MCAS Tustin has a beneficial-use designation as a potential source of drinking water. Therefore, federal MCLs, nonzero MCLGs, and those California MCLs (defined below) that are more stringent than federal MCLs are relevant and appropriate cleanup criteria for OU-1A groundwater. This determination is based on 40 C.F.R. § 300.430(e)(2)(i)(B) and the preamble to the NCP (55 *Federal Register* 8750–8754, 08 March 1990). Table 2-3 lists the federal MCLs and MCLGs for the COCs in groundwater at IRP-13S. Note that MCLs and MCLGs have not been established for 1,2,3-TCP.

2.4.3 California Drinking Water Standards

The Cal. Health & Safety Code provides authority for DHS to develop state MCLs, which have been promulgated in Cal. Code Regs. tit. 22. These state MCLs are applicable in California and consist of primary and secondary standards for drinking water. Similar to federal MCLs, the California MCLs are only directly applicable at the tap, but would be relevant and appropriate for groundwater remediation at Former MCAS Tustin OU-1A. CERCLA provides that state MCLs are to be used as remediation goals only when more stringent than the corresponding federal MCLs.

The applicable California MCLs are listed in Table 2-4. DHS has not established an MCL for 1,2,3-TCP. California drinking water regulations do not have MCLGs.

2.4.4 RCRA Groundwater Protection Standards

The RCRA groundwater protection standards promulgated at 22 Cal. Code Regs. 66264.94 are not applicable for the development of OU-1A remediation goals. However, these standards are considered relevant and appropriate because they address circumstances and contaminants similar to those encountered in the plumes at and downgradient from IRP-13S. Accordingly, the RCRA groundwater protection standards are ARARs for this FS.

The RCRA groundwater protection standards are applicable only for regulated units managing hazardous wastes. For this reason, these standards are not applicable for this FS because OU-1A does not contain a RCRA waste management unit, and the groundwater contaminants to be addressed by this response action are not classified as hazardous wastes. However, the RCRA corrective action is provided for in the CERCLA response and meets those requirements. The following paragraphs provide supporting arguments for this determination.

Table 2-3
Federal MCLs and MCLGs for Chemicals of Concern
(reported in micrograms per liter)

Chemical	MCL	MCLG
Trichloroethene (TCE)	5	0
1,2,3-Trichloropropane (1,2,3-TCP)	NA	NA

Source:
40 C.F.R. § 141.50 (MCLGs) and 40 C.F.R. § 141.61 (MCLs)

Acronyms/Abbreviations:
C.F.R. – *Code of Federal Regulations*
MCL – maximum contaminant level
MCLG – MCL goal
NA – not applicable; no MCL or MCLG is established for 1,2,3-trichloropropane
§ – section

Table 2-4
California MCLs for Chemicals of Concern
(reported in micrograms per liter)

Chemical	MCL
Trichloroethene (TCE)	5
1,2,3-Trichloropropane (1,2,3-TCP)	NA

Source:
Cal. Code Regs. § 64444

Acronyms/Abbreviations:
Cal. Code Regs. – *California Code of Regulations*
MCL – maximum contaminant level
NA – not applicable; no MCL is established for 1,2,3-trichloropropane

U.S. EPA guidance states that substantive RCRA requirements may be applicable to CERCLA sites under one of two conditions (U.S. EPA 1988b). First, such requirements are applicable if a RCRA-listed or characteristic hazardous waste is present at a CERCLA site and if these hazardous wastes were actively managed after the effective date of the corresponding RCRA regulations. Second, CERCLA response actions that involve treatment, storage, or disposal of hazardous waste would also make RCRA requirements applicable. Only the first condition is relevant to the development of remediation goals for OU-1A groundwater.

U.S. EPA recognizes that, often, no information exists on the specific waste materials that were the source of groundwater contamination at a CERCLA site. In such situations, the lead agency should use available site information, manifests, storage records, and vouchers in an effort to ascertain the nature of the contamination. When this documentation is not available, the lead agency may assume that the contamination did not result from the disposal of RCRA-listed hazardous wastes and that RCRA requirements pertaining to listed wastes would not be applicable (U.S. EPA 1988c; see also the NCP preamble at 55 *Federal Register* 8758, 08 March 1990).

TCE and 1,2,3-TCP, the primary VOCs in OU-1A groundwater, are used as solvents in a variety of industrial processes, including metal degreasing, paint removal, and in the cleaning and drying of electronic parts. TCE is the major component of three RCRA-listed hazardous wastes: F001 (spent halogenated solvents used in degreasing), F002 (spent halogenated solvents), and U228 (commercial chemical product, manufacturing intermediate, or off-specification TCE). However, 1,2,3-TCP is not included as a component in any of the RCRA hazardous wastes listed at Cal. Code Regs. tit. 22, § 66261.31 or Cal. Code Regs. tit. 22, § 66261.33.

As the lead federal agency for environmental restoration activities at Former MCAS Tustin, the DON conducted an investigation to determine whether TCE-containing wastes meeting the listing descriptions for F001, F002, or U228 were generated at the station and whether these wastes were disposed of or released on-site after the effective date of the pertinent RCRA regulations. Available historical site information, manifests, and storage records for the station were reviewed under the RFA and the RI. Interviews were conducted with past MCAS Tustin staff. As discussed in Appendix A, no documentation of past waste-disposal practices was found that would serve to classify the sources of groundwater contamination at this IRP site with respect to the RCRA waste listings. Therefore, the DON has made the determination that the TCE in OU-1A groundwater should not be classified as a RCRA-listed hazardous waste because it is not derived from materials meeting the listing description for F001, F002, or U228.

Data collected during the RI have also been evaluated to determine whether there is a potential to classify extracted groundwater at Former MCAS Tustin as a D040 RCRA characteristic hazardous waste. This classification would apply to extracted groundwater exceeding 500 μg/L TCE. No RCRA hazardous waste characteristic level has been established for 1,2,3-TCP, and TCE concentrations at IRP-13S were all below 500 μg/L during the RI. Modeling presented in Appendix B suggests that TCE will not exceed

500 μg/L in the use of groundwater extraction wells that could be installed as part of an OU-1A response action. This information, along with the lack of TCE at elevated concentrations in some RI groundwater samples, was the basis for the determination that the substantive provisions of Cal. Code Regs. tit. 22, § 66264.94 are not ARARs for development of remediation goals for the OU-1A plumes.

The RCRA groundwater protection standards (Cal. Code Regs. tit. 22, § 66264.94) establish remediation goals for contaminated groundwater at RCRA-regulated facilities. These regulations state that COCs must not exceed background levels in groundwater or, if achieving background is shown to be technologically or economically infeasible, some higher concentration limit that is established as part of a corrective action program. Per Cal. Code Regs. tit. 22, § 66264.94(e), a remediation goal greater than background shall never exceed MCLs established under the federal SDWA.

The halogenated VOCs reported in the OU-1A plumes at Former MCAS Tustin do not occur naturally. To achieve background conditions, the groundwater concentrations of these compounds would have to be zero or, for practical purposes, below the analytical detection limit. It is not technically or economically feasible to achieve background (i.e., nondetectable) levels of VOCs in the OU-1A plumes. Therefore, as provided in Cal. Code Regs. tit. 22, § 66264.94(c), OU-1A groundwater remediation goals based on federal or state MCLs, nonzero MCLGs, or health-based criteria would be consistent with the RCRA groundwater protection standard.

2.4.5 Cleanup to Background Levels

Available technologies for remediation of VOC-impacted groundwater at Former MCAS Tustin are discussed in detail in Section 3. For purposes of this subsection, it is important to note that extraction with aboveground treatment is often the only practical method available for removing dissolved constituents such as TCE and 1,2,3-TCP from an aquifer. Past U.S. EPA efforts to restore VOC-affected aquifers to background levels using groundwater extraction have generally not been successful (U.S. EPA 1989a,b). Other approaches, such as *in situ* biodegradation, are generally not effective for chlorinated VOCs unless anaerobic conditions prevail in the saturated zone and the shallow aquifer at Former MCAS Tustin appears to be well oxygenated.

When extraction systems are installed, experience at full-scale remediation sites has often shown that contaminant concentrations in the groundwater decline rapidly during the initial period of operation. However, a potentially significant fraction of the contaminant mass remains adsorbed to or otherwise entrained within the aquifer matrix. Aquifer heterogeneities, abundant clay or organic carbon, and other conditions greatly increase the amount of contamination that can become "locked up." The essentially immobile material remains an active, albeit low-level, contaminant source that is slowly released to groundwater via diffusion, desorption, or dissolution over an extended period of time. This phenomenon, commonly referred to as "tailing," leads to a leveling-off of contaminant concentrations, in many cases above remediation goals. Tailing has been observed at most sites attempting to restore impacted groundwater by means of

extraction. In these circumstances, complete removal of contamination to nondetectable concentrations is virtually impossible.

Removal of TCE, 1,2,3-TCP, and other VOCs from the groundwater at OU-1A would be expected to proceed along similar lines. Initial rates of contaminant removal would be relatively high, but would then decrease as VOC concentrations in extracted groundwater reflect the relatively slow yet continuing release of low levels of TCE and 1,2,3-TCP from finer-grained zones within the shallow aquifer. At some point, a minimal concentration, or asymptote, would be reached. Continued groundwater extraction would produce few benefits in terms of additional environmental restoration.

An illustration of this concept is presented on Figure 2-1, which plots VOC concentration as a function of time for a plume restoration alternative involving groundwater extraction.

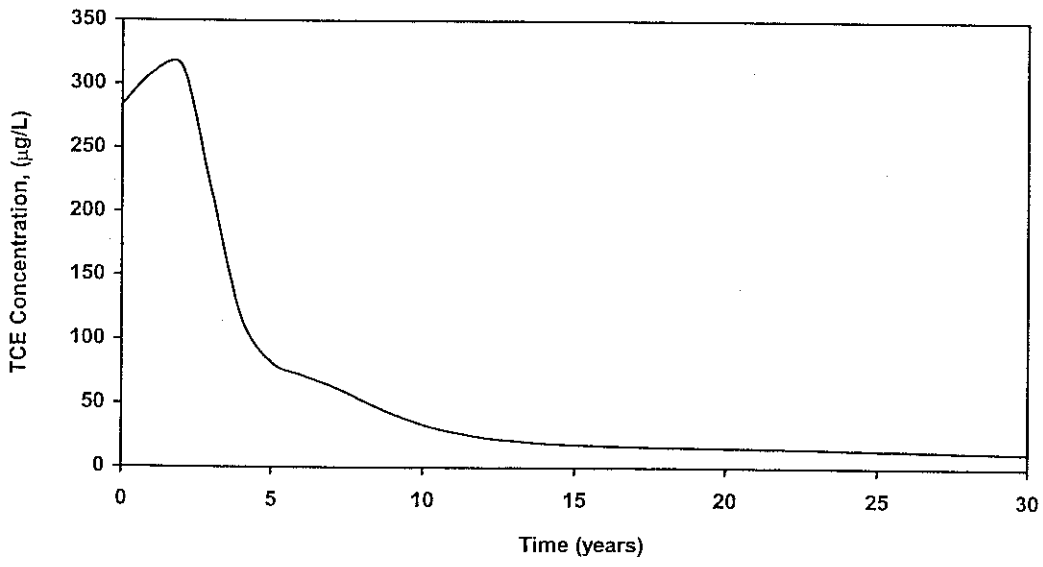


Figure 2-1
TCE Concentration Versus Time for Groundwater Extraction

Concentrations of TCE and 1,2,3-TCP in extracted groundwater would be expected to decline rapidly during the first several years of remediation and then be maintained at an asymptotic level for a long period of time. Removal of all traces of TCE (or other VOC compounds) would require permanent operation of the extraction system, resulting in significant (unreasonable) long-term costs with negligible benefit. Because attaining background levels (i.e., nondetectable VOC concentrations) is not considered technologically feasible, restoration of the shallow aquifer at Former MCAS Tustin to pristine conditions was not included as a remedial action objective at the beginning of this section, nor will background be considered a potential remediation goal for VOCs in OU-1A groundwater. Other concentration limits determined to be protective of human health and the environment (e.g., MCLs), as provided for in Cal. Code Regs. tit. 22,

§ 66264.94(c) and discussed above, will be used to satisfy the RCRA groundwater protection requirements.

2.5 REMEDIATION GOALS FOR OU-1A GROUNDWATER

Remediation goals and cleanup levels serve as endpoints for response actions, establishing performance requirements for remedial technologies, and provide a basis for measuring the success of cleanup. Under CERCLA, remediation goals are typically established using ARARs, when available. ARARs are generally considered to be protective of human health and the environment. When health-based ARARs are not available or are not sufficiently protective due to multiple exposures or contaminants, remediation goals can be set using site-specific criteria that reduce exposure to contaminants. The development of remediation goals and cleanup levels for groundwater should also consider the background quality of the water along with its ability to impact other groundwater or surface water.

2.5.1 Remediation Approach

CERCLA remedial actions for contaminated groundwater are driven by the expectation that aquifers will be returned to beneficial uses wherever practicable. In cases where it is not practicable to return the groundwater to beneficial use, remedial actions are expected to prevent further migration, prevent exposure to the contaminated groundwater, and reduce the risk at the site (40 C.F.R. § 300.430[a][1][iii][F]). It is neither technically nor economically feasible to remediate VOC-contaminated groundwater within the shallow WBZs beneath OU-1A to beneficial use, based on the heterogeneous, fine-grained nature of the shallow WBZs at the site and on the toxicity and physical properties of VOCs, principally 1,2,3-TCP in groundwater. The VOCs reported in groundwater at OU-1A do not occur as natural constituents and, therefore, to achieve cleanup to background levels, the concentrations of these contaminants would have to be zero. Based on groundwater modeling results, concentrations of 1,2,3-TCP in groundwater are not expected to be reduced to a background concentration (i.e., zero) by any of the remedial alternatives for many decades beyond the 30 years evaluated in this FS.

Therefore, the remedial alternatives developed and evaluated in this FS have been selected based on their ability to prevent unacceptable exposure to contaminated groundwater, prevent further migration, and reduce the risk at the site. Potential alternatives to be implemented at the site to achieve those objectives include elements of natural attenuation, containment of the OU-1A plume, aggressive groundwater extraction and injection, vacuum-enhanced groundwater extraction, hot spot groundwater removal, innovative technologies such as permeable reaction walls, and implementation of institutional controls.

Exposure to groundwater contaminated with 1,2,3-TCP that would be used as a potable source for domestic purposes (e.g., drinking, showering) is the primary risk driver at the site. The results from the risk assessment presented in Section 1.8 indicate that through implementation of an institutional control to restrict the use of shallow groundwater, the

overall risk would be reduced from a risk of 4.8×10^{-3} to a risk of 1.0×10^{-5}. For this reason, institutional controls have been incorporated into each of the remedial alternatives (except the no action alternative required by the NCP).

2.5.2 Establishing Remediation Goals and Cleanup Levels

The regional aquifer beneath Former MCAS Tustin is part of the Irvine Pressure Subbasin and has been designated for beneficial use (including municipal and agricultural uses). According to provisions of the Basin Plan, this designation also applies to the shallow groundwater at the station (RWQCB 1995), although it is of low yield and poor quality and is not being actively exploited for any beneficial use. Other potential beneficial uses for groundwater in this area include agricultural supply, industrial service supply, and industrial process supply.

Potential ARARs for restoration of a municipal water supply aquifer include water quality objectives for the Irvine Pressure Subbasin as established in the Basin Plan, federal MCLs and nonzero MCLGs, and California MCLs. The Basin Plan water quality objectives do not include numerical objectives for any of the OU-1A COPCs. However, as stated above, meeting a health-based standard such as an MCL would satisfy the Basin Plan's narrative objective for toxic substances. Therefore, the site remediation goal proposed for the OU-1A COC TCE was based on its respective California or federal MCL, whichever was lowest (Table 2-5).

Table 2-5
Proposed Remediation Goals for Groundwater
(reported in micrograms per liter)

Chemical	Remediation Goal	Basis
Trichloroethene (TCE)	5	Federal MCL*
1,2,3-Trichloropropane (1,2,3-TCP)	0.5	TBD

Note:
* federal MCLs: 40 C.F.R. § 141.61

Acronyms/Abbreviations:
C.F.R. – *Code of Federal Regulations*
MCL – maximum contaminant level
§ – section
TBD – to be determined

Federal and/or state MCLs have not been established for 1,2,3-TCP, the major risk driver in groundwater at OU-1A. For contaminants with no established MCL, a risk value of 10^{-6} is used as the point of departure for determining remediation goals. However, the development of a remediation goal should consider technical limitations such as detection limits for a chemical and other factors related to uncertainty (40 C.F.R. § 300.430[e][I][A][2] and [3]). The DON has developed a remedial goal for 1,2,3-TCP

based on an evaluation of other contaminants with similar characteristics that have established MCLs. U.S. EPA Region 9 has established a tap water PRG of 0.0056 μg/L for 1,2,3-TCP based on a lifetime incremental cancer risk of 1×10^{-6}. For comparison, the state of California has established an "action level" of 0.005 μg/L for 1,2,3-TCP. One contaminant with a tap water PRG similar to 1,2,3-TCP is 1,2-dibromo-3-chloropropane with a PRG of 0.0016 μg/L and a federal and state MCL of 0.2 μg/L (U.S. EPA 2002). The MCL for 1,2-dibromo-3-chloropropane was established by U.S. EPA based on best available technology and has been set to "reduce the risk in cancer or other adverse health effects which have been observed in laboratory animals," but is not considered a health-based standard (U.S. EPA 2000).

U.S EPA Region 9 recognizes that PRGs have been used in the past to establish action levels or cleanup levels by multiplying the cancer PRG concentrations by 10 or 100. The resulting risks for a chemical would represent the carcinogenic risk of 10^{-5} and 10^{-4}, respectively (U.S. EPA 2002). An evaluation of the PRG and corresponding MCL for 1,2-dibromo-3-chloropropane shows that the MCL is essentially calculated by multiplying the tap water PRG by 100. For comparison, a similar evaluation of the action level for 1,2,3-TCP multiplied by 100 would result in an MCL of 0.5 μg/L. The estimated cancer risk for 1,2,3-TCP at 10^{-4} corresponds to a 1,2,3-TCP concentration of 0.56 μg/L. Similar conditions exist for 1,2,3-TCP and 1,2-dibromo-3-chloropropane, including limitations on best available technology for possible cleanup levels (modeling indicates concentrations of 1,2,3-TCP can be reduced to approximately 1 μg/L with proposed technologies) and the practical detection limit for 1,2,3-TCP of 0.5 μg/L (detection limit used by the local water districts). Based on this evaluation, the DON is proposing a remediation goal for 1,2,3-TCP of 0.5 μg/L (tap water PRG multiplied by 100).

In summary, the proposed remediation goal for 1,2,3-TCP is considered to be protective of human health and the environment for the following reasons.

- Implementation of institutional controls to prevent use of groundwater contaminated with 1,2,3-TCP provides for an immediate reduction in total site risk to 1×10^{-5} 1,2,3-TCP in groundwater accounts for greater than 99 percent of the estimated risk at the site.
- Cancer risks to human health are at maximum values under current conditions and will further decrease with time as remediation of VOC-contaminated groundwater proceeds.
- An MCL for 1,2,3-TCP is likely to be developed while the remedial action is in place (30 years or more). If the MCL is more protective (i.e., MCL is lower than 0.5 μg/L), risk managers for the site at the time the MCL is promulgated will decide whether to implement the MCL or stay with the remediation goal based on existing site conditions.
- Technologies may be developed in the future to reduce concentrations to lower levels than the existing technologies employed in general practice.

Furthermore, institutional controls may have to remain in place indefinitely (i.e., run with the land) based on the toxicity of 1,2,3-TCP. Under this scenario, the remediation objectives would be to contain the plume, reduce contaminants to a risk level less than 10^{-6} (point of departure in the NCP), and verify the plume is stable within site boundaries. Risk managers may determine that active remedial action is no longer necessary even though concentrations of 1,2,3-TCP may be higher than the established numerical remediation goal. Protocols for how the site will be evaluated will be developed in the remedial design and discussed during periodic reviews during the remedial action.

Table 2-5 lists the proposed remediation goals for contaminated groundwater at OU-1A. Final remediation goals will be specified in the ROD.

2.6 RESTORATION TIME FRAME

U.S. EPA guidance for groundwater remediation (U.S. EPA 1988b) defines "restoration time frame" as "the period of time required to achieve selected cleanup levels in the groundwater at all locations within the area of attainment." The preamble to the NCP states that U.S. EPA will usually consider several different alternative restoration time periods and methodologies to achieve site remediation goals. The most appropriate option will be selected by balancing tradeoffs between the NCP criteria of long-term effectiveness; reduction of contaminant toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost (55 *Federal Register* 8732, 08 March 1990).

A number of factors influence the choice of groundwater response actions and, thus, the restoration schedule. At IRP-13S, these factors include the current use and value of the aquifer, the ability to monitor and control VOC migration, and technical considerations associated with extracting contaminated groundwater. Each of these issues is examined below.

2.6.1 Current Use and Value of the Aquifer

According to the Basin Plan, groundwater in the shallow aquifer beneath Former MCAS Tustin has been designated by RWQCB for a number of beneficial uses, including use as a potential source of drinking water (RWQCB 1995). Near-term use of this shallow groundwater is unlikely because of its relatively high TDS content, high background concentrations of constituents such as selenium and nitrate, and low yield. For this reason, the shallow aquifer is considered a component of the overall water resource base in the Tustin area, and the ultimate restoration of this groundwater is identified as a desirable outcome of the OU-1A remediation.

2.6.2 Ability to Monitor and Control Contaminant Migration

The areal and vertical extent of VOC contamination originating at IRP-13S has been generally well defined, as have groundwater flow and contaminant migration pathways within the three WBZs that compose the shallow aquifer. Hydrogeologic data and

modeling results (summarized in Sections 1 and 5, respectively) show that further migration of the OU-1A plumes in the shallow aquifer could be controlled through hydraulic containment measures or *in situ* treatment walls. However, uncertainties associated with modeling and the use of groundwater extraction to control contaminant migration exist because of the heterogeneous, complex lithology at OU-1A. These data also indicate that containment could be readily verified through groundwater monitoring within the affected portions of the shallow aquifer.

2.6.3 Technical Considerations

There are several technical issues that could significantly complicate cleanup of the shallow aquifer at and downgradient of IRP-13S. These issues include the heterogeneous, anisotropic nature of the aquifer as well as the presence of VOC contamination in fine-grained, low permeability clay zones. Contamination will not be easily removed from these clays. U.S. EPA guidance on aquifer restoration (U.S. EPA 1990) describes heterogeneous aquifer conditions as potentially unfavorable to the application of remediation technologies that employ groundwater extraction. This guidance indicates that the associated cleanup times for such aquifers will be longer and more difficult to estimate than for similar systems in homogenous media.

2.6.4 Conclusions

Remediation of the VOC plumes originating at IRP-13S is desirable given the regulatory status and potential resource value of shallow groundwater at Former MCAS Tustin. However, an accelerated restoration may not be practical given the technical limitations on contaminant removal from the shallow aquifer. Development of a precise estimate for the restoration time frame is further complicated by the technical uncertainties identified in the previous section.

Recognizing that uncertainty accompanies all groundwater remediation projects, the DON has elected to use modeling to develop restoration time frame estimates for the remedial alternatives evaluated in this FS. Such estimates should not be construed as absolute cleanup schedules for the OU-1A plumes. Rather, the estimated time frames presented in Section 5 were calculated for the purpose of developing cost estimates, conducting a detailed analysis of remedial alternatives, and comparing the relative performance of each alternative. The estimates of remediation time presented in this FS Report should not be used to establish milestones in the ROD or to satisfy other regulatory or legal requirements. In addition, estimating restoration time frames may not be practical for alternatives involving containment, natural attenuation, or no action, especially if such time frames extend for many decades, beyond the point at which modeling remains a technically viable predictive tool.

2.7 AREA OF ATTAINMENT

U.S. EPA guidance defines the area of attainment for a CERCLA groundwater response action as the location where cleanup levels will be achieved at the time a remedial action is considered complete (U.S. EPA 1988b). According to this guidance, the area of attainment generally coincides with the areal extent of groundwater contamination outside the boundary of any waste remaining in place and up to the margin of the contaminant plume at the time restoration begins. U.S. EPA believes that remediation levels should eventually be attained throughout the contaminated plume. The purpose of identifying an area of attainment is to facilitate development and evaluation of remedial alternatives (e.g., to determine where to place extraction wells, hydraulic containment systems, *in situ* treatment walls, or monitoring wells).

Separate areas of attainment have been identified for the IRP-13S plumes. The attainment area is defined as the footprint of contaminated groundwater in each of the affected WBZs. The areal extent of VOC-impacted groundwater at OU-1A has been delineated from quarterly monitoring results obtained during December 2001 (BNI 2002b). These contaminant plumes and, therefore, the areas of attainment for this FS, are presented on Figures 1-19 and 1-20.

Section 3
IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section identifies general response actions and remedial technologies capable of addressing VOC-contaminated groundwater and soil at IRP-13S. The remedial technologies applicable to each general response action are screened following criteria listed in U.S. EPA technical guidance (U.S. EPA 1988a). Screening criteria include technical implementability (considering the characteristics of the site), expected performance, and relative cost. Technologies that pass this screening evaluation are then assembled in Section 4 into complete alternatives capable of achieving the RAOs established in Section 2.

3.1 GENERAL RESPONSE ACTIONS

General response actions are broad categories of remedial approaches that will help achieve cleanup goals. Response actions may stand alone as complete remedial alternatives or may be a combination of response actions to effectively address site-related contamination and meet RAOs.

The following general response action categories have been considered in this FS Report.

- **No action** entails no further response action of any type, including no administrative control or monitoring. The NCP and CERCLA require consideration of a no action alternative as a basis for comparison with other remedial alternatives developed during the FS.
- **Institutional controls** reduce potential hazards by limiting public exposure to site-related contaminants, primarily through administrative measures. Institutional controls do not reduce the volume, mobility, or toxicity of VOCs in groundwater and soil. Examples of such controls include permits for installation of new water supply wells along with access limitations or future use restrictions placed on property deeds or titles. Institutional controls may also include technical measures such as groundwater monitoring to evaluate potential risks and/or changes in site conditions over time.
- **Monitored natural attenuation** refers to a site-cleanup approach that relies on naturally occurring *in situ* processes (such as biodegradation, chemical transformation, volatilization, dilution, dispersion, and adsorption) to achieve RAOs within a time frame that is reasonable compared with more active approaches (U.S. EPA 1997a). Under certain favorable conditions, these natural processes will act without human intervention to reduce the mass, toxicity, mobility, or volume of VOC-contaminated soil and groundwater. Monitoring of subsurface conditions over time is an inherent component of remedial actions, which incorporate natural attenuation.
- **Containment** technologies control risk by eliminating routes of VOC exposure or reducing exposures to acceptable levels through isolation of soils or hydraulic control of groundwater. Containment technologies may reduce contaminant mobility. Hydraulic control using groundwater extraction may help reduce the toxicity or volume of VOCs by extracting contaminated

groundwater. Containment technologies require continued monitoring to determine whether remedial measures are performing successfully.

- **Excavation and extraction** refer to methods typically used to remove contaminated soils or groundwater affected by VOCs. These technologies provide no treatment but are necessary before *ex situ* treatment or disposal.
- **Treatment** technologies involve engineered processes to separate, immobilize, or destroy VOCs and may be applied *in situ* or *ex situ*. Separation technologies transfer VOCs from one medium to another, generally creating a more concentrated and/or easily treated waste stream. Immobilization technologies bind contaminants in a stable matrix that resists leaching or degradation. Destruction technologies transform site-related VOCs into generally benign by-products, although they may produce other (nontarget) contaminants in residual streams.
- **Disposal** technologies involve on-site or off-site transfers of contaminated media (soil and groundwater) or treatment residuals. Discharges to surface water and ambient air are included within this general response action category. The on-site disposal of untreated soil or groundwater is generally limited to material with low contaminant concentrations that is nonhazardous and incapable of releasing VOCs at concentrations of concern. Off-site management of VOC-affected media must meet stringent regulations governing the treatment, storage, and disposal of solid and hazardous waste. The off-site disposal of treated groundwater to surface water requires adherence to substantive NPDES permit requirements.

Potential response actions were developed for groundwater and soils that may contribute to groundwater contamination to satisfy the NCP requirement to consider a broad range of alternatives. Per 40 C.F.R. § 300.430(e), the FS must specifically evaluate no action, source control alternatives that reflect varying degrees of treatment, containment, and institutional controls, and groundwater restoration alternatives that attain remediation goals within different times using one or more different technologies.

General response actions identified for *groundwater* contamination at and downgradient from IRP-13S include the following:

- no action
- institutional controls
- monitored natural attenuation
- containment
- *in situ* treatment
- extraction
- *ex situ* treatment
- disposal

General response actions identified for source area *soils* that may contribute to groundwater contamination at IRP-13S include the following:

- no action
- institutional controls
- containment
- *in situ* treatment
- excavation
- on-site treatment/disposal
- off-site treatment/disposal

The response actions listed for each medium were used to categorize potentially applicable remedial technologies for VOC-impacted groundwater and soil that may contribute to groundwater contamination at OU-1A.

3.2 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

Since the inception of the CERCLA Program in 1980, U.S. EPA has found that certain categories of sites share similar characteristics, including types of contaminants present, past disposal practices, affected environmental media, and preferred remedial technologies. Various initiatives have been undertaken to incorporate this experience and streamline the FS process on the basis of historical patterns of CERCLA remedy selection and site performance data. In particular, U.S. EPA has identified remedial technologies or sets of technologies that are presumptively the most appropriate for addressing contamination at sites affected by chlorinated VOCs in soil and groundwater (U.S. EPA 1993a,b, 1996a,b, 1997b).

U.S. EPA expects that presumptive remedies will be used at all appropriate sites, although alternative technologies may be considered when warranted (U.S. EPA 1993a). To that end, U.S. EPA has published several guidance documents, directives, and policy statements that are relevant to this FS, including the following.

- **Contaminants and Remedial Options at Solvent-Contaminated Sites** (U.S. EPA 1994a) identifies response actions and remedial technologies commonly used and demonstrated to be effective for remediation of soils and groundwater with contaminants similar to those at IRP-13S.
- **Remediation Technologies Screening Matrix and Reference Guide** (U.S. EPA 1994b) provides a comprehensive listing of remedial technologies for VOC-contaminated soil and groundwater. This U.S. EPA reference effectively serves as a preliminary screening step to determine the technical implementability of various technologies for possible use at OU-1A.
- **Presumptive Response Strategy and *Ex Situ* Treatment Technologies for Contaminated Groundwater at CERCLA Sites** (U.S. EPA 1996b) states that groundwater extraction, source removal, and natural attenuation, alone or in

combination, constitute the presumptive remedy for contaminated groundwater at sites where DNAPLs are not a concern. The presumptive technologies listed for *ex situ* treatment of VOCs in extracted groundwater include air stripping, GAC adsorption, chemical oxidation, and aerobic biological treatment.

- **Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils** (U.S. EPA 1993b, 1996a) identifies soil vapor extraction (SVE), thermal desorption, and incineration as presumptive remedies for VOCs in soils.
- **Presumptive Remedy: Supplemental Bulletin Multiphase Extraction (MPE) Technology for VOCs in Soil and Groundwater** (U.S. EPA 1997b) defines VEE (also known as MPE) as another presumptive technology for remediation of VOCs in soil and groundwater. MPE combines key components of conventional groundwater extraction and SVE. U.S. EPA describes it as particularly applicable to sites such as Former MCAS Tustin with significant concentrations of VOCs adsorbed to low-permeability soils below the water table.

Further discussion of the technologies identified through consideration of these U.S. EPA documents is presented in the following section.

3.3 SCREENING OF REMEDIAL TECHNOLOGIES

An important part of the U.S. EPA CERCLA streamlining effort involves reducing the level of documentation required in an FS Report. Earlier guidance (U.S. EPA 1988a) suggested that an FS should include a two-step screening process to identify and select remedial technologies before development of remedial alternatives for detailed analysis. With more experience in the CERCLA Program and the development of presumptive remedies for VOCs in soil and groundwater, U.S. EPA has now determined that this screening process is one part of an FS which can be effectively streamlined (U.S. EPA 1993a).

For this reason, remedial technology screening in this FS has been reduced to a single step based on the U.S. EPA guidance and supporting documentation listed in the previous section as well as a preliminary identification of remediation processes prepared specifically for Former MCAS Tustin (BNI 1995). An initial screening step, involving technology identification and preliminary screening based only on technical implementability, was eliminated from this FS. Elimination of this step is consistent with U.S. EPA directives for the evaluation and selection of remedial alternatives at sites affected by VOCs in groundwater and soil (U.S. EPA 1993b, 1996b).

Remediation technologies and process options identified as potentially applicable at Former MCAS Tustin OU-1A were screened on the basis of the criteria of effectiveness, implementability, and cost. The objective of this screening step was to select representative process options for each technology and thereby simplify the subsequent development and evaluation of alternatives.

3.3.1 Screening Criteria

In accordance with U.S. EPA guidance (U.S. EPA 1988a), technology screening on the basis of effectiveness considered the following.

- **Ability to achieve RAOs for the protection of human health and the environment.** Technologies that will not attain chemical-specific ARARs or health-based cleanup goals, or will not effectively contribute to the protection of public health or the environment at Former MCAS Tustin, were not considered further.
- **Permanent reduction in toxicity, mobility, or volume of VOC-affected groundwater and soil.** Technologies that permanently reduce contaminant toxicity, mobility, or volume were preferred over those that do not.
- **Long-term risks of treatment residuals or containment systems.** Technologies that significantly lower long-term risks were preferred.
- **Risks to the public, workers, or the environment during technology implementation.** Technologies posing less risk during implementation were preferred.

The screening criterion of implementability included the following considerations.

- **Site characteristics limiting the construction or effective functioning of a technology.** Technologies limited by site conditions at Former MCAS Tustin were eliminated.
- **Waste or media characteristics that limit the use or effective functioning of a technology.** Technologies limited by waste or media characteristics were eliminated.
- **Availability of equipment needed to implement a technology along with the capacity of off-site treatment or disposal facilities required.** Technologies that are commercially developed and readily available or innovative technologies that have been pilot tested were given preference.
- **Administrative feasibility of obtaining permits for off-site actions and approvals from regulatory agencies and other offices.** Such feasibility is an important component of implementability because a technically feasible option may be difficult or impossible to permit. Technologies were eliminated if obtaining all necessary administrative approvals was judged to be inordinately difficult.

Cost criteria used to screen remedial technologies were qualitative and based on engineering judgment. The relative magnitude of capital as well as operation and maintenance (O&M) costs was considered when comparing process options within a technology type. Process options with lower costs were preferred if the effectiveness and other implementability criteria were judged to be similar.

The technology screening criteria described above were applied in a stepwise manner based on their relative importance in the FS process. The criterion of effectiveness was

given the most weight in this evaluation, followed by implementability and then cost. When two or more options yielded comparable results, cost criteria were used to determine the most effective approach within a technology type.

Results of the screening process for groundwater remediation at Former MCAS Tustin OU-1A are discussed in the following subsections and summarized in Table 3-1. The screening process for source material (i.e., VOC-affected soil) remedial technologies is also discussed in the following subsections and summarized in Table 3-2.

3.3.2 Groundwater

The screening of groundwater remediation options focused on technologies presented in the U.S. EPA presumptive remedy guidance (U.S. EPA 1996b, 1997b). Additional technologies were also evaluated on the basis of site-specific considerations such as the hydrogeology at Former MCAS Tustin and the RAOs listed in Section 2. The stationwide groundwater numerical model developed for the RI (BNI 1997a) was also used as a tool to evaluate selected response actions or remedial technologies, including containment, groundwater extraction, and *in situ* treatment methods. Appendix B presents further details on the modeling conducted to support groundwater remediation at OU-1A.

3.3.2.1 NO ACTION

No action was included in the technology screening process as a formality since it is automatically retained as the baseline for comparison with other response actions.

3.3.2.2 INSTITUTIONAL CONTROLS

Institutional controls that could be implemented at IRP-13S would not have an effect on continued migration of the plumes but would be used to protect the remedy and effectively limit the risk of human exposure to contaminated groundwater. Institutional controls are considered part of the remedy and complement engineering controls and monitoring.

Institutional controls are nonengineering mechanisms, such as land-use restrictions, that limit exposure of future land owner(s) and land user(s) to COCs, and/or maintain the integrity of the remedial action. The institutional controls identified for application to the remedial action for OU-1A fall into two broad categories: 1) restrictions on future land use and 2) provision for access for future monitoring and maintenance activities by the DON and oversight of those activities by the regulatory members of the BCT. These controls would be placed on the property deeds at the time of land transfer. Engineering controls, such as removal, containment, or treatment of subsurface contaminants, can be used with or without institutional controls.

Institutional controls require monitoring to ensure compliance with the restrictions. This type of monitoring is generally specified in the Land-Use Control Implementation and Certification Plan (LUCICP), which is prepared during the remedial design phase. The draft LUCICP will be provided to the LRA and transferee(s) for review and comment and the BCT signatories for review and approval.

Table 3-1
Screening of Remedial Technologies and Process Options for Groundwater

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
No action	None	None	No further response actions of any type.	Does not remove site-related contamination or control contaminant migration; therefore, does not meet remedial action objectives	Does not entail any action.	No direct costs	Retain as required by CERCLA.
Institutional controls	Land use restrictions	Deed restrictions	Deed restriction issued for property within potentially contaminated areas to restrict future uses that may result in exposures to contaminated groundwater.	Effective for prevention of human contact with contaminated water; reliability is dependent upon long-term enforcement Does not remove site-related contamination or control contaminant migration	Easily implemented; however, may impact future land uses.	Negligible capital and O&M costs.	Retain for further consideration.
	Monitoring	Groundwater sampling and analysis	Periodic sampling and analysis of groundwater to monitor contaminant extent and migration.	Effective means to monitor contaminant movement, intrinsic bioremediation processes, and/or progress of remedial action. Does not remove site-related contamination or control contaminant migration.	Readily implemented. Some groundwater monitoring wells currently in place.	Low capital and moderate O&M costs.	Retain for further consideration.
Monitored natural attenuation	Monitored natural attenuation	Natural attenuation	Naturally occurring attenuation mechanisms (biodegradation, adsorption, dispersion, volatilization, diffusion, and dilution) reduce contaminant concentrations.	Contaminants ultimately transformed to innocuous byproducts; requires extended duration.	Readily implemented.	No direct costs other than expanded monitoring.	Retain for further consideration.
Containment	Vertical barriers	Sheet piling	Drive interlocking sheet piles to construct a vertical low permeability barrier; restricts groundwater flow.	Effectively restricts flow of groundwater. Piling may be negatively impacted by high TDS concentrations in groundwater. Also, FS modeling indicates vertical barriers would not provide for long-term containment.	Readily implemented at sites with unconsolidated soils such as occur at Former MCAS Tustin	High capital costs and low O&M costs.	Eliminate from further consideration on the basis of effectiveness and costs.
		Grout curtains	A cement grout is pressure-injected along contamination boundaries using an overlapping pattern of drilled holes to form barrier to restrict groundwater flow.	Potentially effective in creating low-permeability barrier to inhibit groundwater flow; however, not likely to provide for long-term containment on basis of modeling predictions.	Uses standard construction/drilling and grouting equipment. Limited data showing successful implementation at contaminated sites	High capital and low O&M costs.	Eliminate based on effectiveness, implementability, and costs
		Slurry wall	Trench backfilled with a soil-bentonite or cement-bentonite mix to restrict or divert groundwater flow	Although widely used and generally effective for containing groundwater plumes, site-specific modeling indicates slurry walls would not provide long-term containment at OU-1 sites	Readily implemented in the shallow aquifer.	High capital costs and low O&M costs	Retain as support technology.
	Capping	RCRA cap/ non-RCRA cap	Low-permeability multimedia cap with vegetative cover (RCRA cap); or single or multilayered soil, clay, and/or pavement cap (non-RCRA cap) designed to prevent infiltration of precipitation.	Capping can effectively reduce infiltration, thereby decreasing the loading of contaminants to groundwater if vadose zone is contaminated. Site-specific modeling shows limited benefits from capping	Non-RCRA caps are readily constructed with common construction equipment/methods. Capping may limit/restrict future land uses.	Moderate capital and O&M costs.	Eliminate from further consideration based on effectiveness and implementability.

(table continues)

Table 3-1 (continued)

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Containment (continued)	Hydraulic controls	Extraction/injection	Control of groundwater flow/contaminant transport via the use of extraction and/or injection wells to modify hydraulic gradient.	Effectively controls groundwater flow by creating mounds or depressions through groundwater injection or extraction.	Readily implementable. Potential for biofouling and scaling in injection wells.	Low capital and moderate O&M costs.	Retain for further consideration.
In situ treatment	Biological treatment	Bioremediation	Use of microorganisms to degrade contaminants in an aerobic or anaerobic environment. Can be enhanced through addition of nutrients or cultured microorganisms.	Effectiveness is limited due to heterogeneous, low permeable nature of both saturated and vadose zones.	Difficult to monitor progress in heterogeneous subsurface conditions. Chlorinated VOCs do not degrade aerobically. It will be difficult to create anaerobic conditions in the low permeability shallow aquifer.	Moderate capital and O&M costs.	Eliminate based on effectiveness and implementability.
	Physical treatment	Air sparging	Compressed air, injected into lower portion of affected aquifer, percolates up through saturated zone causing transfer of VOCs from aqueous to vapor phases, which migrate upward to vadose zone and are collected with SVE system.	Effectiveness is limited due to heterogeneous, low permeable nature of both saturated and vadose zones.	Treatability tests required. Implementability decreases as the area of contamination increases. Requires treatment of VOCs in the air stream.	Moderate capital and O&M costs.	Eliminate based on effectiveness and implementability.
	Chemical treatment	Permeable reaction wall	Permeable reaction wall installed across flow path of contaminant plume; treatment occurs as groundwater flows through wall under natural or enhanced gradient. Potentially effective for removal of inorganics from groundwater.	Limited applications to date; reported to be successful in degrading greater than 90% of TCE in groundwater. Limited data concerning effectiveness in attaining final cleanup goals, but technology is generally viewed as promising.	Limited full-scale applications. Would require pilot-scale treatability testing to support design and optimize performance. No full-scale applications of similar magnitude to that required for OU-1 sites.	Moderate capital and O&M costs.	Retain for further consideration as innovative treatment technology.
Extraction	Groundwater extraction	Drains	Underground gravel-filled trenches generally constructed with tile or perforated pipe to collect groundwater.	Expected to be effective for shallow groundwater collection or hydraulic gradient control. Not effective for deeper groundwater contamination in second WBZ.	Implementable. Will require treatment/disposal of extracted groundwater. Entails significant disruption for large plumes.	Moderate capital and low O&M costs.	Eliminate based on effectiveness and implementability.
		Wells	Extraction wells and pumps installed to collect contaminated groundwater for subsequent conveyance to treatment facilities.	Potentially effective for removal of VOC contamination. May not achieve complete aquifer remediation within a reasonable time frame.	Readily implemented. Will require treatment/disposal of extracted groundwater.	Low capital and O&M costs.	Retain for further consideration.
		Vacuum-enhanced extraction	Innovative groundwater extraction technology that employs a submersible pump and a high vacuum to increase the rate of VOC-contaminated groundwater removal. May possibly remove soil vapor from dewatered zone.	Most effective for sites with low permeability soils, VOC contamination, VOCs that slowly desorb into groundwater, and subsurface geology that consists of silty sands to clays.	Implementable. Potentially effective for removal of VOC contamination. May not achieve complete aquifer remediation in a reasonable time frame.	Moderate capital and O&M costs.	Retain for further consideration.

(table continues)

Table 3-1 (continued)

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Extraction (continued)	Groundwater extraction (continued)	Soil vapor extraction	Separates and concentrates VOCs dispersed in vadose zone by applying a vacuum to withdraw vapors from unsaturated soil	Most effective in homogeneous soils with medium to high permeability May be modified to enhance groundwater extraction by multiphase wells, similar to VEE. Requires target zone to be dewatered first. Modeling and field test show that upper clay layer of first WBZ cannot be dewatered.	Implementable but probably ineffective for removal of VOC contamination.	Moderate capital and O&M costs	Eliminate based on effectiveness.
Ex situ treatment	Biological treatment	Biological processes	*Ex situ* anaerobic treatment would be used to degrade TCE and other site contaminants. Process uses sealed treatment reactors to exclude oxygen, provide for nutrient addition, mixing, etc	Chlorinated VOCs may potentially be degraded in an anaerobic system Treatability studies would be needed to develop design for *ex situ* system	Complicated process that requires control and monitoring of large number of variables; it has been successfully implemented.	High capital and O&M costs	Eliminate from further consideration; other technologies offer more cost-effective means for *ex situ* treatment.
	Chemical treatment	Chemical oxidation	UV radiation in conjunction with ozone and/or hydrogen peroxide oxidizes TCE and related compounds to render them nonhazardous or to make them more amenable to subsequent removal or destruction processes.	Effective for oxidation and destruction of chlorinated hydrocarbons. May result in the formation of partially oxidized and undesirable byproducts.	Use of UV radiation may require pretreatment to prevent fouling or scaling of UV lights	High capital costs and O&M costs	Eliminate based on cost; VOCs can be removed more cost-effectively by other means.
		Palladized iron reactor	Reductive dehalogenation in a fixed bed reactor. Iron medium is coated with palladium metal which acts as a catalyst.	Practical dehalogenation rates are achievable based on laboratory studies only Some reaction intermediates may not be completely dehalogenated.	May be technically feasible based on laboratory studies. No full-scale applications reported. Size of reactor likely to be equal to or greater than the size of GAC vessels based on laboratory data.	Moderate capital costs and low O&M costs	Eliminate based on implementability
	Physical treatment	Air stripping	TCE and other VOCs are removed from water by coming in contact with air, usually in a packed column.	Effective for removal of VOCs from water; off-gas would be collected and require further treatment Removal efficiencies greater than 99.9% could be achieved for VOCs.	Well-proven, reliable technology. SCAQMD permit may be required for off-gas treatment; tower height and location may be restricted.	Moderate capital and O&M costs	Not selected as representative technology due to higher costs than GAC
		Carbon adsorption (GAC)	Contaminants transferred to the activated carbon adsorbent from solution Spent carbon regeneration or disposal off-site.	Widely demonstrated effectiveness for removal of VOCs	Available and proven technology Spent carbon must be regenerated or disposed of. Modular units available.	Low capital costs and moderate O&M costs.	Retain for further consideration as representative *ex situ* treatment technology
		Filtration	Isolates solid particles by running a fluid stream through a porous medium. Driving force is either gravity or a pressure differential across the filtration medium.	Effectively removes particulate-borne contaminants from water; effectiveness dependent on pore size and particulate size.	Technically feasible and widely available through commercial vendors. Residuals may require treatment or disposal.	Low capital and O&M costs.	Retain as support technology (*filtering may be needed to enhance effectiveness of GAC treatment*).
Disposal	Off-site disposal	RCRA TSD facility	Untreated groundwater would be collected and transported to a RCRA-permitted facility for treatment/disposal; the receiving facility would determine treatment requirements.	Effective method for disposal of contaminated water.	Implementability dependent on the volume of water requiring off-site transport and geographic location of RCRA facility	Low capital and high O&M costs.	Eliminate based on cost.
	Groundwater discharge	Publicly owned treatment works	Treated groundwater discharged to Former MCAS Tustin industrial sewer system for conveyance to Orange County Sanitation District POTW for subsequent treatment/discharge.	Effective means to dispose of treated groundwater; discharge would have to meet POTW limits for Former MCAS Tustin industrial discharges	Significant administrative problems with POTW acceptance of treated (or untreated) groundwater.	Low capital costs and O&M costs.	Eliminate based on implementability.

(table continues)

Table 3-1 (continued)

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Disposal (continued)	Groundwater Discharge (continued)	Surface outfall	Treated groundwater discharged to nearby surface water (Barranca Channel or a storm drain)	Effective means of disposing of treated groundwater; treatment goals would be determined during remedial design	Technically and administratively feasible; discharge of treated groundwater to a storm drain at Former MCAS Tustin	Low capital and O&M costs.	Retain for further consideration.
		Injection/infiltration	Treated groundwater discharged to the ground via an injection well or infiltration gallery.	Effective means of disposing of treated groundwater. Can be used to enhance hydraulic containment or contaminant removal	Technically feasible	Low capital and moderate O&M costs	Retain for further consideration.
		Beneficial uses	Treated groundwater would be used for landscape irrigation, pond or fountain replenishment, habitat maintenance, or other nonconsumptive uses.	Reuse of water maximizes overall benefit of remediation and is consistent with RWQCB policy for efficient use of water resources.	Technical feasibility depends on type of redevelopment in surrounding areas and ability to tie into infrastructure for distribution of water.	Low capital costs and low O&M costs.	Not selected as representative technology; may be reevaluated during design or implementation as redevelopment occurs

Acronyms/Abbreviations:
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
FS – feasibility study
GAC – granular activated carbon
MCAS – Marine Corps Air Station
O&M – operation and maintenance
OU – operable unit
POTW – publicly owned treatment works
RCRA – Resource Conservation and Recovery Act
RWQCB – California Regional Water Quality Control Board, Santa Ana Region
SCAQMD – South Coast Air Quality Management District
SVE – soil vapor extraction
TCE – trichloroethene
TDS – total dissolved solids
TSD – treatment, storage, and disposal
UV – ultraviolet
VEE – vacuum-enhanced extraction
VOC – volatile organic compound
WBZ – water-bearing zone

Table 3-2
Screening of Remedial Technologies and Process Options for Soil (Source Material)

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
No action	None	None	No further response actions of any type	Does not address continuing release of contamination from soils to groundwater	Does not entail any action	No direct costs	Retain as required by CERCLA
Institutional controls	Land use restrictions	Deed restrictions	Deed restrictions would be used to restrict future development or land uses potentially involving exposures to contaminated soils	Does not address continuing release of contamination from soils to groundwater	Readily implementable but may limit future development of property in area of plume	Negligible capital and O&M costs	Eliminate based on effectiveness
Containment	Capping	RCRA-type cap/ non-RCRA cap	Low-permeability multimedia cap with vegetative cover (RCRA cap); or single/multilayered soil, clay, and/or pavement cap (non-RCRA cap) designed to prevent infiltration and/or exposures to contaminated soils	Capping can effectively reduce infiltration, decreasing the loading of contaminants to groundwater from contaminated soils; however, infiltration does not contribute significantly to groundwater contamination problems at the OU-1 sites, as relatively little contaminant mass is present in the vadose zone	Non-RCRA caps are readily constructed with common construction equipment/methods Capping at these sites may limit acceptable future land uses	Moderate capital and O&M costs	Eliminate based on effectiveness and implementability
Excavation	Soil removal	Mechanical excavation	Excavation of contaminated soils using backhoes, bulldozers, etc	Effective for removal of contaminated soils, thereby eliminating a continuing source of groundwater contamination	Easily implemented using standard construction equipment Requires treatment/disposal of excavated soil	Moderate capital cost; no O&M costs	Retain for further consideration
On-site treatment/ disposal	Thermal treatment	Thermal desorption	On-site TDU heats soils to temperatures that volatilize VOCs and water into carrier gas stream for secondary treatment (e g., oxidation)	TDU has been demonstrated to be an effective technology for treatment of soils contaminated with halogenated VOCs	A mobile TDU with a various locations permit could be deployed to the site temporarily	Modification of existing TDU would entail high capital costs and moderate O&M costs A temporary second TDU would entail lower capital costs and moderate O&M costs	Eliminate modification of existing TDU based on cost; retain temporary second TDU for further consideration
		Incineration	Destroys organic contaminants by heating them to temperatures greater than 1,000 °F in the presence of oxygen	Effective method for destruction of halogenated VOC contamination	Significant community and possibly regulatory opposition to on-site incineration; administrative feasibility uncertain due to need to obtain air discharge permit	High capital and high O&M costs	Eliminate based on implementability and cost; equivalent performance available at lower cost using on-site TDU
	Disposal	Backfill	Remediated soil used for backfill	Effective method for disposal of clean soil	Easily implemented TDU treatment can help disaggregate fine-grained soils to facilitate backfilling	No capital costs; low O&M costs	Retain for further consideration
Off-site treatment/ disposal	Thermal treatment	Thermal desorption	See General Response Action "on-site treatment/disposal"	Effective method for separation of halogenated VOCs from soil	Permitted TDUs capable of treating waste located within reasonable distance of site	No capital costs; moderate O&M costs	Eliminate based on cost; temporary mobile on-site TDU is a more cost-effective option
		Incineration	See General Response Action "on-site treatment/disposal"	Effective method for destruction of halogenated VOC contamination	Readily implementable but may require transport significant distance and high cost	No capital costs; high O&M costs	Eliminate based on cost; equivalent performance available through TDU

(table continues)

Table 3-2 (continued)

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Off-site treatment/ disposal (continued)	Disposal	Beneficial reuse	Remediated soil used for construction fill, landfill cover, or other uses.	Effective method for disposal of remediated soil assuming treatment is successful.	Readily implementable assuming treatment is effective	No capital costs; low O&M costs.	Retain for further consideration.
		Class II landfill	Soil loaded onto trucks and shipped to Class II landfill.	Effective method for disposal of excavated soil if it is not classified as hazardous waste.	Readily implementable. Several Class II landfills are located within reasonable distance of site	No capital cost; moderate O&M costs	Retain for further consideration.
In situ treatment	Physical treatment	Soil vapor extraction	Separates and concentrates VOCs dispersed in vadose zone by applying a vacuum to withdraw vapors from soil.	Not likely to be effective due to heterogeneous, low-permeable nature of soils in vadose zone and shallow water table at IRP sites.	Not applicable for saturated soils	Moderate capital and O&M costs.	Eliminate based on effectiveness and implementability.
		Soil flushing	Aqueous solution injected or infiltrated through contaminated soils increases the mobilization of contaminants. Flushing solution and mobilized contaminants extracted downgradient.	Limited effectiveness in low-permeability, heterogeneous subsurface materials	Leachate from contaminated soils must be collected and treated. Difficult to monitor success in heterogeneous soils	Moderate capital and O&M costs	Eliminate based on effectiveness and implementability.
	Soil vapor extraction	Six-phase soil heating	SPSH is designed to enhance the removal of contaminants from the subsurface during SVE by heating the soil. The soil is heated by installing an array of electrodes into the soil	SPSH is suited to sites where contaminants are tightly bound to clays and are thus difficult to remove by SVE alone. The zone of contamination needs to be dewatered prior to SPSH/SVE. Therefore, SPSH may not be feasible at sites with a significant amount of contamination below the water table.	Limited full-scale applications. Would need to dewater down to depth of targeted contamination. Large power array required for operation.	Moderate capital and high O&M costs.	Eliminate based on effectiveness and implementability. Not compatible for future reuse.
	Biological treatment	Bioventing	Enhances naturally occurring biodegradation by providing oxygen to existing soil microorganisms, usually through direct air injection.	Effectiveness is limited due to heterogeneous, low permeable subsurface conditions. Aerobic process is ineffective for treating halogenated VOCs	Difficult to monitor progress in heterogeneous soils. Problems with inducing air flow through saturated and low permeable soils.	Moderate capital and O&M costs.	Eliminate based on effectiveness and implementability.

Acronyms/Abbreviations:
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
°F – degrees Fahrenheit
IRP – Installation Restoration Program
O&M – operation and maintenance
OU – operable unit
RCRA – Resource Conservation and Recovery Act
SPSH – six-phase soil heating
SVE – soil vapor extraction
TDU – thermal desorption unit
VOC – volatile organic compound

As stated above, institutional controls require a mechanism or mechanisms for their placement and an agency responsible for their enforcement. The institutional controls for Former MCAS Tustin set forth in this FS Report will be incorporated into and implemented through two separate legal instruments: 1) one or more covenant agreements with DTSC addressing on-site real property containing the OU-1A shallow groundwater plumes and 2) one or more quitclaim deeds/leases between transferee(s)/lessee(s) and the DON conveying/leasing Former MCAS Tustin real property containing the OU-1A shallow groundwater plumes. The covenant agreement(s) will incorporate the land-use restrictions into restrictive covenants that run with the land and that are enforceable by DTSC against future transferees. The deed(s) will include the identical land-use restrictions in environmental restrictive covenants that run with the land and that will be enforceable by the DON against future transferees. In essence, the DON and DTSC will each have the legal authority to enforce the land-use restrictions and will share responsibility for their enforcement.

Environmental Restriction Covenant and Agreement(s)

The DON and DTSC shall enter into good faith negotiations to enter into an Environmental Restriction Covenant and Agreement(s) pursuant to the substantive requirements of Cal. Health & Safety Code Division (div.) 20, Chapters (chs.) 6.5 and 6.8 and *California Civil Code* (Cal. Civ. Code) § 1471 regarding environmental land-use restrictions, restrictive covenants, and access provisions. This Environmental Restriction Covenant and Agreement(s) will be consistent with and serve as a mechanism to implement the restrictions set forth in the ROD for OU-1A in accordance with DON policy. Once the Environmental Restriction Covenant and Agreement(s) is finalized, it will be executed immediately prior to execution of the conveyance of the property to the transferee(s) by recordation of a quitclaim deed pursuant to the Defense Base Closure and Realignment Act of 1990, 10 *United States Code* (U.S.C.) § 2687.

The Environmental Restriction Covenant and Agreement(s) will be executed by the DON on behalf of the United States and its successor and assigns (the covenantor) and DTSC and their successors and assigns, who shall be identified in the Environmental Restriction Covenant and Agreement(s) as the covenantees, pursuant to Cal. Civ. Code § 1471. The Environmental Restriction Covenant and Agreement(s) will provide for access as set forth in the ROD. The Environmental Restriction Covenant and Agreement(s) will include the legal description of the property containing the OU-1A containment remedy and adjacent monitoring wells and equipment, and the locations of additional monitoring wells and equipment required for the remedial action. The Environmental Restriction Covenant and Agreement(s) will be binding upon all future owners and/or occupants until legally terminated; that is, it will run with the land. The Environmental Restriction Covenant and Agreement(s) will include information summarizing the remedial actions at OU-1A and provisions for terminating or modifying the Environmental Restriction Covenant and Agreement(s) in the event it is no longer necessary to protect human health and the environment. The Environmental Restriction Covenant and Agreement(s) will be recorded by the DON in the office of the county

recorder for the county of Orange. The DON will provide a copy of the Covenant to DTSC following recordation.

Environmental Restrictive Covenants in the Quitclaim Deed

Pursuant to Cal. Civ. Code § 1471, the DON shall include in the quitclaim deed(s) between the United States and the transferee(s) the same land-use restrictions and equivalent access provisions that are set forth in the ROD and the Environmental Restriction Covenant and Agreement(s). All such provisions shall use the language contained herein.

The deed(s) will include the legal description of the property containing the OU-1A containment remedy and adjacent monitoring wells and equipment, and the locations of additional monitoring wells and equipment required for the remedial action. The land-use restrictions and access provisions in the deed(s) will be binding upon all future owners and/or occupants until legally terminated; that is, they will run with the land. The deed(s) will include information summarizing the remedial actions at OU-1A and provisions for terminating or modifying the restrictive covenants in the deed(s) when cleanup levels established in the ROD have been achieved and the remedial equipment has been removed.

The DON will provide DTSC and U.S. EPA with a copy of the relevant language for the proposed deed for DTSC's and U.S. EPA's review and comment in connection with DTSC's and U.S. EPA's review of the finding of suitability to transfer, finding of suitability to lease, or finding of suitability for early transfer documents, as appropriate. The scope of DTSC's and U.S. EPA's review of the deed would be to evaluate whether the use restrictions set forth in the Environmental Restriction Covenant and Agreement(s) and the ROD have been incorporated into the deed language in accordance with the DON's commitments in the ROD. The deed will be recorded in the office of the county recorder for the county of Orange. A copy of the recorded deed will be provided to DTSC and U.S. EPA following recordation.

Specific land-use restrictions proposed for OU-1A, including the area required for institutional controls, are presented in Section 5. Compatibility with future land use is an important consideration in determining the proposed remedial actions and institutional controls necessary for their support. Proposed future land use is described in the MCAS Tustin SP (The Planning Center 1996, 1998). The SP indicates that the parcels at Former MCAS Tustin currently overlying the OU-1A plumes, as well as the downgradient parcels under which the plumes are expected to migrate, will be redeveloped for residential, commercial, and recreational uses.

Groundwater monitoring, consisting of sampling and laboratory analyses, is another form of institutional control applicable to almost all remedial alternatives. Continued monitoring is necessary to provide early warning of conditions that may warrant modifications to the selected remedial action and to evaluate its effectiveness. Typical components of a monitoring program include installation and periodic sampling of monitoring wells as well as preparation of periodic reports.

3.3.2.3 MONITORED NATURAL ATTENUATION

Monitored natural attenuation takes advantage of naturally occurring subsurface processes to reduce contaminant concentrations in groundwater. Such processes include biodegradation, chemical transformation, adsorption, dispersion, volatilization, diffusion, and dilution. When complete biodegradation of VOCs occurs, these contaminants are ultimately transformed to innocuous by-products (e.g., carbon dioxide, chloride, and water). The other attenuation mechanisms involve either a transfer of contaminants to another medium (such as air or soil) or mixing with groundwater from unaffected portions of the aquifer.

In some situations, natural attenuation will reduce dissolved-phase contaminant concentrations to below MCLs or other cleanup goals. The primary limitation on natural attenuation is that it is controlled by ambient flow conditions in the subsurface. In addition, biodegradation rates are relatively slow for highly chlorinated VOCs, such as TCE, unless reducing conditions are prevalent in at least some portions of the affected aquifer. Heterogeneity of aquifer materials also complicates both the extent and rate of natural attenuation processes.

Continued plume migration under a natural attenuation scenario was evaluated as part of the baseline groundwater modeling completed for Former MCAS Tustin (Appendix B). In this evaluation, the TCE biodegradation rate was assumed to be zero since the shallow aquifer at Former MCAS Tustin is generally aerobic and there is little evidence that VOCs degrade biologically under these conditions. Additional natural attenuation simulations for the FS were completed that involved the excavation of contaminated soils at IRP-13S. The modeling results indicate that removal of source area soils would have no appreciable effect on existing contamination in the first and second WBZs. Even with excavation of all source material from the upper confining layer of the first WBZ, VOC concentrations in both WBZs would remain above RAOs for many years and would continue to migrate toward the station boundary, with eventual discharge to Barranca Channel.

3.3.2.4 CONTAINMENT

Three remedial technologies to contain OU-1A contaminated groundwater were evaluated for this FS. These included vertical barriers, capping, and hydraulic controls. The evaluation included modeling simulations for selected technologies to determine both the basic viability and, if warranted, optimal configuration for deployment of the technology.

Vertical Barriers

Vertical barriers would minimize the horizontal movement of contaminated groundwater or limit the flow of uncontaminated groundwater into the OU-1A plumes. These barriers can be installed on both the upgradient and downgradient margins of the plumes as shown on Figure 3-1.

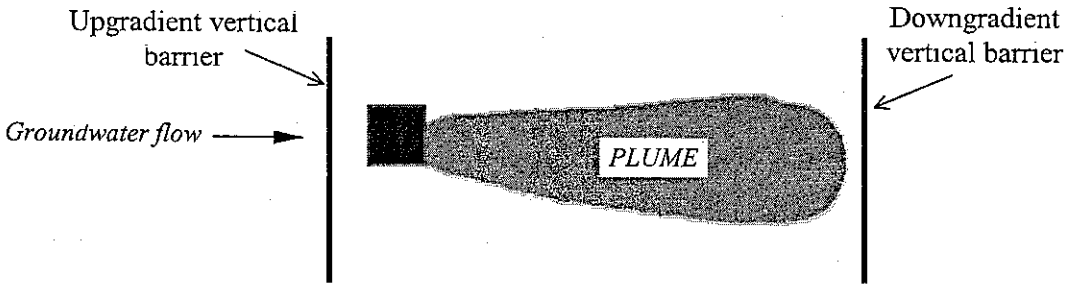


Figure 3-1
Vertical Barriers for Containment

Three vertical barrier options were evaluated: sheet piling, grout curtains, and slurry walls. These technologies should all be capable of containing contaminated groundwater and diverting uncontaminated groundwater at IRP-13S.

Sheet piling consists of barriers formed by driving interlocking carbon steel piles into a low-permeability layer, such as the clay at the bottom of the second WBZ. These walls would restrict horizontal flow in both the first and second WBZs. Sheet piling was not selected as a representative process option due to the elevated TDS concentrations in the shallow aquifer at Former MCAS Tustin. It is likely that TDS-induced corrosion would reduce the long-term effectiveness of the steel wall. Further consideration of sheet piles was not warranted, and it was eliminated on the basis of cost and effectiveness.

A grout curtain is a vertical barrier formed through pressure-injecting bentonite grout into the subsurface along the boundaries of a VOC-affected plume. This technology is more complicated to install than sheet piles or slurry walls. However, it has been used extensively in civil construction. Less is known about its long-term performance at contaminated sites. For this reason, it was eliminated from further consideration.

A slurry wall consists of a vertically excavated trench filled with a slurry, usually a soil-bentonite and water mixture. After it cures, the slurry minimizes groundwater flow by forming a filter cake that creates a low-permeability wall. Slurry walls are typically used at depths less than 50 feet bgs. In order to provide an effective barrier at IRP-13S, the slurry wall would be keyed into a low-permeability clay layer at the bottom of the second WBZ to minimize the likelihood of contaminated groundwater passing under the wall.

An additional application of slurry walls involves their use in conjunction with an *in situ* treatment method. In this application, the purpose of the slurry walls would be to direct contaminated groundwater flow toward specially constructed treatment cells. Slurry walls were found to be effective for this application. Section 3.3.2.5 presents further discussion on the use of slurry walls in conjunction with a permeable reaction wall as a support technology for *in situ* treatment.

Capping

Capping consists of a protective ground surface cover placed over a contaminated area. In general, caps are used to prevent human exposure to contaminants at the surface and to prevent the infiltration of precipitation and other surface liquids. Infiltration has the potential to leach and transport VOCs from the vadose zone and upper confining layer of the first WBZ into the more permeable zones of the shallow aquifer.

Capping was not considered an appropriate technology for addressing VOC contamination problems at IRP-13S. Since the water table at the site is relatively shallow, much of the soil identified as potential source material for groundwater contamination occurs in the saturated upper confining layer of the first WBZ. Reducing surface infiltration by capping would not eliminate continuing VOC releases to groundwater from these sources. Furthermore, capping of source area soils would not result in human-health benefits since the risk assessment completed during the RI did not identify significant ingestion, inhalation (dust or volatilized contaminants), or dermal contact hazards associated with existing VOC contamination in vadose zone soils at IRP-13S.

Capping was also evaluated to determine whether reducing the surface infiltration rate would improve the performance of groundwater extraction technologies. Modeling was used to simulate the impact of placing an impermeable barrier on the surface above the contaminated portions of the upper confining layer of the first WBZ at IRP-13S (i.e., above those areas determined to represent continuing, low-level sources of groundwater contamination). A comparison of groundwater extraction scenarios at nearby sites IRP-3 and IRP-12 with and without capping showed that minimal benefit is gained from capping at either site. For these reasons, capping was not retained for further consideration.

Hydraulic Controls

Two process options were evaluated for hydraulic control at IRP-13S. This technology controls groundwater flow and contaminant migration, modifying the hydraulic gradient around the plumes by extracting and/or injecting groundwater. Performance is determined by the existing hydraulic gradients, aquifer transmissivity, the extent of heterogeneity or anisotropy within the aquifer, and other hydrogeologic considerations.

Containment of contaminated groundwater using hydraulic controls is a well-established and demonstrated technology and was, therefore, retained for further consideration. Both wells and drains can be used. Extraction wells were selected as the representative technology for alternatives involving groundwater removal at Former MCAS Tustin, and evaluation of hydraulic containment technologies is, therefore, also focused on the use of extraction wells.

For IRP-13S, hydraulic controls for plume containment were assumed to consist of extraction wells placed along the downgradient margins of the affected groundwater. These wells would be designed and operated to create a capture zone that would extend the width of the plumes (Figure 3-2).

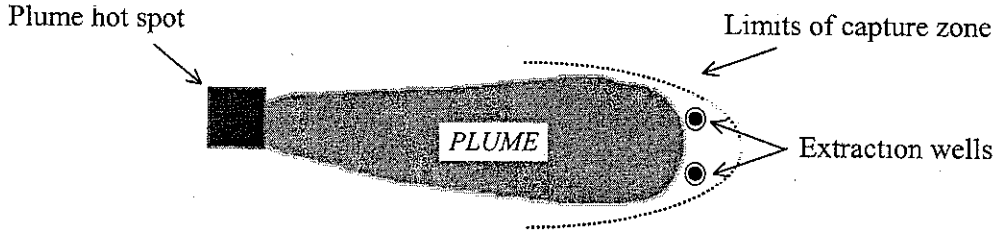


Figure 3-2
Containment Using Groundwater Extraction Wells

Extraction of contamination along the downgradient plume margin would necessitate installation of a groundwater treatment system. The treated water could be either injected back into the shallow aquifer or discharged to surface water.

Discharge to surface water would require adherence to substantive NPDES permit requirements (i.e., discharge limits for surface water discharge of treated groundwater) while on-site injection would be exempt from permit requirements. Injection of treated groundwater requires that VOCs be removed to below the detection limit, and that the treated groundwater be injected into aquifer waters of like quality (i.e., similar TDS and general minerals concentration), if not reinjected to the original aquifer.

3.3.2.5 *IN SITU* GROUNDWATER TREATMENT

The successful application of *in situ* technologies for groundwater restoration is highly dependent on the physical characteristics of the site. Specifically, the hydrogeology and hydraulic characteristics of the vadose and saturated zones must be considered along with the type of contamination present. Three *in situ* treatment processes were evaluated for remediation of groundwater, including bioremediation, air sparging, and permeable reaction walls using zero-valent iron. All three are considered innovative technologies for remediation of the primary VOCs identified in the contaminant plumes originating at IRP-13S. None of these technologies is listed as a presumptive remedy in U.S. EPA guidance for remediation of VOC-contaminated groundwater (U.S. EPA 1996b).

Bioremediation

Under aerobic conditions, TCE and other chlorinated VOCs are considered biologically recalcitrant on the basis of their relative resistance to transformation by naturally occurring microorganisms (U.S. EPA 1992). Measurements of dissolved oxygen and oxidation-reduction (redox) potential during the RI field investigation and subsequent groundwater monitoring indicate that the shallow aquifer beneath IRP-13S is generally well oxygenated and would, therefore, be classified as an aerobic environment (BNI 1997a). Guidance developed by the United States Air Force Center for Environmental Excellence states that biodegradation of TCE and other chlorinated VOCs is not expected to occur at appreciable rates under such conditions (AFCEE 1996). In addition, 1,2-DCE and vinyl chloride (VC), which are both by-products of anaerobic TCE

biodegradation, were not detected in groundwater at significant concentrations during the RI. This is a further indication that biodegradation is not currently occurring at significant rates and is unlikely to have an impact on the fate of 1,2,3-TCP or TCE in the OU-1A plumes under aerobic conditions.

Chlorinated VOCs such as 1,2,3-TCP or TCE can be degraded through anaerobic biological processes, however. In theory, subsurface redox conditions can be manipulated through addition of readily degradable organic substrates, creating an oxygen-deficient environment conducive to the growth of VOC-degrading microorganisms. A number of pilot studies have shown this to be a potentially successful method for remediating chlorinated VOCs in groundwater. However, large, field-scale applications have not been documented. *In situ* bioremediation was, therefore, eliminated from further consideration.

Air Sparging

Air sparging involves the injection of air into the saturated zone to promote *in situ* stripping of VOCs. The stripped VOCs are then captured in the vadose zone with an SVE system (Figure 3-3). This technology is commonly used to remove VOCs from groundwater. However, it is effective only where there is sufficient permeability in both the saturated zone and overlying vadose zone to facilitate stripping and capture of the volatiles.

Vadose zone soils at Former MCAS Tustin are a heterogeneous sequence of predominantly fine-grained, low-permeability materials, while the soils immediately below the water table consist of low-permeability clays (i.e., the upper confining layer of the first WBZ) across most of the station. Evaluation of site conditions and the

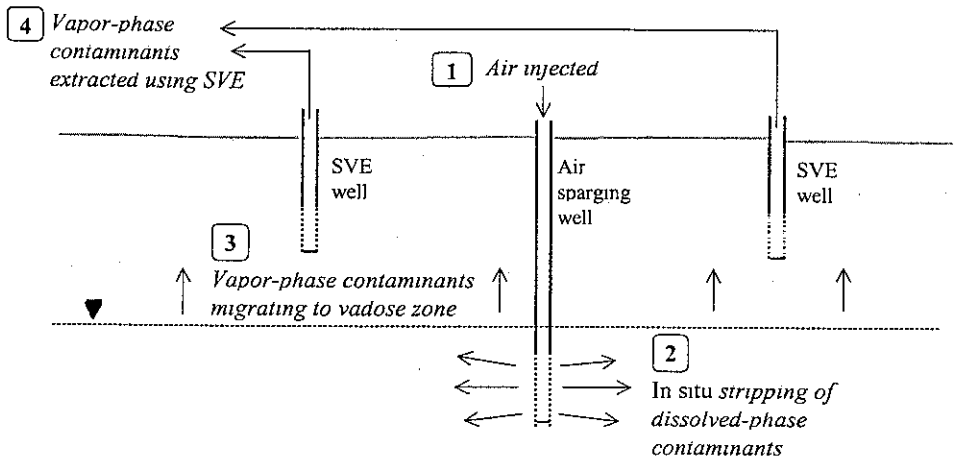


Figure 3-3
Air Sparging for Groundwater Remediation

requirements for effective deployment of air sparging at IRP-13S included consideration of the following.

- Contamination is present in both permeable and impermeable horizons beneath the water table. Injection of air would be limited to the permeable horizons of the first and second WBZs, as it would not be possible to inject air into the clays. Contamination in the less permeable zones thus would not be addressed.
- Once injected, the air and associated vapor-phase contaminants separated from the groundwater would not migrate upward to the vadose zone because an areally extensive clay layer overlies the permeable sand layers in both WBZs. This phenomenon was confirmed during a 1998 VEE pilot test at nearby site IRP-3, when air could not be induced to flow through the upper confining clay of the first WBZ (BNI 1999b). With the saturated clay layer restricting upward air flow, the injection of air may, in fact, be detrimental, causing a lateral spreading of the plume in the sand layers.
- Heterogeneity and low permeability in the vadose zone precludes the effective capture of vapor-phase contaminants, even if air could be induced to flow through the saturated upper clay layer. In addition, the shallow groundwater table at Former MCAS Tustin would further complicate the design and operation of the SVE system required to capture the stripped VOCs.

It was determined that air sparging would not be effective at Former MCAS Tustin, and this process option was, therefore, eliminated from further consideration.

Permeable Reaction Wall

Permeable reaction wall technology represents an innovative *in situ* treatment process for remediating VOC-contaminated groundwater. This is a passive remedial technology in which a wall of permeable iron filings or an iron/sand mixture is installed across the flow path of a plume. The process has been developed and marketed by EnviroMetal Technologies Incorporated (ETI), Guelph, Ontario, Canada.

ETI's laboratory and field studies have demonstrated that zero-valent iron will promote the abiotic reductive dehalogenation of chlorinated compounds dissolved in groundwater, including TCE and 1,2,3-TCP. The process involves simultaneous oxidative corrosion of the reactive iron surface by both water and the chlorinated VOCs (Focht et al. 1996). As groundwater passes through the reaction wall, the chlorine atoms of the contaminants are replaced with hydrogen. Although details of the reaction chemistry are currently debated, it is believed that the iron serves both to lower the redox potential of the groundwater and as the electron source in the VOC degradation reaction, two conditions necessary for reductive dehalogenation.

Zero-valent iron ultimately converts chlorinated VOCs to nonhalogenated, nontoxic reaction products including methane, ethane, ethene, and chloride ions. For compounds such as TCE, reaction intermediates may include 1,2-DCE and VC, which are also degradable. Complete degradation of VOCs to nontoxic end products is controlled by the residence time of the contaminated groundwater within the reaction wall. Residence time

is dictated by the groundwater flow velocity and thickness (breadth) of the wall as measured in the direction of flow. Further information on permeable reaction wall treatment technology is provided in Appendix C.

Reactive iron walls may be constructed as a single element or in conjunction with vertical barriers such as slurry walls in a "funnel-and-gate" configuration, as illustrated on Figure 3-4. The funnel-and-gate configuration is considered most appropriate for the OU-1A plumes. Slurry walls perpendicular to the groundwater flow direction are generally effective in containing and directing contaminants to the reactive gates. The precise configuration of a permeable reaction wall for any given application depends on hydrogeology, plume geometry, and other site-specific considerations.

In 1997, ETI completed a bench-scale test of the iron wall technology using groundwater samples collected at MCAS Tustin (ETI 1998a, BNI 1998a). These samples were spiked with VOCs (including TCE) at concentrations similar to those observed in the field. It was determined that VOCs in the plumes downgradient from IRP-13S could be successfully degraded by zero-valent iron at reaction rates comparable to those reported elsewhere in the literature. Other findings from the bench-scale study are presented below.

- Eight of the nine VOCs spiked into the MCAS Tustin groundwater samples were degraded using zero-valent iron at room temperature. The one VOC that was not removed via contact with iron (1,2-DCA) is biologically degradable under the prevailing aerobic conditions of the shallow aquifer system.
- High nitrate levels in groundwater at the site appear to have a significant impact on VOC degradation rates. The thickness of the permeable reaction wall would have to be increased to counter the effects of the nitrates, thus increasing the cost of this alternative.

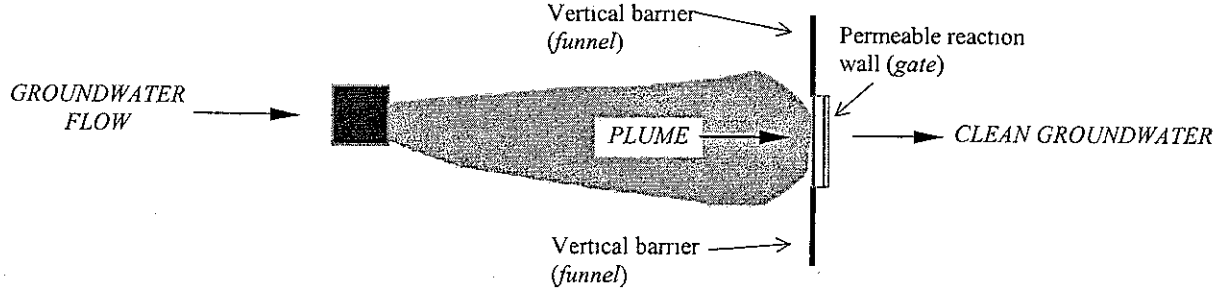


Figure 3-4
Permeable Reaction Wall for Groundwater Remediation

- The bench-scale test data indicated that a porosity loss of up to 10 percent per year may occur in the upgradient portion of the permeable reaction wall due to precipitation of carbonate salts. Several remedies (including mechanical scarification using a large-diameter auger or hydraulic jetting) are considered feasible methods to periodically reduce the effects of carbonate precipitation. However, none of these approaches has been field-tested; therefore, the success and cost of these operations is highly uncertain.

The bench-scale test results were used to obtain site-specific kinetic rate constants necessary for system scale-up. Other factors that govern sizing of the iron walls at Former MCAS Tustin include the areal and vertical extent of the OU-1A plumes, upgradient VOC concentrations, and groundwater velocity.

Long-term performance data are not available for permeable reaction walls. Full-scale systems have been installed at both private and federal government sites to remediate chlorinated VOC plumes, and data from the initial period of operation (up to 5 years) indicate removal of TCE and other contaminants to desired cleanup goals. Successful pilot-scale projects have also been completed by a number of federal agencies, including the DON, the U.S. Air Force, the U.S. Coast Guard, the U.S. Department of Energy, and the National Aeronautics and Space Administration.

According to ETI, conditions at IRP-13S are generally well-suited for an iron wall application. However, while the process chemistry appears feasible, the appropriate installation technique is a major uncertainty. Sheet pile excavation can be used to install iron walls, but only to depths of less than about 30 feet (ETI 1998b). However, the total depth of an iron wall could exceed 65 feet bgs for the deeper contamination at IRP-13S. For these deep applications, possible alternative installation methods include mandrel emplacement, use of caissons and augers, or continuous trenching (ETI 1998b). The cost of permeable reaction wall technology will increase significantly with installation depths beyond 30 feet bgs.

During the BCT meeting of 29 October 2002, the RAB for Former MCAS Tustin and the RWQCB stated their opposition to the application of this iron reactive wall technology at OU-1A. John Broderick, representing the RWQCB, stated that installation of reactive iron in the subsurface would likely generate by-products that would violate the Basin Plan, and that the RWQCB would likely not accept Alternative 5. Dana Ogden, representing the city of Tustin, suggested eliminating Alternative 5 from the OU-1A FS altogether. Alternative 5 was retained for evaluation, however, to be consistent with the FS conducted for OU-1B, and for further consideration as an innovative technology.

Retaining the permeable reaction wall for further consideration as an innovative technology is supported by the ETI bench test results along with other reports in the literature. Modeling results presented in Appendix B suggest that remediation of the OU-1A plumes using this technology will require many decades. In addition, the long-term performance of this process has not been proven, construction techniques need to be resolved for deeper installations (below 45 feet bgs), the technology has been found to be inappropriate by the regulators, and the overall cost is uncertain.

3.3.2.6 GROUNDWATER EXTRACTION

"Extraction" refers to a broad category of response actions aimed at removing VOC-affected groundwater to either remediate a plume (aquifer restoration) or to control hydraulic gradients and limit further contaminant migration (hydraulic containment), discussed previously in Section 3.3.2.4. This subsection focuses on extraction applications associated with aquifer restoration. Four such groundwater extraction technologies were considered in this FS, including drains, conventional wells, VEE, and SVE. In all cases, the extracted groundwater and/or soil vapor would have to be treated using technologies such as those described in Section 3.3.2.7.

Drains

Drains, also called "French drains," are typically designed as gravel-filled trenches with collection pipes leading to sumps. Such systems are often applied where contamination is shallow or other conditions at the site preclude the use of wells. Effective use of a French drain requires the presence of a low-permeability layer into which the trench can be keyed to prevent bypassing of the system through groundwater underflow. Figure 3-5 illustrates a French drain application for aquifer restoration.

Drains are generally more expensive to install than wells and would entail significant surface disruption during installation and place greater restrictions on redevelopment of the property. Therefore, drains were not retained for further consideration.

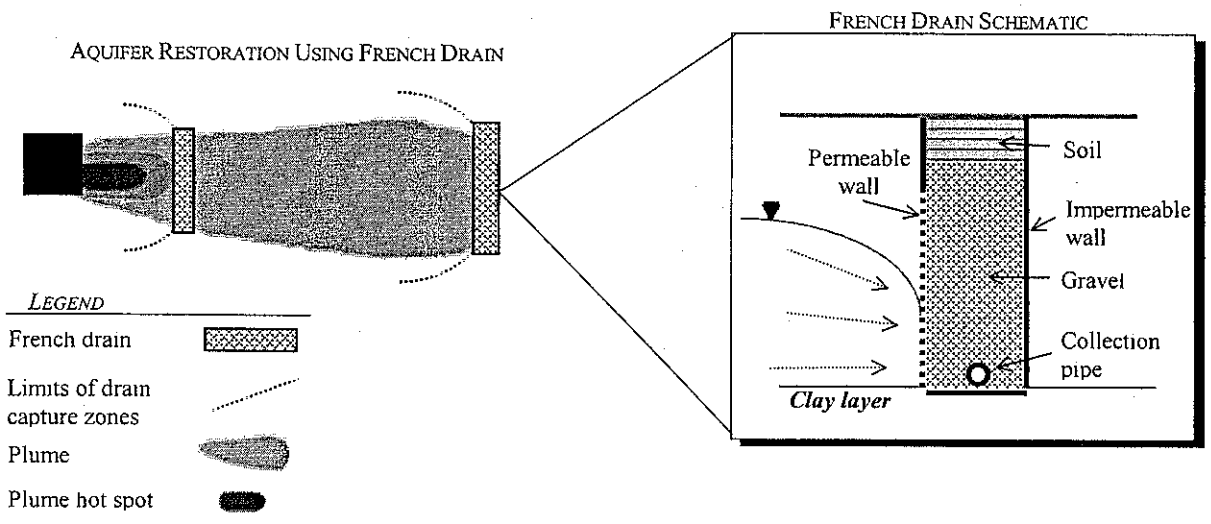


Figure 3-5
Groundwater Extraction Using French Drains

Wells

Groundwater extraction wells consist of specially constructed screens, pumps, and appurtenances (e.g., piping, valves, and instrumentation) that remove contaminated groundwater from an aquifer and convey it to a treatment system. The application of extraction wells to accomplish aquifer restoration is illustrated on Figure 3-6.

Extraction wells are located and operated in a manner that ensures the most efficient removal of contaminated groundwater. Commonly, such an application would place wells near the downgradient margins of the plume, within the center of the plume, and also within or adjacent to plume hot spots.

Use of groundwater extraction wells is an established remedial technology. A groundwater extraction pilot test completed in 1997 at MCAS Tustin showed that a pumping well would be relatively efficient in terms of removing both water and TCE mass from the shallow aquifer. A long-term sustainable pumping rate of 5 gpm appears reasonable for individual wells completed in the first WBZ in the vicinity of nearby site IRP-3 (BNI 1998a). In addition, groundwater modeling (Appendix B) indicates that extraction wells would be effective in applications involving either aquifer restoration or hydraulic containment. Other advantages of extraction wells are their flexibility and relatively low installation cost, which would permit optimization of the extraction system as the remediation system is implemented and operated. For these reasons, extraction wells were retained as a groundwater removal technology for later consideration.

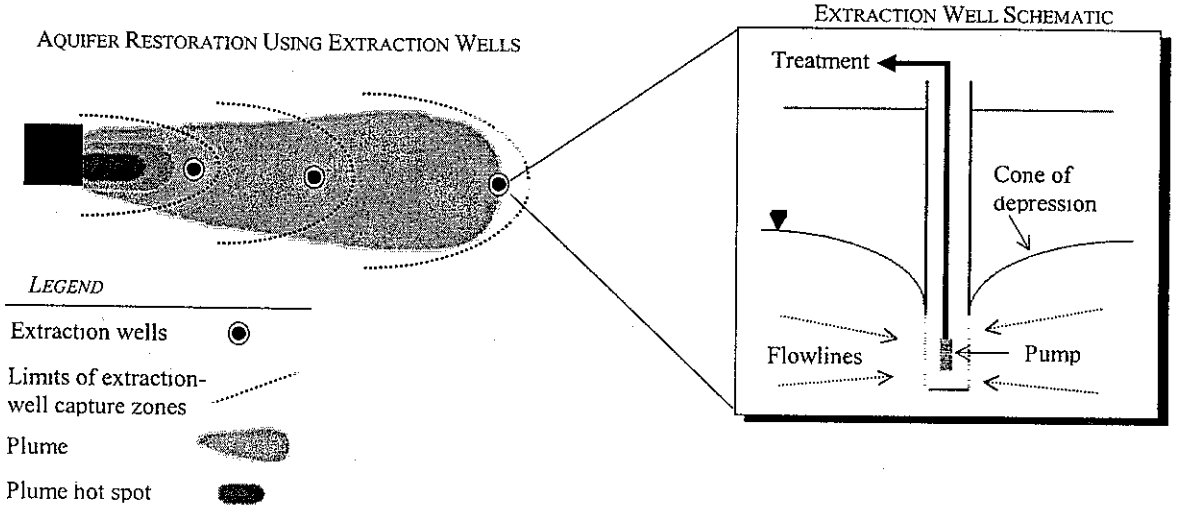


Figure 3-6
Groundwater Extraction Using Wells

Several groundwater extraction scenarios (e.g., different numbers and locations of wells, and different pumping rates) were evaluated through modeling in an attempt to identify the best configuration for remediating the OU-1A plumes to satisfy RAOs in a relatively short period of time (about 10 to 15 years). Model simulations indicated that groundwater pumping along the centerlines of the plumes would effectively prevent further VOC migration while significantly reducing contaminant concentrations within the shallow aquifer.

The model also showed that groundwater pumping in the areas of highest VOC concentrations would increase the vertical migration of contaminants from the upper confining layer (clay layer) of the first WBZ into the more permeable sand layers of the first and second WBZs. The continued slow release of contamination from the clays would cause 1,2,3-TCP concentrations in the sand layers to eventually reach asymptotic levels somewhat above the site cleanup goals established for OU-1A (i.e., a tailing effect would occur). It was concluded from the modeling that groundwater extraction as a stand-alone response action would not effectively remediate the OU-1A plumes.

The site groundwater model was then used to determine whether extraction from wells could be combined with other technologies to better accomplish remedial objectives. This effort was particularly focused on meeting the remediation goals within a reasonable time frame (e.g., 30 years or fewer) and eliminating the tailing effect. Technologies evaluated in conjunction with groundwater extraction and the results of this evaluation are summarized below.

- **Injection of treated groundwater** was evaluated and found to be an effective method for flushing contamination from the permeable sand layers during extraction. A configuration involving equal numbers of extraction and injection wells in the first two WBZs was determined to enhance contaminant removal from the shallow aquifer.
- **Capping of source areas** was evaluated as discussed in Section 3.3.2.4. The model indicated that minimal benefit (in terms of reduced remediation time) would be gained by including a cap at the IRP site because only a minor portion of the subsurface VOC mass is present in the vadose zone.
- **Flushing of contaminated soils** in the upper confining layer during groundwater pumping was evaluated and shown to expedite remediation of the first WBZ. However, flushing also caused a significant increase in the downward migration of contaminants into the second WBZ.
- **Excavation of contaminated subsurface soils from the vadose zone and the upper confining layer of the first WBZ** was evaluated in conjunction with groundwater extraction and upgradient injection systems. Several different soil removal scenarios were considered, and two scenarios were considered effective: 1) excavation of subsurface soils with TCE concentrations greater than 100 µg/kg and 2) excavation of subsurface soils with TCE concentrations greater than 400 µg/kg. Both scenarios would effectively reduce the tailing effect when groundwater was extracted. Cleanup of source area soils at

IRP-13S to less than 100 μg/kg TCE or removal of soil hot spots greater than 400 μg/kg should allow a groundwater extraction alternative to achieve RAOs in a reasonable period of time.

Developing an effective groundwater extraction system requires the collection of sufficient data before design and during operation (U.S. EPA 1989b). For this reason, a predesign study should be conducted to further investigate the hydrogeologic characteristics of the subsurface at Former MCAS Tustin. Installation and operation of extraction wells as part of the TCRA system at IRP-13S has provided valuable information about the hydrogeologic conditions at the site; however, collection of additional hydrogeological data to support remedial design will be important. Such studies are necessary because of the heterogeneity of the shallow aquifer, which makes it difficult to accurately predict groundwater flow patterns as needed to design and install an effective groundwater extraction system.

Vacuum-Enhanced Extraction

Both dissolved VOCs and water are removed using VEE in a manner that is similar to but more effective than conventional groundwater extraction. Application of a vacuum at the wellhead may increase the groundwater extraction rate in low-yield wells such as those that would be installed in the shallow aquifer at the site. Soil vapor is captured by the vacuum system as the groundwater table is lowered in the vicinity of the well and VOCs are stripped from the vadose zone and newly exposed soil. Figure 3-7 illustrates the use of a VEE system for aquifer restoration.

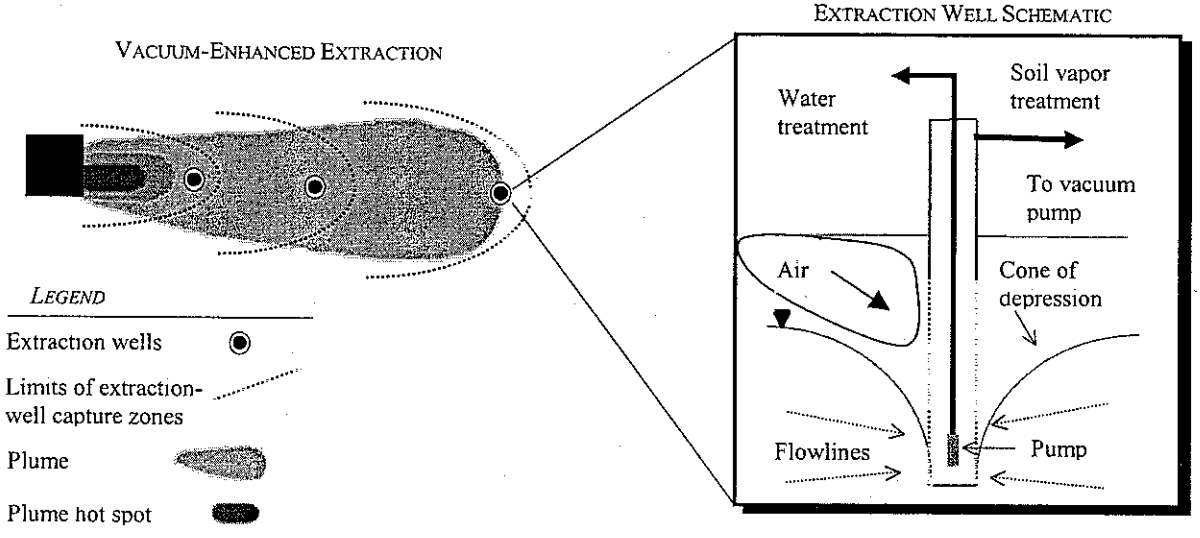


Figure 3-7
Vacuum-Enhanced Extraction Using Wells

VEE has been developed over the last several years as an innovative groundwater extraction technology. Potential benefits of VEE systems include the following:

- increased capture zone for individual extraction wells
- reduced number of recovery wells required to achieve the same remedial objectives
- reduced time for remediation due to the accelerated removal rates for both dissolved and adsorbed contaminants

For these reasons, U.S. EPA lists VEE as a presumptive technology for remediation of VOCs in soil and groundwater (U.S. EPA 1997b).

VEE is most effective under the following conditions.

- Low-permeability soils are present that restrict groundwater flow toward conventional extraction wells.
- Target contaminants are VOCs (dimensionless Henry's law constant greater than 0.01 at 20 degrees Celsius) adsorbed to the soil matrix both above and below the water table.
- Adsorbed VOCs slowly desorb from the aquifer matrix and dissolve back into groundwater in response to chemical equilibrium changes induced by extraction systems.
- Subsurface geology consists of silty sands to clays.

These U.S. EPA guidelines for VEE application are consistent with conditions at Former MCAS Tustin. Chlorinated VOCs are found in a shallow aquifer system consisting primarily of interfingering, discontinuous, and confined or semiconfined sand zones embedded in massive clays and silts. Near the source area at IRP-13S, VOCs are also present in the saturated confining clays and silts. Thus, VEE appears to be well suited to the hydrogeology of the site and has the potential to enhance the overall effectiveness of a conventional groundwater extraction system. VEE will, therefore, be carried forward in the FS as a candidate for groundwater extraction technology.

As pointed out in U.S. EPA guidance (U.S. EPA 1997b), the successful application of VEE is dependent on site-specific parameters. For this reason, a VEE pilot test was conducted during 1988 in the first WBZ at nearby site IRP-3, which has hydrogeologic conditions similar to IRP-13S (BNI 1999b). Operating at a vacuum of approximately 0.35 atmosphere, VEE appeared to slightly enhance the rate of groundwater extraction in the sand layer of the first WBZ. A long-term groundwater extraction rate of 5 gpm per well was estimated from the pilot test data. However, the pilot VEE system was unable to remove VOCs by inducing a flow of air through the dewatered portions of the shallow aquifer. Apparently, the saturated upper clay layer of the first WBZ was an effective barrier to air flow (BNI 1999b).

Modeling was also completed to evaluate VEE systems at IRP-13S (Appendix B). These simulations indicated that a network of VEE wells installed in the sand layer of the first

WBZ would effectively contain the OU-1A plumes and achieve substantial reductions in VOC mass if operated for a period of 15 years. The most effective VEE configuration consisted of four wells at IRP-13S. Each well would be operated at a vacuum of 0.4 atmosphere and a groundwater extraction rate of 12 gpm. As with conventional groundwater extraction, partial excavation of contaminated soils at IRP-13S would remove a continuing source of groundwater contamination and enhance the effectiveness of a VEE system.

Soil Vapor Extraction

SVE is listed by U.S. EPA as a presumptive technology for remediation of VOCs in soils (U.S. EPA 1993b, 1996a). Traditional SVE is the process of stripping VOCs from the soil by applying a vacuum to an extraction well and inducing an air flow, which is conveyed to an *ex situ* treatment system. Generally, this technology is used to remove adsorbed contaminants from the vadose zone.

At Former MCAS Tustin OU-1A, the vadose zone is nearly nonexistent; the water table generally lies at approximately 10 feet bgs at IRP-13S. Furthermore, there is little VOC mass in the vadose zone. Therefore, conventional SVE is not applicable at the site.

However, SVE could possibly be used to enhance the removal of VOCs from the upper saturated clay layer below the water table in a manner analogous to VEE. Figure 3-8 illustrates the potential use of SVE to extract contaminants from the first WBZ at Former MCAS Tustin. Similar to the VEE system discussed above, both water and vapor would

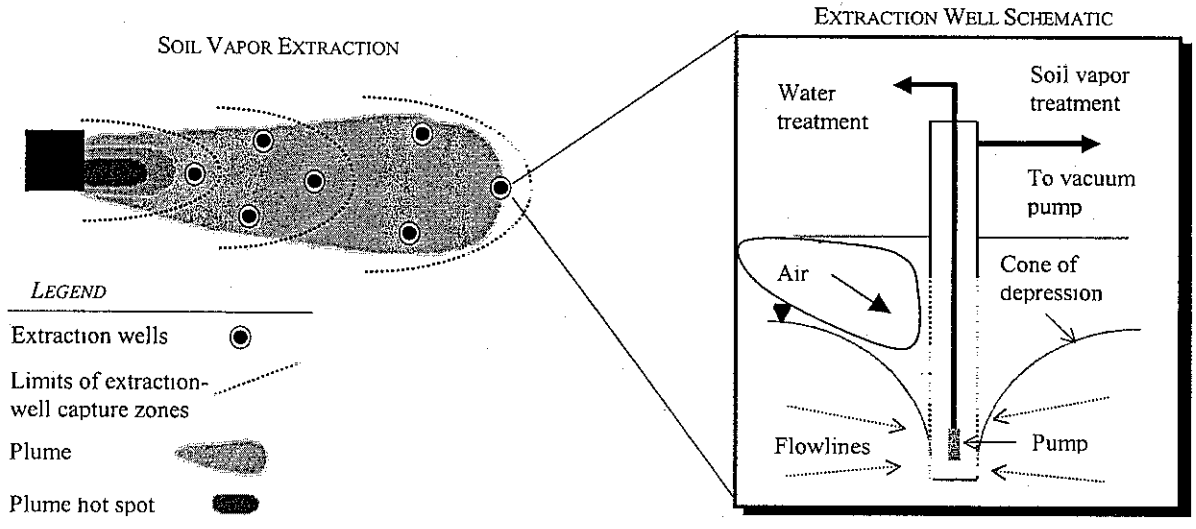


Figure 3-8
Soil Vapor Extraction Using Wells

be extracted from individual wells. The major difference is that the extraction wells would be spaced more closely in an SVE system in order to dewater both the upper confining layer and the sand layer in the first WBZ. Airflow through the exposed soils would be the primary mechanism for VOC removal from the subsurface.

Theoretically, the benefits of this type of SVE system should be similar to VEE. However, both modeling and the 1998 VEE field test suggest that hydrogeologic conditions at Former MCAS Tustin would prevent sufficient air flow from being induced through the clay in the upper confining layer, even after the water table is lowered in the sand zone of the first WBZ. When a VEE system was evaluated at nearby site IRP-3, the saturated upper clay layer formed a flow barrier that prevented air circulation from the surface, even after 6 weeks of testing. Therefore, SVE appears to be technically infeasible and has been eliminated from further consideration. Further information to support this conclusion is provided in a separate report on the 1998 VEE pilot test (BNI 1999b).

3.3.2.7 *EX SITU* GROUNDWATER TREATMENT

Groundwater extracted from the OU-1A plumes would contain TCE, 1,2,3-TCP, and other VOCs at relatively dilute concentrations. The extracted groundwater would be treated and the contaminants removed before discharge. Several technologies were evaluated for this purpose, including physical treatment processes involving either a separation of contaminants, usually involving a phase transfer, or concentration of contaminants within a particular phase (Table 3-1). Filtration can be used to remove suspended sediment in groundwater and increase the effectiveness of other treatment methods. Chemical and biological destruction technologies were also evaluated in which the VOCs were converted into nonhazardous by-products. Chemical treatments including chemical oxidation (in which ultraviolet radiation in conjunction with ozone or hydrogen peroxide oxidizes VOCs) and palladized iron reaction (in which reductive dehalogenation occurs in a fixed bed reactor) and biological treatment including *ex situ* anaerobic treatment (in which sealed treatment reactors provide for nutrient addition and mixing) are described in Table 3-1.

Two standard, well-documented *ex situ* physical treatment options, GAC adsorption and air stripping, are discussed below. Both processes are commonly used at CERCLA sites. They are listed by U.S. EPA as presumptive *ex situ* treatment technologies for groundwater contaminated with VOCs (U.S. EPA 1996b).

Carbon Adsorption

GAC is the most common adsorbent used for treatment of dilute VOCs in water and groundwater. In GAC treatment, the extracted groundwater contacts the carbon in a fixed bed adsorption vessel. Typically, two GAC vessels are operated in series. A filter may be placed upstream of the lead GAC contactor to prevent clogging caused by particulates. The carbon adsorbs most dissolved VOCs and allows a purified liquid stream to pass through. When the adsorptive capacity of the lead bed is exhausted, the spent GAC is

replaced by fresh carbon. The order of the GAC vessels is then reversed. Spent carbon is reactivated, disposed of, or destroyed, usually at a permitted off-site facility.

GAC effectively removes a wide range of VOCs from groundwater to concentrations well below the RAOs established for OU-1A. In general, less soluble and less polar organic compounds adsorb more strongly to GAC. 1,2,3-TCP and TCE can be removed by GAC. GAC has been proven to be not only effective in removing 1,2,3-TCP and TCE, but also other VOC constituents in groundwater extracted and treated through the TCRA system.

GAC is a well-demonstrated technology and it is sufficiently flexible to accommodate variable flow rates and a wide range of influent VOC concentrations. It is also a simple system, requiring minimal operator assistance. For the groundwater extraction rates expected at OU-1A, this technology is readily available in turnkey package systems from vendors who will also provide a complete service, including replacement and disposal of the spent GAC.

Air Stripping

Air stripping removes VOCs from water by transfer from the aqueous to the gaseous phase. VOC removal efficiency depends on a combination of the physical properties of the target contaminants, notably Henry's law constant and diffusivity in air and water, along with the configuration of the stripping system. Close contact between the liquid (water) and the gas (air) in the stripping vessel is essential. Packed-tower air stripping and low-profile air stripping are particularly effective and appropriate for this application because of their simplicity and the relatively low levels of VOCs expected in the recovered groundwater at Former MCAS Tustin.

Air stripping is a well-demonstrated technology, requiring minimal operator assistance. 1,2,3-TCP and TCE can be removed by air stripping. Of these two target contaminants, 1,2,3-TCP is less volatile and thus will require either a larger gas-to-liquid ratio or a larger stripping unit, or both, to meet treatment objectives. This technology is readily available. Air stripping at Former MCAS Tustin would be accompanied by a second treatment process, such as vapor-phase GAC, for removal of contaminants from the exhaust gas.

Selection of Preferred Ex Situ Groundwater Treatment Technology

Both GAC and air stripping can be implemented at Former MCAS Tustin and would effectively treat contaminated groundwater extracted at IRP-13S. Therefore, costs of these processes were qualitatively compared in order to select a representative *ex situ* groundwater treatment technology for the development of the remedial alternatives presented in Section 4. The results of this analysis indicated that O&M costs for GAC and air stripping would be essentially the same given the relatively low VOC concentrations expected in groundwater extracted from IRP-13S. However, the capital costs associated with an air stripper unit would be significantly greater than those for a GAC unit. Therefore, GAC was retained as the preferred *ex situ* treatment technology.

3.3.2.8 GROUNDWATER DISCHARGE (DISPOSAL)

Groundwater extracted for hydraulic containment or aquifer restoration at Former MCAS Tustin must be discharged. Potential discharge options identified for the FS were as follows:

- an off-site RCRA treatment, storage, and disposal facility
- a publicly owned treatment works (POTW)
- surface water that eventually discharges to Peters Canyon Channel
- beneficial use (e.g., domestic or agricultural)
- groundwater injection

Disposal of untreated groundwater at a RCRA treatment, storage, and disposal facility would entail the construction of on-site storage facilities from which water would be transferred to tank trucks and transported to an off-site treatment/disposal facility. Given available data concerning expected 1,2,3-TCP and TCE concentrations in the extracted groundwater during the first several years of remediation, the extracted groundwater would probably be classified as a hazardous waste. Therefore, some type of treatment would be required at the off-site facility before disposal. It would be the responsibility of the owner/operator of the RCRA facility to determine the type and scope of treatment needed. Though technically feasible, this option was eliminated given the large quantities of water that would have to be transported and the associated high costs of off-site treatment/disposal.

In 1996, a discussion was held between Jeff Cange of BNI and Tom Walker of the Orange County Sanitation District to determine the feasibility of discharging treated or untreated groundwater to a sanitary sewer in the project area. In general, POTW in California do not accept extracted groundwater (even after treatment) because they prefer the beneficial reuse of such water. Reinjection of treated water back into the aquifer from which it was withdrawn is an acceptable beneficial reuse. For this reason, the option of disposing extracted groundwater to a POTW was eliminated from further consideration.

Disposal of extracted groundwater to surface water was also considered. Before discharge, the water would be treated to remove VOCs. Treated groundwater would be discharged to a city of Tustin storm drain, which would eventually discharge to Peters Canyon Channel. Sampling requirements would be detailed in the O&M Plan. Discharge to surface water is a viable option that was retained as a potential disposal technology for extracted groundwater after treatment.

Recharge of treated groundwater commonly uses injection wells screened in the targeted WBZ. Injecting water into the shallow aquifer at Former MCAS Tustin would cause a local groundwater mound, which, in turn, would increase the hydraulic gradient and groundwater velocity downgradient from the injection well. The injection of extracted and treated groundwater as part of an overall remedial action can often achieve multiple goals, such as the following.

- Long-term water table drawdown can be minimized, and the aquifer can be depleted; groundwater can be replenished and made available for future use.
- Injection upgradient of the contaminated plume can enhance groundwater restoration because aquifer flushing rates would be increased.
- Injection at the plume margin can create a hydraulic barrier to limit further migration into uncontaminated areas.

Injection of treated groundwater upgradient of the OU-1A plumes would enhance the performance of aquifer restoration systems that employ conventional groundwater extraction. Injection was, therefore, retained as a potential disposal option for treated groundwater. Proper design and maintenance of the injection wells would minimize potential problems such as the clogging of well screens because of biotic factors (algae/organism growth) or abiotic factors (entrapped air bubbles).

Beneficial use of treated groundwater, such as landscape irrigation, was not retained as a potential discharge option given the generally poor quality of the shallow aquifer (high TDS) and the absence of identified users. Beneficial reuse may be a viable option in the future. However, its success depends on a number of factors that are currently undefined, including the remedial alternative that would be implemented at OU-1A, the type of redevelopment that would occur in the vicinity of the site, the quantity and quality of water that would be needed by potential users, and the effluent quality that would be produced by the *ex situ* groundwater treatment system (particularly with regard to TDS, nitrate, selenium and other constituents not related to former operations at the station).

3.3.2.9 SCREENING RESULTS FOR GROUNDWATER

Table 3-3 lists the technologies determined to be suitable for development of the OU-1A groundwater remedial alternatives presented in Section 4 of this FS Report. The results of the screening process can be summarized as follows.

- Twelve remedial technologies involving 27 process options were screened for the collection, treatment, and disposal of contaminated groundwater.
- Nine remedial technologies and 13 process options were eliminated from further consideration on the basis of limited effectiveness or implementability or a finding that equivalent results could be obtained using a lower cost process option.
- Support technologies, defined as those that would not meet response objectives when applied individually but could be valuable when combined with other technologies, were retained.

Disposal options for treated groundwater will be reevaluated in the remedial design to determine the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, effective groundwater mounding geometries and reinjection inflow rates, substantive regulations, regulatory/public input, and total-maximum-daily-load (TMDL) discharge limits for

Table 3-3
Summary of Retained Remedial Technologies and Process Options for OU-1A Groundwater

General Response Action	Remedial Technology	Process Option
No action	None	None
Institutional controls	Land-use restrictions Monitoring	Deed restrictions Groundwater sampling and analysis
Monitored natural attenuation	Monitored natural attenuation	Natural attenuation
Containment	Hydraulic controls Vertical barriers	Extraction wells Slurry walls*
In situ treatment	Chemical treatment	Permeable reaction wall
Extraction	Groundwater extraction	Extraction wells Vacuum-enhanced extraction
Ex situ treatment	Physical treatment	Carbon adsorption Filtration*
Disposal	Groundwater discharge	Injection Surface outfall

Note:
* retained only as a support technology

Acronym/Abbreviation:
OU – operable unit

chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated.

3.3.3 Soil (Source Material)

Source area soils to be addressed in this FS Report are limited to contaminated portions of saturated materials within the upper confining layer of the first WBZ at IRP-13S. The principal rationale for addressing these soils is their role as continuing, low-level sources of groundwater contamination. Modeling results indicate that this contamination will occur under the no action or natural attenuation scenarios as well as when the shallow aquifer is pumped, such as would occur in an aquifer restoration alternative.

Technologies were screened for OU-1A soil remediation using the U.S. EPA presumptive remedy guidance document for sites with VOCs in soils, as discussed in Section 3.2 (U.S. EPA 1993b, 1996a). Additional technologies were also evaluated on the basis of the RAOs developed in Section 2 and other site-specific issues. Results of the screening analysis of soil remedial technologies are summarized below.

3.3.3.1 NO ACTION

No action was included in the screening process to provide a baseline for comparison with other response actions.

3.3.3.2 INSTITUTIONAL CONTROLS

Institutional controls for soils would be the same as those described for groundwater. Included are access controls or future use restrictions placed on property deeds or titles. Institutional controls at IRP-13S would not have any effect on contaminant loadings from source area soils and, thus, were eliminated from further consideration.

3.3.3.3 CONTAINMENT

Capping was not considered an effective method to address subsurface soil contamination at IRP-13S for the same reasons as those described in Section 3.3.2.4. Therefore, capping was eliminated from further consideration.

3.3.3.4 SOIL EXCAVATION

Excavation would be required for any *ex situ* soil treatment technology. Earth-moving equipment would be used to physically remove contaminated soil for on-site treatment or for transport, treatment, and/or disposal off-site. Soil excavation is an effective process option and is an essential component of the U.S. EPA presumptive remedies for VOC-contaminated soils involving thermal desorption or incineration.

The target soils for this response action are those in the vadose zone or the upper confining layer of the first WBZ that are contaminated with TCE above 100 µg/kg. For soil hot spot removal, soil with TCE concentrations greater than 400 µg/kg was considered. The first action would require excavation of approximately 18,600 cubic yards of soil, while hot spot removal would reduce this amount to approximately 2,450 cubic yards. These soils are present at depths of approximately 1 foot bgs to 25 feet bgs at IRP-13S.

Excavation of these target soils would require the removal of overlying soils, which may not be contaminated. VOCs in the vadose zone soils are also below levels of concern from a risk management perspective. Therefore, it is likely that these materials could be reused directly as fill at the IRP site after the contaminated soil is removed. To that end, the excavated soils would be segregated and handled separately to minimize the amount of contaminated material requiring treatment and/or disposal.

Excavation is considered feasible for these soil volumes and is, therefore, retained for further consideration. Further delineation of the three-dimensional distribution of contamination would be needed to more accurately define excavation limits. Such delineation would also be needed to segregate the target soils from less affected vadose zone soils and other soils that may need to be excavated. This additional delineation would be conducted as part of the final remedial design.

3.3.3.5 *EX SITU* SOIL TREATMENT

U.S. EPA considers two *ex situ* thermal treatment processes as presumptive remedies for VOCs in soil (U.S. EPA 1993b). These are thermal desorption and incineration. Both require excavation of the contaminated soils, and both were evaluated for possible use at IRP-13S.

Thermal Desorption

Thermal desorption is a physical separation process in which soil is heated to temperatures between 200 and 1,000 °F, causing VOCs to vaporize. A carrier gas or vacuum system would transport the contaminants to a vapor treatment system. Most of the target soils are composed of silt and clay and are located below the water table. They will be saturated, so disaggregation and dewatering will likely be necessary before treatment to reduce the energy (and costs) required for treatment.

This process option could be used on-site with a mobile treatment unit, or the excavated soil could be hauled off-site for treatment at an established (fixed-base) facility. A mobile TDU designed for halogenated VOCs could be mobilized to Former MCAS Tustin temporarily in order to treat the excavated soil. This type of unit would meet air discharge requirements and is generally permitted by SCAQMD for various locations.

Thermal desorption was retained as the representative treatment technology for the target soils associated with OU-1A. It was assumed that treatment of the target soils (if necessary) would be more cost-effective if conducted at a temporary on-site mobile facility. The factor influencing this choice is the cost of trucking VOC-contaminated soil to an off-site facility.

Incineration

Incineration systems volatilize and combust VOC contaminants by heating the excavated soils to high temperatures (1,400 to 2,200 °F) in the presence of excess oxygen. Commercial incinerator designs are rotary kilns equipped with an afterburner, quench, and air pollution control system to treat incinerator off-gas. With proper design and operation of the incineration processes, the VOC destruction and removal efficiencies can exceed 99.99 percent.

Incineration was eliminated from further consideration because of its high cost. Alternative technologies, such as thermal desorption, are available and will achieve acceptable VOC removals at much lower cost.

3.3.3.6 SOIL DISPOSAL

Beneficial reuse and landfill disposal of removed soils are discussed below.

Beneficial Reuse

Soil treated at a TDU facility would not have remaining contamination above health-based levels. These residuals could be beneficially reused at either Former MCAS Tustin or an off-site location. Potential reuse options include backfill for construction sites or cover material for landfills. Beneficial reuse was retained as the preferred disposal technology for soils removed from IRP-13S that require treatment at a TDU facility. The preferred beneficial reuse option for soils treated at an on-site TDU facility is backfill on-site.

Landfill Disposal

If the source zone soils removed at IRP-13S do not contain excessively high VOC concentrations, they would not be classified as hazardous waste. Such soils could potentially be disposed without further treatment at a Class II landfill that is qualified by U.S. EPA, under 40 C.F.R. § 300.440, to manage wastes from CERCLA sites. Several such commercial landfills are available within a reasonable driving distance of Former MCAS Tustin. Class II landfill disposal was retained for further consideration if the excavated soil is not a hazardous waste and if it meets acceptance criteria at a commercial facility without additional treatment.

3.3.3.7 *IN SITU* SOIL TREATMENT

In situ soil treatment technologies considered in this screening evaluation include SVE, six-phase soil heating (SPSH), soil flushing, and bioventing. Successful application of these technologies is dependent on the physical characteristics of IRP-13S. At Former MCAS Tustin, the target soils occur below the water table and consist of heterogeneous, low-permeability clays; clayey silts; and clayey sands. The overlying vadose zone is also heterogeneous and composed mostly of low-permeability materials.

Soil Vapor Extraction

SVE has been identified by U.S. EPA as a presumptive remedy for VOC-contaminated soils (U.S. EPA 1993b). This is a remedial technology that removes contaminants by inducing airflow through the soil matrix, causing adsorbed VOCs to transfer to the vapor phase. The gases leaving the soil are collected and treated to destroy the vapor-phase contaminants.

In general, SVE has been found effective at relatively low cost (U.S. EPA 1994b).

Traditional SVE applications are targeted at VOCs in the vadose zone. Such a system is unlikely to be effective for soil remediation at Former MCAS Tustin because the water table is shallow and low-permeability silts and clays are present in the subsurface. Previous attempts to collect soil gas samples at nearby site IRP-3 have been unsuccessful, indicating an unfavorable environment for SVE. For these reasons, SVE was eliminated from further consideration as a soil remediation technology.

Six-Phase Soil Heating

SPSH is designed to enhance the removal of VOC contaminants from the subsurface during SVE. The technology combines six-phase electrical heating with SVE to produce a more efficient *in situ* remediation system for difficult clay and silty clay soils. SPSH splits conventional three-phase electricity into six electrical phases, producing an improved subsurface heat distribution. Each phase is delivered into a single electrode, each of which is placed in a hexagonal pattern. The vapor extraction well located at the center of the hexagon removes the contaminants from the soil (DOE 1995).

The SPSH electrodes and SVE wells would cause significant surface disruption during installation and operation.

Field demonstrations conducted by the U.S. Department of Energy indicate that the SPSH technology is generally targeted to treat contaminated soils above the water table. The efficiency of contaminant removal by SPSH increases with soil drying because steam is created, which increases the permeability of the soil formation. Therefore, because of the shallow water table, depths of contaminants, and concern that extensive surface disruption may not be compatible with station reuse activities, SPSH was eliminated from further consideration as a soil remediation technology.

Soil Flushing

Soil flushing involves the removal of VOCs from soil by flushing with water or other suitable aqueous solutions. It is accomplished by allowing an aqueous solution, generally applied using injection wells, drains, or infiltration basins, to pass through the contaminated soils *in situ*. Leachate is collected downgradient and either treated or disposed of.

Groundwater modeling conducted for this FS indicated that flushing may have some success in removing VOCs from the more transmissive sand zones of the first WBZ. However, it would not be effective for the low-permeability confining layers at IRP-13S. Flushing was, therefore, eliminated from further evaluation as a soil remediation technology.

Bioventing

Bioventing is an *in situ* biological treatment technology that uses SVE-type wells and a blower to induce air flow through the unsaturated zone. The purpose of bioventing is to enhance naturally occurring aerobic biodegradation in vadose zone soils by providing oxygen to existing soil microorganisms.

Bioventing was eliminated from further consideration because it would not be effective. First, most of the target soil contamination at IRP-13S is below the water table and, thus, would be unaffected by increased ventilation through the vadose zone. Second, the COCs at the site are chlorinated VOCs that do not readily degrade under aerobic conditions.

3.3.3.8 SCREENING RESULTS FOR SOIL

Table 3-4 lists the technologies suitable for development of OU-1A contaminated soil (source material) remedial alternatives in Section 4. The results of the screening process can be summarized as follows.

- Eight remedial technologies involving 13 process options were evaluated for the excavation, treatment, and disposal of contaminated soil.
- Seven remedial technologies and 8 process options were eliminated from further consideration on the basis of limited effectiveness or implementability or a finding that equivalent results could be obtained using a lower cost process option.

Table 3-4
Summary of Retained Remedial Technologies and Process Options for OU-1A Soil (Source Material)

General Response Action	Remedial Technology	Process Option
No action	None	None
Excavation	Soil removal	Mechanical excavation
On-site treatment/disposal	Thermal treatment Disposal	On-site TDU Backfill
Off-site treatment/disposal	Thermal treatment Disposal	Off-site TDU Beneficial reuse Class II landfill

Acronyms/Abbreviations:
OU – operable unit
TDU – thermal desorption unit

Section 4
DEVELOPMENT OF REMEDIAL ALTERNATIVES

In this section, technologies and process options retained from the screening evaluation in Section 3 have been assembled into nine comprehensive remedial alternatives for OU-1A. Each alternative involves a combination of general response actions. As a group, the alternatives described below represent a range of technically feasible remedial options to address groundwater contamination at and downgradient from IRP-13S.

The process used to develop remedial alternatives for OU-1A is examined in Section 4.1. Section 4.2 presents general descriptions of the nine alternatives, which are then analyzed in detail in Section 5 and compared in Section 6.

4.1 REMEDIAL ALTERNATIVES DEVELOPMENT PROCESS

The primary objective of the FS is to assure appropriate remedial alternatives are developed and evaluated and that an appropriate remedy is ultimately selected. As set forth in 40 C.F.R. § 300.430(e), "The development and evaluation of alternatives shall reflect the scope and complexity of the remedial action under consideration and the site problems being addressed." This regulation further specifies that a range of alternatives be developed and evaluated in which:

- treatment of contaminants is a principal element,
- treatment is used to varying degrees,
- engineering or institutional controls are used to control risk, and
- no action is involved.

For groundwater response actions, alternatives should be capable of attaining site-specific remediation levels within different restoration times by using one or more technologies.

The development of remedial alternatives for OU-1A followed procedures provided in CERCLA, the NCP, and, to the extent possible, U.S. EPA technical guidance (U.S. EPA 1988a). CERCLA Section 121(b) identifies the following statutory preferences for remedial actions:

- "A preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as a principal element"
- "Off-site transport and disposal without treatment is the least favored alternative where practicable treatment technologies are available"
- "The need to assess the use of permanent solutions and alternative treatment technologies or resource recovery technologies and use them to the maximum extent practicable"

Alternatives to address VOC-affected groundwater were developed in light of these statutory preferences and the RAOs presented in Section 2. In addition, consideration

was given to the following criteria that must be addressed in the FS and the ROD to support the eventual selection of a preferred remedial action for OU-1A (U.S. EPA 1988a).

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

4.2 REMEDIAL ALTERNATIVES FOR IRP-13S

Table 4-1 summarizes the nine remedial alternatives developed to address groundwater contamination associated with OU-1A. Each alternative is potentially applicable at the site. Included are no action, monitored natural attenuation, hydraulic containment, aggressive groundwater extraction with off-site soil disposal, aggressive groundwater extraction with on-site soil treatment, permeable reaction wall, VEE with off-site soil disposal, VEE with on-site soil treatment, and hydraulic containment with hot spot removal. As discussed in Section 3 and Appendix B, groundwater modeling was used to refine the conceptual design of certain alternatives, such as the number and location of extraction wells or the length and position of the permeable reaction walls. Since soil excavation is intended to optimize groundwater remedial alternatives, soil technologies are incorporated into the remedial alternatives for groundwater as appropriate.

Disposal options for treated groundwater will be reevaluated in the remedial design to determine the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, effective groundwater mounding geometries and reinjection inflow rates, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated.

The remainder of this section provides a general description of the major components and attributes of each alternative, along with the rationale for inclusion of these components. Section 5 presents the additional descriptive details for each alternative required to develop cost estimates and conduct a detailed analysis using the NCP evaluation criteria.

4.2.1 No Action

The no action alternative (Alternative 1) is included in this FS to serve as the baseline against which other alternatives are compared. This alternative would involve no further remedial action at IRP-13S and is presented to help assess potential risk to human health

Table 4-1
Summary of Remedial Alternatives for IRP-13S

Alternative	Components	Supporting Rationale
Alternative 1 No action	None	• Required under NCP • No current exposure pathway for VOC-affected groundwater • Limited potential for VOC migration into regional aquifer
Alternative 2 Monitored natural attenuation	Groundwater monitoring *Tracks VOC migration and concentration trends; verifies model predictions* Institutional controls *Prevent human exposure to contaminated groundwater* Periodic reviews *Evaluate continued effectiveness of remedy; assess adequacy of monitoring program*	• No current exposure pathway for VOC-affected groundwater • Future exposure at the station readily limited by institutional measures compatible with reuse • Reduces contaminant concentrations over time; migration and discharge of VOCs to Barranca Channel may not occur for 40 years • Potential impacts of VOC migration beyond station boundaries more accurately evaluated in future • Limited potential for VOC migration into regional aquifer
Alternative 3 Hydraulic containment	Groundwater extraction *Contains plumes* Groundwater treatment *Removes site-related contamination from extracted groundwater* Groundwater disposal *Disposes treated groundwater by discharge to surface water* Performance monitoring *Verifies containment; tracks VOC concentration trends* Institutional controls *Prevent human exposure to contaminated groundwater* Periodic reviews *Evaluate continued effectiveness of remedy; assess adequacy of monitoring program*	• Prevents further migration of plumes beyond existing boundaries • No current exposure pathway for VOC-affected groundwater • Could be designed to limit or eliminate potential for VOC migration into third WBZ • Future exposure at the station readily limited by institutional measures compatible with reuse • Limits areas where deed restrictions required • Recognizes that restoration of shallow aquifer may not be possible because of presence of VOC contamination in low-permeability clay layers below the water table • Uses treatment to accomplish significant reductions in VOC concentrations and mass

(table continues)

Table 4-1 (continued)

Alternative	Components	Supporting Rationale
Alternative 4 Aggressive groundwater extraction with off-site soil disposal	Excavation of source material *Removes soils that are long-term sources of VOCs to groundwater* Off-site disposal of source material *Disposes excavated materials* Groundwater extraction *Removes VOCs from first and second WBZs* Groundwater treatment *Removes site-related contamination from extracted groundwater* Injection *Disposes treated groundwater; increases flushing of shallow aquifer WBZs to improve extraction efficiency* Performance monitoring *Tracks VOC concentration trends to evaluate success of remediation* Institutional controls *Prevent human exposure to contaminated groundwater* Periodic reviews *Evaluate effectiveness of remedy; assess adequacy of monitoring program; determine whether plume remediation is feasible by groundwater extraction*	• Aggressive attempt to restore shallow groundwater to beneficial uses, reducing mass and toxicity of contaminants • No current exposure pathway for VOC-affected groundwater • Future exposure to groundwater at the station readily limited by institutional controls compatible with reuse • Limits areas where deed restrictions required; aboveground facilities and conveyance pipelines can be installed with minimal impact on reuse • Uses treatment to accomplish significant reductions in VOC concentrations and mass • Source removal necessary to maximize efficiency of groundwater remediation by extraction • Groundwater extraction for 10 to 15 years predicted to substantially reduce extent of VOC-affected groundwater exceeding cleanup goals in sand layers of first and second WBZs • Groundwater extraction in first and second WBZs creates upward hydraulic gradient, preventing any further downward migration of 1,2,3-TCP to third WBZ through a localized lithologic discontinuity at IRP-13S • No discharges to surface water
Alternative 4A Aggressive groundwater extraction with on-site soil treatment	All components are identical to Alternative 4, except disposition of excavated source material, as follows. On-site treatment and disposal of source material *Treats and disposes of excavated materials*	• Same rationale as Alternative 4
Alternative 5 Permeable reaction wall	Permeable reaction wall *Remediates groundwater VOCs* in situ *by chemical reaction* Performance monitoring *Tracks VOC concentration trends to evaluate success of remediation*	• No current exposure pathway for VOC-affected groundwater

(table continues)

Table 4-1 (continued)

Alternative	Components	Supporting Rationale
Alternative 5 Permeable reaction wall (continued)	Institutional controls *Prevent human exposure to contaminated groundwater* Periodic reviews *Evaluate performance of reaction wall and effectiveness of remedy; assess adequacy of monitoring program*	• Future exposure at the station readily limited by institutional controls compatible with reuse • Limits migration of plumes beyond existing boundaries • Limits areas where deed restrictions required • Uses innovative technology in an attempt to remediate groundwater to beneficial uses • Uses destructive treatment to accomplish significant reductions in VOC concentrations and mass • *In situ* treatment technology compatible with reuse; does not require aboveground treatment facilities • No discharges to surface water
Alternative 6 Vacuum-enhanced extraction with off-site soil disposal	Excavation of source material *Removes soils that are long-term sources of VOCs to groundwater* Off-site disposal of source material *Disposes excavated materials* Groundwater extraction *Removes VOCs from first and second WBZs* Groundwater treatment *Removes site-related contamination from extracted groundwater* Groundwater disposal *Disposes treated groundwater by discharge to surface water* Performance monitoring *Tracks VOC concentration trends to evaluate success of remediation* Institutional controls *Prevent human exposure to contaminated groundwater* Periodic reviews *Evaluate effectiveness of remedy; assess adequacy of monitoring program; determine whether plume remediation is feasible by vacuum-enhanced groundwater extraction*	• Aggressive attempt to restore shallow groundwater to beneficial uses • Use of vacuum may enhance groundwater extraction rates and reduce time required for cleanup in first WBZ • No current exposure pathway for VOC-affected groundwater • Future exposure at the station readily limited by institutional controls compatible with reuse • Prevents further migration of plumes beyond current boundaries • Limits areas where deed restrictions required; aboveground facilities and pipelines can be installed with minimal impacts on reuse • Uses treatment to accomplish significant reductions in VOC concentrations and mass • Source removal necessary to maximize efficiency of groundwater remediation by VEE

(table continues)

Table 4-1 (continued)

Alternative	Components	Supporting Rationale
Alternative 6 Vacuum-enhanced extraction with off-site soil disposal (continued)		• Groundwater extraction using VEE for 10 years predicted to substantially reduce extent of VOC-affected groundwater exceeding cleanup goals in first and second WBZs • Groundwater extraction in first and second WBZs creates upward hydraulic gradient, preventing any further downward migration of 1,2,3-TCP into third WBZ through a localized lithologic discontinuity at IRP-13S
Alternative 6A Vacuum-enhanced extraction with on-site soil treatment	All components are identical to Alternative 6, except disposition of excavated source material, as follows. On-site treatment and disposal of source material *Treats and disposes of excavated materials*	• Same rationale as Alternative 6
Alternative 7 Hydraulic containment with hot spot removal	Components are similar to Alternative 3, except Excavation of source material *Removes hot spot soils that are long-term sources of VOCs to groundwater* On-site treatment and disposal of source material *Treats and disposes of excavated materials on-site* Groundwater extraction *Contains plumes and removes VOCs from first WBZ at near-source locations*	• Same rationale as Alternative 3 with the addition of the following. • Hot spot removal employed to maximize efficiency of hydraulic containment by extraction of groundwater • Additional groundwater containment wells predicted to contain plumes and achieve significant reductions in contaminant mass in a shorter period • Limits building demolition required by more extensive excavations proposed in Alternatives 4 and 6

Acronyms/Abbreviations:
IRP – Installation Restoration Program
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
TCP – trichloropropane
VEE – vacuum-enhanced extraction
VOC – volatile organic compound
WBZ – water-bearing zone

and the environment in the absence of an engineered response to OU-1A groundwater contamination. Modeling was used to simulate groundwater flow and predict contaminant migration patterns within the shallow aquifer over a period of 100 years.

4.2.2 Monitored Natural Attenuation

Monitored natural attenuation (Alternative 2) would not entail any engineered response actions to collect, treat, or contain the contaminant plumes at and downgradient of IRP-13S. However, Alternative 2 would include monitoring, and institutional controls such as deed restrictions. The institutional controls would be used to minimize potential human exposure to groundwater contamination, ensure access for monitoring and maintenance, and protect the monitoring wells. Monitoring would be used to track VOC migration and support future evaluations of the protectiveness of natural attenuation processes.

Alternative 2 is based on the following assumptions:

- Naturally occurring processes in the subsurface at Former MCAS Tustin will reduce contaminant concentrations – and risk – as the VOC plumes at OU-1A continue to migrate through the shallow aquifer.
- Contaminant migration in the subsurface is primarily horizontal toward discharge into Barranca Channel. VOC contamination in the shallow aquifer does not threaten the deeper, regional aquifer used for potable water supply. As noted in Section 1.6.1, this assumption is valid for most of the station, with the exception of a localized area approximately 1,500 feet downgradient of the IRP-13S source area. At that location, a lithologic discontinuity appears to have permitted vertical hydraulic communication and downward migration of 1,2,3-TCP into the third WBZ, which is the apparent transition zone between the shallow aquifer and the underlying regional aquifer at Former MCAS Tustin.
- Contaminant migration in the shallow aquifer can be readily tracked and its impacts reliably predicted.

The natural attenuation mechanisms that appear active at IRP-13S include adsorption, dispersion, volatilization, diffusion, and dilution. Biodegradation is probably negligible given the recalcitrant nature of chlorinated VOCs under the prevailing aerobic conditions in the shallow aquifer underlying Former MCAS Tustin. Modeling conducted for the RI indicated that natural attenuation would eventually result in potentially significant reductions in VOC concentrations within the OU-1A plumes, even with no biodegradation assumed (BNI 1997a). However, the plumes would not disappear quickly, and groundwater contamination would remain above regulatory- and health-based levels for over 100 years.

A major consideration in the development of Alternative 2 is that shallow groundwater at Former MCAS Tustin is not currently used for consumptive purposes and, thus, there are no complete human-exposure pathways for the existing VOC contamination. Based on results from the human-health risk analysis presented in Section 1.8 and Appendix F,

risks associated with contaminated groundwater are elevated primarily for exposure pathways involving a reuse scenario that includes a future residential receptor using the shallow aquifer for potable supply. The assumptions used to estimate health risks were conservative and, therefore, tended to overestimate potential human exposure to VOCs on land redeveloped for residential use at Former MCAS Tustin. Several factors make it highly unlikely that a future resident would drill his or her own water supply well in the shallow aquifer. In addition, exposures of this type are readily controlled through institutional controls (see discussion of risk assessment results in Section 1.8).

Alternative 2 would include long-term monitoring and periodic reviews to assess potential impacts to human health and/or the environment arising from the continued migration of VOC contamination in the shallow aquifer. VOC contamination originating at IRP-13S is not expected to reach the station boundaries for approximately 40 years. Institutional controls would be used to prevent human exposure to this contamination as it migrates beneath the station. Monitoring would track the progress of natural attenuation and help verify model predictions. Periodic reviews would be scheduled at least every 5 years. These evaluations would consider whether the modeling predictions were accurate and also determine if the contaminant levels expected at the station boundaries would impact off-station human and environmental receptors.

Potential off-station impacts resulting from Alternative 2 would be determined by the types of land use in the areas affected by the VOC plumes. The VOC plumes originating at IRP-13S would migrate beneath a future industrial park and discharge to Barranca Channel after passing the station boundary. Proposed land uses within the industrial park include light industry and commercial establishments. For the purposes of this FS, this land use was assumed over the next 30 years in this area. Human exposure to VOC-contaminated groundwater is unlikely in the industrial park because it is within the service area of an existing, high-quality municipal water supply system.

Alternative 2 does not include engineered measures to address the potential downward migration of 1,2,3-TCP from the second WBZ to the third WBZ through a localized lithologic discontinuity identified at IRP-13S. Additional discontinuities may exist downgradient of the existing OU-1A plumes. The third WBZ is considered a transition zone between the shallow groundwater system at Former MCAS Tustin and the regional aquifer, which is used as a drinking water source. Downward movement of 1,2,3-TCP in groundwater at IRP-13S is, therefore, a pathway that could lead to human exposure to VOCs. The monitoring component of Alternative 2 is intended to track this possibility. Periodic reviews of the monitoring data would trigger implementation of additional remedial measures if potential impacts on the regional aquifer are identified.

A final consideration for off-station migration involves potential ecological impacts that could result from the eventual discharge of VOCs originating on Former MCAS Tustin property to Barranca Channel. This issue is discussed in more detail in Section 2.2. Because the discharges of VOC-impacted groundwater to surface water are not expected to begin for almost 40 years, it is difficult to predict potential impacts to ecological resources in the drainage channels or in downstream areas. Monitoring and periodic

reviews under Alternative 2 would be used to more accurately evaluate the significance of the future discharges, and contingency measures would be implemented to mitigate any expected environmental impacts.

4.2.3 Hydraulic Containment

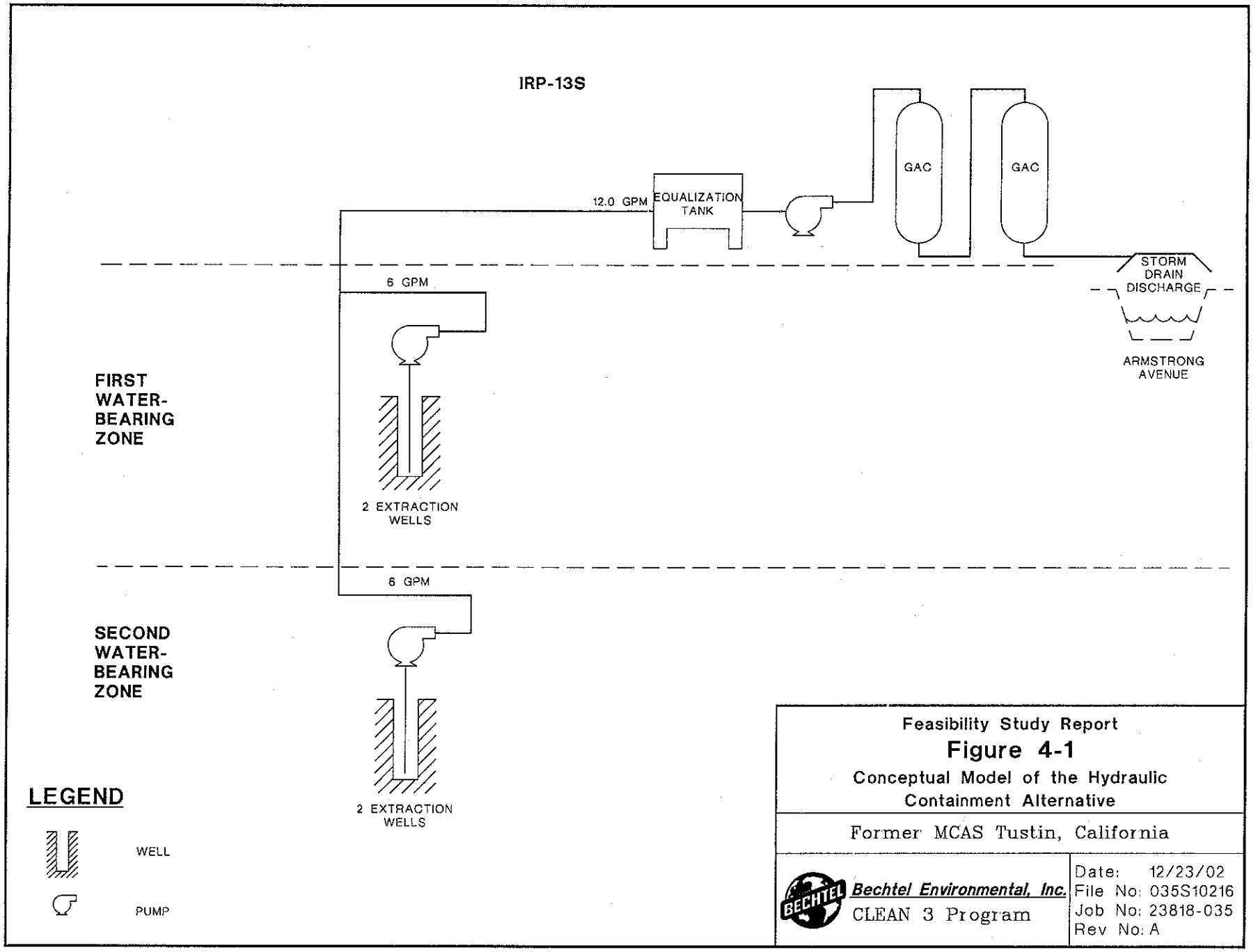
Hydraulic containment (Alternative 3) would use a combination of engineering and administrative controls to limit further migration of the OU-1A groundwater plumes and prevent human exposure to VOC-contaminated groundwater. One or two extraction wells would be placed along the downgradient margin of each plume identified in the first and second WBZs. The capture zones created by these wells would create a hydraulic barrier to effectively restrict further downgradient migration of VOCs within the shallow aquifer. Extracted groundwater would be treated at an aboveground facility located near IRP-13S and then discharged to city of Tustin storm drains. The treatment system would be similar in design to the existing TCRA system at IRP-13S.

RWQCB Santa Ana Region intends to issue an NPDES permit if the selected OU-1A remedial action includes surface water discharge. The DON and RWQCB have "agreed to disagree" concerning the applicability of the permit exclusion of CERCLA Section 121(e). Consistent with this agree-to-disagree compromise, the DON continues to maintain that surface water discharge related to OU-1A remedial action is exempt from such permit requirements based on discharges currently being conducted on-site. But the DON agrees to comply with the substantive requirements of the permit as a means to assure compliance with the substantive provisions of the Basin Plan (RWQCB 1995) and other state ARARs as provided by Section 121(d) of CERCLA.

Sampling requirements will be detailed in the O&M Plan. Figure 4-1 shows a conceptual model of the hydraulic containment alternative.

The basis for the development of Alternative 3 is similar to that described for Alternative 2. Currently there are no complete human exposure pathways for groundwater contamination originating at IRP-13S. Estimated risks for potential exposure pathways under the planned reuse scenarios are relatively low, except for a future residential receptor. The exposure assumptions used to estimate future residential risks may not be as high realistically as indicated in this FS Report. In addition, residential exposures to contaminated groundwater are readily controlled through institutional measures such as deed restrictions.

The principal benefit of implementing Alternative 3 is that VOCs would not migrate beyond the existing plume boundaries. Contamination would be kept within the Former MCAS Tustin property, enhancing the feasibility of the institutional controls necessary to minimize future risks. Containment under Alternative 3 would entail extraction of contaminated groundwater from both the first and second WBZs. While not primarily intended as an aquifer restoration alternative, this remedial action would, over time, accomplish a potentially significant reduction in both VOC mass and concentration within the plumes and accomplish risk reduction as well.



Feasibility Study Report

Figure 4-1

Conceptual Model of the Hydraulic Containment Alternative

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/23/02
File No: 035S10216
Job No: 23818-035
Rev No: A

Other considerations supporting the development of a hydraulic containment alternative at Former MCAS Tustin are based on site hydrogeology and plume geometry. Given the limited transmissivities associated with the upper two WBZs, only one or two wells would be needed to contain each of the identified plumes. Two wells, each extracting groundwater at 3 gpm, would be required in each WBZ to contain the plumes at IRP-13S. Placement of the hydraulic containment wells at IRP-13S could be optimized during remedial design to eliminate the potential downward migration of 1,2,3-TCP from the second WBZ to the third WBZ, thereby reducing potential risk to the regional aquifer.

Alternative 3 would entail extraction of a limited volume of water (total extraction rate of 12 gpm), which would simplify treatment requirements as well as long-term O&M. In addition, the areal and vertical distribution of contamination has been well-defined, making it easy to verify containment of the plumes and the performance of this alternative.

Institutional controls in the form of deed restrictions would be put in place for the redevelopment parcels overlying the OU-1A contaminant plumes. The purpose of these institutional controls would be to restrict future activities that may result in human exposure to groundwater contamination, such as installation of private water supply wells. A performance monitoring program and periodic reviews would be implemented to evaluate the effectiveness of hydraulic containment, track VOC concentration trends, and ensure that the remedy remains protective.

4.2.4 Aggressive Groundwater Extraction

Alternatives 4 and 4A are some of the more aggressive response actions evaluated in this FS. They include removing source material and installing a network of groundwater extraction and injection wells to contain the OU-1A plumes and attempt to reduce the risk due to groundwater contamination as quickly as possible.

Source removal under Alternatives 4 and 4A would entail excavating a significant portion of the contaminant mass within the upper confining layer of the first WBZ at IRP-13S including the TCE-contaminated vadose zone soil at MWA-18 (IRP-13S). The purpose of the source removal would be to accelerate the rate of cleanup in the underlying permeable sand layers and to maximize the overall efficiency of the remedial action. Alternatives 4 and 4A differ only in the disposal of the excavated source area soil. All other components of these two alternatives are identical.

Alternatives 4 and 4A were included in this FS based on the need to evaluate remedial actions that satisfy the NCP expectation that contaminated groundwater would be returned to its beneficial uses "wherever practicable" (40 C.F.R. § 300.430[a][1][iii][F]). Although it is widely recognized that groundwater restoration (defined as contaminant reduction to MCLs or other health-based levels) is not practicable at many sites, decisions regarding the "restorability" of an aquifer typically can only be made after remediation systems have been implemented and monitored for a period of time (U.S. EPA 1993c, 1995). Alternatives 4 and 4A represent a viable technical approach to support such a determination.

Development of Alternatives 4 and 4A was based on modeling that indicated that source removal combined with an aggressive 15-year groundwater extraction program should remove enough VOC mass to permanently prevent contaminant migration exceeding site cleanup goals beyond the boundaries of Former MCAS Tustin property. The source removal component focuses on the most highly contaminated materials within the vadose zone and the upper confining layer of the first WBZ. Ultimately, groundwater extraction would be expected to remove the bulk of the VOC mass from the permeable sand layers of the first and second WBZs.

The contaminant mass in the upper confining clay layer of the first WBZ appears to serve as a chronic source of low-level groundwater contamination to the underlying sand layers. Modeling results presented in Appendix B show that the magnitude of the VOC contribution from the upper clay is limited under natural flow (ambient) conditions. However, loadings from the upper clay to the permeable layers would increase significantly if the first WBZ were pumped, to the extent that it would not be possible to attain groundwater remediation goals without removing at least some portion of the upper contaminated clays. This concept is illustrated on Figure 4-2. Modeling shows that removal of VOC-affected soils from the upper confining layer (and portions of the vadose zone at IRP-13S) would reduce contaminant loadings from the clay and increase the effectiveness of groundwater extraction.

During the technology-screening step, several approaches were evaluated to identify an effective method for removing source material VOCs from the upper confining clay layer at IRP-13S. Source removal scenarios included excavation, SVE, and contaminant flushing (through infiltration of up to 2 feet per year of clean water). Results of this evaluation are presented in Appendix B and Section 3.3.3. Excavation was determined to

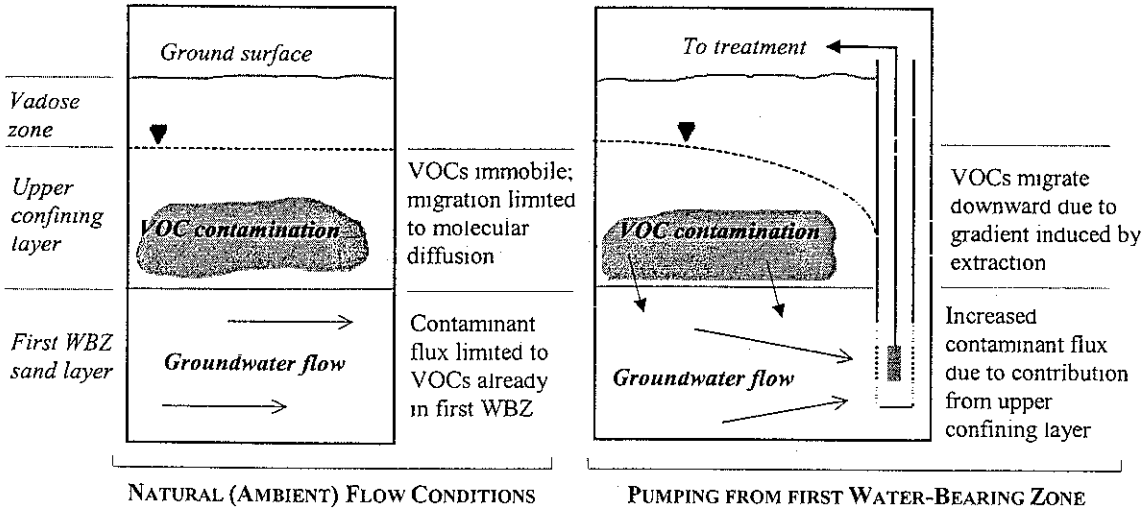


Figure 4-2
Contaminant Flux From Upper Confining Layer

provide the best performance and was retained as the source removal component of Alternatives 4 and 4A.

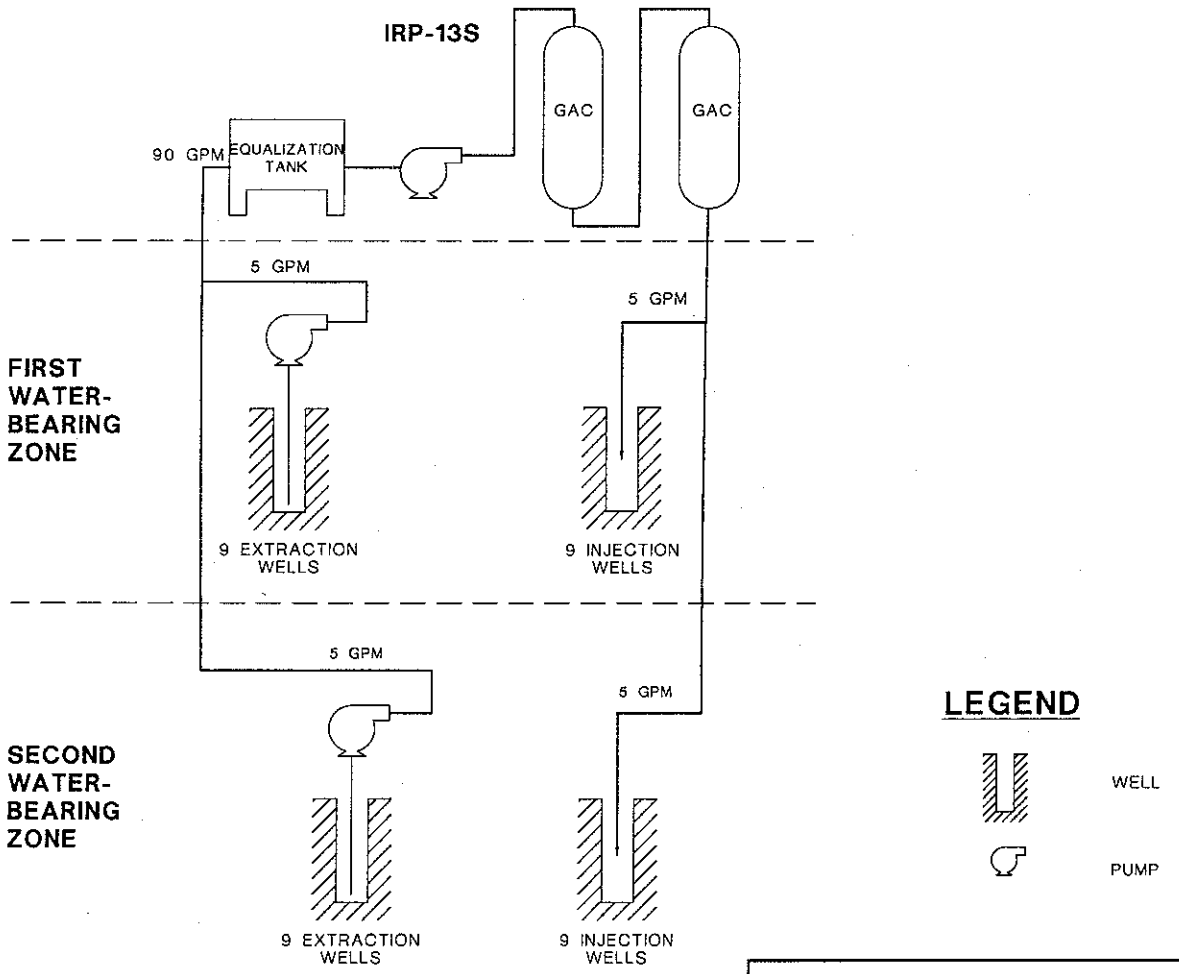
The extent of the proposed soil excavation was evaluated through the modeling analysis (Appendix B). It was determined that the appropriate soil excavation criteria for TCE and 1,2,3-TCP are 100 µg/kg and 10 µg/kg, respectively. Removal of soil exceeding these criteria represents an optimum balance between the volume of excavated material that must be managed and reductions in long-term VOC loadings to groundwater.

The objective of the aggressive groundwater extraction alternative is to reduce concentrations of site-related contaminants in the first and second WBZs to the maximum extent practicable within a reasonable time frame. The extraction system would be designed and operated with the intent of ultimately attaining site remediation goals in all groundwater passing across the existing plume boundaries. However, as discussed in Section 2.6, there are significant technical complications regarding the realization of these cleanup goals throughout the OU-1A plumes, primarily due to the heterogeneous, anisotropic nature of the aquifer and the presence of potentially significant quantities of contamination in fine-grained, low permeability zones. Not all of the contamination associated with OU-1A would (or even could) be removed by extraction. For instance, this alternative is not expected to have a significant effect on the existing levels of VOC contamination in the lower confining clay layer at the bottom of the first WBZ.

A conceptual depiction of the groundwater extraction and treatment components of Alternatives 4 and 4A is provided on Figure 4-3. Extraction wells would be located throughout the entire area of affected groundwater at and downgradient of IRP-13S. The number, locations, and operating parameters for the extraction wells were estimated through modeling, as described in Appendix B. The primary consideration in this analysis was the development of an extraction well network in the first and second WBZs sufficient to capture all groundwater impacted by site-related contaminants. In addition, aggressive extraction from the second WBZ would create an upward hydraulic gradient and eliminate the potential for 1,2,3-TCP to migrate to the third WBZ through a localized lithologic discontinuity downgradient of the IRP-13S source area.

Modeling results indicate that 18 groundwater extraction wells would be required to accomplish the objectives established for Alternatives 4 and 4A. The total groundwater extraction rate would be 90 gpm. Groundwater extraction would continue until contaminant levels in the sand layers of the first two WBZs reached asymptotic levels. Based on the modeling results presented in Appendix B, extraction is expected to continue for 15 years at IRP-13S. Extraction for longer periods of time would not result in significant additional contaminant reduction. After the extraction systems are shut down, either natural attenuation processes would continue to reduce VOCs to site remediation goals or monitoring would show the plume has stabilized.

As shown on Figure 4-3, the extracted groundwater would be treated by GAC adsorption to remove organic contaminants to below site cleanup requirements. An aboveground treatment facility would be constructed at IRP-13S, similar to the existing TCRA system.



Feasibility Study Report

Figure 4-3

Conceptual Model of the Aggressive Groundwater Extraction Alternative

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/23/02
File No: 035S10214
Job No: 23818-035
Rev No: A

Treated groundwater would be discharged through 18 injection wells into the first and second WBZs of the shallow aquifer. Injection of treated groundwater upgradient of the contaminant plumes would enhance flushing of VOCs to the extraction wells (thus reducing the time required for aquifer restoration) while diverting clean (upgradient) groundwater around the areas of contamination. The injection wells would be located in areas of the shallow aquifer where background levels of TDS and other inorganic constituents are not markedly different from the treated groundwater.

Deed restrictions on the redevelopment parcels overlying the OU-1A plumes would be used to restrict potential human exposure to contaminated shallow groundwater. As with Alternative 3, this alternative has the advantage of limiting the areas where deed restrictions would be required, since the extent of VOC-affected groundwater would not expand significantly beyond current plume boundaries. A performance monitoring program with periodic progress reviews would be an integral component of this alternative.

4.2.5 Permeable Reaction Wall

Alternative 5 consists of permeable reaction walls installed within the shallow aquifer to remediate the contaminant plumes downgradient of IRP-13S. Similar to Alternative 3, the overall objectives of the permeable reaction wall alternative would be to contain the OU-1A plumes, achieve significant reductions in VOC concentrations, and prevent human exposure to VOC-affected groundwater.

Permeable reaction walls represent an innovative technology that offers a number of advantages at Former MCAS Tustin. As noted in Appendix C, studies reported in the literature have shown that TCE, 1,2,3-TCP, and other chlorinated VOCs can be completely degraded to nonchlorinated, nontoxic reaction products as groundwater flows through an *in situ* bed of reactive iron. The likelihood that this technology would be successful at Former MCAS Tustin has been confirmed in bench tests using groundwater samples collected from the OU-1A plumes (BNI 1998a). The passive nature of the permeable reaction wall process results in reduced O&M requirements compared to remediation using groundwater extraction and aboveground treatment.

Alternative 5 would rely on natural groundwater flow for contaminant transport to the reactive walls. Therefore, remediation of the VOC plumes at IRP-13S in less than 30 years is not possible with this technology. Furthermore, this alternative would not address the potential for seasonal downward migration of 1,2,3-TCP to the third WBZ through a localized lithologic discontinuity identified downgradient of the IRP-13S source area. These disadvantages are somewhat offset by the fact that the surface "footprint" of Alternative 5 would be minimal, possibly reducing potential complications with regard to property redevelopment.

During the BCT meeting of 29 October 2002, the Restoration Advisory Board (RAB) for Former MCAS Tustin and the RWQCB stated their opposition to the application of this iron reactive wall technology at OU-1A. John Broderick, representing the RWQCB, stated that installation of reactive iron in the subsurface would likely generate by-products that would violate the Basin Plan, and that the RWQCB would likely not accept Alternative 5.

Dana Ogden, representing the city of Tustin, suggested eliminating Alternative 5 from the OU-1A FS altogether. Alternative 5 was retained for evaluation, however, to be consistent with the FS conducted for OU-1B, and for further consideration as an innovative technology.

For conceptual design purposes, it was assumed that the permeable reaction walls at IRP-13S would be used in a funnel-and-gate configuration (Figure 3-4), although other configurations may also be feasible. Slurry walls would be used to direct (funnel) the contaminated groundwater through permeable sections of reactive iron. The slurry walls and permeable reaction walls would be configured such that all upgradient groundwater within the plumes would eventually pass through the reactive iron wall. The reactive wall sections would be sized to reduce TCE, 1,2,3-TCP, and other chlorinated VOCs to concentrations below site remediation goals. The low levels of existing VOC contamination downgradient of the walls would be remediated by natural attenuation processes, including dilution, dispersion, and adsorption.

Since permeable reaction walls are considered innovative, Alternative 5 includes a year-long pilot test to be conducted at the smaller, western plume in the first WBZ at an adjacent site (IRP-12, Plume 12W) to evaluate the effectiveness of this alternative. For the purpose of this FS, it was assumed that the pilot test would be successful and that full-scale permeable reaction walls would then be placed near the downgradient margins of the remaining plumes within the first WBZ. These walls would extend vertically to effectively intercept VOC-affected groundwater in both the first and second WBZs. The walls would be keyed into the low-permeability soils beneath first or second WBZ, depending on location. To reduce the contaminant transport distance to the reactive media and, thus, shorten the time required for remediation, it was assumed that iron treatment walls would also be placed across the center of the IRP-13S plumes. The actual wall configuration would depend on the outcome of the pilot study.

Similar to Alternatives 3 and 4, this alternative would include a performance monitoring program to track VOC migration and confirm the effectiveness of the reaction walls. Deed restrictions at the redevelopment parcels overlying the OU-1A plumes would prevent human exposure to shallow groundwater. Periodic reviews would be conducted to evaluate system performance and determine the need for flushing or replacement of the reactive iron materials.

4.2.6 Vacuum-Enhanced Extraction

Alternatives 6 and 6A are refinements of Alternatives 4 and 4A. They include source removal plus groundwater extraction to contain the OU-1A plumes while attempting to shorten the time required to remediate VOC-affected groundwater. Source removal, treatment, and disposition under Alternatives 6 and 6A are identical to that described under Alternatives 4 and 4A, respectively. With the exception of the treatment and disposition of excavated soils, all other components of Alternative 6 are identical to those of Alternative 6A.

Alternatives 6 and 6A would impose a high vacuum (approximately 0.3 to 0.4 atmosphere) on the groundwater extraction wells completed in the first WBZ. The

purpose of the VEE system would be to increase the groundwater extraction rate and, thus, the rate of VOC removal from the sand layer of the first WBZ. Additional contaminants would be removed with any soil vapor captured by the vacuum system as the groundwater table is lowered in the vicinity of the VEE wells and VOCs are stripped from newly exposed soil. Conventional groundwater extraction wells would be installed to remove dissolved contaminants from the second WBZ.

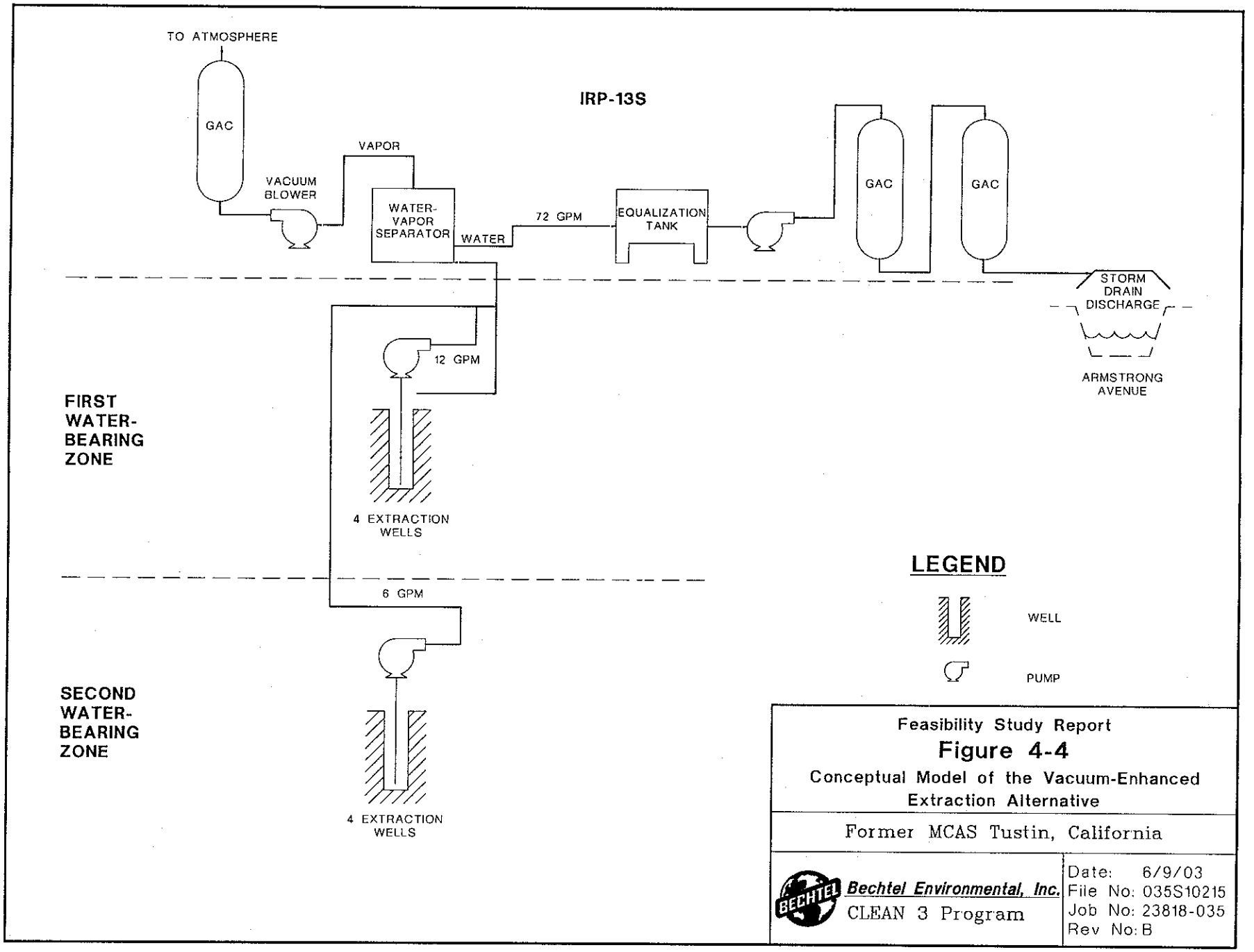
Figure 4-4 depicts the groundwater extraction and treatment components of Alternatives 6 and 6A. As with Alternatives 4 and 4A, the VEE system would consist of a network of extraction wells located to capture the OU-1A plumes in the first and second WBZs. Modeling results presented in Appendix B suggest that four VEE wells and four conventional groundwater extraction wells would be required. The extraction wells would be configured to create an upward hydraulic gradient and thereby control the seasonal potential for 1,2,3-TCP to migrate to the third WBZ through a localized lithologic discontinuity downgradient of the IRP-13S source area.

The total groundwater extraction rate from the first two WBZs would be 72 gpm. Groundwater extraction would continue until contaminant levels in the sand layers of the first two WBZs reach asymptotic levels. Based on the modeling results presented in Appendix B, extraction is expected to continue for 15 years at IRP-13S. Extraction for a longer period of time would not result in significant additional contaminant reduction. After the extraction system shuts down, natural processes (dilution, dispersion, and adsorption) would continue to reduce VOCs to site cleanup goals.

The extracted groundwater would be treated by GAC to remove organic contaminants. An aboveground treatment facility would be constructed near IRP-13S. Treated groundwater would be discharged in a manner identical to Alternative 3.

The modeling results presented in Appendix B also predict that the VEE wells at IRP-13S could remove a combined total of 1.3 standard cubic feet per minute (scfm) of soil gas. In contrast, a recent VEE pilot test at nearby IRP-3 found that vapor flow in these wells is unlikely because residual moisture in the upper clay layer in the first WBZ acts as an effective barrier to air circulation from the surface (BNI 1999a). Nevertheless, because extraction of soil gas is theoretically possible with a VEE system, provisions to handle VOC-containing vapors would be included in the design of the treatment facilities to be constructed near IRP-13S.

Deed restrictions on the redevelopment parcels overlying the OU-1A plumes would be used to prevent potential human exposure to contaminated groundwater. As with Alternatives 3 and 4/4A, this alternative has the advantage of limiting the areas where deed restrictions would be required, since the extent of VOC-affected groundwater would not expand significantly beyond current plume boundaries. A performance monitoring program with periodic progress reviews would also be included as an integral component of Alternatives 6 and 6A.



Feasibility Study Report

Figure 4-4

Conceptual Model of the Vacuum-Enhanced Extraction Alternative

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 6/9/03
File No: 035S10215
Job No: 23818-035
Rev No: B

4.2.7 Hydraulic Containment With Hot Spot Removal

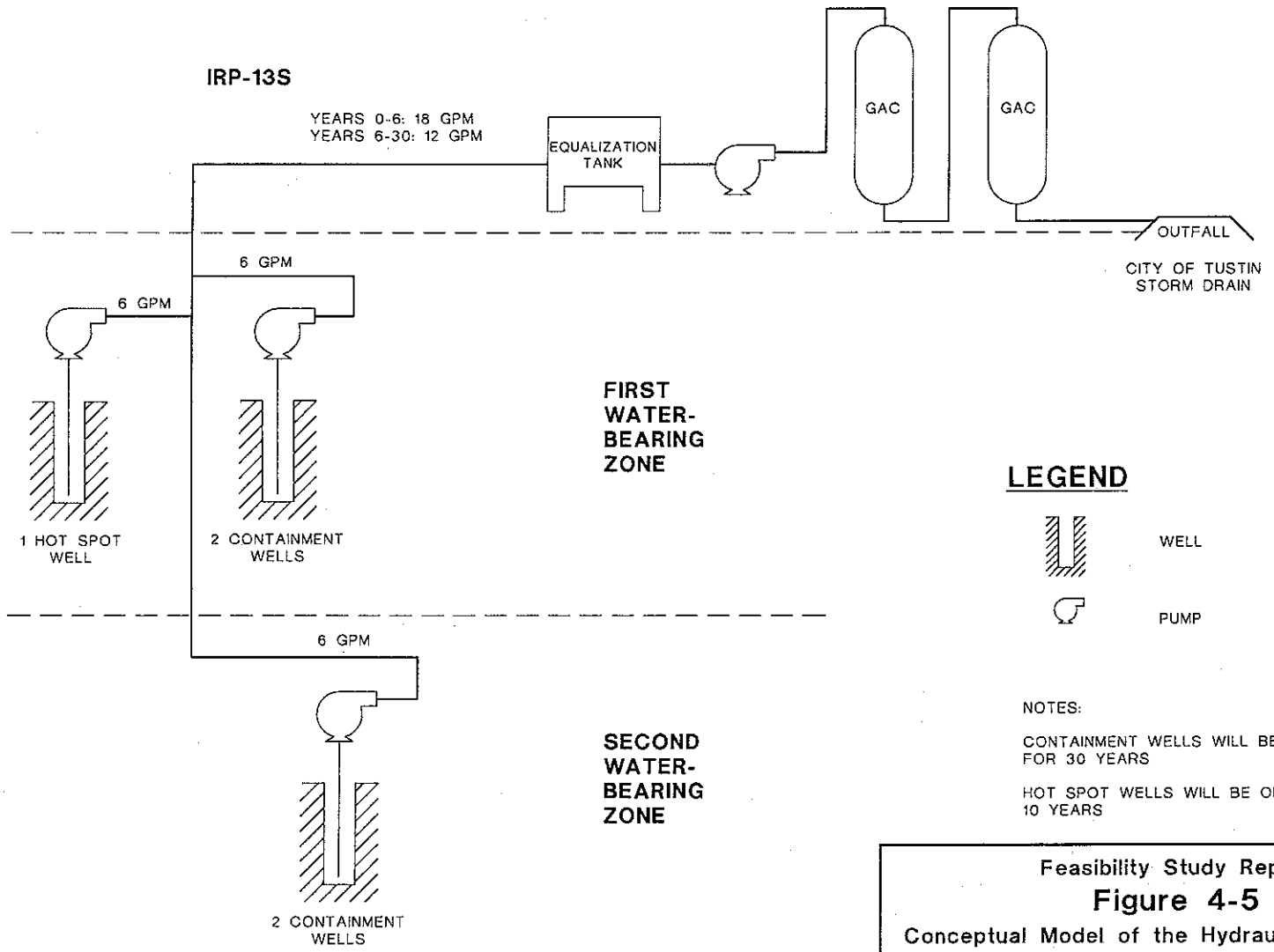
Alternative 7 is an enhancement of Alternative 3 that includes hot spot groundwater extraction and hydraulic containment described under Alternative 3, as well as limited hot spot soil excavation and on-site soil treatment using a thermal desorption unit (TDU). Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel.

Alternative 7 was developed to reduce the time required to reach cleanup goals while retaining the effective containment of Alternative 3. This is accomplished by excavating contaminated soil hot spots and extracting groundwater from the central portions of the plumes. Hot spot extraction wells would operate approximately 6 years after start-up of the remediation system. Excavation of hot spot soils and extraction of groundwater from the central portions of the contaminant plumes improves the efficiency of the groundwater treatment system and reduces the time required to attain the cleanup goals established for the site. Figure 4-5 shows a conceptual model of Alternative 7.

Contaminated soil would be excavated and treated on-site with a TDU. Treated soil would be used as excavation backfill. An aboveground groundwater treatment facility, similar in design to the existing TCRA system, would be constructed south of IRP-13S. Groundwater would be extracted and treated using GAC before discharge to a storm drain and ultimately to Peters Canyon Channel.

Groundwater extraction under Alternative 7 would use the identical extraction well configuration proposed for hydraulic containment under Alternative 3, plus one additional hot spot groundwater extraction well. Hydraulic containment wells would be placed along the downgradient margin of each plume identified in the first and second WBZs at IRP-13S, and the additional hot spot groundwater extraction well would be placed in the area of the highest VOC groundwater concentrations. The purpose of the more aggressive hot spot groundwater extraction under Alternative 7 is to reduce the highest contaminant concentrations in groundwater, thereby reducing the time required for cleanup.

Groundwater modeling results indicate that a total of five wells, including the four hydraulic containment wells proposed under Alternative 3 plus one additional hot spot groundwater extraction well, would be required. Groundwater extraction using the additional hot spot well would continue until contaminant levels in groundwater extracted from the hot spot well reached asymptotic levels. Based on the modeling results, groundwater extraction using the hot spot well is expected to continue for 6 years at IRP-13S. The total groundwater extraction rate from the five wells extracting groundwater from the first two WBZs would be 18 gpm for years 0 to 6, and 12 gpm for years 6 to 30. Extraction for longer periods of time would not result in significant additional contaminant reduction. After the extraction systems are shut down, natural processes would continue to reduce VOCs to site remediation goals.



LEGEND

WELL

PUMP

NOTES:

CONTAINMENT WELLS WILL BE OPERATED FOR 30 YEARS

HOT SPOT WELLS WILL BE OPERATED FOR 10 YEARS

Feasibility Study Report

Figure 4-5

Conceptual Model of the Hydraulic Containment with Hot Spot Removal Alternative

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/23/02
File No: 035S10213
Job No: 23818-035
Rev No: A

Deed restrictions on the redevelopment parcels overlying the OU-1A plumes would be used to prevent potential human exposure to contaminated groundwater. These deed restrictions would supplement the existing permitting process in Orange County for installation of new water supply wells. As with Alternatives 3 and 4/4A, Alternative 7 has the advantage of limiting the areas where deed restrictions would be required, since the extent of VOC-affected groundwater would not expand significantly beyond current plume boundaries. A performance monitoring program with periodic progress reviews would also be included as an integral component of Alternative 7.

4.3 ALTERNATIVES SCREENING

U.S. EPA guidance (U.S. EPA 1988a) suggests that the remedial alternatives initially developed during an FS should first be screened on the basis of effectiveness, implementability, and cost before a detailed analysis is completed. However, such a screening step is optional and was not deemed necessary for this FS for three reasons. First, the process option and technology screening evaluation presented in Section 3 was focused on the remediation of a single medium (groundwater) containing a limited number of COCs (VOCs only) with similar chemical characteristics. This significantly limited the list of viable process options and candidate technologies. Second, it was possible to use the modeling described in Appendix B to screen certain technologies and optimize the configuration of various hydraulic control, extraction, or injection systems prior to the development of alternatives. Third, reliance on U.S. EPA presumptive remedy guidance in Section 3 further streamlined the evaluation of available remedial measures. Taken together, these three factors resulted in a limited number of realistic remedial options for the OU-1A plumes, thus eliminating the need for an alternatives screening step prior to the detailed analysis presented in Section 5.

A conceptual alternative for closure of OU-1A Sites (IRP-3, -12, and -13S) within 10 years was developed to evaluate a short-term alternative for cleanup and associated costs. Under this conceptual alternative, all contaminated soil and groundwater would be removed and closure would be reached within 10 years. The total cost for this alternative was estimated at approximately $34 million: $29 million for excavation and dewatering and $5 million for groundwater extraction. The total cost, however, excludes additional costs for engineering design, oversight for the excavation, screening of the soil, monitoring for 10 years or more, and producing reports and other documentation.

This conceptual alternative presents the magnitude of what would be involved in an expedited cleanup, without constraints on the total cost. At the beginning of the FS process, three NCP evaluation criteria, including implementability, effectiveness, and cost, are applied to evaluate a wide range of technologies. An alternative can often be screened out right away based on one or more of these criteria. If this alternative had been developed, it would have been screened out early in the FS process due to high cost and implementability issues.

The technical infeasibility of achieving total aquifer restoration in the short term using available technologies and given site-specific conditions at OU-1A is discussed further in Section 2.4.5, Cleanup to Background Levels.

Section 5
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The nine remedial alternatives for OU-1A are described and evaluated in detail in this section. Section 5.1 describes the criteria specified in CERCLA and the NCP for assessment of remedial alternatives. Sections 5.2 through 5.10 present a detailed analysis of the remedial alternatives and include the following:

- a description of each remedial alternative, emphasizing how selected technologies and process options will be applied at OU-1A
- an assessment of each remedial alternative by comparison with the CERCLA/NCP evaluation criteria described in Section 5.1

Table 5-1 presents a summary of the nine OU-1A remedial alternatives and Section 6 compares their relative advantages and disadvantages.

5.1 EVALUATION CRITERIA

The following nine criteria are stipulated in the NCP at 40 C.F.R. § 300.430(e)(9)(iii) for the evaluation of remedial alternatives under CERCLA:

- overall protection of human health and the environment
- compliance with ARARs
- long-term effectiveness and permanence
- reduction of toxicity, mobility, or volume through treatment
- short-term effectiveness
- implementability
- cost
- state acceptance
- community acceptance

These criteria are further defined by a number of subcriteria and factors presented in U.S. EPA RI/FS technical guidance (U.S. EPA 1988a). Explanations of the nine NCP criteria, along with a summary of the relevant subcriteria and factors, are provided below.

5.1.1 Overall Protection of Human Health and the Environment

This criterion assesses the extent to which an alternative protects human health and the environment after consideration of site characteristics and expected risk reduction. Evaluation of the overall protection of human health and the environment afforded by each alternative draws on assessments made under several other NCP criteria, especially short-term effectiveness, long-term effectiveness and permanence, and compliance with ARARs.

The following issues are addressed for each alternative under this criterion:

- elimination, reduction, and/or control of the sources of groundwater contamination
- reduction in risk to human health and the environment
- achievement of remediation goals for OU-1A groundwater

5.1.2 Compliance With ARARs

This criterion determines whether an alternative will comply with all federal and state ARARs, as defined by CERCLA Section 121 and identified in Appendix A for OU-1A. ARARs are summarized for each alternative, and the following factors are addressed.

- Compliance with chemical-specific ARARs (e.g., MCLs). This factor addresses whether chemical-specific ARARs can be met and, if not, whether a waiver may be appropriate.
- Compliance with location-specific ARARs (e.g., preservation of historic sites, regulations pertaining to activities near wetlands or floodplains). This factor addresses whether location-specific ARARs can be met and, if not, whether a waiver may be appropriate.
- Compliance with action-specific ARARs (e.g., RCRA requirements to classify wastes at the point of generation). This factor addresses whether action-specific ARARs can be met and, if not, whether a waiver may be appropriate.

The evaluation made under this criterion evaluates compliance with TBCs, which are not ARARs, only when necessary and appropriate for specific remedial alternatives.

5.1.3 Long-Term Effectiveness and Permanence

This criterion examines the impact of a remedial alternative in the long term, defined in U.S. EPA guidance as the time after remedial action objectives have been met (U.S. EPA 1988a). Evaluation of a remedial alternative relative to its long-term effectiveness and permanence is made considering the following factors:

- magnitude of the residual risk to human and environmental receptors from remaining VOC-impacted soils or groundwater contaminants at the completion of remedial activities
- type, degree, and adequacy of long-term management (including engineering controls, monitoring, and O&M) required for VOC-impacted soils or groundwater contaminants remaining at the site
- long-term reliability of engineering and/or institutional controls to provide continued protection from VOC-impacted soils and groundwater contaminants
- potential need to replace components of the remedy (such as the reactive iron beds in Alternative 5) and the continuing need for repairs or maintenance

Table 5-1
Summary of Detailed Analysis[a] of OU-1A Remedial Alternatives

	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternative 4 Aggressive Groundwater Extraction With Off-Site Soil Disposal	Alternative 4A Aggressive Groundwater Extraction With On-Site Soil Treatment	Alternative 5 Permeable Reaction Wall
Major Components	No remedial action	• Groundwater monitoring • Institutional controls • Periodic reviews	• Groundwater extraction (four wells) • GAC treatment of extracted groundwater • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • Off-site disposal of excavated soil • Groundwater extraction (18 wells) • GAC treatment of extracted groundwater • Injection of treated water (18 wells) • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site treatment and backfilling of excavated soil • Groundwater extraction (18 wells) • GAC treatment of extracted groundwater • Injection of treated water (18 wells) • Institutional controls • Performance monitoring, periodic reviews	• *In situ* treatment of groundwater using permeable reaction walls • Institutional controls • Performance monitoring, periodic reviews
Short-Term Effectiveness	No short-term impacts; does not affect existing conditions; VOCs would remain above site remediation goals for over 100 years.	Minimal short-term impacts during well installation and sampling; further reduces potential for human exposure to VOCs in shallow groundwater once deed restrictions have been implemented	Short-term risks from installing wells, building treatment plant, and handling contaminated groundwater readily managed.	Short-term risks to workers and community from excavation/ handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/ handling/treatment of contaminated soils; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; minimal impact on community during operational period, other than possible iron replacement at assumed 15-year intervals.
Long-Term Effectiveness and Permanence	Does not meet remedial action objectives; residual risks unchanged from baseline conditions; does not prevent migration of 1,2,3-TCP to third WBZ, with possible threat to regional aquifer; allows off-station migration with eventual discharge of contaminants to Barranca Channel.	Does not meet remedial action objectives; residual risks unchanged from baseline conditions; does not prevent migration of 1,2,3-TCP to third WBZ; institutional controls prevent human exposure to VOCs; allows off-station migration with eventual discharge of contaminants to Barranca Channel; long-term success uncertain due to heterogeneity of aquifer	Prevents VOC migration beyond existing plume boundaries, eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction over 30 years; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; monitoring and periodic reviews assure effectiveness; would require long-term operation; long-term success uncertain due to heterogeneity of aquifer	Prevents VOC migration beyond existing plume boundaries and reduces OU-1A contaminants; eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness	Prevents VOC migration beyond existing plume boundaries and reduces OU-1A contaminants; eliminates off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness	Long-term effectiveness uncertain due to innovative technology; captures most existing VOC contamination, with minimal plume migration beyond existing boundaries; does not address threat to third WBZ and regional aquifer; achieves significant risk reduction; institutional controls prevent human exposure to VOCs; monitoring and periodic reviews assure effectiveness; long-term success uncertain due to heterogeneity of aquifer.
Reduction of Toxicity, Mobility, or Volume Through Treatment	No reduction other than that attributed to natural attenuation processes; maximum VOC concentrations decrease by 55% to 72% over 30 years due to dilution, dispersion, and adsorption; no decrease in VOC mass; continued migration of VOCs increases the volume of contaminated groundwater	No reduction other than that attributed to natural attenuation processes; maximum VOC concentrations decrease by 55% to 72% over 30 years due to dilution, dispersion, and adsorption; no decrease in VOC mass; continued migration of VOCs increases the volume of contaminated groundwater	Controls contaminant mobility through containment; extraction reduces toxicity and volume of contamination; TCE and 1,2,3-TCP mass reduced by more than 40% and 60%, respectively; maximum VOC concentrations reduced by 69% to more than 99% over 30 years; adsorbed VOCs destroyed during GAC regeneration	Controls contaminant mobility through containment; aggressive extraction reduces toxicity and volume; TCE and 1,2,3-TCP mass reduced by 95% and 74%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils placed in secure landfill; adsorbed VOCs destroyed during GAC regeneration.	Controls contaminant mobility through containment; aggressive extraction reduces toxicity and volume; TCE and 1,2,3-TCP mass reduced by 95% and 74%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils thermally treated and used as backfill; adsorbed VOCs destroyed during GAC regeneration.	Reduces toxicity, mobility, and volume due to contaminant destruction as plume migrates through reactive iron; TCE and 1,2,3-TCP mass reduced by 45% and 60%, respectively; maximum VOC concentrations reduced by 50% to more than 99% over 30 years.
Implementability	Does not entail active remediation or any further response actions; readily implementable	Readily implementable due to limited scope of action; deed restrictions compatible with redevelopment.	Uses readily available components with high operational reliability; deed restrictions compatible with redevelopment	Uses readily available, proven, highly reliable technologies; deed restrictions compatible with redevelopment.	Uses readily available, proven, highly reliable technologies; deed restrictions compatible with redevelopment	Limited full-scale applications; ability to install deep (75 feet bgs) iron walls uncertain; deed restrictions could constrain redevelopment on some parcels.

(table continues)

Table 5-1 (continued)

	Alternative 6 Vacuum-Enhanced Extraction With Off-Site Soil Disposal	Alternative 6A Vacuum-Enhanced Extraction With On-Site Soil Treatment	Alternative 7 Hydraulic Containment With Hot Spot Removal
Major Components	• Excavation of source area soils • Off-site disposal of excavated soil • Groundwater extraction by VEE in first WBZ (four wells) and conventional extraction in second WBZ (four wells) • GAC treatment of extracted groundwater and soil gas • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site thermal treatment and backfilling of excavated soil • Groundwater extraction by VEE in first WBZ (four wells) and conventional extraction in second WBZ (four wells) • GAC treatment of extracted groundwater and soil gas • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews	• Excavation of source area soils • On-site thermal treatment and backfilling of treated soil • Groundwater extraction (five wells) • GAC treatment of extracted groundwater • Discharge of treated water to city of Tustin storm drain • Institutional controls • Performance monitoring, periodic reviews
Short-Term Effectiveness	Short-term risks to workers and community from excavation/ handling of contaminated soils; transportation risks with off-site disposal; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks to workers and community from excavation/ handling/treatment of contaminated soils; extensive safety controls needed; risks from installing wells, building treatment plants, and handling groundwater readily managed	Short-term risks from installing wells, building treatment plant, and handling contaminated groundwater readily managed with engineering controls and standard health and safety protocols
Long-Term Effectiveness and Permanence	Prevents VOC migration beyond station boundaries and reduces VOCs within OU-1A plume; eliminates future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; VEE wells may draw 1,2,3-TCP upward from lower clay to sand layer of first WBZ; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness; actual VEE performance may not match model predictions based on pilot study results	Prevents VOC migration beyond station boundaries and reduces VOCs within OU-1A plume; eliminates future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction; VEE wells may draw 1,2,3-TCP upward from lower clay to sand layer of first WBZ; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; long-term success uncertain due to heterogeneity of aquifer; monitoring and periodic reviews assure effectiveness; actual VEE performance may not match model predictions based on pilot study results.	Prevents VOC migration beyond existing plume boundaries, eliminating potential off-station migration and future discharges to Barranca Channel; prevents migration of 1,2,3-TCP to third WBZ; achieves significant risk reduction over 30 years; institutional controls prevent human exposure to VOCs; minimizes area needing deed restrictions; monitoring and periodic reviews assure effectiveness; would require long-term operation; long-term success uncertain due to heterogeneity of aquifer
Reduction of Toxicity, Mobility, or Volume Through Treatment	Reduces contaminant toxicity, mobility, and volume through extraction; TCE and 1,2,3-TCP mass reduced by over 90% and 80%, respectively; maximum concentrations of VOCs reduced by 70% to over 99% during 10 to 15 year operating period; contaminated soils placed in secure landfill; adsorbed VOCs destroyed during GAC regeneration	Reduces contaminant toxicity, mobility, and volume through extraction; TCE and 1,2,3-TCP mass reduced by over 90% and 80%, respectively; maximum concentrations of VOCs reduced by 70% to over 99% during 10 to 15 year operating period; contaminated soils thermally treated and used as backfill and desorbed VOCs incinerated; adsorbed VOCs destroyed during GAC regeneration	Controls contaminant mobility through containment; extraction reduces toxicity and volume of contamination; TCE and 1,2,3-TCP mass reduced by more than 73% and 65%, respectively; maximum VOC concentrations reduced by factors greater than 98% over 30 years; contaminated soils thermally treated and used as backfill; adsorbed VOCs destroyed during GAC regeneration
Implementability	Proven and reliable technologies are used; deed restrictions compatible with redevelopment	Proven and reliable technologies are used; deed restrictions compatible with redevelopment.	Uses readily available components with high operational reliability; deed restrictions compatible with redevelopment

(table continues)

Table 5-1 (continued)

	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternative 4 Aggressive Groundwater Extraction With Off-Site Soil Disposal	Alternative 4A Aggressive Groundwater Extraction With On-Site Soil Treatment	Alternative 5 Permeable Reaction Wall
Cost[b]	No cost	$0.8 million	$3.8 million	$8.5 million	$7.6 million	$19.0 million
Compliance with ARARs	Not applicable. ARARs are not triggered by the no action alternative	Chemical-Specific Meets site cleanup standards, although attainment will take over 100 years. Location-Specific Meets all location-specific ARARs. Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs.	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; eventually attains remediation goals within OU-1A plume after many decades Location-Specific Meets all location-specific ARARs. Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; should restore beneficial uses within all portions of shallow aquifer in 50 to 60 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, as well as all other action-specific ARARs.	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; should restore beneficial uses within all portions of shallow aquifer in 50 to 60 years. Location-Specific Meets all location-specific ARARs. Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, as well as all other action-specific ARARs.	Chemical-Specific Attains site remediation goals, but only after many decades. Location-Specific Meets all location-specific ARARs. Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given slow rate of process; complies with all other action-specific ARARs.
Overall Protection of Human Health and the Environment	Does not protect HH/E in an overall sense; significant expansion of the OU-1A plume will occur; allows for potential discharges to Barranca Channel; does not actively address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; allows migration of VOCs beyond installation boundaries at significant concentrations; uncontrolled groundwater contamination could negatively affect site redevelopment; lack of long-term monitoring means that future risks, such as 1,2,3-TCP migration to the third WBZ or regional aquifer, would not be identified	Offers a fair degree of protection to HH/E; institutional controls limit future human consumption of VOC-affected groundwater; does not comply with all action-specific ARARs; allows for significant expansion of the OU-1A plume; allows for potential discharges to Barranca Channel; does not actively address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; allows migration of VOCs beyond installation boundaries at significant concentrations; continued migration of VOC-affected groundwater could have a negative affect on site redevelopment; deficiencies mitigated somewhat by long-term monitoring and periodic reviews to track plume migration and provide basis for additional remedial actions, if needed.	Protects HH/E; uses proven technology to contain OU-1A plume, prevent off-station migration and discharge into Barranca Channel, and control threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls prevent human exposure to VOCs in shallow groundwater; eventually removes OU-1A contamination; requires long-term operations and enforcement of institutional controls; monitoring and periodic reviews assure protection of HH/E.	Removal of source areas at the IRP site and remediation of plume would provide permanent solution to OU-1A contamination and thus high level of protection to HH/E; some short-term risks from handling and transport of large volumes of contaminated soil; contains OU-1A plume; prevents off-station migration and potential discharge to Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility.	Removal of source areas at the IRP site and remediation of plume would provide permanent solution to OU-1A contamination and thus high level of protection to HH/E; some short-term risks from handling and treatment of large volumes of contaminated soil; contains OU-1A plume; prevents off-station migration and potential discharge to Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility.	Remediation of OU-1A plume using a destructive process would provide a permanent solution and thus protect HH/E; uncertainties regarding deep construction reduce implementability rating; short-term risks due to soil excavation and off-site transport; captures most of OU-1A plume and prevents significant off-station migration; prevents potential discharge to Barranca Channel; does not address threat to water quality in third WBZ and deeper regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews assure protection of HH/E.

(table continues)

Table 5-1 (continued)

	Alternative 6 Vacuum-Enhanced Extraction With Off-Site Soil Disposal	Alternative 6A Vacuum-Enhanced Extraction With On-Site Soil Treatment	Alternative 7 Hydraulic Containment With Hot Spot Removal
Cost[b]	$6.4 million	$5.6 million	$4.3 million
Compliance with ARARs	Chemical-Specific Maintains site remediation goals at plume margins and prevents off-station VOC migration; should restore beneficial uses to aquifer in about 50 years, except for first WBZ, which will require many additional decades. Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly; complies with all other action-specific ARARs.	Chemical-Specific Maintains site remediation goals at plume margins and prevents off-station VOC migration; should restore beneficial uses to aquifer in about 50 years, except for first WBZ, which will require many additional decades. Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly; complies with all other action-specific ARARs.	Chemical-Specific Maintains site remediation goals at plume margins and prevents further VOC migration; eventually attains remediation goals within OU-1A plume a little after 30 years Location-Specific Meets all location-specific ARARs Action-Specific Complies with Basin Plan requirements relating to maintenance of beneficial use and water quality objectives, but not quickly, given limited scale of extraction; complies with all other action-specific ARARs
Overall Protection of Human Health and the Environment	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and transport of large volumes of contaminated soil; contains OU-1A; prevents off-station migration and potential discharge to Barranca Channel; VEE could induce TCE to move upward from lower clay to sand layer of first WBZ; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility (VEE and conventional wells).	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and treatment of large volumes of contaminated soil; contains OU-1A; prevents off-station migration and potential discharge to Barranca Channel; VEE could induce TCE to move upward from lower clay to sand layer of first WBZ; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls would prevent human exposure to VOCs in shallow groundwater; monitoring and periodic reviews needed to verify model-based predictions regarding time frame and technical feasibility (VEE and conventional wells)	Removal of source areas at IRP-13S and remediation of plume would provide permanent solution to OU-1A contamination and thus protect HH/E; some short-term risks from excavation, handling, and treatment of large volumes of contaminated soil; uses proven technology to contain OU-1A plume; prevents off-station migration and discharge into Barranca Channel; controls threat to water quality in third WBZ and regional aquifer at IRP-13S; institutional controls prevent human exposure to VOCs in shallow groundwater; eventually removes OU-1A contamination; requires shorter time of operations than Alternative 3; enforcement of institutional controls; and monitoring and periodic reviews assure protection of HH/E.

Notes:
[a] NCP criteria of state and community acceptance will be addressed after public review and comment on this document
[b] costs shown are net present values expressed in 2002 dollars; cost estimates are order-of-magnitude (+50% to -30%)

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
bgs – below ground surface
GAC – granular-activated carbon
HH/E – human health and the environment
IRP – Installation Restoration Program
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
OU – operable unit
TCE – trichloroethene
TCP – trichloropropane
VEE – vacuum-enhanced extraction
VOC – volatile organic compound
WBZ – water-bearing zone

5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses CERCLA's statutory preference for remedial alternatives that employ treatment technologies to permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances compared to baseline conditions. For OU-1A, this preference would be satisfied when treatment is used to destroy VOCs in soil and groundwater, reduce the total mass of VOCs in the subsurface, reduce the volume of VOC-affected material, or irreversibly reduce VOC mobility. Alternatives that do not use treatment technologies to achieve these goals, such as excavation and off-site landfill disposal of VOC-affected soil, are not considered to reduce the toxicity or volume of contaminants; however, such alternatives may be very effective at reducing contaminant mobility.

The evaluation of alternatives by this criterion considers several specific factors:

- treatment processes employed
- amount of hazardous materials that will be treated, including how the principal threats at OU-1A will be addressed
- degree of expected reduction in toxicity, mobility, or volume measured as a percentage of baseline conditions
- degree to which the treatment is irreversible
- type and quantity of treatment residuals that would remain following treatment

5.1.5 Short-Term Effectiveness

This criterion considers the impact of an alternative in the short term, defined in U.S. EPA guidance as the time required to plan, design, construct, and operate remediation systems until RAOs are achieved (U.S. EPA 1988a). The short-term effectiveness of a remedial alternative is evaluated relative to its effect on human health and the environment during implementation. The following factors are considered:

- short-term risks that might be imposed on the community, such as dust from excavation or transportation of VOC-affected soils to an off-site landfill
- potential impacts on workers during construction and O&M, along with the effectiveness and reliability of the protective measures that would be taken
- potential environmental impacts of the remedial action and the effectiveness and reliability of mitigation measures that would be taken during implementation
- amount of time required before RAOs are achieved, i.e., the duration of the short term

5.1.6 Implementability

This criterion evaluates the technical and administrative feasibility of implementing an alternative. The availability of required equipment, materials, and services is also considered. To assess implementability, the following factors are examined:

- technical feasibility, or the relative ease of implementing or completing an action based on site-specific constraints, including the use of established technologies; considerations include:
  - ability to construct the alternative as a whole
  - operational reliability, or the ability of a technology to meet specified process efficiencies or performance goals
  - ability to undertake future remedial actions that may be required and how difficult it would be to implement such actions
  - ability to monitor the effectiveness of the remedy
- administrative feasibility, including the ability (as well as time) required to obtain any necessary approvals and permits from other agencies or governmental bodies
- availability of services and materials required to implement an alternative, including:
  - capacity and location of off-site treatment, storage, and disposal services
  - equipment (such as heavy construction equipment) and specialists
  - timing to develop new or innovative technologies under consideration, including the time required for pilot tests
  - potential for competitive construction bids, a factor which may be particularly important for innovative technologies such as permeable reaction walls

5.1.7 Cost

In keeping with U.S. EPA guidance (U.S. EPA 1988a), the costs of the OU-1A remedial alternatives are estimated more precisely in this detailed analysis than in the screening-level technology evaluation presented in Section 3. For each remedial alternative, a -30 to +50 percent order-of-magnitude cost estimate was developed from data available in the RI (BNI 1997a) and subsequent monitoring programs and field investigations completed at Former MCAS Tustin (BNI 1998a,b; 2002b). Procedures outlined in U.S. EPA guidance (U.S. EPA 1987) were followed in developing the cost estimates for each alternative, which are based on the conceptual engineering designs presented in this section. All estimates are expressed in 2002 dollars. Cost details are presented in Appendix D.

The cost estimate for each remedial alternative consists of three principal elements.

- **Capital cost** consists of direct (e.g., construction) and indirect (e.g., site supervision and overhead) costs. Direct costs include expenditures incurred for equipment, labor, and materials to develop, construct, and implement a remedial action. Indirect costs include all other expenses necessary to support the construction that cannot be directly associated with a specific equipment item or remedial activity. For this FS Report, indirect costs include the following:
  - health and safety items
  - permitting and legal fees
  - site supervision
  - engineering
  - contractor overhead and profit
  - startup costs
  - contingency allowances

  These indirect expenditures are included in the detailed cost analyses, either as separate line items or as a percentage of the direct capital cost.
- **O&M cost** refers to those postconstruction items necessary to assure the continued effectiveness of a remedial action. Typical O&M expenses include power, operating labor, consumable materials, purchased services (such as laboratory services), replacement of spent GAC, equipment replacement, maintenance, sampling of monitoring wells and treatment facilities, permit fees, annual reports, and periodic site reviews.
- **Present value analysis** converts all current and future capital and O&M expenditures to a 2002 baseline. The net present value for a given alternative is equal to the full amount of all costs incurred through the end of the first year of operation (capital cost), plus the series of expenditures in following years reduced by the appropriate discount factor. This represents an amount that, if invested during the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. The present value provides a single cost figure for each alternative and allows for economic comparisons to be made among options with different cash flows. A real (inflation-adjusted) discount rate of 4 percent was assumed in this FS Report for all present value calculations, reflecting the anticipated difference between the long-term rate of inflation (3 percent) and the investment rate of return on government securities (7 percent). This assumption is consistent with U.S. EPA guidance (U.S. EPA 1988a).

5.1.8 State Acceptance

This criterion evaluates the remedial alternatives with respect to the concerns of state agencies. Some of these concerns have already been ascertained through review of policy and guidance documents, written comments submitted by the RWQCB and DTSC for the November 1996 Draft FS Report for OU-1 (BNI 1996a), the October 2001 Draft Final FS for OU-1B (BNI 2001b), and input provided through the MCAS Tustin BCT during preparation of this FS Report. Formal comments made by the state of California during review of this FS Report will be evaluated and included in the PP for OU-1A. State comments on the remedy selected for OU-1A will also be addressed in the ROD. Because state acceptance will be evaluated after receipt of comments on this FS Report, this criterion is not evaluated as part of the detailed analysis of each alternative presented in Sections 5.2 through 5.10.

5.1.9 Community Acceptance

This criterion assesses issues of concern to the community regarding each remedial alternative. Comments will be solicited from community members during the public review period for this FS Report and the PP for OU-1A. These comments will be considered in the remedy selection process. A summary of public comments and responses will be included in the ROD. Since community acceptance will be evaluated after the public comment period for this document, this criterion is not evaluated as part of the detailed analysis of each alternative presented in Sections 5.2 through 5.10.

5.2 ALTERNATIVE 1 – NO ACTION

Alternative 1 is the no action alternative. Per the NCP at 40 C.F.R. § 300.430(e)(6), this alternative must be evaluated in the same manner as the other remedial response actions considered in this FS Report. Alternative 1 serves as the baseline against which the remaining alternatives are compared.

5.2.1 Description

Alternative 1 involves no engineered remediation measures, administrative controls, or monitoring of contaminated media at OU-1A. This alternative would not include any activities to limit the migration of VOC-affected groundwater. It likewise would have no effect on the physical, biological, or chemical processes controlling the fate and transport of the existing contamination. If implemented, Alternative 1 would be considered a final remedy for OU-1A and would not entail any periodic reviews to verify its protectiveness.

Under the no action alternative, the VOC plume originating at IRP-13S would continue to migrate, reaching Barranca Channel in approximately 40 years.

Shallow groundwater at Former MCAS Tustin is not currently used for domestic purposes, and there are no complete human exposure pathways for the existing VOC contamination. Such exposures should remain very limited over the next several decades,

at least until the VOC plume reaches the surface drainage channel south of the station. The areas overlying the projected plume migration pathway are designated in the SP for redevelopment as an urban regional park, community core, and commercial business (The Planning Center 1998). Much of the VOC plume in the first WBZ lies directly under the city of Tustin's right-of-way for the planned extension of Armstrong Avenue. Utility improvements will be constructed below grade along this corridor. Under this redevelopment scenario, potential human exposure to VOCs at Former MCAS Tustin could occur with the extraction and domestic use of groundwater (an unlikely occurrence, but one that would not be completely precluded by Alternative 1) or with work in building and utility excavations that extend below the water table.

Modeling of groundwater flow and contaminant transport, discussed in detail in the RI Report (BNI 1997a) and Appendix B, was used to predict the long-term behavior of the VOC plumes under the no action scenario. Modeling output from these simulations is presented in Figures 5-1 and 5-2. Under the no action alternative, the 1,2,3-TCP and TCE plumes in the sand layer of the first WBZ are predicted to migrate approximately 2,900 and 2,000 feet, respectively, farther downgradient over the next 30 years. In the sand layer of the second WBZ, the 1,2,3-TCP plume is predicted to migrate approximately 3,200 feet farther downgradient in 30 years (Figure 5-2).

Although not illustrated on the figures in this FS Report, the estimated extent of 1,2,3-TCP in the third WBZ is limited and localized near the intersection of Cross Street and McCord Road. Under the no action alternative, further potential downward migration of VOCs could also continue. The downward migration of 1,2,3-TCP to the third WBZ at this location appears to be seasonally related and occurs during the summer months when the prevailing upward gradient reverses. VOC contamination in the third WBZ represents a potential threat to the deeper regional aquifer, which is of good quality and is currently used as a primary source of municipal drinking water and irrigation water. The lateral distribution of 1,2,3-TCP in the third WBZ and potential mechanisms for migration of 1,2,3-TCP into the third WBZ were evaluated and reported in the Final Technical Memorandum: Limited Deep HydroPunch Investigation at IRP-13S (BNI 1999c) and are also described in Section 1.5.3.2. It should be noted that additional discontinuities in the aquitard between the second and third WBZs may exist in locations downgradient from the current plume boundaries.

Groundwater modeling results indicate that with no active remediation, the VOC plumes in both the first and second WBZs would move downgradient in the direction of Barranca Channel and eventually discharge to surface water. Figure 5-3 illustrates projected concentrations of 1,2,3-TCP in these discharges over time. 1,2,3-TCP reported at concentrations exceeding the detection limit in groundwater in the first WBZ would begin to impact Barranca Channel in approximately 50 years, reaching an approximate maximum concentration of 4 μg/L in 90 years. VOCs in groundwater in the second WBZ would initially reach Barranca Channel in approximately 40 years, reaching an approximate maximum concentration of 13 μg/L in approximately 70 years.

As discussed in Section 1.8, the HHRA completed for this report identified potential future residential exposures to VOC-contaminated drinking water as the principal risk driver for the VOC plumes. Risks associated with this exposure pathway, based on a number of conservative assumptions, exceed the U.S. EPA acceptable upper incremental lifetime cancer risk of 10^{-4} as well as the target threshold for noncancer health risks (hazard index less than 1.0).

The human exposures assumed in the HHRA calculations are very unlikely, since the chemical and physical characteristics of the shallow aquifer at Former MCAS Tustin make it an unattractive drinking water source.

5.2.2 Detailed Analysis

Alternative 1 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.2.2.1 SHORT-TERM EFFECTIVENESS

The no action alternative would not entail any active remediation at OU-1A. In the absence of on-site construction or other activities, there would be no adverse impacts to site workers, the surrounding community, or the environment associated with implementation of Alternative 1. The time required for this alternative to achieve remedial action objectives would be determined by the natural processes controlling VOC fate and transport in groundwater. The groundwater modeling results for the no action scenario, discussed in Section 5.2.1 and in Appendix B, predict that contaminant concentrations in the permeable sand layers of the first and second WBZs would exceed remediation goals for OU-1A groundwater for more than 100 years at IRP-13S.

5.2.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

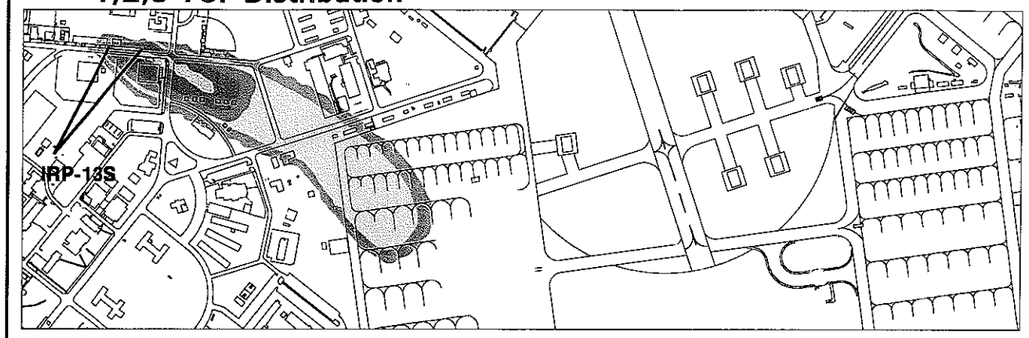
The no action alternative does not entail removal, treatment, or containment technologies and would, therefore, have no effect on existing levels of contamination. Residual risk (i.e., that remaining after the remedial action has occurred) would be as predicted for the baseline HHRA. These risks exceed U.S. EPA targets for both carcinogenic and systemic toxicants if VOC-affected groundwater were to be extracted for domestic use.

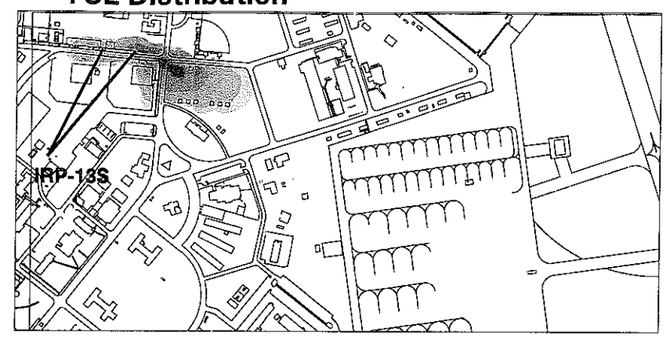
Drinking water exposures of the type assumed for the HHRA are unlikely, as discussed in Sections 1.8 and 2.2. Reasons include the relatively poor quality of the shallow groundwater due to circumstances unrelated to former USMC operations and the availability of high-quality alternative water supplies in an urban area. However, this alternative still presents a risk of human exposure to VOCs via drinking water, since the potential further migration of 1,2,3-TCP to the third WBZ at IRP-13S, and potentially to the regional aquifer, would still be a possibility. Therefore, the protectiveness of this alternative with respect to human health is uncertain over the long term.

1,2,3-TCP Distribution

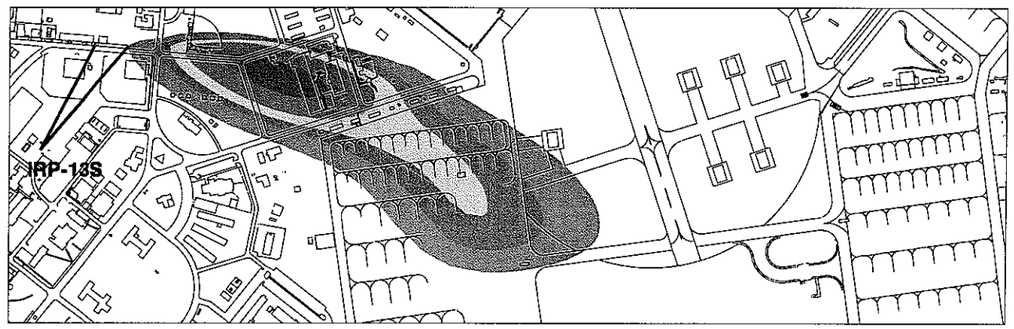
TCE Distribution

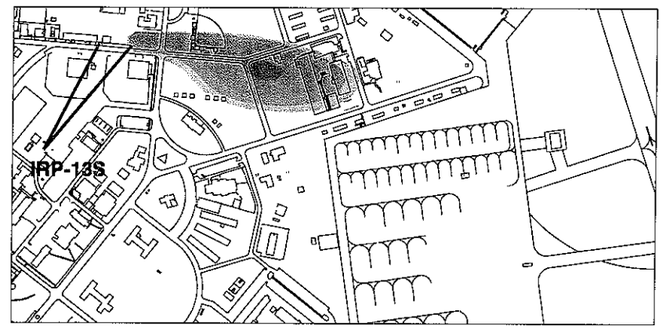
Alternative 1: No Action



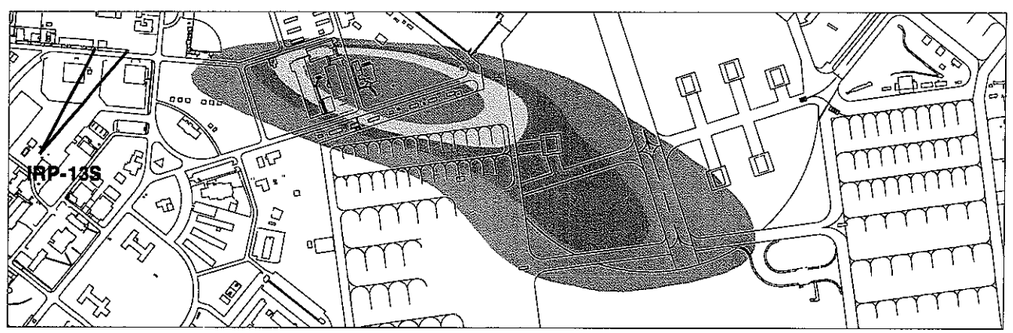


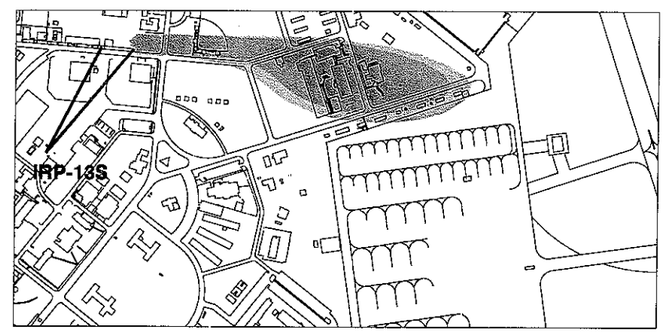
Current Conditions



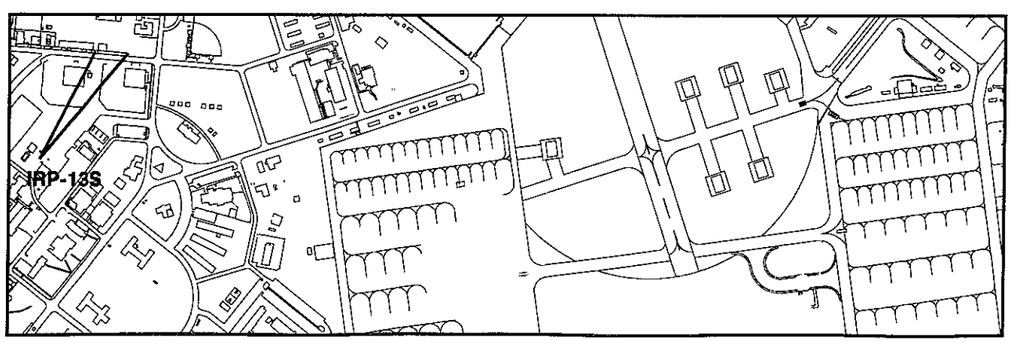


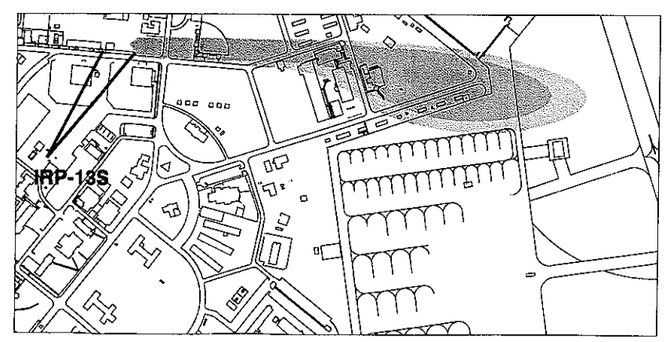
After 10 Years



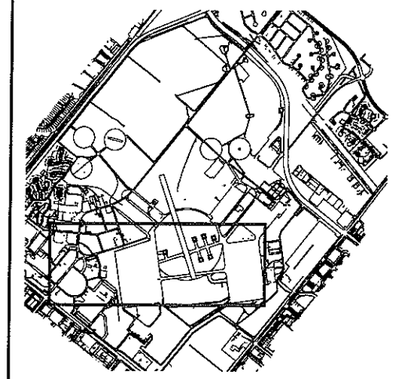


After 20 Years

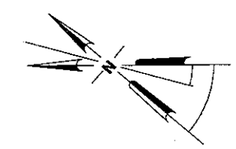




After 30 Years



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-1
Alternative 1: No Action
Simulated TCE and 1,2,3-TCP
Concentrations in the 1st WBZ at IRP-13S

Former MCAS Tustin, California

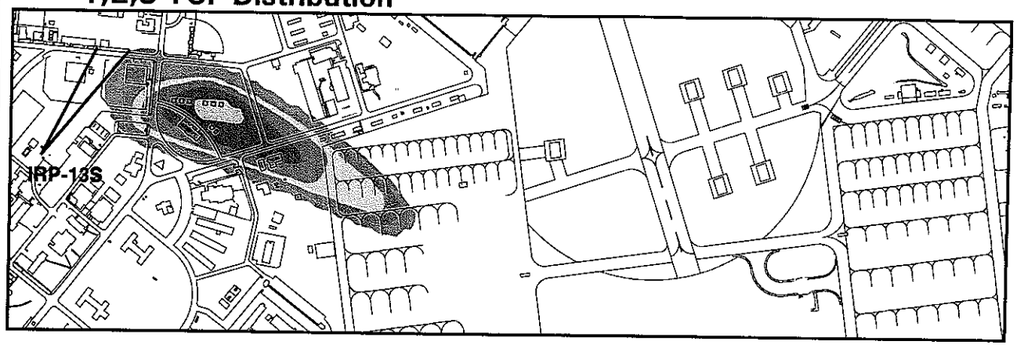
Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/23/03
File No 035L8612
Job No.:23818-035

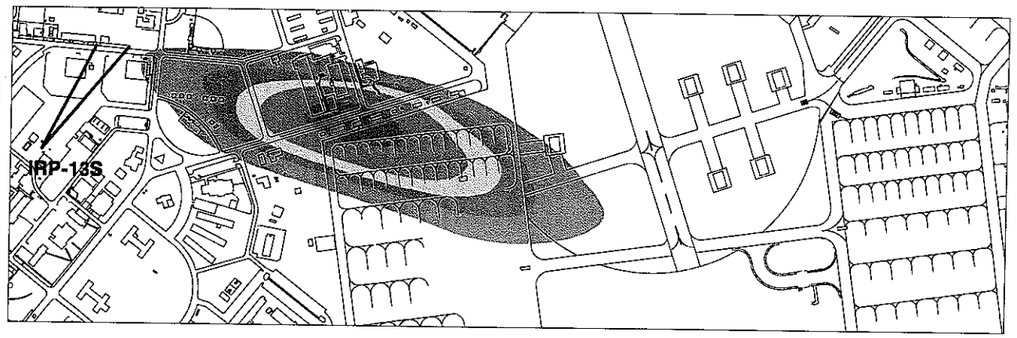
gwm72altlfs 01/23/03 /f/tustin/tustinsun

1,2,3-TCP Distribution

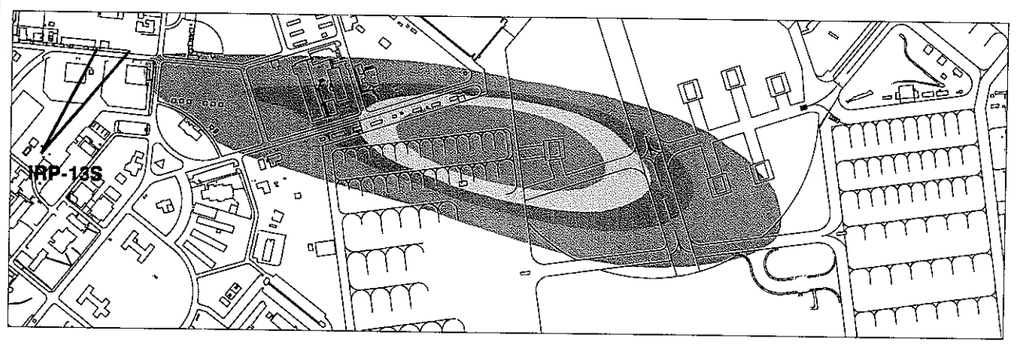
Alternative 1: No Action



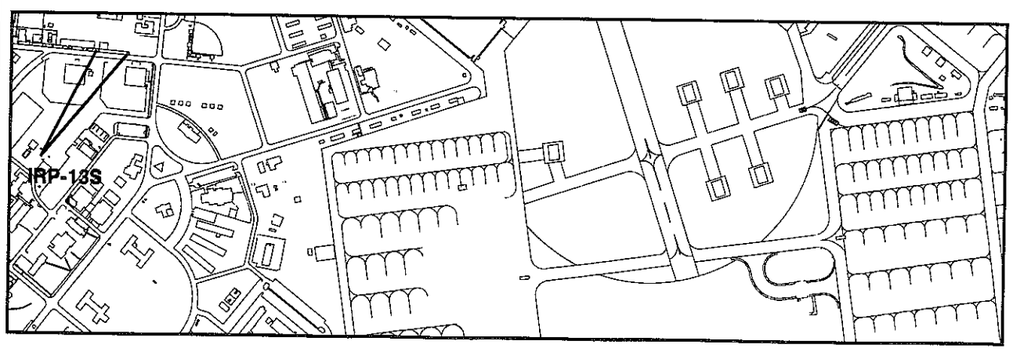
Current Conditions



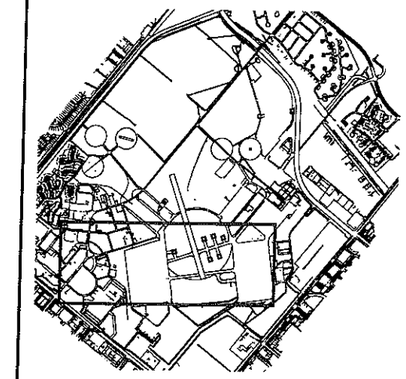
After 10 Years



After 20 Years

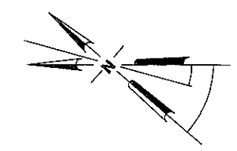


After 30 Years



1,2,3-TCP

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-2
Alternative 1: No Action
Simulated 1,2,3-TCP
Concentrations in the 2nd WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/23/03
File No. 035L8613
Job No.:23818-035

gwm72alt12fs 01/23/03 /f/tustin/tustinsun

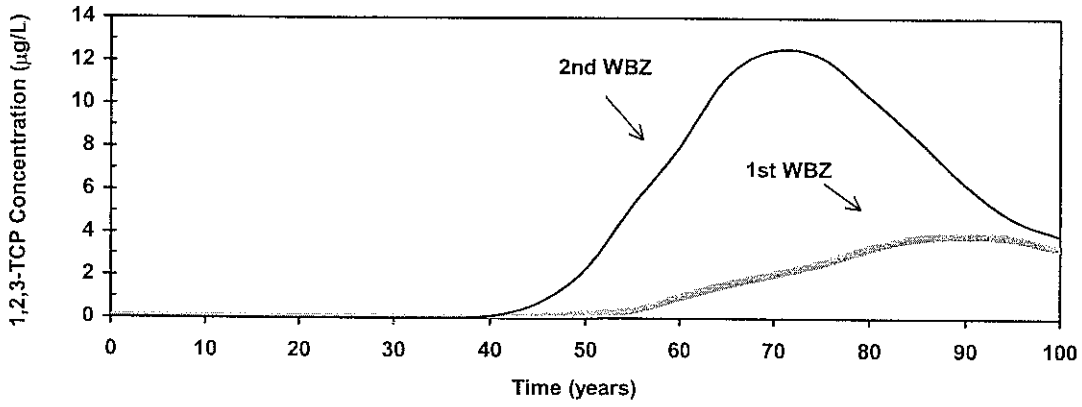


Figure 5-3
Predicted 1,2,3-TCP Concentrations in First and Second WBZs at Barranca Channel Under No Action

The release of VOC-containing wastes at OU-1A and their subsequent migration to the water table have created secondary sources of groundwater contamination in the low-permeability clays in the upper and lower confining layers of the first WBZ. These secondary sources will remain active for a long period of time, perhaps hundreds of years, creating elongated "tails" of residual contamination along the plume migration paths. The plume is predicted to eventually discharge to Barranca Channel, possibly impacting ecological receptors in surface water, as discussed in Section 2.2. For this reason, the long-term effectiveness of Alternative 1 is uncertain with respect to protection of the environment.

In addition, Alternative 1 does not include long-term groundwater monitoring. Thus, there would be no means in place to verify the groundwater modeling simulations described in Section 5.2.1 and Appendix B. Should VOC-contaminated groundwater migrate differently than predicted, the potential ecological impacts in the surface drainage channels could be more serious than suggested by the results of the groundwater fate and transport model. The lack of a monitoring program further detracts from the long-term effectiveness of the no action alternative, since it provides no means to detect or prevent possible ecological impacts due to unanticipated groundwater migration patterns.

5.2.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 1 would not result in any reduction in the mobility, toxicity, or volume of VOCs, other than that attributable to natural attenuation processes. Selection of the no action alternative would not have any effect on the rate at which these processes are currently acting to decrease contaminant concentrations in the subsurface.

The groundwater modeling results presented in Appendix B show that with no action, the maximum predicted TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs should decrease from existing levels by factors of from 55 to 72 percent

over the next 30 years. However, the mass of VOCs in the subsurface would not be reduced and the volume of contaminated groundwater would increase over time as the plume migrates into previously uncontaminated areas.

5.2.2.4 IMPLEMENTABILITY

This alternative does not involve any on-site or off-site remediation activities and, therefore, would be readily implementable.

5.2.2.5 COST

There are no costs associated with Alternative 1.

5.2.2.6 COMPLIANCE WITH ARARs

The no action alternative does not trigger chemical-, action-, or location-specific ARARs. Therefore, it is not appropriate to evaluate Alternative 1 with respect to ARARs compliance.

5.2.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would not reduce contaminant mass in the subsurface or affect existing conditions at or downgradient of IRP-13S. Overall protection of human health and the environment is considered poor for the reasons discussed below. In summary, Alternative 1 allows for significant expansion of the VOC plumes, does not address the potential threat to water quality in the third WBZ and deeper regional aquifer at IRP-13S, would incur possible ecological risks in the downgradient drainage channels, and would require more than 100 years to reach remediation goals in shallow groundwater.

The HHRA identified future residential exposures to contaminated drinking water as the principal risk driver for the VOC plumes. Health risks associated with this exposure pathway, based on a number of conservative assumptions, exceed U.S. EPA thresholds established in the NCP. As stated in Section 2.2, there is no current exposure to the VOC-contaminated shallow groundwater at Former MCAS Tustin. Consumption of this groundwater is considered unlikely in the future, given the permitting process in Orange County, the availability of high-quality municipal water, and the high TDS concentrations and low yields associated with the shallow aquifer. Therefore, while contaminated shallow groundwater at OU-1A presents a health risk if consumed as drinking water, there is limited potential for such adverse exposures to actually occur under Alternative 1.

Under the no action alternative, VOC-affected groundwater would continue to migrate toward the station boundaries. The eventual discharge of contaminated groundwater into Barranca Channel could adversely affect ecological receptors in surface water, although the extent of such impacts is difficult to predict. Given this uncertainty, it cannot be concluded that Alternative 1 offers long-term protection to the environment.

Remediation goals for OU-1A groundwater would not be achieved for over 100 years under Alternative 1, limiting its short-term effectiveness. Furthermore, expanding VOC plumes could affect many redevelopment parcels at Former MCAS Tustin. While VOC

contamination would generally be limited to the first and second WBZs, Alternative 1 would do nothing to prevent the further seasonal migration of 1,2,3-TCP to the third WBZ at its current localized area, downgradient of IRP-13S. This could threaten the deeper regional aquifer, which is a source of drinking water and irrigation water.

5.3 ALTERNATIVE 2 – MONITORED NATURAL ATTENUATION

Alternative 2, monitored natural attenuation, also would not entail any active measures to extract, treat, or contain the VOC plumes. However, compared to Alternative 1, this alternative features institutional controls in the form of deed restrictions to further limit potential human exposure to site-related contaminants. Long-term monitoring would also be included to track VOC migration and support future evaluations of the continued protectiveness of natural attenuation processes.

5.3.1 Description

Alternative 2 would allow the VOC plumes to continue to migrate downgradient, while recognizing the potential of natural attenuation processes within the aquifer to reduce contaminant concentrations, along with overall risk to human health and the environment. This alternative incorporates deed restrictions on those redevelopment parcels at Former MCAS Tustin overlying the current area of the VOC plumes and the future plume migration pathways, long-term groundwater monitoring, and periodic reviews.

Under Alternative 2, the continued migration of the contaminant plumes would be identical to that described under the no action alternative (Alternative 1) as discussed in Section 5.2.1. The 1,2,3-TCP originating at IRP-13S would migrate downgradient at about 100 feet per year in both the first and second WBZs. The VOC plumes would eventually discharge to Barranca Channel, with contaminated groundwater initially expected to reach the surface drainages in about 40 years. In addition, the seasonal migration of 1,2,3-TCP from the second to the third WBZ could still occur in a localized area downgradient of the IRP-13S source area.

Alternative 2 includes deed restrictions to supplement the existing permitting process in Orange County for installation of new water supply wells. These institutional controls would prevent human exposure to groundwater contamination as it migrates beneath the station.

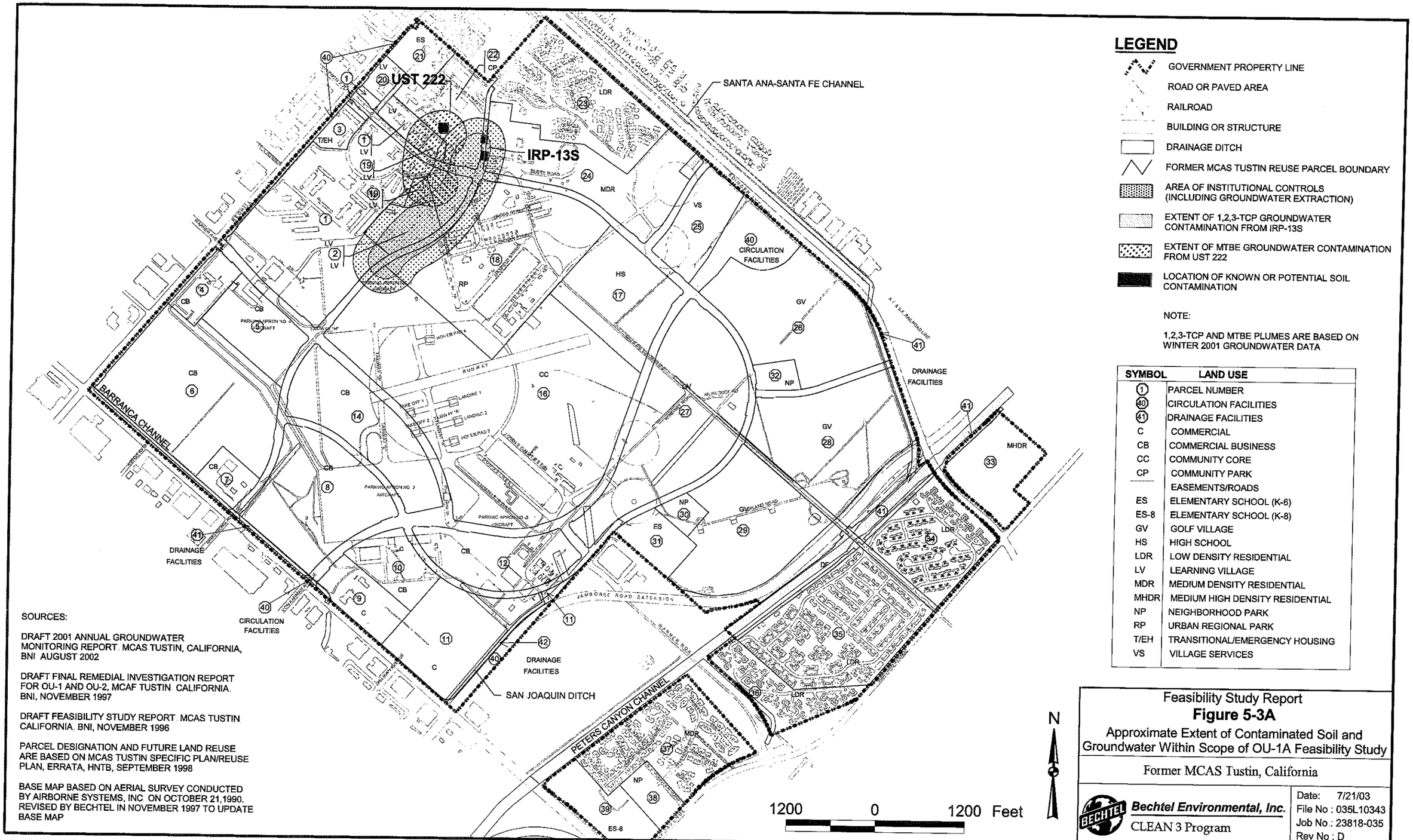
Long-term monitoring and periodic reviews are also included as components of Alternative 2 to assess potential impacts to human health and/or the environment arising from the continued migration of contaminated groundwater in the shallow aquifer. In addition, an evaluation of site conditions approximately 10 years after implementation of this action would provide a better assessment of the likelihood and potential magnitude of any ecological impacts resulting from the discharge of VOC-affected groundwater into the off-station drainage channels.

5.3.1.1 INSTITUTIONAL CONTROLS

Institutional controls are nonengineering mechanisms, particularly legal measures, designed to limit activities or access at a site to protect the selected remedy. Institutional controls fall into two broad categories, restrictions on future land use and provisions for access for future monitoring and maintenance. Proposed future land use is described in the MCAS Tustin SP. The SP indicates that the parcels at Former MCAS Tustin currently overlying VOC plumes, as well as the downgradient parcels under which the plumes are expected to migrate, will be redeveloped for residential, commercial, and recreational use (The Planning Center 1998).

Alternative 2 includes deed restrictions for parcels overlying the VOC plumes as well as at the downgradient parcels under which the plumes are expected to migrate (approximately 140 acres). Additional acreage would be restricted from groundwater extraction (Figure 5-3A). The land-use control objective within the RAOs is for protection of human health by preventing extraction of VOC-impacted shallow groundwater. Restrictions designed to limit inhalation of VOCs are not necessary, as long as groundwater extraction is prohibited within the OU-1A plume boundary (Appendix F). The deed restrictions include the following elements to achieve the land-use control RAO:

- prohibitions on the installation of public or private water supply wells in the shallow aquifer within the area of institutional controls without the review and approval by the DON and other regulatory agencies
- prohibitions on the installation of underground utilities, including trenches, within the groundwater in the area requiring institutional controls without the review and approval by the DON and other regulatory agencies; improperly designed subsurface utilities including the backfilled trenches may create preferential pathways for the transport of contaminated groundwater and negatively impact the remedial alternative
- prohibitions on construction or other activities that would disturb or otherwise negatively impact the monitoring wells without prior approval from the DON
- provisions to allow access to the DON and the regulatory agencies to install new or destroy old monitoring wells and implement supplemental remedial measures in the future, if necessary
- provisions to allow access to the DON and the regulatory agencies to monitor the remedial action
- requirements to notify the DON in advance of any plan to lease or transfer affected parcels
- requirements to notify the DON and regulatory agencies in a timely manner of any change in site conditions that potentially compromises the remedy or endangers public health or the environment


UST 222
IRP-13S
SANTA ANA-SANTA FE CHANNEL
BARRANCA CHANNEL
PETERS CANYON CHANNEL
SAN JOAQUIN DITCH
JAMBOREE ROAD EXTENSION
RUNWAY
CIRCULATION FACILITIES
DRAINAGE FACILITIES
LEGEND
GOVERNMENT PROPERTY LINE
ROAD OR PAVED AREA
RAILROAD
BUILDING OR STRUCTURE
DRAINAGE DITCH
FORMER MCAS TUSTIN REUSE PARCEL BOUNDARY
AREA OF INSTITUTIONAL CONTROLS (INCLUDING GROUNDWATER EXTRACTION)
EXTENT OF 1,2,3-TCP GROUNDWATER CONTAMINATION FROM IRP-13S
EXTENT OF MTBE GROUNDWATER CONTAMINATION FROM UST 222
LOCATION OF KNOWN OR POTENTIAL SOIL CONTAMINATION
NOTE:
1,2,3-TCP AND MTBE PLUMES ARE BASED ON WINTER 2001 GROUNDWATER DATA
SYMBOL LAND USE
1 PARCEL NUMBER
40 CIRCULATION FACILITIES
41 DRAINAGE FACILITIES
C COMMERCIAL
CB COMMERCIAL BUSINESS
CC COMMUNITY CORE
CP COMMUNITY PARK
EASEMENTS/ROADS
ES ELEMENTARY SCHOOL (K-6)
ES-8 ELEMENTARY SCHOOL (K-8)
GV GOLF VILLAGE
HS HIGH SCHOOL
LDR LOW DENSITY RESIDENTIAL
LV LEARNING VILLAGE
MDR MEDIUM DENSITY RESIDENTIAL
MHDR MEDIUM HIGH DENSITY RESIDENTIAL
NP NEIGHBORHOOD PARK
RP URBAN REGIONAL PARK
T/EH TRANSITIONAL/EMERGENCY HOUSING
VS VILLAGE SERVICES
SOURCES:
DRAFT 2001 ANNUAL GROUNDWATER MONITORING REPORT. MCAS TUSTIN, CALIFORNIA, BNI AUGUST 2002
DRAFT FINAL REMEDIAL INVESTIGATION REPORT FOR OU-1 AND OU-2, MCAF TUSTIN CALIFORNIA. BNI, NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT. MCAS TUSTIN CALIFORNIA. BNI, NOVEMBER 1996
PARCEL DESIGNATION AND FUTURE LAND REUSE ARE BASED ON MCAS TUSTIN SPECIFIC PLAN/REUSE PLAN, ERRATA, HNTB, SEPTEMBER 1998
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21,1990. REVISED BY BECHTEL IN NOVEMBER 1997 TO UPDATE BASE MAP
1200 0 1200 Feet
N
Feasibility Study Report
Figure 5-3A
Approximate Extent of Contaminated Soil and Groundwater Within Scope of OU-1A Feasibility Study
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 7/21/03
File No : 035L10343
Job No.: 23818-035
Rev No : D

No deed restrictions are possible in areas not owned by the DON. However, if necessary, the DON would negotiate and obtain any easements necessary to install, sample, and maintain additional monitoring wells installed off-site.

The deed restrictions required for Alternative 2 would not hinder the development of Former MCAS Tustin property. None of the expected land-use scenarios for the affected parcels would require the installation of wells and use of groundwater from the shallow aquifer. The deed restrictions would require that wells installed in the regional aquifer be constructed with well screen depths and seals sufficient to prevent cross-contamination with the shallow aquifer. These restrictions will protect the selected remedy and will not affect development of the groundwater resource. Deed restrictions regarding the installation of underground utilities can be addressed with appropriate engineering controls.

The deed restrictions would remain in effect until monitoring data show that the VOC contamination levels in the groundwater meet the site remediation goals. VOC contamination levels would decline due to continued downgradient migration of the plumes and the natural attenuation processes of adsorption, dispersion, and dilution. There is no evidence that natural biodegradation processes are removing significant quantities of chlorinated VOCs in groundwater at the site, although such reactions could also occur at a slow rate in localized areas and would act to retard plume migration. The time estimated for remediation, based on groundwater modeling, is greater than 100 years.

Groundwater modeling results for Alternative 2 are presented in Figures 5-4 and 5-5. As with Alternative 1, the groundwater model assumed no biodegradation of TCE or 1,2,3-TCP. Declines in contaminant concentrations are predicted to occur at different rates at OU-1A. Maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs would decrease from existing levels by factors ranging from 60 to 75 percent over 30 years. However, in no case would the maximum VOC concentrations in the sand layers be less than the site remediation goals of 5 µg/L TCE and 0.6 µg/L 1,2,3-TCP.

It is also noteworthy that maximum TCE concentrations are predicted to reach their minimum values at IRP-13S (approximately 40 µg/L) after 20 years of monitored natural attenuation. Thereafter, maximum TCE concentrations in the first WBZ would begin to increase slowly with time (Figure 5-4). This behavior is a result of the leaching of TCE that is adsorbed to vadose zone soils at MWA-18. It would take several years before the impacts of this source on groundwater quality in the first WBZ became discernable.

From trends presented on Figures 5-4 and 5-5, predicted concentrations of TCE and 1,2,3-TCP in shallow groundwater would exceed site cleanup goals for many decades under Alternative 2. Deed restrictions preventing exposure to contaminated groundwater at OU-1A would therefore need to remain in place and be effective far into the future.

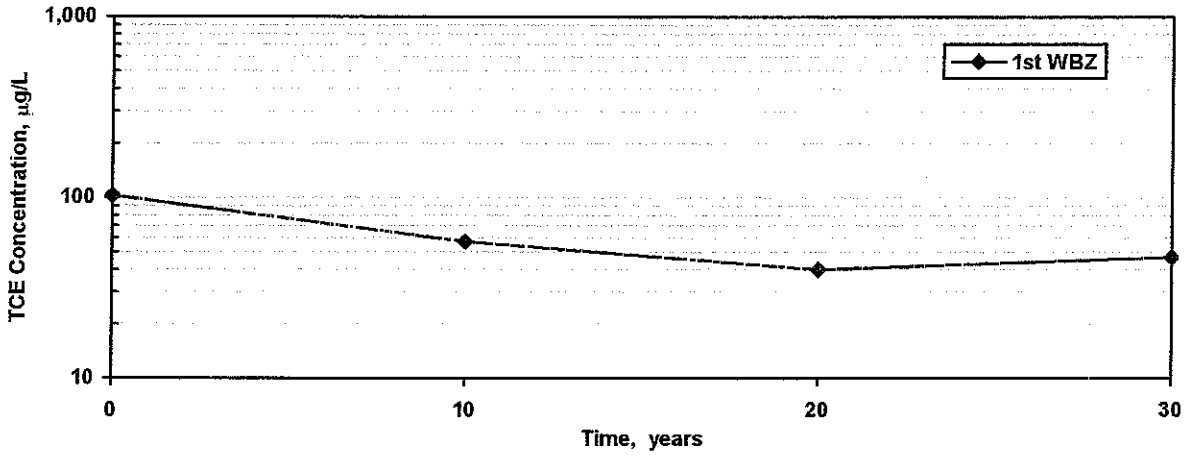


Figure 5-4
Predicted Maximum TCE Concentrations Under Monitored Natural Attenuation

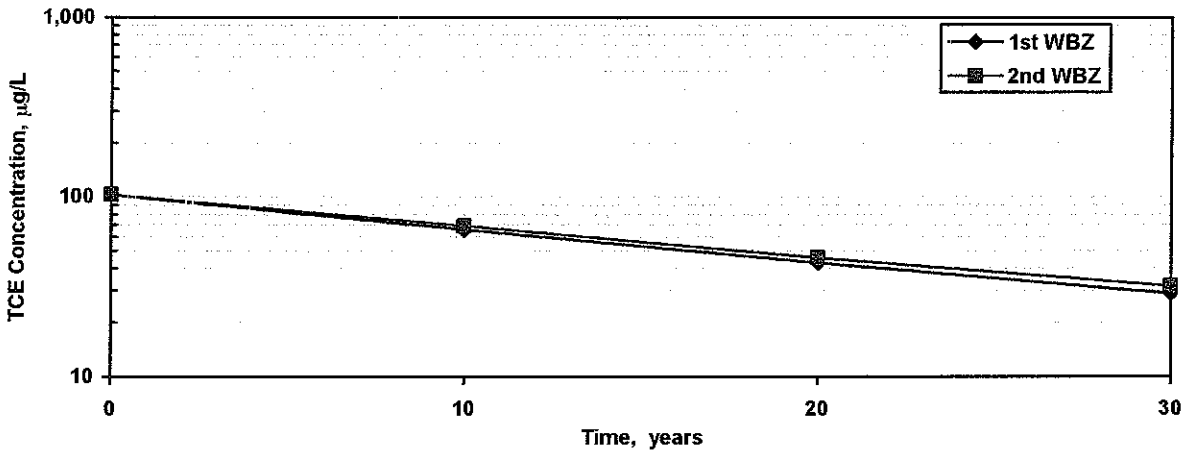


Figure 5-5
Predicted Maximum 1,2,3-TCP Concentrations Under Monitored Natural Attenuation

5.3.1.2 GROUNDWATER MONITORING

Alternative 2 entails a focused yet comprehensive groundwater monitoring program that would be used to track contaminant migration and support future assessments of the protectiveness of natural attenuation. From a risk management perspective, monitoring would assure timely detection of any unexpected contaminant migration trends that might warrant additional response actions to prevent or minimize future human exposure to VOC-affected groundwater. The monitoring data would also be used to better assess potential ecological impacts in Barranca Channel as the VOC plumes migrate toward this receptor. Monitoring would be limited to the collection and analysis of groundwater samples from wells placed within and along the downgradient migration pathways of each contaminant plume in both the first and second WBZs at IRP-13S. The existing monitoring well network at IRP-13S would be used to track the potential downward and lateral migration of 1,2,3-TCP into the third WBZ.

The monitoring approach developed for Alternative 2 is based on the results of groundwater modeling presented in Appendix B. The emphasis of this program would be on confirming both the rate of VOC migration and concentration trends over time within the VOC plumes. The use of 5-year reviews would also be important, allowing for detailed evaluations of plume migration patterns and the overall protectiveness of the remedy. Figure 5-6 illustrates the basic concept of the groundwater monitoring program envisioned for Alternative 2.

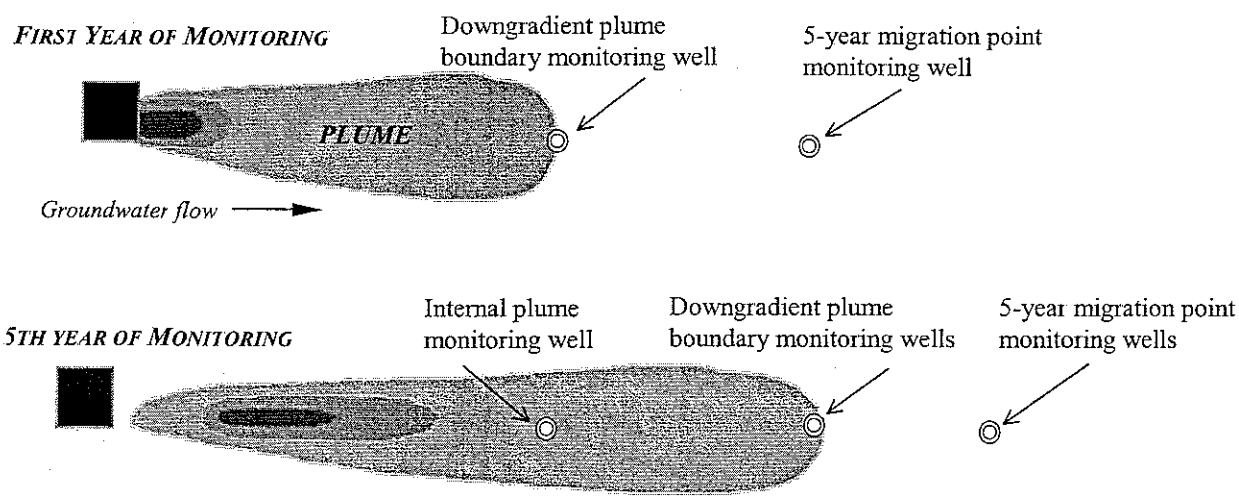


Figure 5-6
Groundwater Monitoring Approach for Monitored Natural Attenuation

Groundwater monitoring would be conducted along the expected flow paths of the VOC plumes. Wells would be installed at the downgradient margin of the plume in the first and second WBZ. Prior to each review cycle, an additional downgradient well would be installed at a distance equivalent to the predicted length of plume migration over the next 5 years. The wells at the plume boundary would be used to verify contaminant trends over time. The 5-year migration point wells would confirm that plume migration rates were as predicted.

The wells would be monitored annually for the OU-1A COCs. In addition, groundwater levels would be measured in new and existing wells to confirm groundwater flow patterns and vertical hydraulic gradients between WBZs. Annual monitoring is considered reasonable for Alternative 2 since projected TCE and 1,2,3-TCP concentrations are expected to change very slowly under the influence of natural attenuation processes in the shallow aquifer.

At the end of every 5 years (i.e., during the periodic review), data collected during the preceding period would be evaluated to identify the location of the next set of wells to be installed along the plume migration pathway. Wells placed at the initial 5-year migration distance would become the plume boundary wells. The process of adding step-out wells would continue, with one new well being installed for each plume in each WBZ, until the plumes reached their predicted discharge points at Barranca Channel.

For the purpose of developing a cost estimate for Alternative 2, it was assumed that annual groundwater monitoring would be limited to a period of 30 years. While this time frame is consistent with U.S. EPA RI/FS technical guidance (U.S. EPA 1988a), it is recognized that monitoring under the natural attenuation alternative would actually continue for many decades more.

Table 5-2 summarizes the number of wells to be installed and sampled during the 30-year monitoring period assumed for this FS Report. A total of 12 new groundwater monitoring wells are projected for Alternative 2.

Figure 5-7 presents a conceptualized layout for Alternative 2 showing predicted migration pathways and 5-year monitoring well locations for plumes in the first and second WBZs downgradient of IRP-13S. Actual monitoring well locations and specifications (depths, screened intervals, and well construction materials) would be determined during remedial design (for the initial network of wells) and as part of the periodic reviews (for subsequent well installations).

Well locations and surface completion methods would take into consideration the DON's need for accessibility. Impacts on future land use at Former MCAS Tustin, consistent with the SP (The Planning Center 1998), would also be minimized to the extent possible. A long-term monitoring plan, included as part of the remedial design, would provide details concerning the monitoring well network, sampling frequency, sampling procedures, a final list of analytes, analytical methods, field and laboratory quality assurance (QA) /quality control (QC), and reporting requirements. This plan would also

Table 5-2
Groundwater Monitoring for Monitored Natural Attenuation

Year	Number of Existing Wells Sampled	Number of New Wells Installed and Sampled	Total Number of Wells Sampled
1–5	4	2	6
6–10	6	2	8
11–15	8	2	10
16–20	10	2	12
21–25	12	2	14
26–30	14	2	16

describe the evaluation of monitoring data that would be conducted annually (i.e., after each sampling round) to verify that no unexpected VOC migration trends were occurring.

5.3.1.3 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data would be conducted every 5 years to determine the adequacy of the natural attenuation remedy and to revise the ongoing monitoring program as needed to meet project objectives. For example, it may become apparent over time that the number of wells or the frequency of sampling could be reduced. Results of each periodic review would be documented in a summary report submitted by the DON to the regulatory agencies responsible for program oversight.

The importance of the periodic reviews would increase as the VOC plumes approach the station boundaries and the expected discharge point at Barranca Channel. The scope of the review at these times would be expanded to evaluate possible ecological impacts of the off-station discharges and determine the need for any further response actions. Reviews would have to be scheduled to assure adequate time to implement such actions prior to the actual releases or discharges. For example, assuming that further migration of VOC plumes beyond station boundaries would occur in about 40 years, decisions regarding the need for additional remedial actions to mitigate potential threats from this release would have to be made during the seventh 5-year review. This would occur 35 years after implementation of Alternative 2, allowing approximately 5 more years to select, design, and implement any necessary remedial actions before the plumes migrated beyond the Former MCAS Tustin boundaries.

5.3.2 Detailed Analysis

Alternative 2 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.3.2.1 SHORT-TERM EFFECTIVENESS

On-site construction activities associated with the monitored natural attenuation alternative would be limited to the installation of two new wells to establish the initial groundwater monitoring network, with two additional wells installed at 5-year intervals thereafter. A site-specific health and safety plan and remedial action work plan with provisions for personnel protection and air monitoring would be developed and implemented to minimize potential risks to workers and the nearby community during well installation. The duration of the initial on-site well drilling and development activities would be short (approximately 1 month). Once the wells were installed, a field monitoring program (including measurement of water levels and collection of groundwater samples) would be conducted annually for a period of 30 years (assumed for cost estimating purposes). Short-term impacts from the field sampling activities would be readily controlled through adherence to standardized sampling protocols and the site-specific health and safety plan.

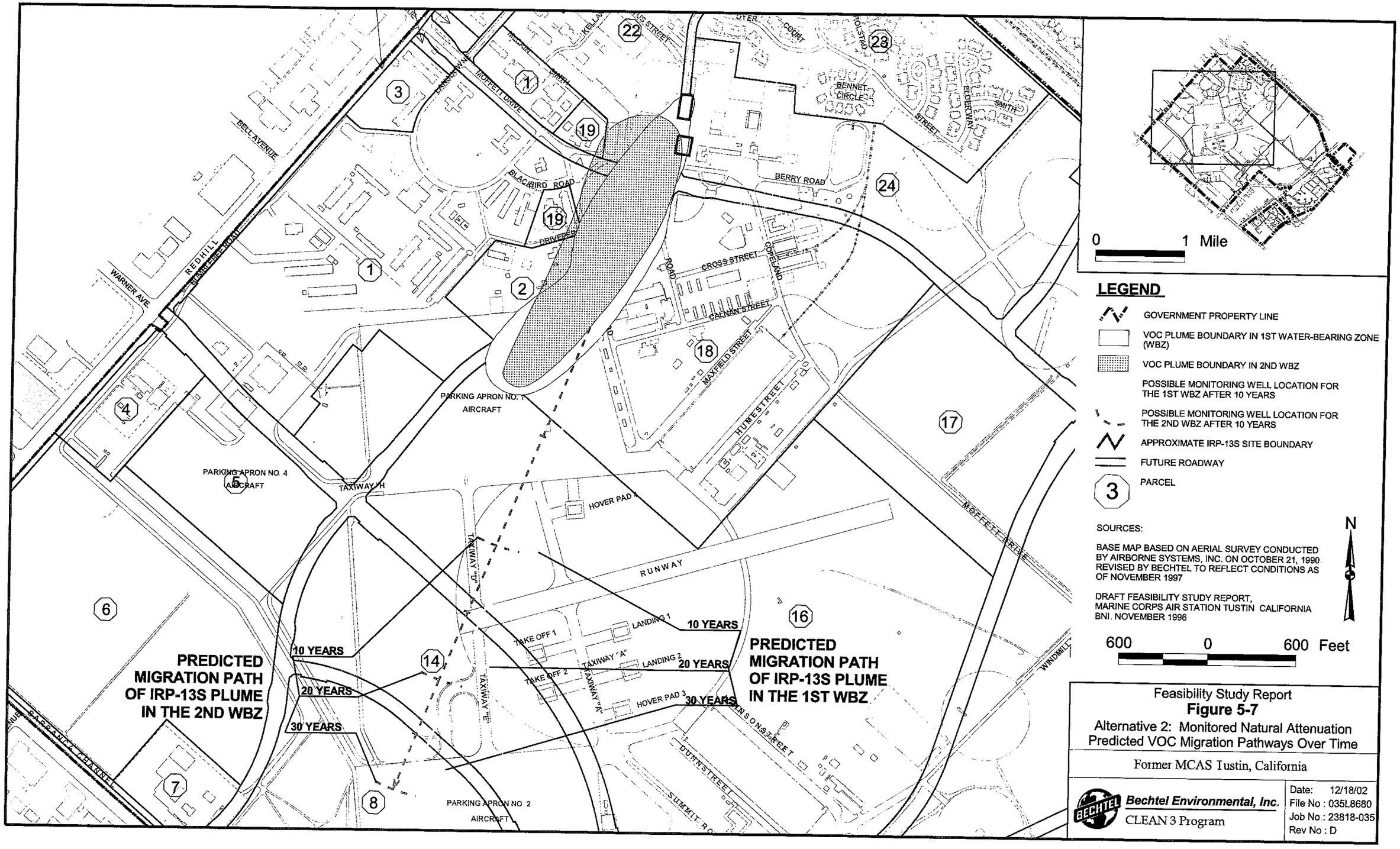
The deed restrictions, monitoring plan, and well installation required by Alternative 2 could be implemented in the year following issuance of the ROD. Once these institutional controls had been implemented, the potential for human exposure to VOCs in shallow groundwater would be negligible. Thereafter, contamination levels in groundwater would be expected to decline due to natural attenuation processes within the shallow aquifer. However, VOCs would not be expected to reach site cleanup goals for many years, if at all. As discussed in Section 1.6.2 and in Appendix B, VOCs adsorbed on fine-grained soils in the vadose zone and/or the upper confining clay layer of the first WBZ would continue to contribute low-level contamination for many decades to the underlying sand layer at IRP-13S.

5.3.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

The monitored natural attenuation alternative does not include removal, treatment, or containment of contaminants in the subsurface at Former MCAS Tustin. Over the long term, residual risks at most locations associated with the VOC plumes would be as predicted for the baseline HHRA summarized in Section 1.8. These risks exceed U.S. EPA targets for both carcinogenic and systemic toxicants if VOC-affected groundwater were to be extracted for purposes of domestic water supply.

However, residential drinking water exposures of the type assumed in the HHRA would be unlikely for the same reasons listed in Section 5.2.2.2. Institutional controls would be an effective means to prevent future human exposures and risks within the boundaries of the Former MCAS Tustin property. The long-term effectiveness of these measures would be contingent upon their continued enforcement, which would be the responsibility of the DON and DTSC. Long-term effectiveness would also require successful implementation of the monitoring program.

Deed restrictions, permit procedures, and long-term groundwater monitoring have been routinely implemented at hazardous waste release sites in the United States. These activities are expected to be reliable in minimizing future health risks associated with OU-1A groundwater.


PREDICTED MIGRATION PATH OF IRP-13S PLUME IN THE 2ND WBZ
PREDICTED MIGRATION PATH OF IRP-13S PLUME IN THE 1ST WBZ
10 YEARS
20 YEARS
30 YEARS
10 YEARS
20 YEARS
30 YEARS
PARKING APRON NO. 1 AIRCRAFT
PARKING APRON NO. 4 AIRCRAFT
PARKING APRON NO 2 AIRCRAFT
TAXIWAY "H"
TAXIWAY "D"
TAXIWAY "E"
TAXIWAY "A"
RUNWAY
HOVER PAD 1
HOVER PAD 2
HOVER PAD 3
TAKE OFF 1
TAKE OFF 2
LANDING 1
LANDING 2
BELL AVENUE
REDHILL
WARNER AVE
MOFFETT DRIVE
BLACKBIRD ROAD
DRIVEWAY
BERRY ROAD
BENNET CIRCLE
CROSS STREET
CAINAN STREET
MAXFIELD STREET
HUMES STREET
DUNN STREET
SUMMIT ROAD
MOFFETT DRIVE
WINDMILL
SANTA ANA CHANNEL
0 1 Mile
LEGEND
GOVERNMENT PROPERTY LINE
VOC PLUME BOUNDARY IN 1ST WATER-BEARING ZONE (WBZ)
VOC PLUME BOUNDARY IN 2ND WBZ
POSSIBLE MONITORING WELL LOCATION FOR THE 1ST WBZ AFTER 10 YEARS
POSSIBLE MONITORING WELL LOCATION FOR THE 2ND WBZ AFTER 10 YEARS
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
SOURCES:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT, MARINE CORPS AIR STATION TUSTIN CALIFORNIA BNI. NOVEMBER 1996
N
600 0 600 Feet
Feasibility Study Report
Figure 5-7
Alternative 2: Monitored Natural Attenuation
Predicted VOC Migration Pathways Over Time
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/18/02
File No : 035L8680
Job No : 23818-035
Rev No : D

As with Alternative 1, the monitored natural attenuation remedy does not employ active measures to reverse the downward migration of 1,2,3-TCP to the third WBZ in a localized area downgradient of IRP-13S. Alternative 2 would entail monitoring in the third WBZ to evaluate this concern. However, the potential for contamination of the deeper regional aquifer would remain, detracting from the long-term effectiveness of monitored natural attenuation in this application.

A further limitation on the long-term effectiveness of Alternative 2 is its potential need for future remedial actions resulting from the eventual migration of groundwater contamination beyond the station boundaries. In this respect, Alternative 2 may not represent a permanent remedy for the plumes originating at IRP-13S. Should additional response actions be necessary, close coordination with local agencies and future landowners would be required to prevent or minimize any interference with redevelopment of the Former MCAS Tustin property.

The eventual discharge of groundwater from OU-1A to Barranca Channel also raises the possibility of future ecological impacts in surface water. As discussed in Section 2.2, the significance of these impacts, which would begin in about 40 years, cannot be predicted. Nevertheless, the possibility of future discharges of VOCs to surface water creates uncertainties regarding long-term protection of the environment under Alternative 2.

Groundwater monitoring and periodic reviews would reduce some of the uncertainties noted above, enhancing the long-term effectiveness of Alternative 2. These activities are integral components of the remedy and would be used to evaluate the potential impacts of off-station VOC migration on human health and the environment. The reviews would also determine the need for and scope of future response actions that might be necessary.

5.3.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 2 would not result in any reduction in the mobility, toxicity, or volume of VOCs, other than that attributable to natural attenuation processes. Selection of this alternative would not have any effect on the rate at which these processes are currently acting to decrease contaminant concentrations in the subsurface.

Groundwater modeling results presented in Appendix B indicate that predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs would decrease from existing levels by factors of approximately 55 to 72 percent over the next 30 years under a natural attenuation scenario. However, the mass of VOCs in the subsurface would not be reduced and the volume of contaminated groundwater would increase over time as the plumes migrate into areas that were previously uncontaminated.

5.3.2.4 IMPLEMENTABILITY

Alternative 2 would be readily implemented, with no anticipated difficulties regarding technical feasibility, reliability, or scheduling. Deed restrictions such as those described in Section 5.3.1.1 are not expected to prevent or unnecessarily complicate future redevelopment of the Former MCAS Tustin property.

Groundwater monitoring, an important component of Alternative 2, would be implemented through the use of existing monitoring wells and by installing additional monitoring wells using conventional drilling equipment and materials. The monitoring wells would be located for easy access and minimal impact on future land uses at Former MCAS Tustin and the adjacent industrial park.

This alternative would necessitate coordination with state and local agencies to implement and enforce the deed restrictions required on the Former MCAS Tustin property. These agencies are familiar with OU-1A groundwater contamination issues through participation on the MCAS Tustin BCT and involvement in the station closure and redevelopment process. Administrative complications are not anticipated for implementation of the deed restrictions required by Alternative 2.

5.3.2.5 COST

Table 5-3 summarizes the cost estimate developed for Alternative 2. The net present cost for monitored natural attenuation would be approximately $0.75 million. The bulk of this cost would be associated with groundwater monitoring over the assumed 30-year period considered in this FS Report. Such activities would include the installation of two new monitoring wells every 5 years, yearly groundwater sampling and analysis, and periodic reviews involving comprehensive evaluations of the monitoring data. The indirect capital cost is high because mobilization to the site is required every 5 years.

Backup and supporting details for the Alternative 2 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.3.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 2 with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

Alternative 2 would comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. However, as with Alternative 1, TCE and 1,2,3-TCP would remain above regulatory-based limits for over 100 years and prevent (or at least restrict) beneficial use of the shallow groundwater due to potential migration of site-related contamination.

Chemical-specific requirements that would eventually be met through implementation of Alternative 2 include the following:

- **Federal:** SDWA MCL (40 C.F.R. § 141.61[a] for TCE) and nonzero MCLGs (40 C.F.R. § 141.50) for VOCs; RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); Clean Water Act (CWA) of 1977 (40 C.F.R. §§ 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs. tit. 22, §§ 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])

Table 5-3
Summary of Cost Estimate[a] for Alternative 2

Description	Capital Cost	O&M Costs		Total Costs[b]
		Annual Average	5th Year	
Engineering study/design/monitoring plan (1,500 hours @ $85.00/hour)	$128,000			$128,000
Monitoring wells (install two wells every 5 years = 10 wells)	$154,000			$154,000
Monitoring and Reporting				
Groundwater monitoring (average 30 years) (includes sample collection, analysis, and water levels)		$10,567		$317,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$994,000**
Contingency (20%)[d]				$199,000
Escalation (Base 01 January 2001)				$774,000
Total Cost				**$1,967,000**
Net Present Value of Alternative 2 (2002 $'s)				**$753,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect monitoring activities (annual and 5-year) for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs are not incurred on studies, plans, and reports

Acronym/Abbreviation:
O&M – operation and maintenance

- **State:** Substantive portions of the beneficial uses and water quality objectives in the Water Quality Control Plan (WQCP) for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2 in Appendix A; and Cal/EPA DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261.22[a][4], and 66261.24[a][2]–[8])

Available promulgated MCLs or MCLGs have been identified as the controlling chemical-specific ARARs for TCE. As discussed in Section 2.5, a groundwater cleanup goal has been proposed for 1,2,3-TCP after consideration of the best available toxicological information on the drinking water health risk posed by 1,2,3-TCP, along with the limitations of current analytical methodology.

Location-Specific ARARs

The primary activities under Alternative 2 that may trigger location-specific requirements are those related to the installation of wells and subsequent monitoring activities. These actions do not entail major construction, earthwork, or drainage manipulation. Well installation and monitoring under Alternative 2 would be designed and implemented to meet all location-based requirements, which are identified as ARARs in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

Alternative 2 entails only limited remedial construction activities and thus does not trigger a large number of action-specific requirements. As identified in Appendix A (Section A4.2), the action-specific requirements for monitored natural attenuation include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs. tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34) and for groundwater monitoring (Cal. Code Regs. tit. 22, § 66264.91[a] and [c], 66264.97, 66264.98, and 66264.100[a] and [b])
- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); California Civil Code requirements for land-use controls (Cal. Civ. Code § 1471); and California Health and Safety Code requirements for institutional controls (Cal. Health & Safety Code §§ 25202.5, 25222.1, and 25233[c])

Well installation and monitoring activities under Alternative 2 would be designed and implemented to meet all federal and state action-specific ARARs for solid waste generators at Cal. Code Regs. tit. 22, § 66262. The wastes that would be generated under this alternative include soil cuttings and wastewater from monitoring well development,

purging, and decontamination of equipment. All wastes would be characterized with respect to criteria for the identification of RCRA and non-RCRA hazardous waste. If these wastes were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the hazardous waste requirements of Cal. Code Regs. tit. 22, §§ 66262 and 66264 would also be potential ARARs for management of the waste for off-site disposal. Implementing Alternative 2 in compliance with these requirements would not be expected to present any significant complications from a technical or administrative viewpoint.

Alternative 2 would be conducted in a manner that would comply with potential action-specific requirements established in the WQCP regarding beneficial uses and water quality objectives (WQOs) applicable to groundwater and surface water. Because Alternative 2 is expected to eventually meet cleanup goals for groundwater, and implementation and enforcement of institutional controls should be effective in preventing unacceptable human-health risk due to exposure to contaminated groundwater in the interim, this alternative is considered to comply with requirements established in the WQCP regarding beneficial uses and water quality objectives for groundwater until these objectives are reached. The TCRA was implemented at OU-1A to contain the VOC plumes in groundwater and reduce contaminant mass at the plume margins. If groundwater monitoring indicates that the continuing trend in contaminant mass reduction after 30 years of implementation of Alternative 2 is not sufficient to achieve surface water discharge limits prior to the predicted discharge at Barranca Channel (i.e., 40 years), appropriate additional action would be implemented to remain in compliance with surface water ARARs.

5.3.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 2 would not reduce contaminant concentrations in the subsurface or affect existing conditions at or downgradient of IRP-13S. For the reasons discussed below, overall protection of human health and the environment is considered fair with monitored natural attenuation. Institutional controls would prevent consumption of contaminated groundwater as drinking water. However, Alternative 2 would not comply with all identified ARARs, does not actively address the threat to water quality in the third WBZ and deeper regional aquifer at IRP-13S, would incur possible ecological risks in the downgradient drainage channel, and would require many decades to reach remediation goals in shallow groundwater. Some of these deficiencies would be mitigated by long-term groundwater monitoring and periodic reviews, which would track plume migration and provide information to support future remedial actions, if necessary.

The baseline HHRA identified future residential exposures to contaminated drinking water as the principal risk driver for the VOC plumes. Health risks associated with this exposure pathway, based on a number of conservative assumptions, exceed U.S. EPA thresholds established in the NCP. As stated in Section 2.2, there is no current human exposure to VOC-contaminated shallow groundwater at OU-1A. Consumption of this groundwater is considered unlikely in the future, given the well permitting process in Orange County, the availability of high-quality municipal water, and the high TDS

concentrations and low yields associated with the shallow aquifer. Deed restrictions would be placed on redevelopment parcels at the station overlying the current footprint of the VOC plumes and their projected migration pathways on-site. Therefore, while contaminated shallow groundwater at Former MCAS Tustin presents a health risk if consumed as drinking water, institutional controls would limit the potential for such adverse exposures to actually occur under Alternative 2.

Alternative 2 would eventually achieve the remediation goals established for OU-1A groundwater. However, these goals would not be attained for more than 100 years, limiting the short-term effectiveness of monitored natural attenuation.

VOC-affected groundwater would continue to migrate toward the station boundaries under Alternative 2. The eventual discharge of contaminated groundwater into Barranca Channel could adversely affect ecological receptors in surface water, although the extent of such impacts is difficult to predict. The potential would also remain for 1,2,3-TCP to migrate downward to the third WBZ in a localized area at IRP-13S, possibly resulting in future VOC contamination reaching the regional aquifer that is currently a source of drinking and irrigation water. A detailed monitoring program would be implemented under Alternative 2 to track the VOC plumes, with periodic reviews designed primarily to determine whether further response actions are warranted to address the above concerns. In this respect, Alternative 2 may not be the final remedy for contaminated groundwater OU-1A.

Furthermore, the expanding VOC plumes would affect many redevelopment parcels at Former MCAS Tustin. Future monitoring and periodic reviews would allow for a detailed evaluation of the off-station migration in the context of the time at which the VOC plumes reach Barranca Channel, currently predicted to occur in approximately 40 years. However, these measures alone would not prevent the release of VOCs beyond the boundaries of the Former MCAS Tustin property or mitigate potential exposures that might occur if land use adjacent to the station changes.

Considering all these factors, the continued migration of VOC-affected groundwater under Alternative 2 would be expected to have a substantial negative impact on redevelopment of the Former MCAS Tustin property. Potential legal or administrative problems could be created once this contamination moves beyond the station boundaries or possibly into deeper portions of the regional groundwater system. Long-term monitoring and periodic reviews would provide an opportunity to identify potential adverse impacts associated with the migrating plume. However, any necessary corrective actions would entail additional undefined remedial measures that would be beyond the scope of Alternative 2 as defined in this FS Report. Therefore, Alternative 2 is considered to offer only a fair degree of overall protection to human health and the environment.

5.4 ALTERNATIVE 3 – HYDRAULIC CONTAINMENT

Alternative 3, hydraulic containment, would use a combination of engineering and institutional controls to restrict further migration of the VOC plumes and to prevent human exposure to site-related contaminants. The key feature of this alternative is the installation of interceptor wells at the downgradient plume margins. Other components include treatment and discharge of the extracted water, institutional controls within areas currently overlying VOC-affected groundwater, long-term monitoring, and periodic reviews.

5.4.1 Description

Alternative 3 involves groundwater extraction in the upper two WBZs to hydraulically contain the VOC plumes in the shallow aquifer at and downgradient of IRP-13S. Operation of the extraction wells would capture contaminated groundwater, eliminating further downgradient migration in the direction of Barranca Channel. The extracted groundwater would be conveyed to a treatment facility located near IRP-13S, treated, and then discharged to a storm drain. The treatment system would include equalization, prefiltration, and GAC adsorption to remove TCE, 1,2,3-TCP, and other chlorinated VOCs to acceptable discharge levels. Long-term performance monitoring would verify the effectiveness of the containment action, supported by detailed reviews at 5-year intervals to evaluate its continued protectiveness. Deed restrictions would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes, effectively preventing human exposure to contaminated groundwater for as long as VOC concentrations exceed the site remediation goals presented in Section 2.5.

A site layout depicting the surface components of Alternative 3 is shown on Figure 5-8. A description of each major element of the hydraulic containment remedy is presented below.

5.4.1.1 GROUNDWATER EXTRACTION

Groundwater extraction wells would be installed in the first and second WBZs at the downgradient margins of the plumes originating at IRP-13S. Operation of these wells would create a cone of depression that would act as a hydraulic barrier to capture the leading edge of contamination and prevent any additional horizontal or vertical migration of VOCs in the upper two WBZs. The containment wells in the second WBZ at OU-1A would be carefully placed and operated to maintain a sustained upward hydraulic gradient from the third to the second WBZ. Proper placement of these wells would eliminate the potential for seasonal downward migration of 1,2,3-TCP in a localized area near the intersection of Cross Street and McCord Road.

The number of extraction wells, well locations, and pumping rates required by Alternative 3 were determined based on aquifer tests, geologic cross-sections, and groundwater monitoring completed for the RI and the RFA (BNI 1997a,b). This information was used as input to a groundwater model used to evaluate the hydraulic containment option, as described in Appendix B.

Given the limited transmissivities associated with the shallow aquifer at the site, as well as the results of the aquifer pumping tests performed during the RI (BNI 1997a), the numerical modeling results presented in Appendix B indicate that two wells, each extracting groundwater at 3 gpm, would be required to achieve hydraulic containment in each WBZ at IRP-13S. Thus, a total of four extraction wells would be installed under Alternative 3. The proposed completion depths and pumping rates for these wells are summarized in Table 5-4. Actual well locations and completion depths would be determined during remedial design.

Assuming a combined extraction rate of 12 gpm (6 gpm from the first WBZ and 6 gpm from the second WBZ), the hydraulic containment system at IRP-13S would produce 17,280 gallons per day (gpd) of extracted groundwater for treatment and disposal.

Figure 5-9 presents a schematic diagram of the type of extraction well that would be constructed under Alternative 3. Each well would be completed as a 6-inch-diameter, production-type water well. For cost estimation purposes, it was assumed that the wells would be constructed using stainless steel casings and well screens. The actual construction materials would be determined during remedial design. A sand pack would be placed around each screen. The annular space between the screened interval and ground surface would be sealed with grout. The wells would be completed with dedicated submersible pumps, along with the necessary piping and electrical controls.

Installation and completion of the extraction wells would be in accordance with the substantive requirements of Orange County Ordinance No. 2607. In addition, the wells would be constructed to meet California Department of Water Resources (DWR) specifications and safety and health standards (DWR 1991).

The estimated groundwater extraction rates shown in Table 5-4 were determined through modeling of the hydraulic containment alternative, as discussed in Appendix B. The steady-state drawdown attained in each WBZ is predicted to establish a capture zone of sufficient width to contain the leading edges of the VOC plumes at OU-1A, as is shown on Figure 5-8. Actual extraction rates and drawdowns may vary from these estimates due to the heterogeneity of the shallow aquifer and the uncertainties inherent in groundwater modeling. This issue would be addressed through evaluation of performance monitoring data collected during operation of the TCRA system and from groundwater extraction tests conducted at the proposed well locations during remedial design.

5.4.1.2 GROUNDWATER CONVEYANCE AND TREATMENT

The extraction wells installed under Alternative 3 would yield nearly 6.3 million gallons of water per year. For the purpose of developing a cost estimate, it was assumed that the groundwater extraction and treatment system would operate for 30 years. The cumulative volume of water to be managed over a 30-year period would be approximately 189 million gallons.

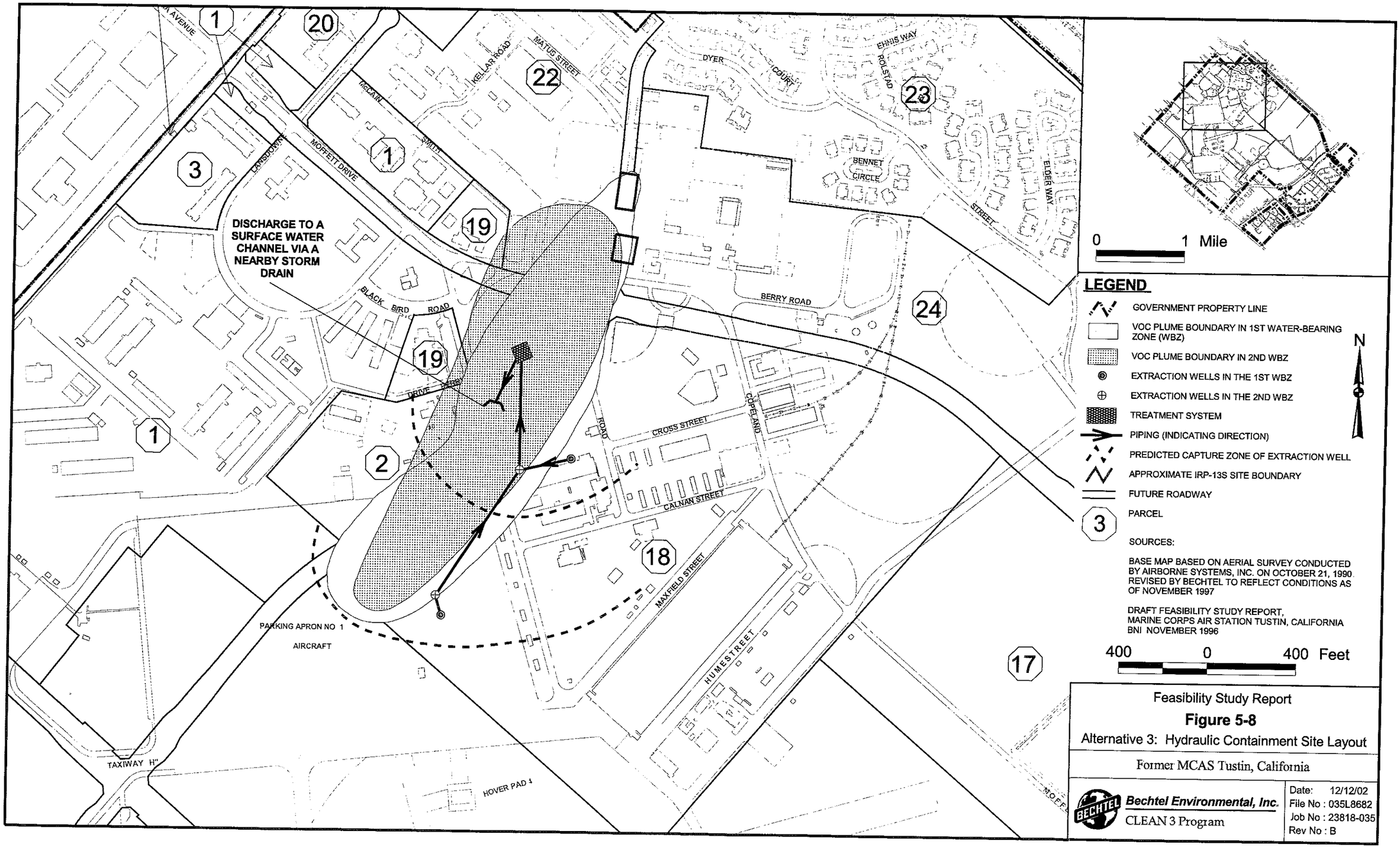

DISCHARGE TO A SURFACE WATER CHANNEL VIA A NEARBY STORM DRAIN
PARKING APRON NO 1
AIRCRAFT
TAXIWAY H"
HOVER PAD 4
MOFFETT DRIVE
LANSDOWNE
MCCAIN
SMITH
KELLAR ROAD
MATUS STREET
DYER
COURT
EHNIS WAY
ROLSTAD
BENNET CIRCLE
ELDER WAY
STREET
BERRY ROAD
BLACK BIRD ROAD
DRIVE
CROSS STREET
COPELAND
ROAD
CALNAN STREET
MAXFIELD STREET
HUMESTREET
1
2
3
17
18
19
20
22
23
24
0 1 Mile
LEGEND
GOVERNMENT PROPERTY LINE
VOC PLUME BOUNDARY IN 1ST WATER-BEARING ZONE (WBZ)
VOC PLUME BOUNDARY IN 2ND WBZ
EXTRACTION WELLS IN THE 1ST WBZ
EXTRACTION WELLS IN THE 2ND WBZ
TREATMENT SYSTEM
PIPING (INDICATING DIRECTION)
PREDICTED CAPTURE ZONE OF EXTRACTION WELL
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
SOURCES:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT, MARINE CORPS AIR STATION TUSTIN, CALIFORNIA BNI NOVEMBER 1996
400 0 400 Feet
N
Feasibility Study Report
Figure 5-8
Alternative 3: Hydraulic Containment Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/12/02
File No : 035L8682
Job No : 23818-035
Rev No : B

Table 5-4
Extraction Well Details for Hydraulic Containment

Water-Bearing Zone	Number of Wells	Completion Depth* (feet bgs)	Pumping Rate (gpm)
First	2	30–34	6
Second	2	55–60	6
Total	4	N/A	12

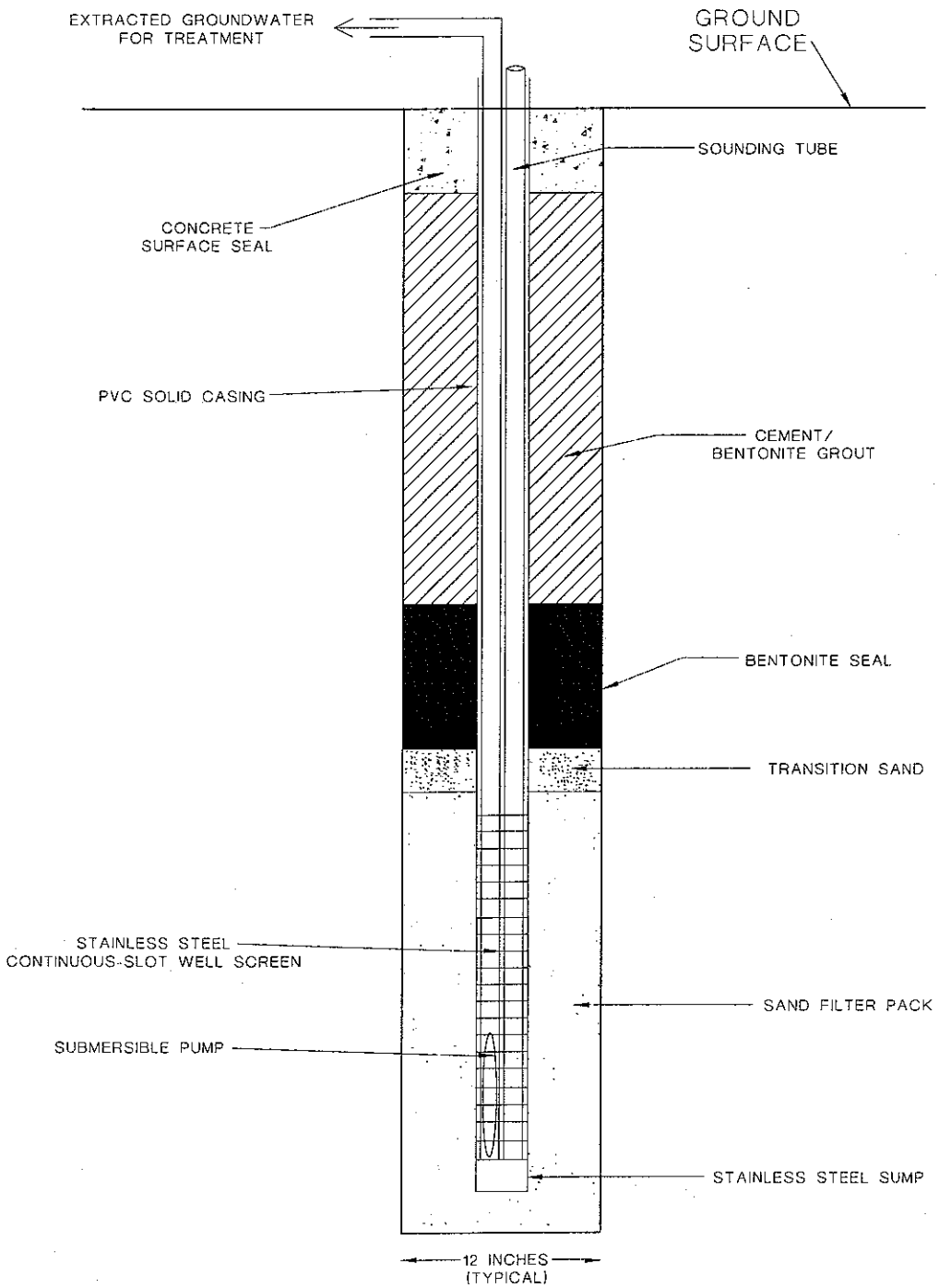
Note:
* completion depths shown are estimated; actual depths would vary depending on conditions encountered at each location

Acronyms/Abbreviations:
bgs – below ground surface
gpm – gallons per minute
NA – not applicable

Groundwater would be pumped from the extraction wells and delivered to the treatment system via buried pipelines constructed according to applicable city of Tustin codes. Approximately 1,480 feet of 4-inch-diameter, double-walled conveyance piping and approximately 200 feet of 2-inch-diameter, single-walled discharge piping would be required by Alternative 3.

As shown on Figure 5-8, the groundwater treatment plant for this alternative would be constructed near the location of the active TCRA treatment system. Water would be conveyed to a 5,000-gallon equalization tank, sufficient to hold approximately 5 hours of flow under average conditions. The equalization tank would be used to prevent flow surges due to cyclic operation of pumps in the individual extraction wells. Such surges might affect the performance of the treatment system if not properly controlled. The equalization tank would also be equipped with level control switches to shut down the extraction wells if necessary to prevent overflows.

From the equalization tank, the extracted water would be pumped through a cartridge filtration system followed by two-stage GAC adsorption. As discussed in Section 3.3.2.7, GAC adsorption is a proven and reliable method for removal of VOCs from water and has been used successfully as the main treatment component of the existing TCRA system. It has been identified by U.S. EPA as a presumptive *ex situ* treatment technology for groundwater contaminated with VOCs (U.S. EPA 1996b) and is widely used to treat aqueous waste streams containing chlorinated organics at concentrations comparable to those expected from the extraction wells installed for Alternative 3. Design criteria have been published in the literature for similar GAC systems treating TCE, 1,2,3-TCP, and related VOCs. Therefore, treatability studies would not be needed to design and install this technology at Former MCAS Tustin.



Feasibility Study Report

Figure 5-9

Typical Extraction Well

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/16/02
File No: 035X8681
Job No: 23818-035
Rev No: B

NOT TO SCALE

Preliminary specifications for the GAC treatment system were based on discussions with equipment vendors and the anticipated flows and VOC concentrations for the groundwater to be extracted under Alternative 3. Predicted TCE and 1,2,3-TCP concentrations in the extraction wells over time are shown on Figures 5-10 and 5-11, respectively. Other VOCs, such as 1,1-DCE, have been reported at much lower concentrations than the primary OU-1A contaminants, and these concentrations would also be expected to decline with time in the extracted groundwater. The flow-weighted design maximum influent concentrations at the treatment facility, based on groundwater modeling results, are 12 μg/L and 13 μg/L for TCE and 1,2,3-TCP, respectively.

The treatment system would be designed to remove TCE, 1,2,3-TCP, and other OU-1A COCs to concentrations below the site remediation goals listed in Table 2-5. Sample taps would be provided so that the effluent could be monitored for compliance with discharge requirements. Samples could also be obtained from individual extraction wells, from the equalization tank effluent, and from between the GAC vessels to monitor the performance of individual carbon units and determine when to replace spent GAC in the lead adsorber.

Using the predicted groundwater extraction rates and design concentrations for TCE and 1,2,3-TCP, an estimated carbon usage rate of 0.074 pound per thousand gallons was calculated for the first year of operation. This equates to an annual GAC consumption of approximately 500 pounds. Thirty years of operation (the basis for the FS cost estimate) would produce a maximum of approximately 14,000 pounds of spent GAC. The maximum VOC loading on the GAC removed from the treatment facility is anticipated to be less than 1 percent by weight.

Regeneration or disposal of the spent carbon would be the responsibility of the GAC supplier under a long-term service contract. For purposes of this FS Report, it was assumed that spent GAC would be taken off-site for regeneration, which is the typical practice on groundwater remediation projects. Prior to shipment from the site, the spent GAC would be tested to determine its waste classification (nonhazardous, RCRA hazardous, and/or non-RCRA hazardous). Characterization, packaging, and transport of this material would be in accordance with U.S. Department of Transportation (DOT), U.S. EPA, and DTSC requirements.

5.4.1.3 GROUNDWATER DISPOSAL

Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel. The eventual discharge of treated groundwater to Peters Canyon Channel would comply with substantive ARARs for discharge to surface water. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if discharge to the storm drain system is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium).

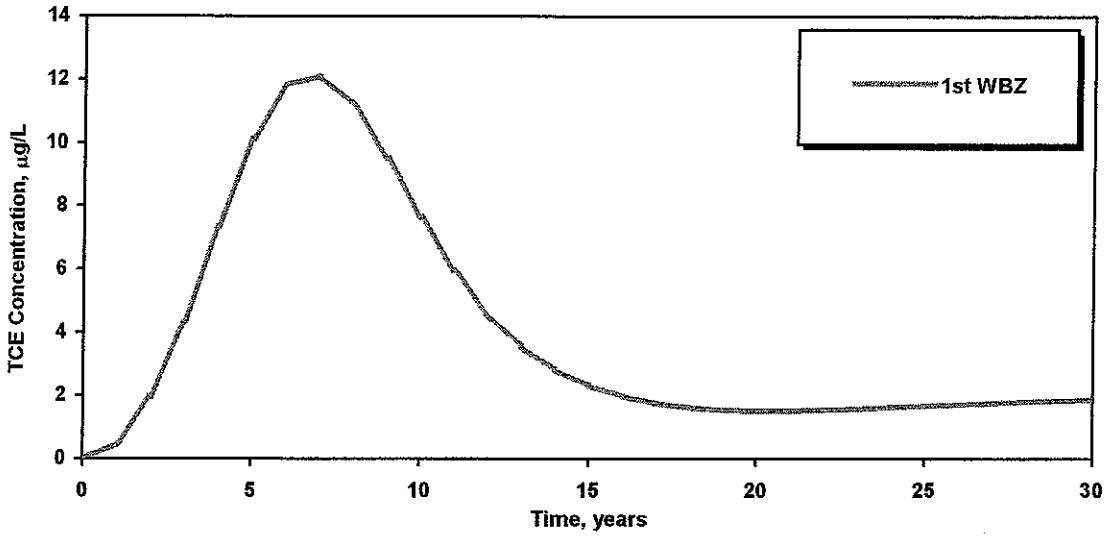


Figure 5-10
Predicted TCE Concentrations
in Hydraulic Containment Wells Under Alternative 3

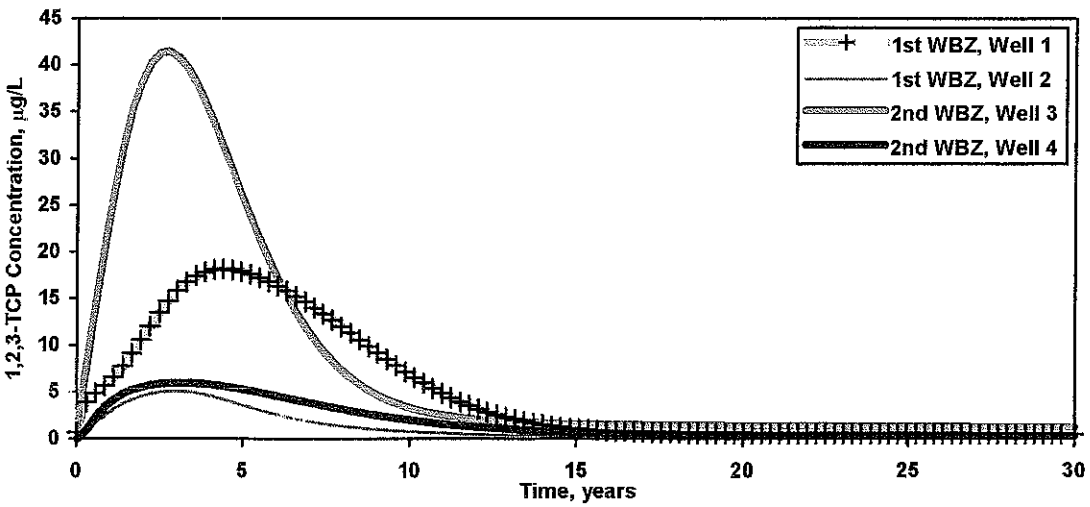


Figure 5-11
Predicted 1,2,3-TCP Concentrations
in Hydraulic Containment Wells Under Alternative 3

Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated.

The DON has reviewed the need to obtain an NPDES permit for the discharge of treated water to neighboring drainage channels and has determined that such a permit would not be necessary. The groundwater treatment system associated with Alternative 3 would be operated entirely on-site as defined under CERCLA and the NCP. The U.S. EPA has consistently maintained that the migration of treated water beyond site boundaries after the response action has treated the water so that it complies with ARARs is consistent with the on-site permit exclusion in Section 121(e) of CERCLA and does not constitute an "off-site" response action that must obtain an NPDES permit (see *In the Matter of the Former Weldon Spring Ordnance Works, Weldon Spring, Missouri*, Federal Facility Docket No. VII-90-F-0033, 01 November 1995).

Although the DON is not required to obtain an NPDES permit, the DON would assure that the discharge of treated groundwater complies with all ARARs as provided by Section 121 of CERCLA and the NCP, including the beneficial uses and water quality objectives for surface water in the Basin Plan. The DON plans to achieve compliance with these ARARs by complying with the substantive requirements of the RWQCB General Groundwater Cleanup Permit, CAG918001, represented by numerical discharge limits for surface water, and by regularly monitoring the influent and effluent of the treatment system. Details of the monitoring would be developed as part of the remedial design/remedial action phase. The groundwater treatment subcontractor would be responsible for documentation of the on-site treatment activities. This documentation would consist of a summary report detailing quantities removed, treated, and discharged; discharge flow rates; the number and types of samples collected; and the results of analyses.

The RWQCB has reviewed the DON's position on a similar issue, the need to obtain a permit for groundwater discharge at Site 16 at Former MCAS El Toro (RWQCB 2001). The DON and RWQCB have agreed to disagree on this matter.

5.4.1.4 PERFORMANCE MONITORING

Performance monitoring during implementation of Alternative 3 would be used to optimize operation of the extraction system, verify containment of the VOC plumes, and demonstrate successful treatment of the extracted groundwater prior to discharge. Monitoring would include water level measurements as well as the collection and analysis of samples from wells placed within the plume areas. Process streams within the treatment plant would also be tested. The overall approach to monitoring for Alternative 3 is consistent with that presented in U.S. EPA technical guidance (U.S. EPA 1994c). A summary of the proposed performance monitoring anticipated for the hydraulic containment alternative is presented in Table 5-5.

Table 5-5
Performance Monitoring for Hydraulic Containment

Type of Monitoring Data	Monitoring Locations	Purpose/Use of Data
Water levels	Monitoring wells throughout and around the VOC plumes	Prepare potentiometric surface maps and hydrographs Determine horizontal and vertical hydraulic gradients Confirm capture zones (containment of plume)
VOC concentrations in the shallow aquifer	Monitoring wells throughout and around the VOC plumes	Delineate areal and vertical extent of contamination Confirm containment of plume
VOC concentrations in extracted groundwater	Extraction wells and equalization tank effluent	Estimate cumulative mass of VOCs removed from aquifer Characterize extracted groundwater from individual wells and combined treatment plant influent with respect to RCRA and non-RCRA hazardous waste criteria
VOC concentrations in treatment plant effluent	Effluent lines from GAC vessels	Assess performance of treatment system Demonstrate compliance with discharge requirements
Flow rates	Extraction wells and various points in treatment system	Confirm that extraction and treatment systems are operating to specifications
Other operational parameters (e g , water line pressures)	Various locations	As needed to assess proper operation or incipient failure of pumps and filters

Acronyms/Abbreviations:
GAC – granular activated carbon
RCRA – Resource Conservation and Recovery Act
VOC – volatile organic compound

The long-term groundwater monitoring program for this alternative would use a combination of existing and new wells. For the purpose of developing a cost estimate, it was assumed that two new groundwater monitoring wells would be installed, one well in each WBZ at IRP-13S. In addition, it was assumed that four existing wells would be included in the groundwater monitoring plan. Thus, a total of six wells would be monitored for Alternative 3. The actual number of monitoring wells to be sampled and the locations and specifications for any new monitoring wells (depth, screened interval, and well construction materials) would be determined during remedial design and documented in the long-term monitoring plan. This plan would also provide details concerning sampling procedures, target analytes, analytical methods, field and laboratory QA/QC, and reporting requirements. Well locations and surface completion methods would take accessibility into consideration, along with the need to minimize impacts on redevelopment of the Former MCAS Tustin property.

The frequency of groundwater monitoring would vary over time. During the initial stages of system start-up and equilibration, monitoring of water levels would be on a near-continuous basis using pressure transducers and data loggers. This initial period of monitoring was assumed to extend for no more than 2 weeks, after which water level monitoring would switch sequentially to daily, weekly, monthly, and finally quarterly measurements. Groundwater samples for VOC analysis would be collected quarterly for the first 3 years after implementation of Alternative 3, semiannually for the next 7 years, and annually through the 30th year of operation.

VOC samples for performance monitoring at the treatment plant would be collected monthly from the equalization tank effluent, GAC vessel effluent, and final effluent. Additional effluent monitoring (e.g., for parameters such as toxicity or metals) would be conducted as needed to satisfy discharge requirements.

5.4.1.5 INSTITUTIONAL CONTROLS

Institutional controls are nonengineering mechanisms, particularly legal measures, designed to limit activities or access at a site to protect the selected remedy. Institutional controls fall into two broad categories, restrictions on future land use and provisions for access for future monitoring and maintenance. Proposed future land use is described in the MCAS Tustin SP. The SP indicates that the parcels at Former MCAS Tustin currently overlying the VOC plumes, as well as the downgradient parcels under which the plumes are expected to migrate, will be redeveloped for residential, commercial, and recreational use (The Planning Center 1998).

Alternative 3 includes deed restrictions for parcels overlying the VOC plumes (approximately 40 acres), plus an approximately 200-foot buffer zone surrounding the plume and the alignment of the conveyance piping connecting the extraction wells to the treatment system, the treatment system compound, and the discharge location (Figure 1-5). The land-use control objective within the RAOs is for protection of human health by preventing extraction of VOC-impacted shallow groundwater. Restrictions designed to limit inhalation of VOCs are not necessary as long as groundwater extraction

is prohibited within the OU-1A plume boundaries (Appendix F). The deed restrictions would include the following elements to achieve the land-use control RAO:

- prohibitions on the installation of public or private water supply wells in the shallow aquifer within the area of institutional controls
- prohibitions on the installation of underground utilities, including trenches, within the groundwater in the area requiring institutional controls without the review and approval by the DON and other regulatory agencies; improperly designed subsurface utilities, including the backfilled trenches, may create preferential pathways for the transport of contaminated groundwater and negatively impact the remedial alternative
- prohibitions on construction or other activities that would disturb or otherwise negatively impact the monitoring wells, extraction wells, treatment system, conveyance piping, or the discharge structure without prior approval from the DON
- provisions to allow the DON and other regulatory agencies access to install new and destroy old monitoring wells and implement supplemental remedial measures in the future, if necessary
- provisions to allow the DON and other regulatory agencies access to monitor the remedial action (i.e., the monitoring wells, extraction wells, conveyance piping, treatment system, and discharge structure)
- requirements to notify the DON in advance of any plan to lease or transfer affected parcels
- requirements to notify the DON and regulatory agencies in a timely manner of any change in site conditions that potentially compromises the remedy or endangers public health or the environment

Based on the current extent of the VOC plumes, deed restrictions would be needed over an area of approximately 54.1 acres plus an approximately 200-foot buffer zone surrounding the plume and the remediation components.

The deed restrictions required for Alternative 3 would not hinder the development of the Former MCAS Tustin property. None of the expected land-use scenarios for the affected parcels would require the installation of wells and use of groundwater from the shallow aquifer. The deed restrictions only require that wells installed in the regional aquifer be constructed with well screen depths and seals sufficient to prevent cross-contamination with the shallow aquifer. These restrictions will protect the selected remedy and will not affect development of the groundwater resource. Deed restrictions on the installation of underground utilities can be addressed with appropriate engineering controls.

The deed restrictions would remain in effect until monitoring data show that the VOC contaminant concentrations in groundwater meet the remediation goals established for the site. The time estimated for remediation, based on groundwater modeling, is greater than 30 years.

5.4.1.6 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data would be conducted every 5 years to evaluate whether the extraction wells were effectively containing the VOC-contaminated shallow groundwater. These reviews would also assess the adequacy of the performance monitoring program and suggest revisions as necessary to meet project objectives. Results of each periodic review would be documented in a summary report submitted by the DON to the regulatory agencies responsible for program oversight.

5.4.2 Detailed Analysis

Alternative 3 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.4.2.1 SHORT-TERM EFFECTIVENESS

Short-term risks during implementation of Alternative 3 would include potential exposure to contaminated groundwater and soil during installation of the extraction system, conveyance pipelines, and monitoring wells. Additional construction activities would include assembly of the treatment plant with its associated piping, instrumentation, mechanical systems, and electrical controls. Potential short-term impacts from these activities would be minimized by developing and implementing a site-specific health and safety plan and remedial action work plan. These plans would include provisions for personnel protection, air monitoring, and contingency actions as needed to protect workers and the nearby community.

Other short-term risks would be associated with the start-up of both the extraction wells and the treatment plant, as these activities would entail management of VOC-contaminated groundwater in otherwise untested systems. Potential impacts from inadvertent releases would be controlled through a spill prevention plan developed prior to construction. This plan would identify procedures for rapid spill response and cleanup as well as measures to prevent or contain releases. Impacts on the community or on-site workers would be minimal under these circumstances.

The duration of the activities for well installation and treatment plant construction would be approximately 4 months. Following construction, the system would be tested to confirm the performance of each component before long-term operations commenced. This initial "shake-down" period should last no more than 2 months. Assuming that the deed restrictions could be established concurrently with remedial design, the major components of Alternative 3 would be in place approximately 6 months after mobilization for field construction. At that point, this remedy's combination of institutional controls and engineered remediation systems would effectively limit the further migration of the VOC plumes while significantly reducing the potential for human exposure to VOCs in shallow groundwater underlying the station.

5.4.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 3 is intended to contain the VOC plumes within the limits of the existing areas of contamination on the Former MCAS Tustin property. Groundwater modeling presented in Appendix B indicates that only a small number of strategically placed extraction wells would be sufficient to meet this objective in the first two WBZs at and downgradient of IRP-13S.

Results from groundwater modeling simulations are presented on Figures 5-12 and 5-13. These figures show that the primary COCs (TCE and 1,2,3-TCP) would not migrate beyond the existing downgradient margins of the VOC plumes in the sand layers of the first and second WBZs. This would eliminate concerns regarding the potential off-station migration of contaminated groundwater and future discharges to Barranca Channel. Additionally, the two containment wells planned for the second WBZ at IRP-13S could be placed to maintain a constant upward vertical hydraulic gradient from the third WBZ, thereby eliminating the potential for localized, seasonal downward migration of 1,2,3-TCP (BNI 1999c). The most effective locations for IRP-13S extraction wells presented on Figure 5-8 were selected using a trial-and-error procedure. Based on groundwater modeling data, two wells each in the first and second WBZs would be sufficient to contain the plumes. While not primarily intended as an aquifer restoration measure, Alternative 3 would also, over time, accomplish significant reductions in both VOC concentrations and mass as the plumes are captured by the hydraulic containment system.

Groundwater that would be extracted by the hydraulic containment wells would be treated using GAC adsorption, a process identified by U.S. EPA as a proven and effective method for removing TCE and other chlorinated VOCs from water (U.S. EPA 1996b). All components of the extraction, treatment, and monitoring systems required by Alternative 3 have been extensively implemented for groundwater remediation at other sites, demonstrating a high degree of long-term operational reliability.

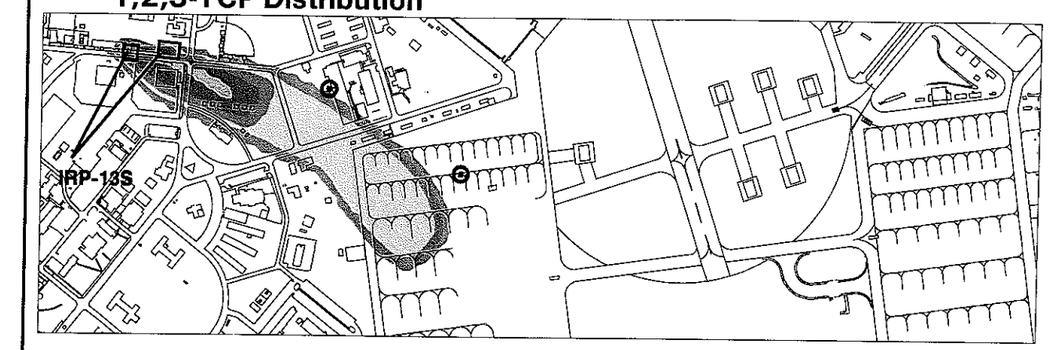
Residual risks associated with VOCs plumes would be expected to decline as VOC-contaminated water is withdrawn from the shallow aquifer under hydraulic containment. The magnitude of this decline is illustrated on Figures 5-14 and 5-15, which plot predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs. From trends presented in Figures 5-14 and 5-15, maximum concentrations of TCE and 1,2,3-TCP in shallow groundwater would exceed site cleanup goals for many decades under Alternative 3. Deed restrictions preventing exposure to contaminated groundwater at OU-1A would therefore need to remain in place and be effective far into the future.

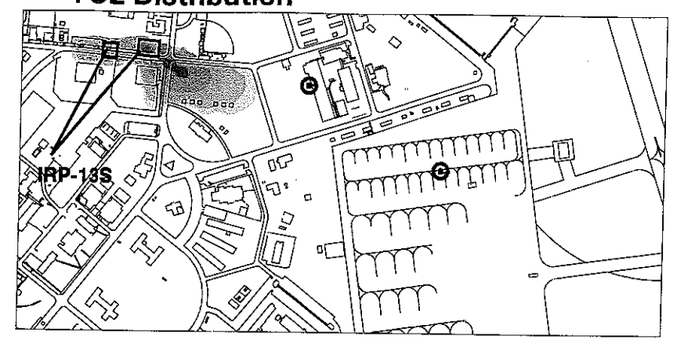
It is noteworthy that predicted maximum TCE concentrations are expected to reach relatively low values (approximately 22 μg/L) 10 years after Alternative 3 is implemented. Thereafter, predicted maximum TCE concentrations in the first WBZ would begin to increase slowly with time (Figure 5-14). This behavior results from leaching of TCE adsorbed to vadose zone soils at MWA-18. It would take several

1,2,3-TCP Distribution

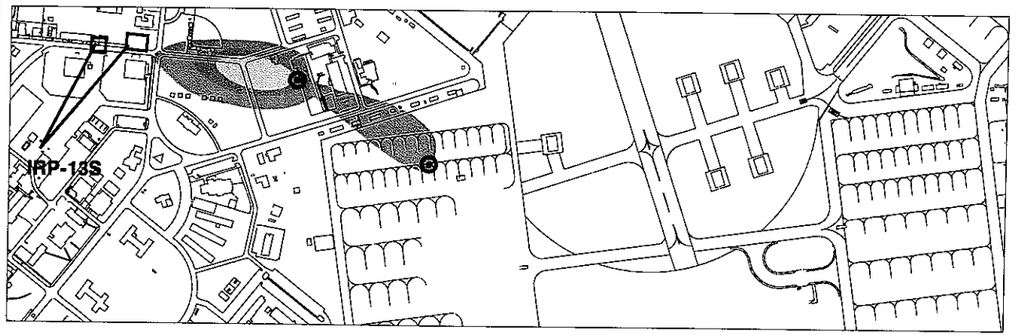
TCE Distribution

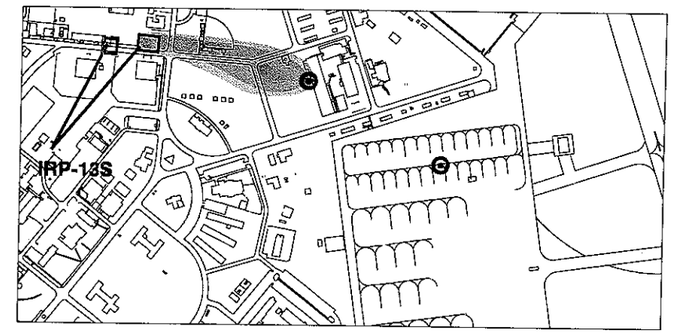
Alternative 3: Hydraulic Containment



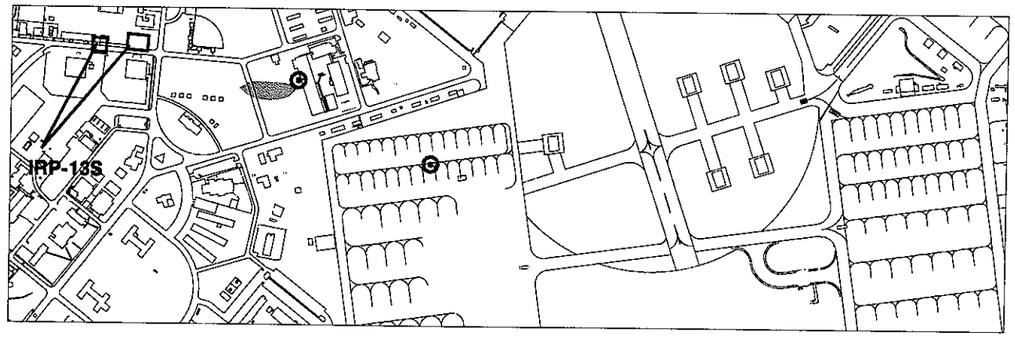


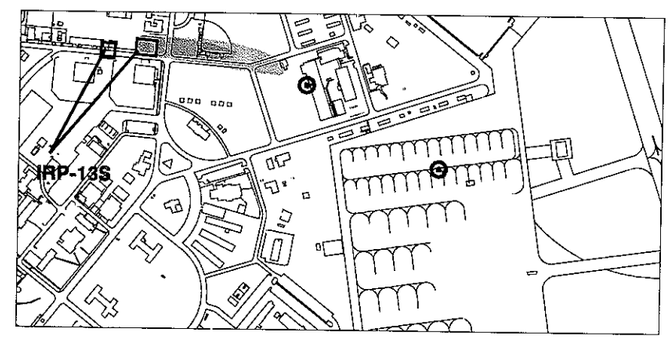
Current Conditions



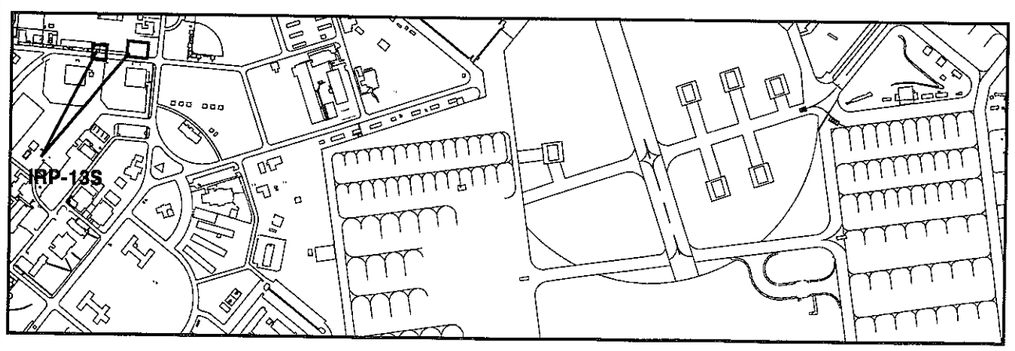


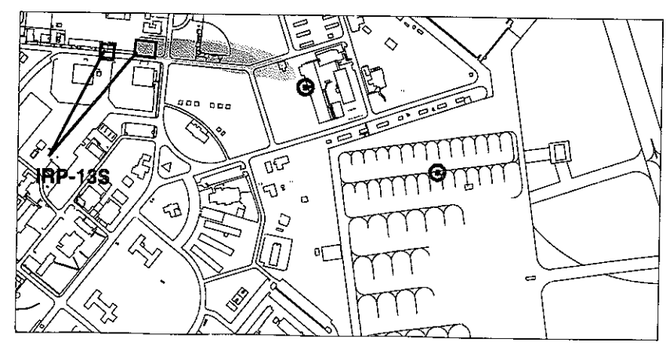
After 10 Years



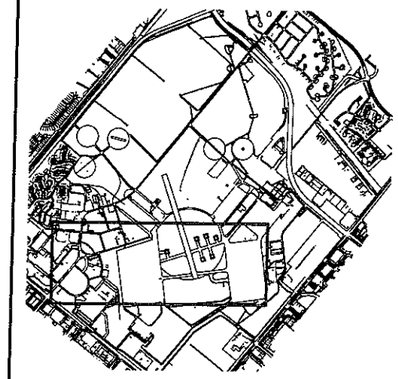


After 20 Years





After 30 Years



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L

EXTRACTION WELL

N

0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-12
Alternative 3: Hydraulic Containment
Simulated TCE and 1,2,3-TCP
Concentrations in the 1st WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

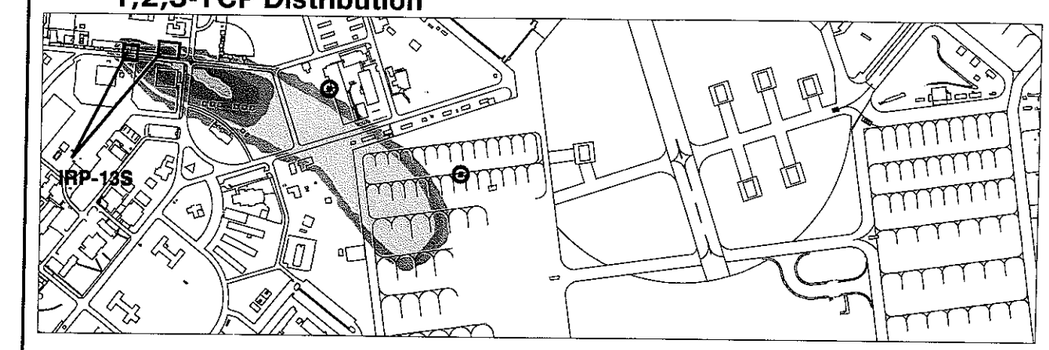
Date: 07/31/03
File No. 035L8614
Job No.:23818-035

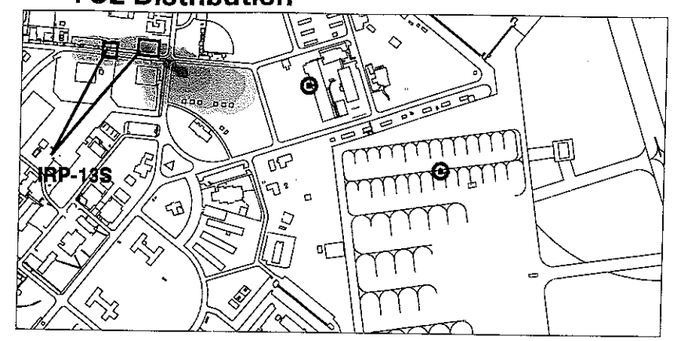
gwm72alt3lfs 07/31/03 /f/tustin/tustinsun

1,2,3-TCP Distribution

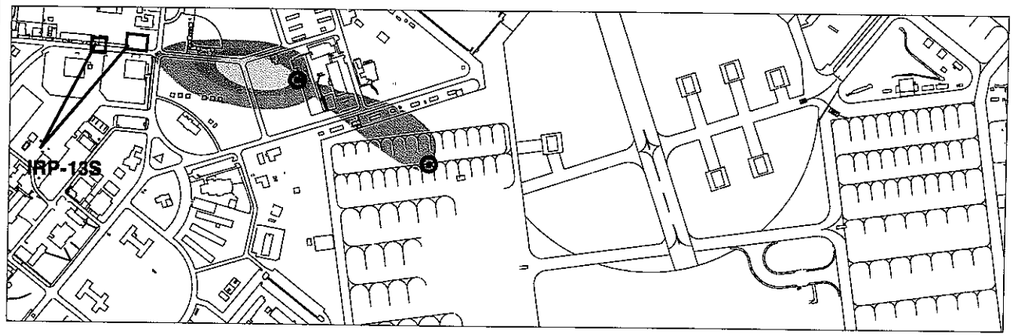
TCE Distribution

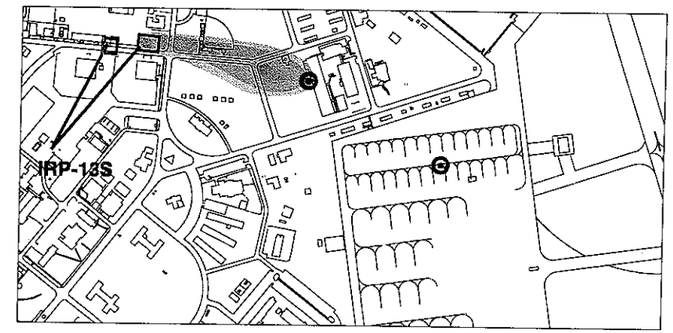
Alternative 3: Hydraulic Containment



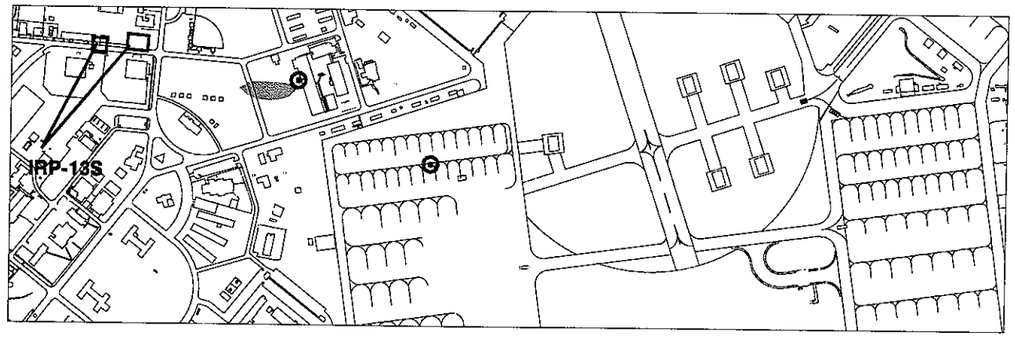


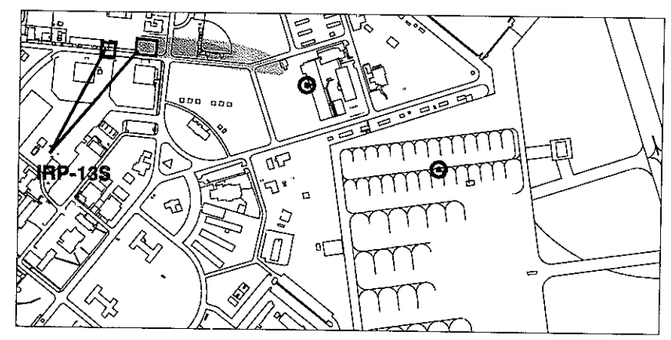
Current Conditions



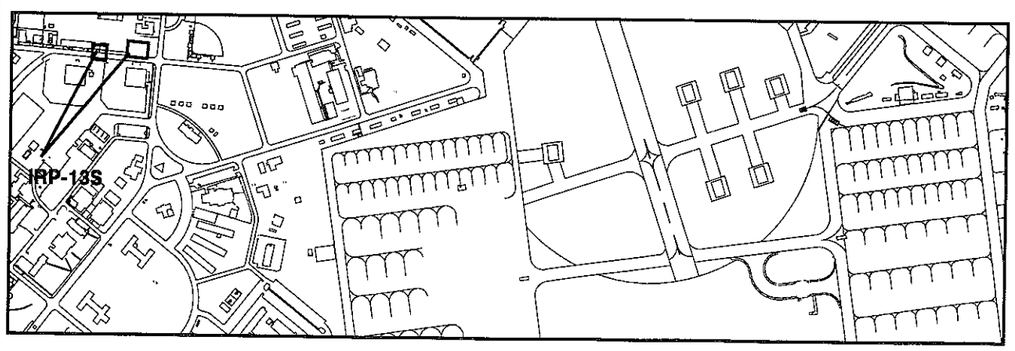


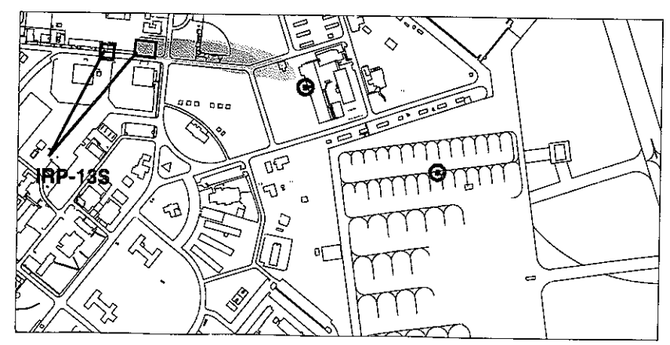
After 10 Years



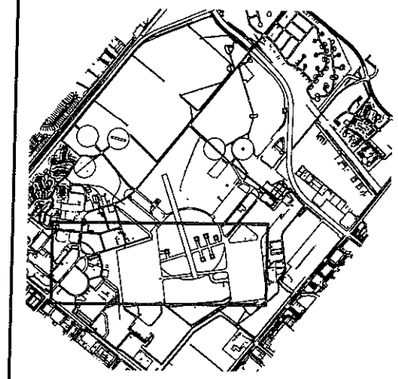


After 20 Years





After 30 Years



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L

EXTRACTION WELL

N

0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-12
Alternative 3: Hydraulic Containment
Simulated TCE and 1,2,3-TCP
Concentrations in the 1st WBZ at IRP-13S

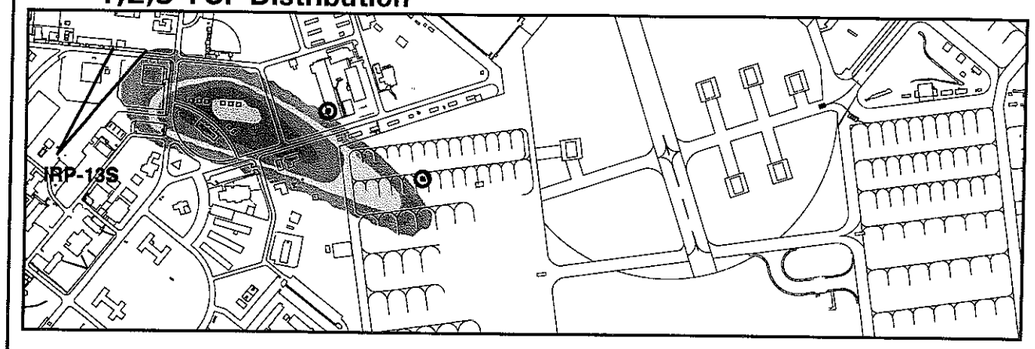
Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 07/31/03
File No. 035L8614
Job No.:23818-035

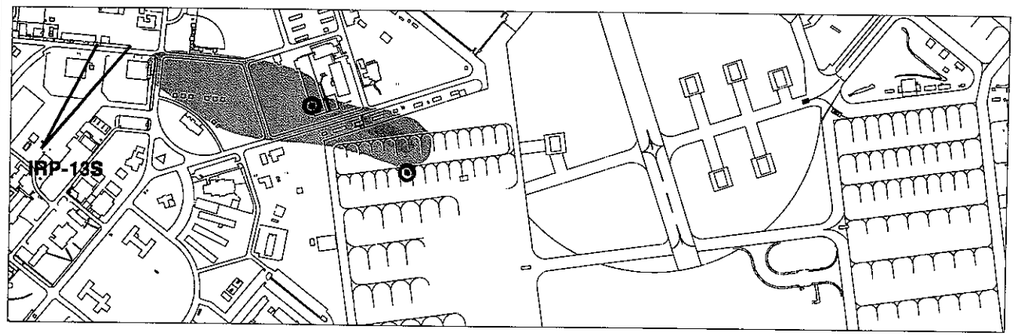
gwm72alt3lfs 07/31/03 /f/tustin/tustinsun

1,2,3-TCP Distribution

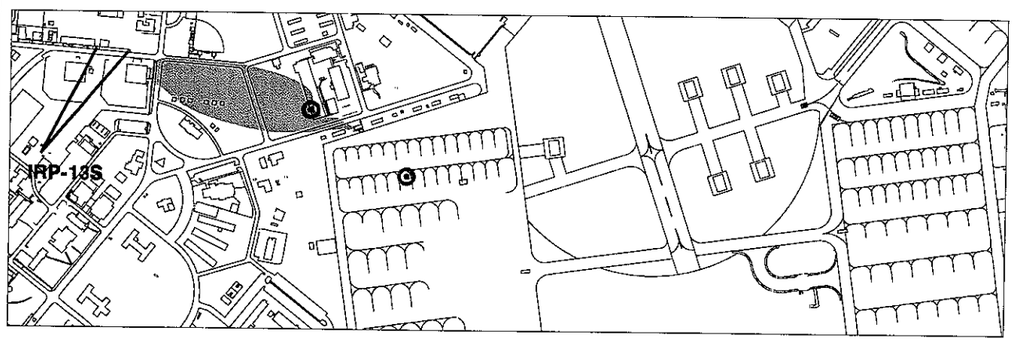


Alternative 3: Hydraulic Containment

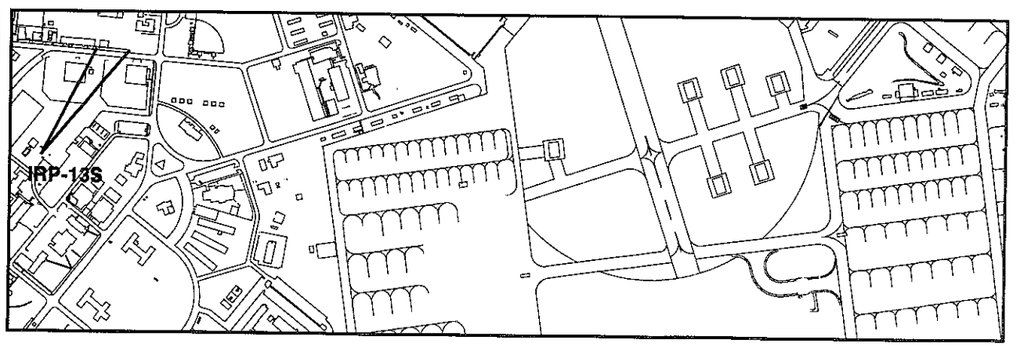
Current Conditions



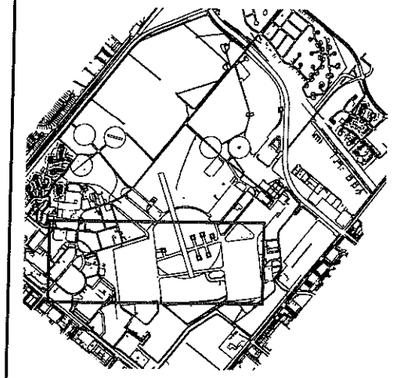
After 10 Years



After 20 Years



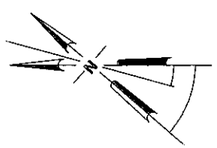
After 30 Years



1,2,3-TCP

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L

⊙ EXTRACTION WELL



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-13
Alternative 3: Hydraulic Containment
Simulated 1,2,3-TCP
Concentrations in the 2nd WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/23/03
File No 035L8615
Job No :23818-035

gwm72alt32fs 01/23/03 /f/tustin/tustinsun

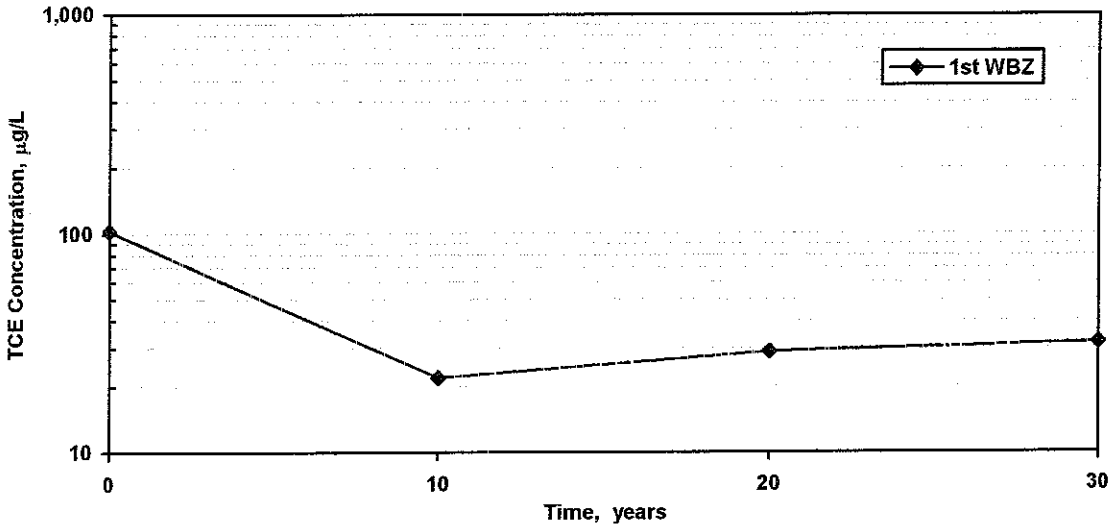


Figure 5-14
Predicted Maximum TCE Concentrations Under Hydraulic Containment

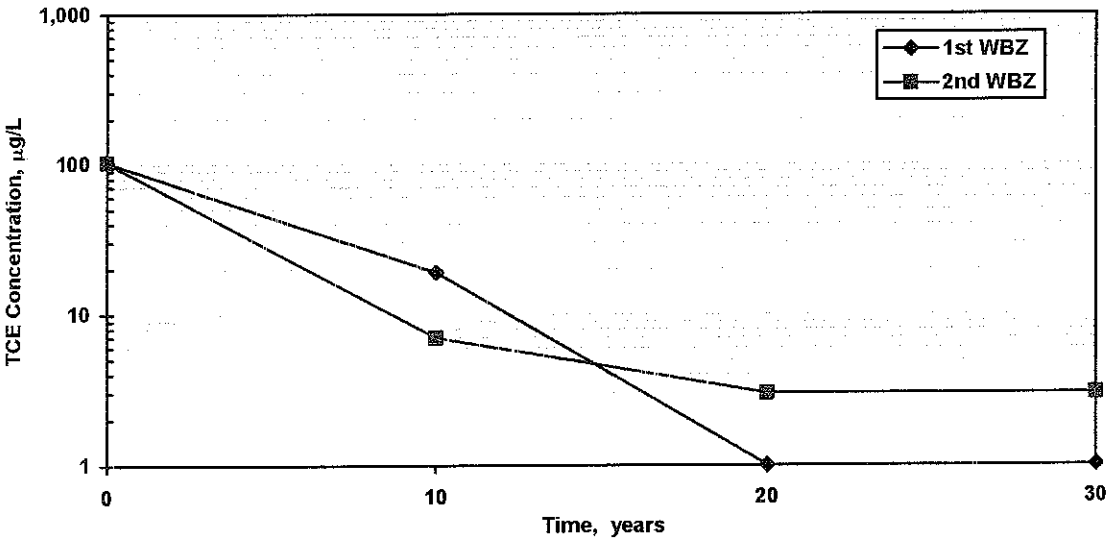


Figure 5-15
Predicted Maximum 1,2,3-TCP Concentrations
Under Hydraulic Containment

years before the impacts of this source on groundwater quality in the first WBZ became discernible.

Deed restrictions would be used under Alternative 3 to prevent future human exposure to VOC-affected groundwater within the area of contamination. Deed restrictions are expected to be effective and reliable methods of controlling health risks in areas impacted by the VOC plumes. Furthermore, by preventing further expansion of the plumes beyond their current limits, Alternative 3 minimizes the area over which deed restrictions must be applied. The long-term effectiveness of these measures would be contingent upon their continued enforcement, which would be the responsibility of the DON and the DTSC.

Residuals generated by the treatment system under Alternative 3 would consist of an estimated 500 pounds of spent GAC per year. Spent GAC, which would be managed by the carbon supplier under a long-term service contract, would be taken off-site for regeneration or disposal. Because this material would be a solid waste that might contain relatively high concentrations of TCE and other VOCs, it would have to be characterized prior to being transported off-site. Long-term management of spent GAC would be in accordance with RCRA and California waste management regulations. Therefore, residual risks associated with the spent GAC are considered negligible.

5.4.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 3 would eliminate contaminant mobility by capturing the VOC plumes and preventing further migration either laterally or vertically. Long-term operation of the extraction system is also expected to accomplish a potentially significant reduction in the volume and mass of subsurface contamination. According to the modeling results presented in Appendix B, hydraulic containment operated for 30 years would remove, on a mass basis, over 40 percent of the TCE and over 60 percent of 1,2,3-TCP currently contained in the plumes downgradient of IRP-13S. As shown in Figures 5-14 and 5-15, maximum predicted TCE and 1,2,3-TCP concentrations under Alternative 3 would decline from existing levels by factors of 69 percent to greater than 99 percent over 30 years, representing a significant reduction in the toxicity of the VOC plumes.

Groundwater extracted under this alternative would be treated using GAC, which involves a transfer of dissolved contaminants to a solid phase (i.e., carbon). The spent GAC would most likely be regenerated in a high-temperature furnace at a permitted off-site facility operated by the carbon supplier. The adsorbed VOCs would be destroyed during the carbon regeneration process.

5.4.2.4 IMPLEMENTABILITY

Alternative 3 would be readily implemented, with no anticipated difficulties regarding technical feasibility, reliability, or scheduling. The technical components of this alternative are well established and have been widely used at other sites with TCE and related VOC contamination in groundwater. The equipment and construction methods to be used are proven, reliable, and readily available. In addition, multiple vendors are

available to supply, at competitive prices, the equipment and services necessary for the groundwater extraction, monitoring, and treatment systems of Alternative 3.

The deed restrictions that would be instituted as part of Alternative 3 are not expected to prevent or unnecessarily complicate future redevelopment of the Former MCAS Tustin property. The reasoning supporting this conclusion is presented in Section 5.3.1.1. The deed restrictions for Alternative 3 would most likely remain in force beyond the 30-year period considered in this FS Report. Implementation of this alternative would require coordination with state and local agencies to enforce the deed restrictions.

Treated water from the treatment system would be discharged to a city of Tustin storm drain that eventually discharges into Peters Canyon Channel. The discharge of water to this channel would comply with substantive ARARs for surface water discharges.

The DON has reviewed the need to obtain an NPDES permit for the discharge of treated water to Peters Canyon Channel and has determined that such a permit would not be necessary. A discussion of this determination is presented in Section 5.4.1.3.

5.4.2.5 COST

Table 5-6 summarizes the estimated costs developed for Alternative 3. The net present cost for hydraulic containment would be approximately $3.8 million. Major cost elements include the installation of extraction wells and construction of the conveyance piping and treatment system. Long-term monitoring of groundwater quality, sampling of the treatment plant influent and effluent, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that operation of the extraction and treatment systems and performance monitoring would be conducted for 30 years.

Backup and supporting details for the Alternative 3 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.4.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 3 with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

The trend lines presented on Figures 5-14 and 5-15 suggest that Alternative 3 would eventually comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. However, maximum TCE and 1,2,3-TCP concentrations would remain elevated at the end of the 30-year operating period assumed in this FS Report, and an extended period of time would be required to attain compliance throughout the entire area affected by the VOC plumes.

Table 5-6
Summary of Cost Estimate[a] for Alternative 3

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering study/design/monitoring plan (2,000 hours @ $85.00/hour)	$170,000			$170,000
Carbon adsorption treatment system	$172,000			$172,000
GAC unit O&M (average 30 years)		$14,767		$443,000
Install four extraction wells	$170,000			$170,000
O&M (average 30 years)		$15,533		$466,000
Install two monitoring wells	$26,000			$26,000
Piping	$94,000			$94,000
Electrical distribution	$40,000			$40,000
Monitoring and Reporting				
Performance monitoring (average 30 years) sample collection, analysis, and water levels		$89,500		$2,685,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$4,662,000**
Contingency (20%)[d]				$932,000
Escalation (Base 01 January 2001)				$3,142,000
Total Cost				**$8,736,000**
Net Present Value of Alternative 3 (2002 $'s)				**$3,786,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect monitoring activities (annual and 5-year) for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports

Acronyms/Abbreviations:
GAC – granular activated carbon
O&M – operation and maintenance

Chemical-specific requirements that would eventually be met through implementation of Alternative 3 include the following:

- **Federal:** SDWA MCL (40 C.F.R. § 141 61[a]) for TCE; RCRA groundwater protection standards in Cal. Code Regs tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); CWA of 1977 (40 C.F.R. § 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs tit. 22, §§ 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])
- **State:** Substantive portions of the beneficial uses and water quality objectives in the WQCP for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2; and Cal/EPA DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261 22[a][4], and 66261.24[a][2]–[8])

The persistence of VOC contamination within the plume areas would prevent beneficial use of shallow groundwater on approximately 54.1 acres of the Former MCAS Tustin property for many decades, until site cleanup goals had been achieved. No such restrictions on beneficial use would occur in presently uncontaminated areas of the site, on adjacent off-site properties, or for any portion of the deeper Irvine Pressure Subbasin (regional aquifer) underlying the station.

Location-Specific ARARs

The primary activities under Alternative 3 that might trigger location-specific requirements are those related to the installation and operation of extraction wells, monitoring wells, and the groundwater conveyance/treatment/discharge system. Given the minimal groundwater extraction rates expected and the limited size of the treatment plant and related appurtenances, the "footprint" associated with Alternative 3 is expected to be small. Approximately 1,680 feet of trenching (less than 4 feet deep) would be required to install the groundwater conveyance and discharge piping. Otherwise, no major construction, earthwork, or drainage manipulation activities of the type most likely to complicate compliance with location-based ARARs would occur under Alternative 3.

Construction activities for Alternative 3 would be designed and implemented to meet all location-based requirements, which are identified as ARARs in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

The major components of Alternative 3 that trigger action-specific ARARs are the generation of solid waste (soil cuttings from well installations, trench spoils, and spent GAC), extraction and treatment of contaminated groundwater containing VOCs, and the eventual discharge of treated groundwater to Peters Canyon Channel. As identified in

Appendix A (Section A4.3), the action-specific requirements for hydraulic containment include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs. tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34); groundwater monitoring (Cal. Code Regs. tit. 22, § 66264.91[a] and [c], 66264.97, 66264.98 and 66264.100[a] and [b]); and SDWA underground injection control regulations (40 C.F.R. § 257.3–257.4 and Appendix I) as specified in Table A4-1 in Appendix A
- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); antidegradation provisions of SWRCB Resolution No. 68-16 (SWRCB 1968); California Civil Code requirements for land-use controls (Cal. Civ. Code § 1471); and California Health and Safety Code requirements for institutional controls (Cal. Health & Safety Code §§ 25202.5, 25222.1, and 25233[c])

All activities under Alternative 3 that produce solid waste (soil cuttings, trench spoils, and spent GAC) would be implemented in a manner compliant with federal and state action-specific ARARs at Cal. Code Regs. tit. 22, § 66262. These residuals would be characterized with respect to criteria for the identification of RCRA and non-RCRA hazardous waste. If any of these wastes were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the hazardous waste requirements of Cal. Code Regs. tit. 22, §§ 66262 and 66264 would also be potential ARARs for management of the waste for off-site disposal. Implementing Alternative 3 in compliance with these requirements would not be expected to present significant complications from a technical or administrative viewpoint.

Another action-specific consideration for Alternative 3 involves classification of the extracted groundwater under RCRA. As noted in Appendix A (Section A1.4.1), none of the groundwater samples collected from the first and second WBZs during the RI had TCE concentrations exceeding 500 μg/L, the limit established for designation as a RCRA characteristic hazardous waste. Based on the groundwater modeling described in Appendix B, it is predicted that maximum TCE concentrations in the extracted groundwater for Alternative 3 would be less than 103 μg/L, well below the 500 μg/L RCRA threshold (Figure 5-14). More accurate estimates of expected TCE concentrations in the extracted groundwater would be obtained during remedial design. If groundwater from the wells were classified as hazardous waste, then the requirements of Cal. Code Regs. tit. 22, § 66264 would be potential ARARs for portions of the extraction and treatment system. TCE concentrations below the RCRA limits would not trigger any hazardous waste management ARARs. RCRA hazardous waste criteria have not been set for 1,2,3-TCP.

Alternative 3 would comply with the Basin Plan requirements to maintain beneficial uses and meet water quality objectives for groundwater in the Irvine Pressure Subbasin (regional aquifer) by limiting further migration of contaminated groundwater and *ex situ*

treatment. However, attaining these requirements in the shallow aquifer system underlying Former MCAS Tustin, which is also required by the Basin Plan, would take many decades because of the limited scale of the extraction scheme under Alternative 3.

Performance goals for treatment of the extracted groundwater would be based on reducing 1,2,3-TCP, TCE, and other site-related VOC contaminants to concentrations acceptable for discharge. The NPDES general permit discharge limits would be used as TBC guidance for conducting on-site discharge of treated groundwater in compliance with the beneficial uses and WQOs for the surface water provided in the Basin Plan. The DON and RWQCB have "agreed to disagree" concerning the applicability of the permit exclusion of CERCLA Section 121(e). Consistent with this agree-to-disagree compromise, the DON maintains that surface water discharge related to OU-1A remedial action is exempt from such permit requirements, but the DON agrees to comply with the substantive requirements of the permit as a means of ensuring compliance with the substantive provisions of the WQCP and other state ARARs as provided by Section 121(d) of CERCLA. Performance monitoring requirements will be detailed in the Operation and Maintenance Plan. This issue is discussed in more detail in Section 2.5 and in Appendix A (Section A4.6.2).

5.4.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 3 would protect human health and the environment. Proven technology would be used to contain the VOC plumes at OU-1A. This alternative would eventually comply with all identified ARARs, prevent any further migration of contaminated groundwater in the shallow aquifer underlying Former MCAS Tustin, control the threat to water quality in the third WBZ and deeper regional aquifer at IRP-13S, avoid further migration of the VOC plume onto adjacent properties, and eliminate potential ecological impacts associated with future discharges of contaminated groundwater to Barranca Channel. Treatment of the extracted groundwater using GAC, a well-established process, would remove VOCs to concentrations acceptable for discharge to surface water. Implementation and enforcement of institutional controls (deed restrictions and Orange County Health Care Agency [OCHCA] permits for installation of new water supply wells) should effectively prevent human exposure to VOC-affected shallow groundwater. The deed restrictions required by Alternative 3 would be limited to approximately 54.1 acres overlying the existing area of OU-1A contamination. Over time, concentrations of TCE and 1,2,3-TCP in shallow groundwater, along with the associated risks to potential residential receptors, would decline due to the removal of contaminant mass by the extraction wells. Performance monitoring and periodic reviews would verify plume containment and track the overall performance of the remedy.

The primary disadvantage of Alternative 3 is that it must be implemented and maintained for a potentially significant length of time to remain protective. Modeling completed for this FS Report indicates that the groundwater extraction and treatment system would have to remain effective for much longer than 30 years to reduce contaminant concentrations to site cleanup goals listed in Table 2-5. A prolonged period of operation increases the

chance that unforeseen problems, such as equipment breakdowns or a failure to enforce institutional controls, could reduce the overall protectiveness of Alternative 3.

5.5 ALTERNATIVE 4 – AGGRESSIVE GROUNDWATER EXTRACTION WITH OFF-SITE SOIL DISPOSAL

Alternative 4, aggressive groundwater extraction with off-site soil disposal, would combine institutional controls, source removal, and an expanded groundwater extraction system to remediate significant portions of the VOC plumes. The overall objective of Alternative 4 is to contain VOC-affected groundwater within existing plume boundaries while reducing VOC concentrations in the shallow aquifer.

5.5.1 Description

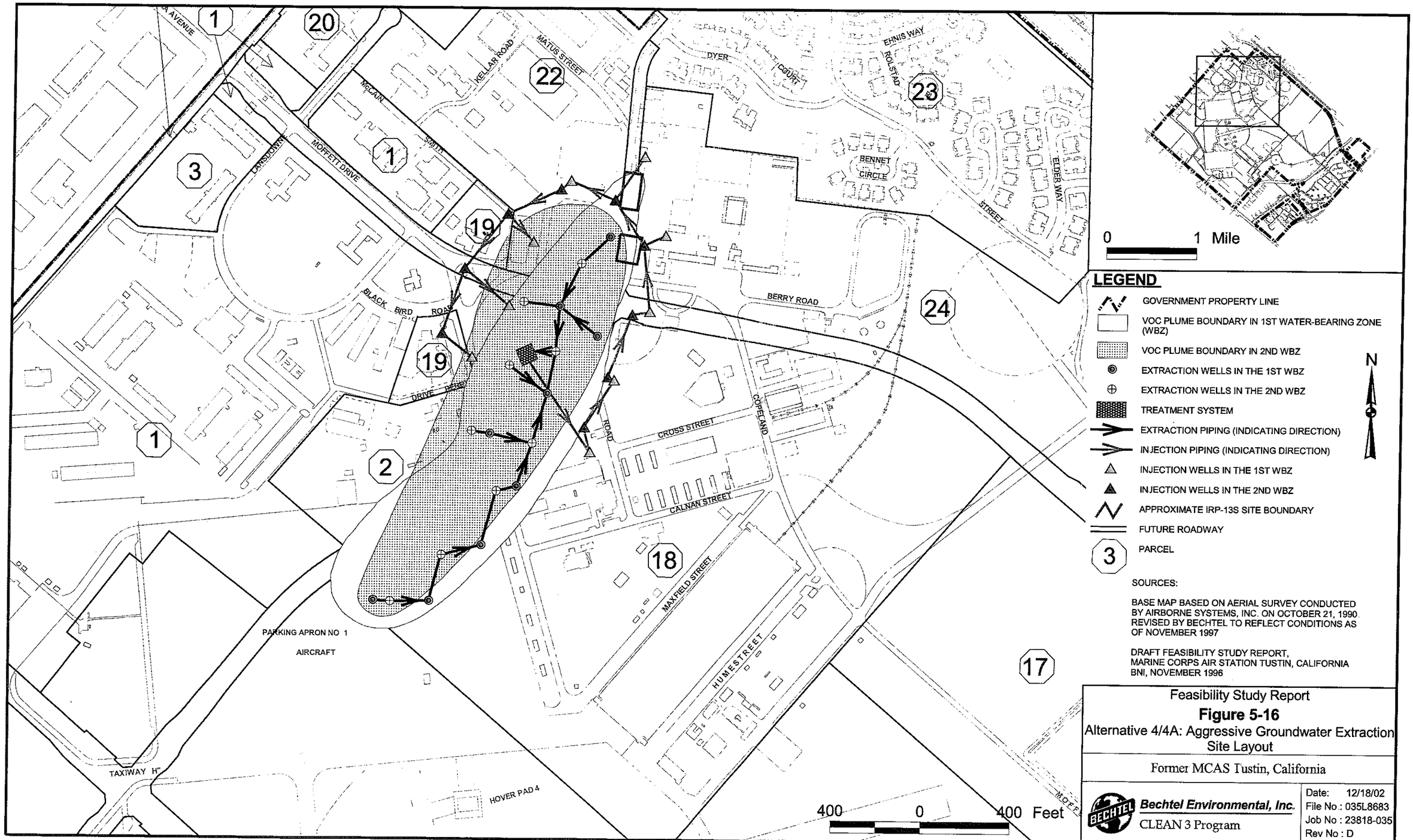
Alternative 4 is one of the more aggressive remedial response actions evaluated in this FS Report. Major components include mechanical excavation plus off-site disposal of VOC-contaminated soils, groundwater extraction and treatment using GAC, and injection of treated groundwater upgradient from the VOC plumes. Long-term performance monitoring would track the progress of remediation, supported by detailed reviews every 5 years to evaluate its continued protectiveness. Deed restrictions would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes.

Figure 5-16 presents a conceptual site layout for Alternative 4. Individual components of this alternative are discussed in greater detail in the following subsections.

5.5.1.1 EXCAVATION OF SOURCE MATERIAL

As discussed in Section 1.6.2, TCE in vadose zone soils at MWA-18 could be leached by percolating rainwater and may act as a continuing source of contamination to shallow groundwater. In addition, the VOCs adsorbed in the upper confining clays of the first WBZ could be chronic low-level sources of contamination to groundwater in the underlying sand layer under certain conditions. Groundwater modeling indicates that the VOC flux from the upper clays is currently limited (Appendix B). However, contaminant loadings to the permeable sand layer would increase significantly if the first WBZ were pumped. The continued slow release of contamination from the clays would cause TCE and 1,2,3-TCP concentrations in the sand layer of the first WBZ to eventually reach asymptotic levels somewhat above the site cleanup goals established in Section 2.5. For this reason, it would not be possible to use extraction as a stand-alone remedy to restore VOC plumes to regulatory-based standards in a reasonable time frame.

It is important to note that VOC-affected soils at OU-1A do not pose an unacceptable human-health risk (BNI 1997b). Furthermore, the mass of TCE contributed by the upper confining clay layer to the sand layer of the first WBZ is an issue only when the objective is to remediate site-related groundwater contamination by aggressive extraction. VOCs in the upper clays are not a significant concern when remediation is based on either natural attenuation (Alternative 2) or containment (Alternative 3).


LEGEND
GOVERNMENT PROPERTY LINE
VOC PLUME BOUNDARY IN 1ST WATER-BEARING ZONE (WBZ)
VOC PLUME BOUNDARY IN 2ND WBZ
EXTRACTION WELLS IN THE 1ST WBZ
EXTRACTION WELLS IN THE 2ND WBZ
TREATMENT SYSTEM
EXTRACTION PIPING (INDICATING DIRECTION)
INJECTION PIPING (INDICATING DIRECTION)
INJECTION WELLS IN THE 1ST WBZ
INJECTION WELLS IN THE 2ND WBZ
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
SOURCES:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT, MARINE CORPS AIR STATION TUSTIN, CALIFORNIA BNI, NOVEMBER 1996
0 1 Mile
N
400 0 400 Feet
MOFFETT DRIVE
LANSDOWNE
KELLAR ROAD
MATUS STREET
MCLAIN
SMITH
DYER
COURT
ELNIS WAY
ROLSTAD
BENNET CIRCLE
ELDER WAY
STREET
BERRY ROAD
BLACK BIRD ROAD
DRIVE
CROSS STREET
COPELAND
ROAD
CALNAN STREET
MAXFIELD STREET
HUMESTREET
PARKING APRON NO 1
AIRCRAFT
TAXIWAY "H"
HOVER PAD 4
1
2
3
17
18
19
20
22
23
24
Feasibility Study Report
Figure 5-16
Alternative 4/4A: Aggressive Groundwater Extraction Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/18/02
File No.: 035L8683
Job No.: 23818-035
Rev No.: D

Groundwater modeling results presented in Appendix B indicate that removal of VOC-affected soils from the upper clay layer (along with portions of the TCE-contaminated vadose zone) would markedly increase the effectiveness of groundwater extraction. The extent of the required soil excavation was also evaluated through modeling. Solely on the basis of groundwater remediation considerations, it was determined that the appropriate soil excavation criteria for TCE and 1,2,3-TCP would be 100 and 10 µg/kg, respectively. As noted in Section 2, cleanup of contaminated soils at OU-1A to health-based criteria (based on direct human contact) is not a remedial action objective for this FS Report. The development of soil excavation criteria for Alternative 4 is explained in greater detail in Appendices B and E.

The areas to be excavated under Alternative 4 are shown on Figure 5-17. Available data were sufficient to estimate soil excavation volumes for this FS Report and are considered adequate for remedial design (BNI 1997b, 1998a).

Appendix E presents estimated soil excavation volumes for two excavation techniques. An open-cut excavation technique using a slope factor of 2.5:1 would require the excavation of approximately 63,700 cubic yards of soil. Using sheet piling to shore the sides of a vertical excavation, the volume of excavated soil could be reduced to approximately 18,600 cubic yards. Construction dewatering would be necessary with both excavation methods, since soils containing elevated concentrations of TCE and 1,2,3-TCP extend below the water table to the top of the sand layer in the first WBZ. It was assumed that an excavation project using sheet piling and construction dewatering could be successfully implemented. The cost estimate for Alternative 4 was developed on this basis.

The target soil horizon for the excavation would be those portions of the vadose zone and upper confining layer of the first WBZ containing TCE at concentrations exceeding 100 µg/kg or 1,2,3-TCP exceeding 10 µg/kg. These soils generally occur at depths of approximately 1 foot bgs to 25 feet bgs at the source area

Excavated soils would be segregated into three groups according to expected concentrations of TCE and 1,2,3-TCP. Management of the soil in this manner would minimize the volume of material for off-site disposal. It would also facilitate reuse of the cleaner soil fractions as excavation backfill. One soil stockpile would include all material with expected TCE or 1,2,3-TCP concentrations exceeding 100 or 10 µg/kg, respectively. A second stockpile would contain soils with detectable but low-level VOC concentrations, i.e., material with TCE and 1,2,3-TCP at concentrations below 100 µg/kg and 10 µg/kg, respectively. A third stockpile would contain soil with no expected concentrations of TCE or 1,2,3-TCP. Figure 5-18 summarizes the expected volumes of excavated soil in each stockpile.

A temporary storage area with a liner, a berm, and leachate collection, run-on diversion, and dust control features would be constructed for the soil stockpiles at the site. The stockpiled material would be tested to determine its classification under both federal and California hazardous waste management regulations. Based on data from the RI

(BNI 1997a), it was assumed for purposes of this FS Report that none of the excavated soils would be classified as RCRA or non-RCRA hazardous waste.

After confirmation of the appropriate waste classification, soil from the first stockpile with the highest VOC concentrations would be placed in trucks, transported to a permitted Class II landfill, and disposed as nonhazardous solid waste. The off-site disposal of approximately 5,200 cubic yards of excavated soil is discussed further in Section 5.5.1.4. It was also assumed that approximately 13,400 cubic yards of soil from the other two categories (stockpiles), containing either not reported or low concentrations of TCE (up to 100 μg/kg) and/or 1,2,3-TCP (up to 10 μg/kg), would be backfilled directly into the excavations as discussed in Section 5.5.1.3. The effects on groundwater of this backfilled soil are discussed in Section 5.5.1.4.

The use of sheet piles would limit groundwater seepage into each excavation, both by minimizing the areal extent of the open area and by preventing lateral inflow. Water pumped out of the excavations and collected from the temporary soil storage areas would be stored in Baker®-type tanks and treated using mobile GAC units or the existing VOC groundwater treatment system. The treated water could be reused on-site for dust control or irrigation.

Confirmation samples would be collected at the bottom of each excavation to demonstrate removal of all soil with TCE and 1,2,3-TCP at concentrations exceeding 100 and 10 μg/kg, respectively. Analytical results would be obtained quickly, either by requesting 24-hour turnaround at an off-site laboratory or through use of an on-site field laboratory. This would minimize the time that the excavations must remain open and would reduce the volume of groundwater infiltration that must be managed by the excavation contractor.

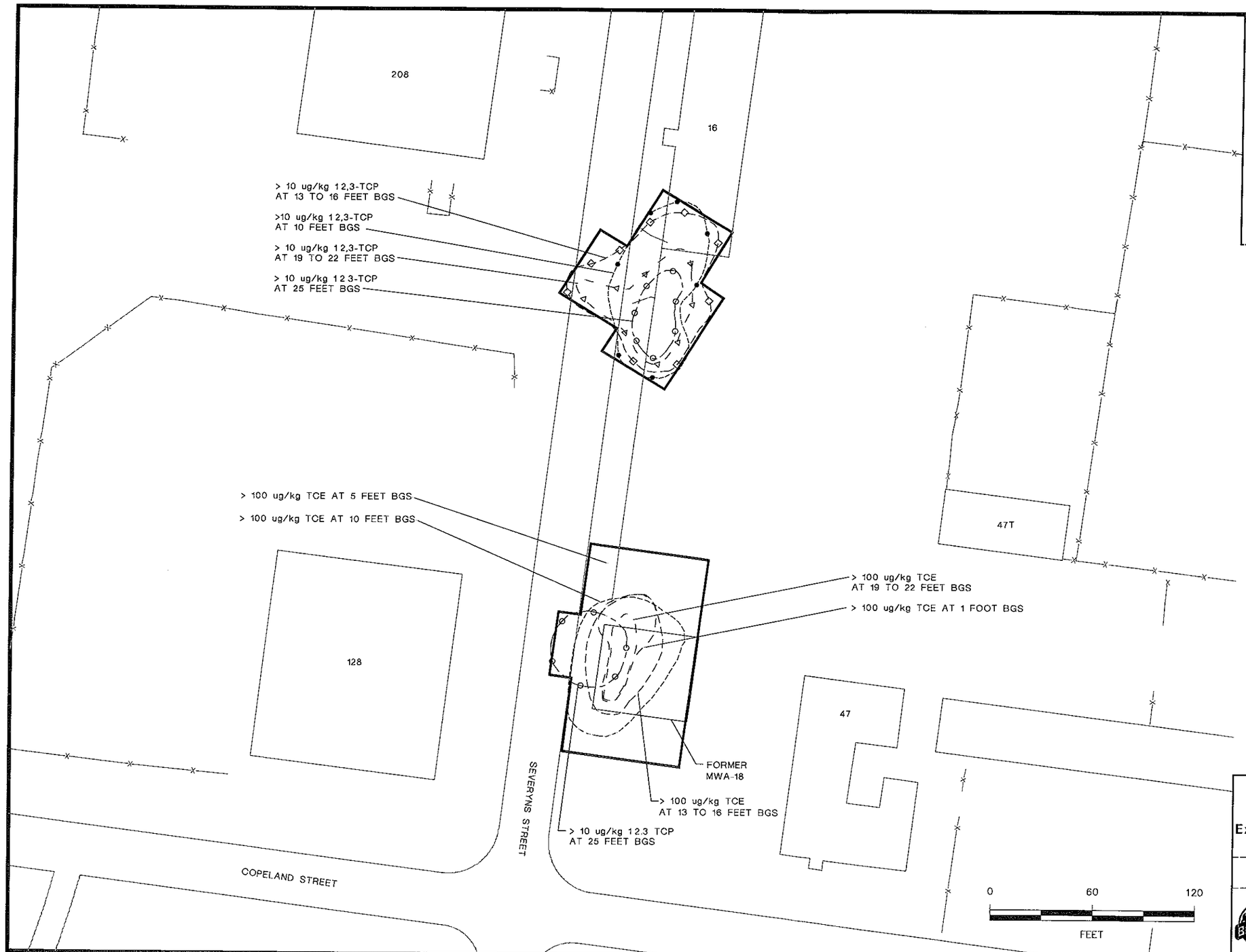
5.5.1.2 BUILDING DEMOLITION

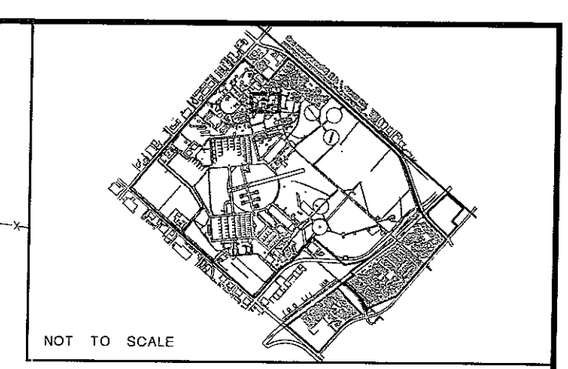
One existing structure at Former MCAS Tustin, Building 16, is located over an area that would be excavated under Alternative 4, and the building would have to be removed prior to excavation. According to the SP, Building 16 is slated for demolition (The Planning Center 1998).

Based on previous asbestos surveys conducted at Former MCAS Tustin, Building 16 contains varying amounts of asbestos-containing materials (ACMs). The presence of ACMs in Building 16 is expected to significantly increase the demolition costs for the building (Section 5.5.2.5).

5.5.1.3 BACKFILLING OF EXCAVATIONS

Excavation of source area soils under Alternative 4 would extend beneath the water table at IRP-13S. Based on the estimates presented on Figure 5-18, excavated soils that would be available as backfill would include approximately 8,700 cubic yards of soil with detectable but low concentrations of TCE and 1,2,3-TCP (less than 100 and 10 μg/kg,





LEGEND

BGS BELOW GROUND SURFACE

- > 100 ug/kg TCE AT 1 FOOT BGS
- > 100 ug/kg TCE AT 5 FEET BGS
- > 100 ug/kg TCE AT 10 FEET BGS
- > 100 ug/kg TCE AT 13 TO 16 FEET BGS
- > 100 ug/kg TCE AT 19 TO 22 FEET BGS
- > 10 ug/kg 1,2,3-TCP AT 10 FEET BGS
- > 10 ug/kg 1,2,3-TCP AT 13 TO 16 FEET BGS
- > 10 ug/kg 1,2,3-TCP AT 19 TO 22 FEET BGS
- > 10 ug/kg 1,2,3-TCP AT 25 FEET BGS
- VERTICAL SHEET PILE EXCAVATION LIMIT

NORTH — N — TRUE

NOTES:

AREA OF EXCAVATION INCLUDED ALL TCE CONTAMINATION > 100 ug/kg AND ALL 1,2,3-TCP CONTAMINATION > 10 ug/kg EXCAVATION AREAS ARE APPROXIMATE ASSUMING VERTICAL SHEET PILING

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report

Figure 5-17

Extent of TCE and 1,2,3 - TCP Soil Contamination and Excavation Areas at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 1/22/03
File No: 035L8684
Job No: 23818-035
Rev No: C

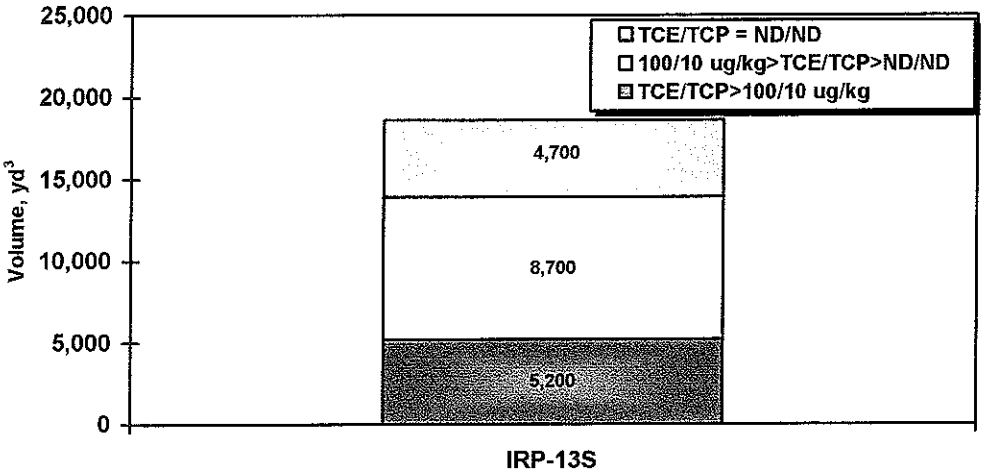


Figure 5-18
Volume of Soil to Be Excavated Under Alternative 4

respectively) and approximately 4,700 cubic yards of soil with no reported VOC contamination. Approximately 5,200 cubic yards of clean fill, assumed to be ungraded sand for purposes of this FS Report, would have to be obtained from an off-site commercial source to complete the backfilling to grade.

Excavation backfill would be placed to minimize the amount of soil with low concentrations of VOCs below the water table. The intent would be to prevent creation of a new contaminant source that could desorb VOCs under the influence of groundwater extraction. To the extent possible, only soil with no reported concentrations of TCE and 1,2,3-TCP would be replaced below the water table. Soil with reported concentrations of VOCs ranging up to the 100 µg/kg TCE and 10 µg/kg 1,2,3-TCP action levels would be placed between a depth of 1 foot to 2 feet above the seasonal high water table and the ground surface. This concept is illustrated on Figure 5-19. As discussed in Section 5.5.1.4, leaching of VOCs from backfilled soil with VOC concentrations below the action levels is not expected to cause VOC concentrations in groundwater to be above the MCLs.

5.5.1.4 EFFECTS OF BACKFILL WITH LOW LEVELS OF VOCs

As discussed in Sections 5.5.1.1 and 5.5.1.3, the appropriate excavation criteria for soils that will be used as backfill are 100 µg/kg of TCE and 10 µg/kg of 1,2,3-TCP, respectively. Soil with VOCs at concentrations that do not exceed these criteria will be used as backfill above the seasonal high water table (vadose zone). However, for the saturated flow modeling using MODFLOW, it was assumed that there was no vadose zone source of TCE or 1,2,3-TCP for most remediation alternatives. In addition, a few alternatives did not include a saturated zone source for the saturated portion of the

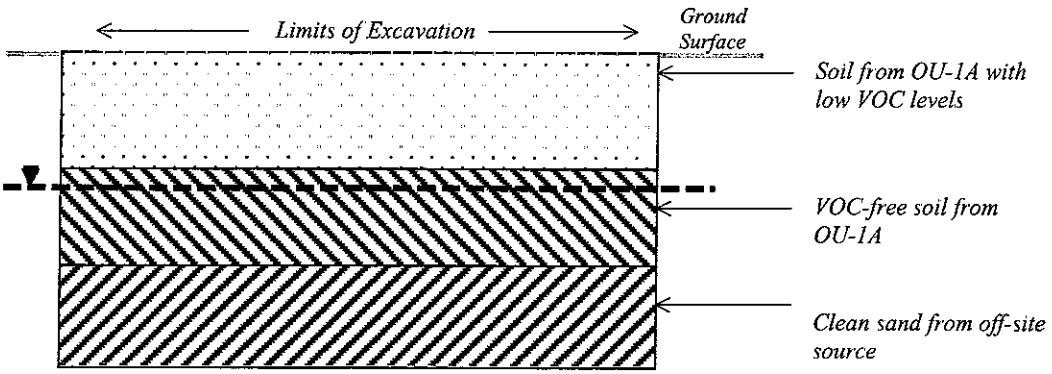


Figure 5-19
Backfilling of Excavation Following Source Removal

confining clay. The assumptions used in the saturated flow modeling for the VOC source in the first WBZ (which consists of saturated and vadose zone portions) were as follows:

- vadose zone TCE source varied, using two conditions:
  - all reported TCE is present
  - all reported TCE is removed (no vadose zone source)
- no vadose zone 1,2,3-TCP source
- saturated zone TCE and 1,2,3-TCP sources

These assumptions were based on the results of the vadose zone leachate modeling conducted using VLEACH, which was used in the RI (Appendix W) to predict VOC concentrations in groundwater in the first WBZ sand resulting from leaching in the vadose zone (BNI 1997a). These results indicated that TCE and 1,2,3-TCP concentrations in groundwater resulting from vadose zone leaching are much less than the existing concentrations in groundwater. Since predicted TCE and 1,2,3-TCP concentrations in groundwater due to vadose zone leaching make up a very small portion of the total TCE and 1,2,3-TCP to be remediated, vadose zone leaching was ignored in most cases using the saturated flow model.

Since any TCE and 1,2,3-TCP remaining in the backfilled soil could continue to be a source of groundwater contamination, the VLEACH results were reexamined to evaluate the potential impact to groundwater of this backfill. As discussed in Appendix W of the RI (BNI 1997a), evaluation of the impact of a TCE and 1,2,3-TCP source in the vadose zone consisted of three steps, as follows.

- Initial screening (Step 1) was performed using a conservative estimate of the maximum predicted groundwater concentration from leaching based on maximum COPC soil concentration.

- If applicable water quality criteria and background concentrations were exceeded, then VLEACH modeling (Step 2a) was performed using a conservative estimate of the maximum predicted groundwater concentration based on the maximum COPC soil concentrations.
- If the predicted concentration in groundwater exceeded two times the tap water PRG, then VLEACH modeling (Step 2b) was performed using a more realistic estimate of the maximum and 30-year average predicted groundwater concentrations based on the average COPC soil concentrations.

The assumptions used for the VLEACH model are as follows.

- Aquifer mixing occurred (leachate mixing with groundwater attenuates the leachate concentrations).
- The upper 10-foot-thick confining clay layer is absent (conservative assumption, since clay would retard movement of VOCs to the underlying sand)
- Biodegradation is neglected (conservative assumption).
- Infiltration (recharge) is 1.3 inches (conservative assumption, since based on the MODFLOW sensitivity analysis, recharge is probably 0.5 inch or less; significantly higher values such as 1.5 inches resulted in unrealistic water levels).

Predicted concentrations of TCE and 1,2,3-TCP in groundwater due to vadose zone leaching were based on the reported concentrations in vadose zone soil (from Table W-12b in the RI [BNI 1997a]). A summary of the reported VOC concentrations in soil and the predicted 30-year average concentrations of TCE and 1,2,3-TCP in the first WBZ resulting from the vadose zone backfill leachate are presented in Table 5-7.

Predicted concentrations of TCE and 1,2,3-TCP in soil are generally within the range expected for the backfilled soil above the water table. Therefore, the results of the VLEACH modeling for these soil concentrations are considered to produce predicted TCE and 1,2,3-TCP concentrations in groundwater that are representative of expected concentrations due to leaching from the backfill.

The modeling results presented in Table 5-7 indicate that the leachate from vadose zone backfill would result in TCE and 1,2,3-TCP at concentrations in groundwater that are near or below their respective site remediation goals of 5 and 0.6 µg/L. Moreover, the actual TCE concentrations may be lower than these predicted concentrations due to biodegradation, a probable lower infiltration rate, and the attenuating effects of the clay layer, all of which were either ignored or conservatively assumed in the VLEACH model.

5.5.1.5 OFF-SITE DISPOSAL OF SOURCE MATERIALS

As noted in Section 3.3.3.6, shipment of VOC-contaminated soil to a commercial Class II landfill was determined to be the preferred means to dispose of this material, provided that it is not classified as hazardous waste. This disposal option was assumed for Alternative 4. Transport of approximately 5,200 cubic yards of VOC-contaminated soil

Table 5-7
Predicted VOC Concentrations in Groundwater From Backfilled Soils

VOC	Reported Concentration Range in Soil (µg/kg)	Predicted Concentration Range in Groundwater (µg/L)[a]
TCE	46–138	6.5[b]
1,2,3-TCP	5–20	0.55–0.89

Notes:
[a] 30-year average
[b] no range reported since only one loading cell in the model had soil concentrations on the order of 100 µg/L or less

Acronyms/Abbreviations:
µg/kg – micrograms per kilogram
µg/L – micrograms per liter
TCE – trichloroethene
TCP – trichloropropane
VOC – volatile organic compound

from OU-1A would be conducted by a licensed waste hauler in accordance with applicable state and federal regulations. Upon receipt and acceptance of the excavated materials by the Class II landfill, ongoing management of the soil would be the responsibility of the commercial facility and no further action would be required of the DON. It was assumed that all intermediate storage and final disposal activities at the Class II landfill would be conducted in accordance with the operating permit and applicable regulations under which the facility operates.

Information was obtained from several commercial landfills in the Los Angeles metropolitan area that are permitted to accept soil contaminated with low concentrations of chlorinated solvents, waste oils, PAHs, and metals. These facilities are located in Los Angeles, Riverside, and San Bernardino Counties. A Class II landfill in northern Los Angeles County, about 100 miles from Former MCAS Tustin, was selected as a representative facility for the purpose of developing a cost estimate for this FS Report. During detailed design, bids would be solicited from several landfills to identify the least costly option for off-site management of the excavated soils. In conjunction with the final design effort, U.S. EPA must also determine that the Class II landfill ultimately selected for off-site disposal of OU-1A soils is qualified to receive waste from a CERCLA site per 40 C.F.R. § 300.440.

The owner/operator of the Class II landfill would establish acceptance criteria for the soils to be removed from OU-1A. To demonstrate compliance with these requirements, testing would be conducted before the excavated source material is shipped from the site.

5.5.1.6 GROUNDWATER EXTRACTION

The groundwater extraction systems under Alternative 4 would be designed to contain and remediate the VOC plumes, as shown on Figure 5-16. Extraction wells would be installed to achieve these objectives in both the first and second WBZs. Extraction wells would maintain a constant upward hydraulic gradient from the second to the third WBZ, eliminating the potential for seasonal downward migration of 1,2,3-TCP in a localized area near the intersection of Cross Street and McCord Road.

The actual number of extraction wells, well locations, and pumping rates required by Alternative 4 was determined based on aquifer tests, geologic cross-sections, and groundwater monitoring completed for the RI and the RFA (BNI 1997a,b). Modeling was used to optimize the conceptual design of the groundwater extraction system, as detailed in Appendix B.

A total of 18 groundwater extraction wells would be required under Alternative 4. Table 5-8 summarizes the proposed completion depths and pumping rates for these wells. As shown on Figure 5-16, extraction wells would be located along the centerlines of the VOC plumes, with at least one well placed near the portion of each plume with the highest VOC concentrations. Actual extraction well locations and depths would be determined during remedial design.

Groundwater modeling results, discussed in Section 5.5.1.7, indicate that the groundwater extraction wells would produce a combined 90 gpm (45 gpm from each of the first and second WBZs), equivalent to an influent flow rate of approximately 130,000 gpd to the treatment system. Actual extraction rates may vary from these estimates due to the heterogeneity of the shallow aquifer and the uncertainties related to groundwater modeling. This issue would be addressed through groundwater extraction tests conducted at the proposed well locations during remedial design.

Figure 5-9 presents a conceptual schematic design of the type of extraction well that would be constructed under Alternative 4. Each well would be completed as a 6-inch-diameter, production-type water well. For cost estimation purposes, it was assumed that the wells would be constructed using stainless steel casings and well screens. The actual materials of construction would be determined during remedial design. A sand pack would be placed around each screen. The annular space between the screened interval and ground surface would be sealed with grout. The wells would be completed with dedicated submersible pumps along with the necessary piping and electrical controls.

Installation and completion of the extraction wells would be in accordance with the substantive requirements of Orange County Ordinance No. 2607. In addition, the wells would be constructed to meet DWR specifications and safety and health standards (DWR 1991).

The groundwater extraction wells installed under Alternative 4 would be operated in a pulsed mode, with the submersible pumps cycled on and off every 2 to 3 days. Field testing completed at an adjacent site (IRP-3) in 1997 showed that pulsed pumping can

Table 5-8
Extraction Well Details for Aggressive Groundwater Extraction

Water-Bearing Zone	Number of Wells	Completion Depth* (feet bgs)	PUMPING RATE (gpm)	
			Each Well	Combined
First	9	30–34	5	45
Second	9	55–60	5	45
Total	18			90

Note:
* completion depths shown are estimated; actual depths would vary depending on conditions encountered at each location

Acronyms/Abbreviations:
bgs – below ground surface
gpm – gallons per minute

significantly improve the overall effectiveness of groundwater extraction (BNI 1998a). This mode of operation appears capable of removing similar amounts of VOC mass as continuous extraction, while pumping only about half the groundwater volume. During each cycle, pulsed pumping allows the groundwater to reequilibrate with the VOC mass adsorbed to the soil matrix in the pumping cone of depression. Such periodic "flushing" of the soil matrix moves adsorbed VOCs to the dissolved phase for removal with the extracted groundwater during the next pumping cycle. Because hydraulic recovery is relatively rapid in the shallow aquifer at Former MCAS Tustin (full recovery takes less than a day after the well pumps are shut off), a pumping cycle of 2 to 3 days appears to be optimal from an operational standpoint (BNI 1998a).

Under Alternative 4, the groundwater extraction wells would continue to operate until VOC concentrations in the sand layers of the first two WBZs approached asymptotic levels. Based on the modeling described in Appendix B, extraction is expected to continue for 15 years at OU-1A. Extraction for longer periods is not expected to result in significant additional contaminant reduction (Figures 5-20 and 5-21). After the extraction systems are shut down, natural attenuation processes would continue to reduce residual VOCs to site cleanup goals.

5.5.1.7 GROUNDWATER CONVEYANCE AND TREATMENT

With all extraction wells operating in pulsed mode, Alternative 4 would yield nearly 24 million gallons of water per year. The total volume of groundwater to be managed by this alternative would be almost 350 million gallons, assuming pulsed operation of the extraction systems for 15 years at IRP-13S. Groundwater would be delivered to treatment via buried pipelines constructed according to applicable city of Tustin codes. Approximately 2,560 feet of double-walled conveyance piping would be required by Alternative 4.

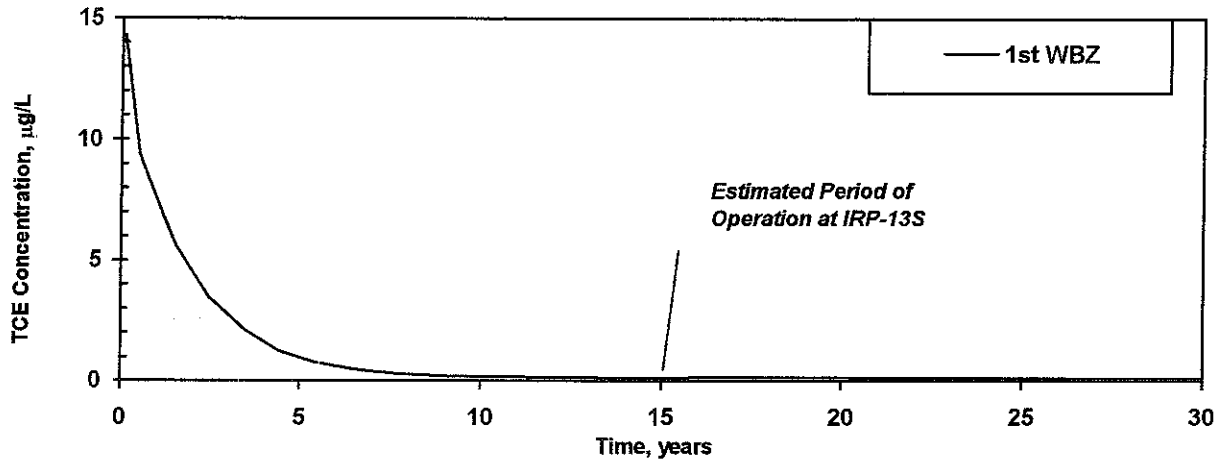


Figure 5-20
Predicted TCE Concentrations
in Aggressive Groundwater Extraction Wells

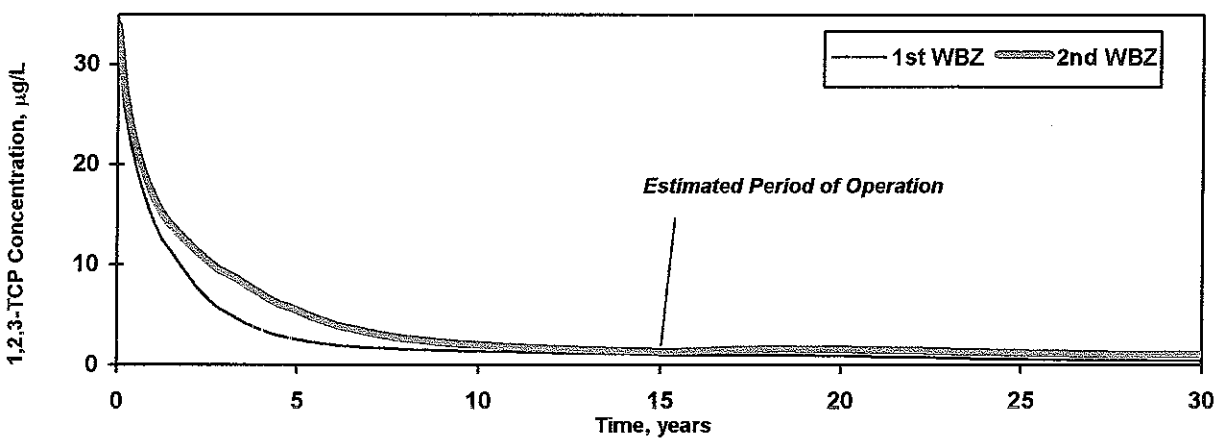


Figure 5-21
Predicted 1,2,3-TCP Concentrations
in Aggressive Groundwater Extraction Wells

A groundwater treatment facility would be constructed under Alternative 4. As shown on Figure 5-16, the treatment facility would be constructed near the location of the existing TCRA treatment system.

The treatment facility would consist of an equalization tank, cartridge filters, modular GAC units, and associated pumps, piping, and controls. Two-stage GAC adsorption would be used to reduce the OU-1A COCs to concentrations that would permit upgradient injection of the treated water to enhance flushing of the shallow aquifer. The injection system is discussed in more detail in Section 5.5.1.8, and the selection of GAC as the preferred process option for removing VOCs from groundwater is documented in Sections 3.3.2.7 and 5.4.1.2.

The capacity of the equalization tank at the treatment facility would be 20,000 gallons, sufficient to hold between 4 and 5 hours of flow with all wells operating. The equalization tank would be used to prevent flow surges due to cyclic operation of the pumps in the individual extraction wells. Such surges might affect the performance of the GAC adsorbers if not properly controlled. The tank would be equipped with level control switches to shut down the extraction wells if necessary to prevent overflows.

Sample taps would be provided so that the effluent at the plant could be monitored against treatment objectives. Samples could also be obtained from the individual extraction wells, from the equalization tank effluent, and from between the GAC vessels to monitor the performance of individual carbon units and determine when to replace spent GAC in the lead adsorber.

Modeling was used to predict influent TCE and 1,2,3-TCP concentrations to the treatment plant, as shown on Figures 5-20 and 5-21. Other VOCs occur at much lower concentrations in groundwater at OU-1A, and these concentrations would be expected to decline with time in the extracted groundwater in a similar manner. At the treatment facility, the maximum influent concentrations of the flow-weighted design are 15 and 31 μg/L for TCE and 1,2,3-TCP, respectively. Using the predicted groundwater extraction rates and design influent VOC concentrations, an estimated carbon usage rate of 0.087 pound per thousand gallons treated (equivalent to approximately 2,100 pounds of GAC annually) was calculated for the first year of operation at the treatment facility.

Operation of the OU-1A treatment plant for 15 years (the basis for the FS cost estimate) would produce a maximum of approximately 31,000 pounds of spent GAC. The maximum VOC loading on the GAC removed from the treatment facility is anticipated to be less than 1.5 percent by weight. Regeneration or disposal of the spent carbon would be the responsibility of the GAC supplier under a long-term service contract. For purposes of this FS Report, it was assumed that spent GAC would be taken off-site for regeneration, which is the typical practice on groundwater remediation projects. Prior to shipment from the site, the spent GAC would be tested to determine its waste classification (nonhazardous, RCRA hazardous, and/or non-RCRA hazardous). Characterization, packaging, and transport of this material would be in accordance with DOT, U.S. EPA, and DTSC requirements

5.5.1.8 INJECTION OF TREATED GROUNDWATER

Treated effluent from the groundwater treatment system would be pumped to injection wells installed hydraulically upgradient of the VOC plumes at IRP-13S. Injection into the first and second WBZs would create a mound of groundwater that would increase the hydraulic gradient towards the extraction systems, diverting upgradient clean groundwater around the contaminated areas while enhancing the flushing of the contaminated areas and reducing the time required for aquifer restoration. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if reinjection is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, effective groundwater mounding geometries and injection inflow rates, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using percolation ponds, or use in wetlands, will also be evaluated.

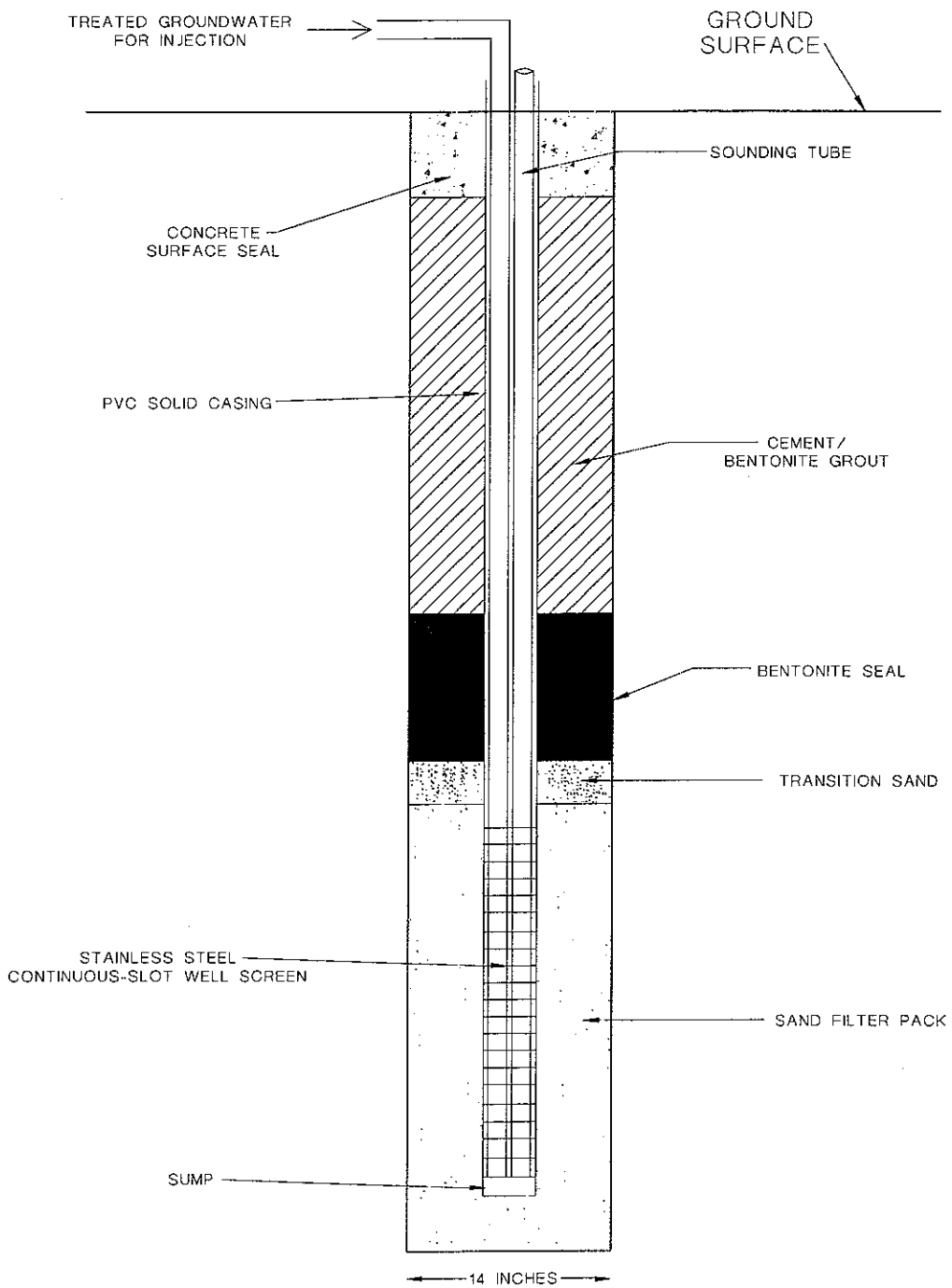
As a CERCLA remediation activity conducted entirely on-site, the injection of treated groundwater would not require a permit from the RWQCB. However, the substantive provisions of the Basin Plan would constitute an ARAR for groundwater injection, and the treatment system and injection wells would be designed and operated to comply with these requirements. This issue is discussed in more detail in Section 2.3 and Appendix A.

VOC concentrations in the injected water would be at or below the site remediation objectives listed in Table 2-5. However, the groundwater treatment systems would not be designed to remove TDS, nitrate, sulfate, selenium, or other inorganics. As discussed in Section 1.4.2, these constituents are known to be at elevated background concentrations in the shallow aquifer at Former MCAS Tustin for reasons unrelated to USMC operations. The treated groundwater would therefore be injected into portions of the first and second WBZs with similar background conditions. Groundwater injection, as proposed for Alternative 4, would not markedly change or increase the mass or concentration of TDS, nitrate, or other inorganics in the shallow aquifer.

Pipelines would convey VOC-free treated effluent from the treatment plants to the injection wells. Approximately 3,800 feet of single-walled buried conveyance piping would be required. These pipelines would be installed according to applicable city of Tustin codes.

A total of 18 injection wells would be installed under Alternative 4 at the proposed locations illustrated on Figure 5-16. Nine injection wells each would be completed in the first and second WBZs. These wells would receive and inject a combined maximum flow of approximately 90 gpm of treated water.

The basic design for the injection wells would be similar to that proposed for the extraction wells. As shown on Figure 5-22, treated water would be fed to the well screen via a conductor pipe. An orifice plate and diffuser screen would control flow into the well at the end of the submerged pipe, minimizing turbulence. Facilities at the wellhead would include ports to allow for measurements of water levels and depth. For cost



NOT TO SCALE

Feasibility Study Report

Figure 5-22

Typical Injection Well

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/16/02
File No: 035X8685
Job No: 23818-035
Rev No: B

estimation purposes, it was assumed that the wells would be constructed using stainless steel casings and well screens. The actual materials of construction would be determined during remedial design. Screen lengths would vary depending on conditions encountered at each location. A sand pack would be placed around each well screen, and the annular space between the screened interval and ground surface would be sealed with grout in compliance with DWR specifications (DWR 1991).

5.5.1.9 PERFORMANCE MONITORING

Performance monitoring during the operating period for Alternative 4 (expected to be 15 years) would verify capture of the plume, monitor changes in the distribution and magnitude of TCE and 1,2,3-TCP contamination within the shallow aquifer, and demonstrate successful treatment of the extracted groundwater. Performance monitoring requirements are summarized in Table 5-9. After active operations cease, monitoring would continue to track the migration of the VOC plume remnants in the first and second WBZs. Over time, residual TCE and 1,2,3-TCP concentrations would slowly attenuate due to naturally occurring processes such as dilution, dispersion, and adsorption. Modeling-based predictions presented in Appendix B indicate that the plume remnants would not migrate significantly beyond existing plume boundaries at concentrations above site cleanup goals. For purposes of this FS Report, the postoperational monitoring period was assumed to last through the 30th year after remediation begins, or 15 years after groundwater extraction ceases. The actual length of the operational and postoperational monitoring periods would dictated by field conditions.

The long-term groundwater monitoring program for this alternative would use a combination of existing and new wells. For the purpose of developing a cost estimate, it was assumed that two new groundwater monitoring wells would be installed, one well in each WBZ. In addition, it was assumed that four existing wells would be included in the groundwater monitoring plan. Thus, a total of six wells would be monitored for Alternative 4. The actual number of monitoring wells to be sampled and the locations and specifications for any new monitoring wells (depths, screened intervals, and well construction materials) would be determined during remedial design and documented in the long-term monitoring plan. This plan would also provide details concerning sampling procedures, target analytes, analytical methods, field and laboratory QA/QC, and reporting requirements. Well locations and surface completion methods would take accessibility into consideration, along with the need to minimize impacts on redevelopment of the Former MCAS Tustin property.

The frequency of groundwater monitoring would vary over time. During the initial stages of system start-up and equilibration, monitoring of water levels in the extraction and injection wells would be on a near-continuous basis using pressure transducers and data loggers. This initial period of monitoring was assumed to extend for no more than 2 weeks, after which water level monitoring would switch sequentially to daily, weekly, monthly, and finally quarterly measurements. Groundwater samples for VOC analysis would be collected quarterly for the first 3 years after implementation of Alternative 4, semiannually for the next 7 years, and annually through the 30th year of operation.

Table 5-9
Performance Monitoring for Aggressive Groundwater Extraction

Type of Monitoring Data	Monitoring Locations	Purpose/Use of Data
Water levels	Monitoring wells throughout and around the VOC plumes	Prepare potentiometric surface maps and hydrographs Determine horizontal and vertical hydraulic gradients Confirm capture zones
VOC concentrations in the shallow aquifer	Monitoring wells throughout and around the VOC plumes	Delineate areal and vertical extents of contamination Confirm remediation of plumes and assess progress toward cleanup goals Estimate remaining contaminant mass
VOC concentrations in extracted groundwater	Extraction wells and equalization tank effluent	Estimate cumulative mass of VOCs removed from aquifer Characterize extracted groundwater from individual wells and combined treatment plant influent with respect to RCRA and non-RCRA hazardous waste criteria Determine when extraction should cease because contaminants have reached asymptotic levels
VOC concentrations in treatment plant effluent	Effluent lines from GAC vessels	Assess performance of treatment system Demonstrate that treated groundwater meets site cleanup requirements prior to injection
Flow rates	Extraction/injection wells and various points in treatment system	Confirm that extraction, treatment, and injection systems are operating to specifications
Other operational parameters (e.g., water line pressures, water levels in injection wells)	Various locations	As needed to assess proper operation or incipient failure of pumps and filters as well as rising water levels in injection wells that may signal clogging

Acronyms/Abbreviations:
GAC – granular activated carbon
RCRA – Resource Conservation and Recovery Act
VOC – volatile organic compound

Performance monitoring samples from each treatment plant would be collected monthly from the equalization tank effluent, lead GAC vessel effluent, and final effluent and would be analyzed for VOCs. Total extraction rates and line pressures would also be recorded. The specifics of the treatment plant performance monitoring activities would be determined during remedial design and documented in the long-term monitoring plan.

5.5.1.10 INSTITUTIONAL CONTROLS

Institutional controls are nonengineering mechanisms, particularly legal measures, designed to limit activities or access at a site to protect the selected remedy. Institutional controls fall into two broad categories, restrictions on future land use and provisions for access for future monitoring and maintenance. Proposed future land use is described in the MCAS Tustin SP. The SP indicates that the parcels at Former MCAS Tustin currently overlying the VOC plumes, as well as the downgradient parcels under which the plumes is expected to migrate, will be redeveloped for residential, commercial, and recreational use (The Planning Center 1998).

Alternative 4 includes deed restrictions for parcels overlying the VOC plumes (approximately 54.1 acres), plus an approximately 200-foot buffer zone surrounding the plume and the alignment of the conveyance piping connecting the extraction wells to the treatment system, the treatment system facility, and the discharge location (Figure 1-5). The land-use control objective within the RAOs is for protection of human health by preventing extraction of VOC-impacted groundwater. Restrictions designed to limit inhalation of VOCs are not necessary as long as groundwater extraction is prohibited within the current OU-1A plume boundaries (Appendix F). Deed restrictions would include the following elements to achieve the land-use control RAO:

- prohibitions on the installation of public or private water supply wells in the shallow aquifer within the area of institutional controls
- prohibitions on the installation of underground utilities, including trenches, within the groundwater in the area requiring institutional controls without the review and approval by the DON and other regulatory agencies; improperly designed subsurface utilities including the backfilled trenches may create preferential pathways for the transport of contaminated groundwater and negatively impact the remedial alternative
- prohibitions on construction or other activities that would disturb or otherwise negatively impact the monitoring wells, extraction wells, treatment system, conveyance piping, or the discharge structure without prior approval from the DON
- provisions to allow the DON and other regulatory agencies access to install new or destroy old monitoring wells and implement supplemental remedial measures in the future, if necessary
- provisions to allow the DON and other regulatory agencies access to monitor the remedial action (i.e., the monitoring wells, extraction wells, conveyance piping, treatment system, and discharge structure)

- requirements to notify the DON in advance of any plan to lease or transfer affected parcels
- requirements to notify the DON and regulatory agencies in a timely manner of any change in site conditions that potentially compromises the remedy or endangers public health or the environment

Based on the current estimated extent of the VOC plumes, the deed restrictions would be needed over an area of approximately 54.1 acres plus an approximately 200-foot buffer zone surrounding the plume and the remediation system components.

The deed restrictions required for Alternative 4 would not hinder the development of the Former MCAS Tustin property. None of the expected land-use scenarios on the affected parcels would require the installation of wells and use of groundwater from the shallow aquifer. The deed restrictions only require that wells installed in the regional aquifer are constructed with well screen depths and seals sufficient to prevent cross-contamination with the shallow aquifer. These restrictions will protect the selected remedy and will not affect development of the groundwater resource. Deed restrictions on the installation of underground utilities can be addressed with appropriate engineering controls.

The deed restrictions would remain in effect until monitoring data show that the VOC contamination levels in the groundwater meet the remediation goals. The time estimated for remediation, based on groundwater modeling, is greater than 30 years.

5.5.1.11 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater monitoring and system performance data would be conducted every 5 years to determine whether the extraction wells were effectively containing the contaminated shallow groundwater and reducing VOC concentrations as expected. If satisfactory progress toward site remediation goals was not being demonstrated, it might be necessary to modify the design and/or operation of the groundwater extraction system. Possible modifications might include relocating or adding extraction wells, increasing or decreasing pumping rates, or adjusting certain wells from a pulsed pumping mode to continuous extraction.

These 5-year reviews would also assess the adequacy of the performance monitoring program and suggest revisions as necessary to meet project objectives. Modifications might include the abandonment of some monitoring wells as portions of the VOC plumes are restored. Adjustments in monitoring frequency would also be made in response to field data.

Results of each periodic review would be documented in a summary report submitted by the DON to the regulatory agencies responsible for program oversight.

5.5.2 Detailed Analysis

Alternative 4 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.5.2.1 SHORT-TERM EFFECTIVENESS

The greatest short-term risks during implementation of Alternative 4 would occur to workers and the surrounding community during excavation and handling of contaminated soils at the site. Workers involved in these activities might also be exposed to contaminated groundwater, since the excavations would extend below the water table. Potential impacts to the surrounding community might occur as a result of a relatively large-scale excavation project and its associated noise, dust, and vehicular traffic. Transport of contaminated materials over public highways would present short-term risks to other drivers and residents along transportation routes.

The greatest potential short-term risks to the community would be associated with the increased vehicular traffic. Based on the excavation volumes discussed in Section 5.5.1.1, approximately 270 truck trips (270 round trips are equivalent to 540 trips total) would be required to transport contaminated soils from the site to the off-site Class II landfill, and then return to the site with clean backfill. This volume of truck traffic would be negligible compared to overall traffic levels within the metropolitan Los Angeles area, especially when spread out over several months. However, no overland transport is risk free, and Alternative 4 would entail the possibility of a vehicular accident potentially involving the release of contaminated material. Short-term transportation impacts would be minimized through use of a licensed commercial hauler required to follow all applicable federal, state, and local regulations dealing with transport of the soils removed from the station.

A rigorous health and safety plan and remedial action work plan would have to be developed and successfully implemented to minimize short-term risks to workers and the surrounding community during soil excavation and handling. These plans would prescribe personal protection equipment as well as monitoring and mitigation measures needed to minimize risks. Appropriate engineering and industrial hygiene controls would be required, such as dust suppression measures, perimeter monitoring, traffic safety planning, spill prevention, and contingency planning.

Other short-term risks during implementation of Alternative 4 would include potential exposure to contaminated groundwater and soil during installation of the extraction system, conveyance pipelines, injection wells, and monitoring wells. Additional construction work would include assembly of the treatment plants and associated piping, instrumentation, mechanical systems, and electrical controls. Potential short-term impacts from these activities would be controlled through the site-specific health and safety plan and remedial action work plan.

Short-term risks would also be associated with the start-up of the extraction wells and the treatment plants, as these activities would entail management of VOC-contaminated groundwater in otherwise untested systems. Potential impacts from inadvertent releases would be controlled through a spill prevention plan developed prior to construction. This plan would identify procedures for rapid spill response and cleanup as well as measures to prevent or contain releases. Impacts on the community or on-site workers would be minimal under these circumstances.

The duration of the soil excavation, well installation, and treatment plant construction activities would be approximately 6 months. Following construction, the system would be tested to confirm the performance of each component before long-term operations commenced. This initial "shake-down" period should last no more than 3 months. Assuming that the deed restrictions could be established concurrent with remedial design, the major components of Alternative 4 would be in place approximately 9 months after mobilization for field construction. At that point, the combination of institutional controls and engineered remediation systems that this remedy comprises would effectively limit the further migration of the VOC plumes, while significantly reducing the mass and concentration of VOCs in the subsurface along with the potential for human exposure to contaminated shallow groundwater.

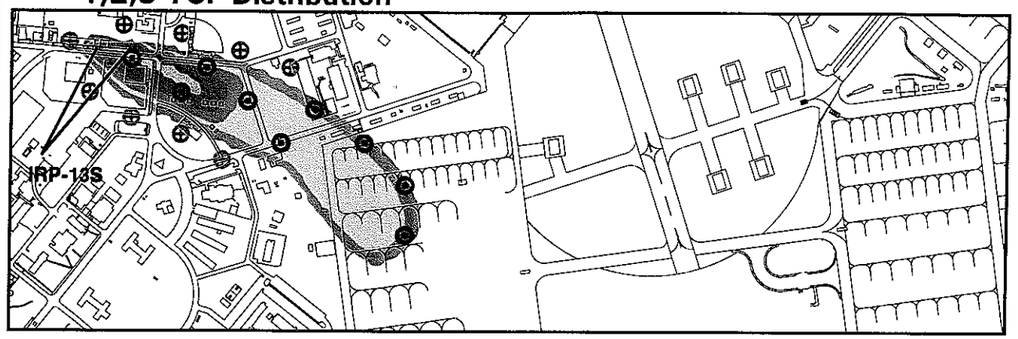
5.5.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

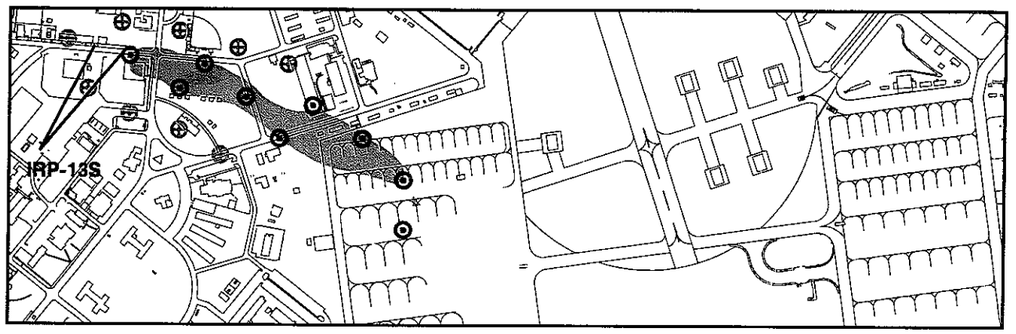
Alternative 4 would be designed and implemented to contain VOC-affected groundwater within existing plume boundaries while reducing concentrations of site-related contaminants in the first and second WBZs to the site remediation goals established in Section 2.5. This alternative would use proven, conventional technologies in an aggressive remediation program. When all components have been successfully implemented, Alternative 4 would be an effective, permanent means to address the plume at and downgradient of IRP-13S.

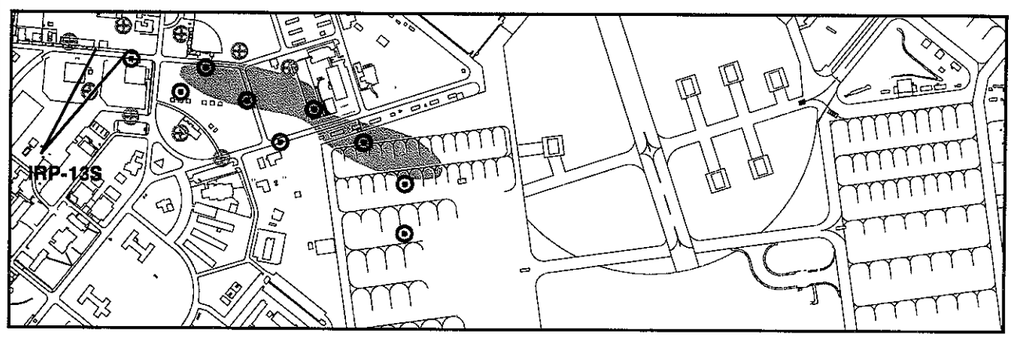
There are, however, potentially significant technical issues that could complicate achieving site cleanup goals throughout the VOC plumes under Alternative 4. Major complications could arise from the heterogeneous, anisotropic nature of the shallow aquifer and the presence of potentially significant quantities of contamination in fine-grained, low-permeability clay layers. As noted in Section 2.6, these low-permeability soils cannot easily be remediated. Extraction from the sand layers of the first two WBZs would not significantly reduce VOC concentrations in the clays. In some cases, adsorbed VOCs in the lower confining clay layer of the first WBZ may actually serve as a continuing source of contamination to other, more transmissive portions of the shallow aquifer. The impact of site heterogeneity and other characteristics will not be known until the OU-1A groundwater extraction systems have been installed and operated for a period of time, perhaps a year or more.

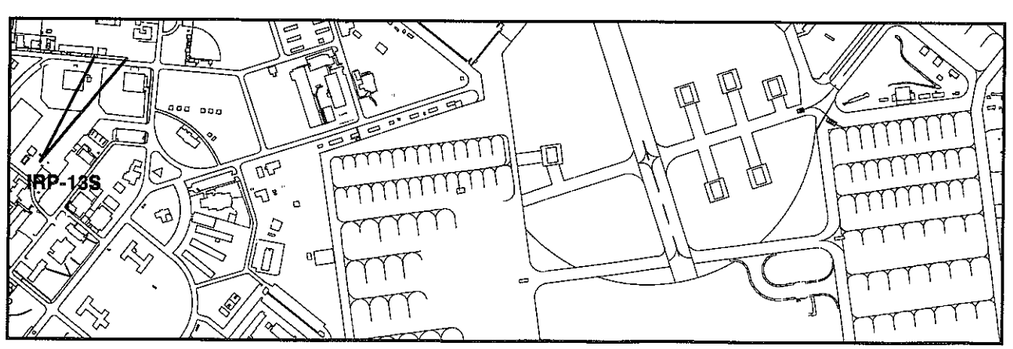
Computer modeling of the groundwater extraction/treatment/injection system under Alternative 4 is discussed in Appendix B. Results of the simulation are depicted in Figures 5-23 and 5-24. These figures show that the proposed network of extraction

1,2,3-TCP Distribution

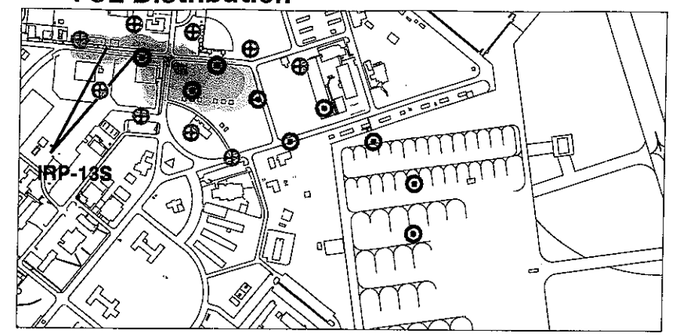




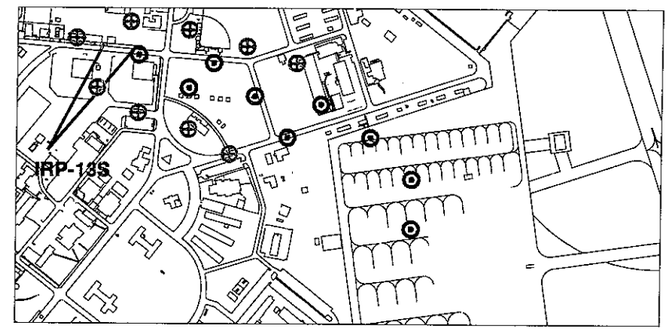




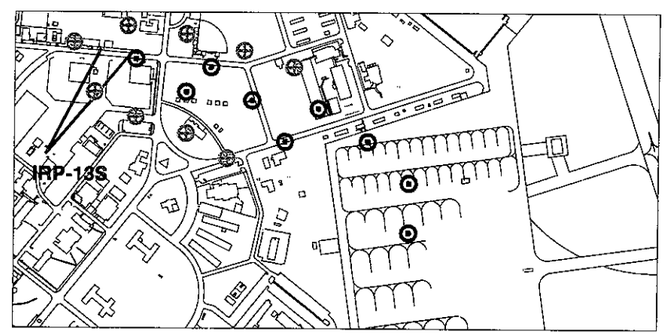
TCE Distribution



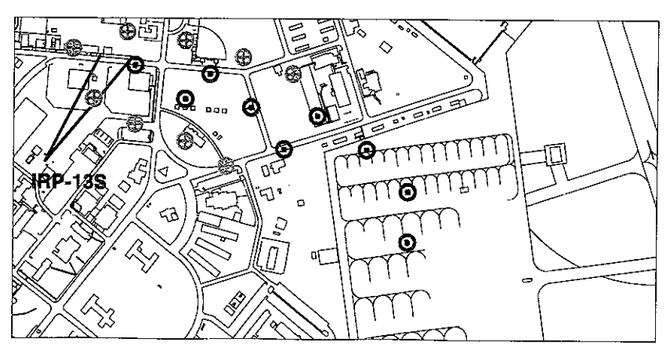
Current Conditions



After 10 Years

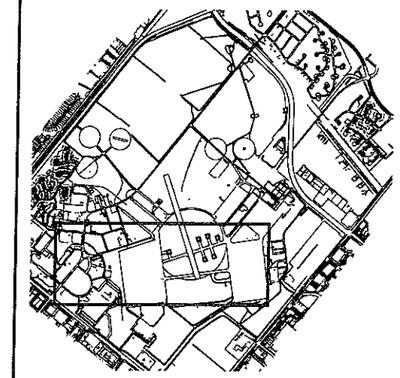


After 20 Years



After 30 Years

Alternative 4: Aggressive Groundwater Extraction



1,2,3-TCP

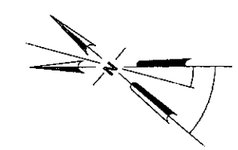
- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L

TCE

- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- 100 to 200 ug/L
- 200 to 500 ug/L
- 500 to 1000 ug/L
- 1000 to 2000 ug/L
- 2000 to 5000 ug/L
- > 5000 ug/L

EXTRACTION WELL

INJECTION WELL



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-23
Alternative 4/4A: Aggressive Groundwater Extraction
Simulated TCE and 1,2,3-TCP
Concentrations in the 1st WBZ at IRP-13S

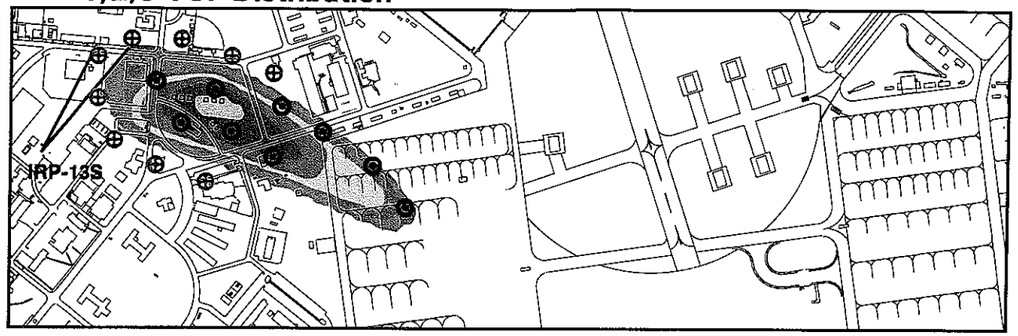
Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

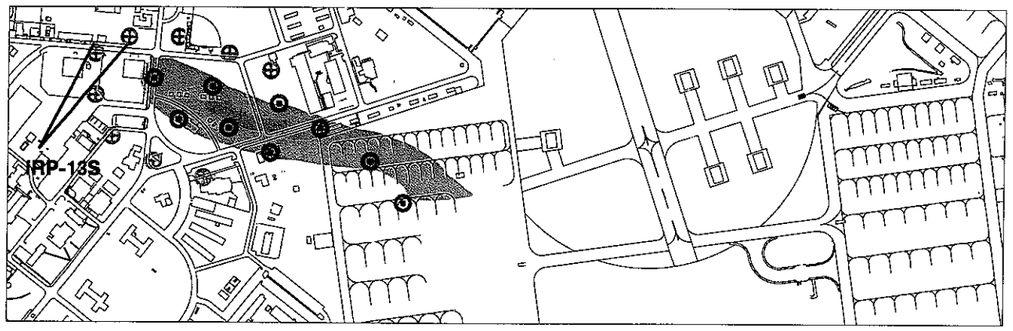
Date: 01/23/03
File No. 035L8616
Job No.:23818-035

gwm72alt4lfs 01/23/03 /f/tustin/tustinsun

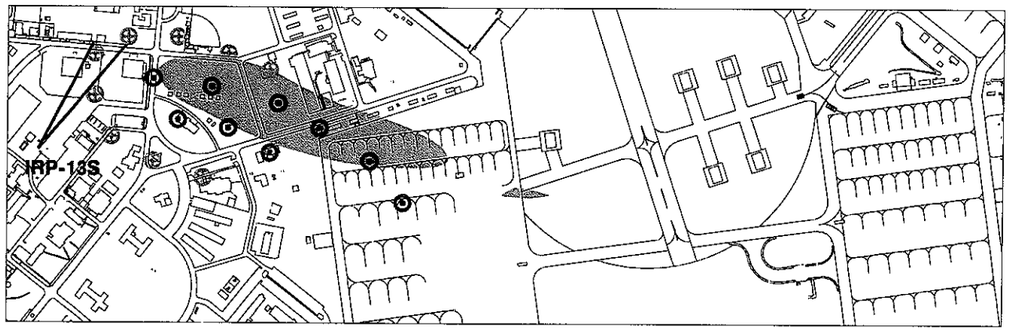
1,2,3-TCP Distribution



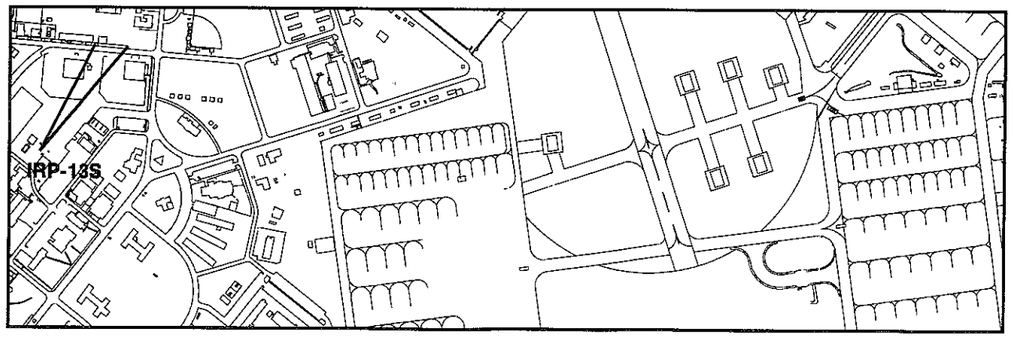
Current Conditions



After 10 Years

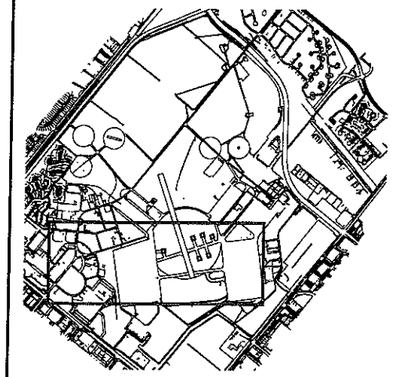


After 20 Years



After 30 Years

Alternative 4: Aggressive Groundwater Extraction

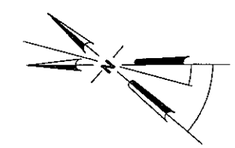


1,2,3-TCP

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L

EXTRACTION WELL

INJECTION WELL



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-24
Alternative 4/4A: Aggressive Groundwater Extraction
Simulated 1,2,3-TCP
Concentrations in the 2nd WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc
CLEAN 3 Program

Date: 01/23/03
File No. 035L8617
Job No.:23818-035

gwm72alt42fs 01/23/03 /f/tustin/tustinsun

wells would be sufficient to fully capture the VOC plumes in the sand layers of the first and second WBZs. Most of the TCE and 1,2,3-TCP contamination in these zones would be removed during the 15-year period of active groundwater extraction. After the extraction systems are shut down, the plume remnants would be attenuated by natural processes (dilution, dispersion, and adsorption) and should not migrate significantly beyond the existing areas of contamination at concentrations exceeding site cleanup goals.

Alternative 4 would eliminate concerns regarding the potential off-station migration of contaminated groundwater and future discharges to Barranca Channel. Additionally, groundwater extraction from nine wells in the second WBZ would maintain a constant upward hydraulic gradient between the second and third WBZs, thereby eliminating the potential for localized, seasonal downward migration of 1,2,3-TCP, described in the Final Technical Memorandum: Limited Deep HydroPunch Investigation at IRP-13S (BNI 1999c).

Extracted groundwater would be treated using GAC adsorption, identified by U.S. EPA as a proven and effective method for removing TCE and other chlorinated VOCs from water (U.S. EPA 1996b). All components of the extraction, treatment, injection, and monitoring systems required by Alternative 4 have been extensively implemented for groundwater remediation at other sites, demonstrating a high degree of long-term operational reliability.

Residual risks associated with VOCs in groundwater at OU-1A would be expected to decline as VOC-contaminated water is withdrawn from the shallow aquifer. The magnitude of this decline is illustrated on Figures 5-25 and 5-26, which plot predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs. Substantial reductions in the concentrations of VOCs (and therefore risk reductions) are expected during the initial 15 years of groundwater extraction. Predicted maximum concentrations of TCE would be reduced to below the site remediation goal (5 μg/L) by 10 years after implementing Alternative 4. Predicted maximum concentrations of 1,2,3-TCP would not be reduced below the site remediation goal even after 15 years of groundwater extraction followed by 15 more years of natural attenuation (Figure 5-26). Predicted maximum concentrations of 1,2,3-TCP would be within a factor of four of the site remediation goal (0.6 μg/L) after 30 years under Alternative 4.

As discussed in Section 5.5.1.6, active groundwater extraction would continue until significant additional contaminant reduction could no longer be achieved. Extrapolation of the modeling results presented on Figures 5-25 and 5-26 suggests that natural attenuation processes should eventually reduce 1,2,3-TCP concentrations to site cleanup goals in all areas affected by the VOC plumes, most likely within 2 to 3 decades after the 30-year period considered in this FS Report. Because of natural attenuation processes within the shallow aquifer, it would be possible to leave residual contamination at levels slightly higher than the cleanup goals.

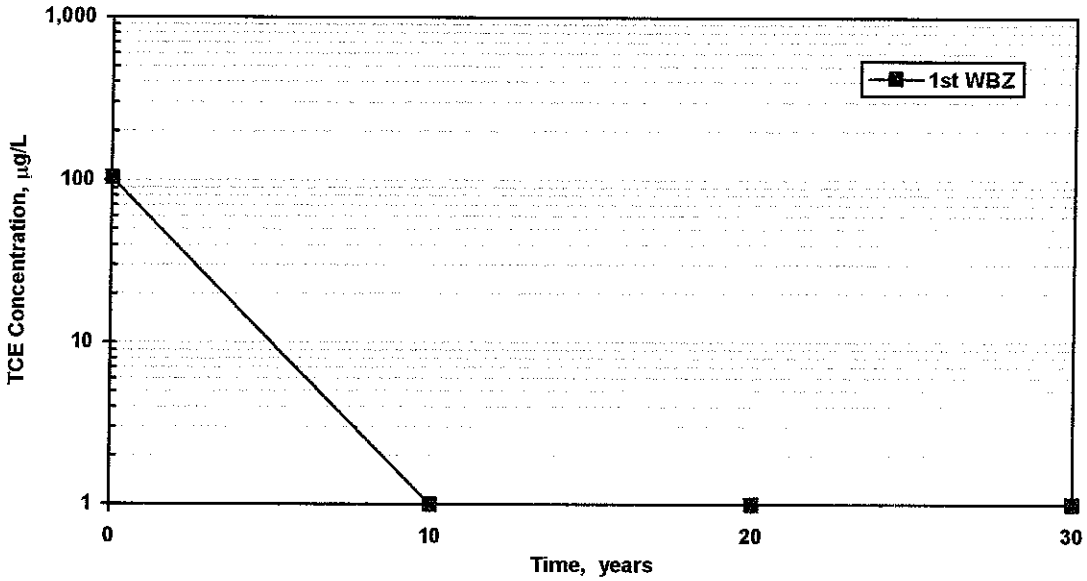


Figure 5-25
Predicted Maximum TCE Concentrations
Under Aggressive Groundwater Extraction

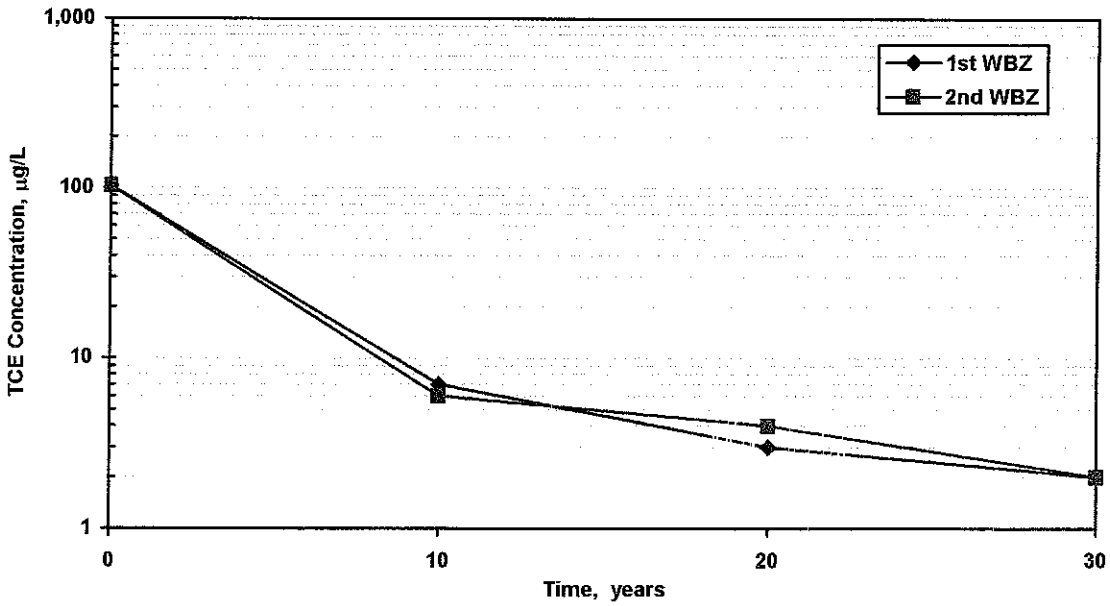


Figure 5-26
Predicted Maximum 1,2,3-TCP Concentrations
Under Aggressive Groundwater Extraction

Deed restrictions would be used under Alternative 4 to prevent future human exposures to VOC-affected groundwater within the area of contamination. Deed restrictions are expected to be effective and reliable methods of controlling health risks in areas impacted by the VOC plumes. Furthermore, by preventing further expansion of the plume beyond current limits, Alternative 4 minimizes the area over which deed restrictions must be applied. The long-term effectiveness of these measures would be contingent upon their continued enforcement, which would be the responsibility of the DON and DTSC.

Residuals generated by the two treatment systems under Alternative 4 would consist of an estimated 2,100 pounds of spent GAC per year. Spent GAC, which would be managed by the carbon supplier under a long-term service contract, would be taken off-site for regeneration or disposal. Because this material would be a solid waste that might contain relatively high concentrations of TCE and other VOCs, it would have to be characterized prior to transport off-site. Long-term management of spent GAC would be in accordance with RCRA and California waste management regulations. Therefore, residual risks associated with the spent carbon are considered negligible.

5.5.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 4 would accomplish a significant reduction in the toxicity, mobility, and volume of VOC-contaminated groundwater and source material (soils). Excavation of soils with TCE and 1,2,3-TCP at concentrations exceeding 100 and 10 µg/kg, respectively, would require transport of approximately 5,200 cubic yards of soil from the site to a secure Class II landfill in compliance with 40 C.F.R. § 300.440. Long-term operation of the groundwater extraction system is also expected to accomplish a potentially significant reduction in the volume and mass of subsurface VOC contamination. According to the modeling results presented in Appendix B, soil excavation and operation of the extraction systems for 15 years would remove approximately 95 and 74 percent of the TCE and 1,2,3-TCP mass, respectively, at and downgradient of IRP-13S.

Alternative 4 would essentially eliminate contaminant mobility by capturing the VOC plumes and preventing further migration either laterally or vertically. Figures 5-25 and 5-26 indicate that predicted maximum TCE and 1,2,3-TCP concentrations under aggressive groundwater extraction would decline from existing values by factors of greater than 98 percent over 30 years, representing a significant reduction in the toxicity of the VOC plumes.

As stated in Sections 2.6 and 5.5.2.2, remediation of VOC contamination is a complex process in a heterogeneous aquifer such as the shallow groundwater system at Former MCAS Tustin. The potential for successful cleanup can best be evaluated once a remediation system has been installed and operated. It is technically infeasible to remove all contamination from the subsurface at OU-1A, given the prevalence of fine-grained materials, the propensity of organic contaminants to partition between the adsorbed and dissolved phases, and other factors that limit contaminant recovery. Therefore, while

Alternative 4 should effectively remove nearly all of the mobile contamination in the first two WBZs, the extent to which the residual, immobile VOCs would continue to affect the aquifer over the long term remains unknown. Modeling-based predictions indicate that VOC concentrations within the plume areas would remain slightly above site remediation goals after 30 years.

The extracted groundwater under this alternative would be treated using GAC, which involves a transfer of dissolved contaminants to a solid phase (i.e., carbon). The spent GAC would most likely be regenerated in a high-temperature furnace at a permitted off-site facility operated by the carbon supplier. The adsorbed VOCs would be destroyed during the carbon regeneration process.

5.5.2.4 IMPLEMENTABILITY

Alternative 4 would be readily implemented, with no anticipated difficulties regarding technical feasibility, reliability, or scheduling. The technical components of this alternative are well established and have been widely used at other sites with TCE and related VOC contamination in groundwater. The equipment and construction methods to be used are proven, reliable, and readily available. In addition, multiple vendors are available to supply, at competitive prices, the equipment and services necessary for the groundwater extraction, monitoring, treatment, and injection systems of Alternative 4.

The deed restrictions that would be instituted as part of Alternative 4 are not expected to prevent or unnecessarily complicate future redevelopment of the Former MCAS Tustin property. The reasoning supporting this conclusion is presented in Section 5.3.1.1. The deed restrictions under Alternative 4 would most likely remain in force beyond the 30-year period considered in this FS Report. Implementation of this alternative would therefore require administrative coordination with state and local agencies to enforce the deed restrictions.

VOC concentrations in treated groundwater would have to be below site remediation goals prior to injection to comply with the substantive portions of the Basin Plan (RWQCB 1995). The GAC treatment system planned for this alternative would be capable of remediating groundwater to meet or exceed these standards. However, as discussed in Section 5.5.1.8, groundwater extracted from the shallow aquifer would also contain TDS and possibly other inorganics at concentrations greater than the water quality objectives established by the RWQCB for the Irvine Pressure Subbasin (Table A2-4 in Appendix A). These constituents are not site-related and thus would not be addressed by groundwater treatment under Alternative 4. As the injection of treated water would be into the same hydrogeologic unit from which it was withdrawn, in areas with comparable TDS concentrations, there would be no further degradation of groundwater quality at Former MCAS Tustin under this alternative.

5.5.2.5 COST

Table 5-10 summarizes the cost estimate developed for Alternative 4. The net present cost for aggressive groundwater extraction would be approximately $8.5 million. Major

Table 5-10
Summary of Cost Estimate[a] for Alternative 4

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering study/design/monitoring plan (3,500 hours @ $85 00/hour)	$298,000			$298,000
Carbon adsorption treatment system (15 years) (includes equalization tank, prefilter, pumps and controls)	$53,000			$53,000
GAC unit O&M (average 15 years)		$61,400		$921,000
Groundwater Treatment (15 years)				
Install 18 extraction and 18 injection wells	$1,355,000			$1,355,000
O&M (average 15 years)		$51,400		$771,000
Piping	$309,000			$309,000
Removal of Source Materials				
Excavate and dispose of soil off-site	$2,049,000			$2,049,000
Building 16 demolition (8,000 square feet)	$152,000			$152,000
Install two monitoring wells	$26,000			$26,000
Electrical distribution	$126,000			
Monitoring and Reporting				
Performance monitoring (average 30 years) (includes groundwater and influent/effluent sample collection, analysis, water levels)		$50,800		$1,524,000
Annual monitoring report[c]		$10,000[c]		$240,000
5-year review			$26,000	$156,000
Total				**$7,980,000**
Contingency (20%)[d]				$1,596,000
Escalation (base 01 January 2001)				$1,872,000
Total Cost				**$11,448,000**
Net Present Value of Alternative 4 (2002 $'s)				**$8,479,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect groundwater extraction for 15 years at OU-1A; monitoring activities (annual and 5-year) continue for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports

Acronyms/Abbreviations:
O&M – operation and maintenance
OU – operable unit

cost elements include excavation and off-site disposal of source area soils, installation of the extraction injection wells, and construction of the conveyance piping and treatment systems. Long-term monitoring of groundwater quality, sampling of the treatment plant influent and effluent, replacement of spent GAC, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that the groundwater extraction/treatment/injection systems would operate for 15 years. Performance monitoring would be conducted for 30 years.

The costs associated with excavation and off-site disposal of contaminated soils from IRP-13S would total approximately $2 million before inclusion of indirect costs, escalation, and contingencies. Source area soil excavation is the major reason that Alternative 4 would entail significantly greater costs than Alternative 3, which also includes a groundwater extraction and treatment component (although on a smaller scale). As demonstrated by the modeling results in Appendix B, this soil removal is necessary for this alternative to achieve site remediation goals in 50 to 60 years. In addition, according to the data presented in Appendix B, this time frame would be substantially longer without soil excavation.

Backup and supporting details for the Alternative 4 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.5.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 4 with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

The aggressive groundwater extraction alternative would be designed and implemented to comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. Figures 5-25 and 5-26 show that significant progress toward these ARARs would be made by groundwater extraction systems operating 15 years. While TCE and 1,2,3-TCP contamination would remain slightly above site cleanup goals at the end of the 30-year period assumed in this FS Report, these objectives should be attained through natural attenuation within another 20 to 30 years. After the extraction wells are shut off, further migration of VOC plume remnants at concentrations above site cleanup objectives is not expected to be significant.

Chemical-specific requirements that would eventually be met through implementation of Alternative 4 include the following:

- **Federal:** SDWA MCL (40 C.F.R. § 141.61[a]) for TCE; RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); CWA of 1977 (40 C.F.R. § 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs. tit. 22, §§ 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])

- **State:** Substantive portions of the beneficial uses and water quality objectives in the WQCP for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2; and Cal/EPA DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261.22[a][4], and 66261.24[a][2]–[8])

The persistence of VOC contamination within the plume areas would prevent beneficial use of shallow groundwater on approximately 54.1 acres at OU-1A. No such restrictions on beneficial use would occur in presently uncontaminated areas of the station, on adjacent off-site properties, or for any portion of the deeper Irvine Pressure Subbasin (regional aquifer) underlying the station.

Location-Specific ARARs

The primary activities under Alternative 4 that may trigger location-specific requirements are those related to the excavation of contaminated soils; installation of extraction, injection, and monitoring wells; and construction of the conveyance pipelines and treatment plants. Given the limited size of the treatment plants and related appurtenances, the "footprint" associated with Alternative 4 is expected to be relatively small. Approximately 14,300 feet of trenching (less than 4 feet deep) would be required to install the conveyance piping for extracted and treated groundwater. Otherwise, none of the groundwater-related remedial systems would involve major construction, earthwork, or drainage manipulation activities of the type most likely to complicate compliance with location-specific ARARs.

Alternative 4 would be designed and implemented to meet all location-based requirements, which are identified as ARARs in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

The major components of Alternative 4 that trigger action-specific ARARs are the generation of solid waste (excavated soil from the site source areas, soil cuttings from well installations, trench spoils, and spent GAC), extraction and treatment of contaminated groundwater containing VOCs, and the injection of treated groundwater to the first and second WBZs. As identified in Appendix A (Section A4.4), the action-specific requirements for aggressive groundwater extraction include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs. tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34); groundwater monitoring (Cal. Code Regs. tit. 22, §§ 66264.91[a] and [c], 66264.97, 66264.98 and 66264.100[a] and [b]); secondary containment for piping (Cal. Code Regs. tit. 22, § 66264.193 [a], [b], [c], and [f]); and SDWA underground

injection control regulations (40 C.F.R. § 257.3–257.4 and Appendix I) as specified in Table A4-1 in Appendix A

- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); antidegradation provisions of SWRCB Resolution No. 68-16 (SWRCB 1968); California Civil Code requirements for land-use controls (Cal. Civ. Code § 1471); and California Health and Safety Code requirements for institutional controls (Cal. Health & Safety Code §§ 25202.5, 25222.1, and 25233[c]); and substantive provisions of SCAQMD Rules 401, 403, 404, and 405

All activities under Alternative 4 that produce solid waste (excavated soil, soil cuttings, trench spoils, and spent GAC) would be implemented in a manner compliant with federal and state action-specific ARARs at Cal. Code Regs. tit. 22, § 66262. These residuals would be characterized with respect to criteria for the identification of RCRA and non-RCRA hazardous waste. If any of these wastes were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the hazardous waste requirements of Cal. Code Regs. tit. 22, §§ 66262 and 66264 would also be potential ARARs for management of the waste for off-site disposal. Implementing Alternative 4 in compliance with these requirements would not be expected to present significant complications from a technical or administrative viewpoint.

Another action-specific consideration for Alternative 4 regards classification of the extracted groundwater under RCRA. As noted in Appendix A (Section A1.4.1), none of the groundwater samples collected from the first or second WBZs during the RI had TCE at concentrations exceeding the 500 µg/L limit established for designation as a RCRA characteristic hazardous waste. Based on the modeling described in Appendix B, it is predicted that maximum TCE concentrations in the extracted groundwater for Alternative 4 would be less than the 500 µg/L RCRA threshold (Figure 5-25). More accurate estimates of expected TCE concentrations in the extracted groundwater would be obtained during remedial design. If groundwater from the wells were classified as hazardous waste, then the requirements of Cal. Code Regs. tit. 22, § 66264 would be potential ARARs for portions of the extraction and treatment systems. TCE concentrations below the RCRA limits would not trigger any hazardous waste management ARARs. RCRA hazardous waste criteria have not been set for 1,2,3-TCP.

Underground injection control (UIC) regulations established pursuant to the SDWA would designate the injection wells for Alternative 4 as Class V wells per 40 C.F.R. § 144.6(e). There are currently no specific UIC program technical requirements for injection into Class V wells that apply to this alternative. However, the narrative provisions of the UIC rules require that injection of treated groundwater through Class V wells must not cause the shallow aquifer at Former MCAS Tustin to violate primary drinking water MCLs established by U.S. EPA. This substantive requirement would be satisfied by GAC treatment of extracted groundwater to remove VOCs to the site remediation goals established in Section 2.5.

SWRCB Resolution No. 68-16 (SWRCB 1968) also applies to the reinjection of treated groundwater. Alternative 4 would comply with this ARAR by reinjecting treated water back only into the same aquifer from which it was initially extracted. The groundwater treatment system would be designed to reduce VOC concentrations below site cleanup levels listed in Table 2-5, but it would not remove the inorganic constituents known to be at elevated background concentrations. Treated groundwater would be injected into portions of the first and second WBZs with similar background water quality. Injection of treated groundwater under these circumstances would not markedly change or increase the concentrations or mass of TDS, nitrate, sulfate, or selenium in the shallow aquifer. As Alternative 4 would not degrade the shallow aquifer system at Former MCAS Tustin, it would conform to SWRCB Resolution No. 68-16.

Alternative 4 would comply with the Basin Plan requirements to maintain beneficial uses and meet water quality objectives for groundwater in the Irvine Pressure Subbasin (regional aquifer) by limiting further migration of contaminated groundwater and *ex situ* treatment.

Performance goals for treatment of extracted groundwater obtained prior to injection would be based on reducing concentrations of TCE, 1,2,3-TCP, and other site-related VOC contaminants to the remediation goals established in Section 2.5. This would assure compliance with the narrative water quality objective for toxic substances provided in the Basin Plan as well as the antidegradation provisions of SWRCB Resolution No. 68-16 and the substantive provisions of the federal UIC program.

Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements.

5.5.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 4 would protect human health and the environment. Proven technologies would be used to remove contaminant source material and remediate VOC-affected groundwater at and downgradient of IRP-13S. Aggressive groundwater extraction would provide a permanent solution to VOC contamination at OU-1A, reduce potential risk to human health and the environment, comply with ARARs, and achieve site remediation goals as quickly as possible. Alternative 4 would also prevent significant downgradient migration of VOCs, control the threat to water quality in the third WBZ and the deeper regional aquifer, avoid migration of contaminated groundwater onto adjacent properties, and eliminate potential ecological impacts associated with future releases of VOCs to Barranca Channel. Treatment of extracted groundwater using GAC, a well-established process, would remove VOCs to concentrations acceptable for injection to the shallow aquifer system. Implementation and enforcement of institutional controls should effectively prevent human exposure to VOC-affected shallow groundwater. The deed restrictions required by this alternative would be limited to approximately 54.1 acres overlying the existing areas of VOC contamination. Over time, concentrations of TCE and 1,2,3-TCP in shallow groundwater, along with risks to potential residential receptors, would decline due to the removal of contaminant mass by the extraction wells.

Performance monitoring and periodic reviews would verify and track the overall performance of the remedy.

Groundwater modeling results indicate that source removal combined with a 15-year groundwater extraction, treatment, and injection program should remove most of the contaminant mass in the subsurface. During the postextraction period, natural attenuation processes would prevent further significant migration of VOCs at concentrations exceeding site cleanup goals beyond existing plume boundaries. Although Alternative 4 is not designed to remove all contamination from the subsurface, it does address the most highly contaminated materials in the upper confining layer of the first WBZ as well as that portion of the contaminant mass that is most mobile (i.e., VOCs associated with the transmissive sand layers of the first and second WBZs).

An assessment of the protectiveness of Alternative 4 should consider the uncertainty associated with aquifer restoration by extraction. Conclusions regarding the performance of this option are based almost entirely on modeling projections. Actual performance of a full-scale extraction system at OU-1A may be different. U.S. EPA reports that the most accurate assessments of aquifer "restorability" can be made only after groundwater remediation systems have been implemented and monitored for a period of time (U.S. EPA 1996b). While no such systems or data exist for OU-1A, Alternative 4 represents a viable technical approach for collecting this information and completing such an assessment.

It is also important to note that the uncertainties surrounding Alternative 4 are limited primarily to the effectiveness of groundwater extraction as a method of aquifer restoration. There is a high degree of confidence that the extraction wells would contain the VOC plumes at OU-1A, that source removal would reduce the migration of VOCs to the permeable sand layers of the first and second WBZs, that monitoring and periodic reviews would allow for ongoing evaluation and adjustment of the remedy, and that deed restrictions would reliably prevent potential human exposure to contaminated groundwater. For these reasons, Alternative 4 would be protective in an overall sense.

5.6 ALTERNATIVE 4A – AGGRESSIVE GROUNDWATER EXTRACTION WITH ON-SITE SOIL TREATMENT

Alternative 4A is identical to Alternative 4 in all aspects except for the disposition of excavated source soils, which would be treated on-site instead of disposed at a landfill off-site.

Alternative 4A would combine institutional controls, source removal at the site, and an expanded groundwater extraction system to remediate significant portions of the VOC plumes. The overall objective of Alternative 4A is to contain VOC-affected groundwater within existing boundaries while reducing VOC concentrations in the shallow aquifer.

5.6.1 Description

Alternative 4A is one of the more aggressive remedial response actions evaluated in this FS Report. Major components include mechanical excavation and on-site treatment of VOC-contaminated soils for use as excavation backfill, groundwater extraction and treatment using GAC, and injection of treated groundwater upgradient from OU-1A. Long-term performance monitoring would track the progress of remediation, supported by detailed reviews every 5 years to evaluate its continued protectiveness. Deed restrictions would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes.

Figure 5-16 presents the conceptual site layout for Alternative 4A, which is identical to Alternative 4. Individual components of the aggressive groundwater extraction alternative are discussed in detail in the subsections of Section 5.5.

5.6.1.1 EXCAVATION OF SOURCE MATERIAL

The areas to be excavated under Alternative 4A are identical to those under Alternative 4, and are shown on Figure 5-17. Stockpiled soil would be segregated into three stockpiles, according to expected TCE and 1,2,3-TCP concentrations, as described in Alternative 4. Figure 5-18 shows the volume of excavated soil estimated in each category.

After confirmation of the appropriate waste classification, soil from the stockpile with the highest VOC concentrations would be treated on-site using a TDU and reused as excavation backfill. The treatment and disposal of approximately 5,200 cubic yards of excavated soil are further discussed in subsequent sections.

5.6.1.2 TREATMENT OF SOURCE MATERIAL

Excavated source soils with concentrations of TCE greater than 100 μg/kg or 1,2,3-TCP greater than 10 μg/kg would be treated using a TDU. Thermal desorption is a physical process in which soil is heated to temperatures between 200 and 1,000 °F, causing VOCs to vaporize from the soil matrix. A carrier gas or vacuum system transports the volatilized water and organics to a vapor treatment system where the contaminants are thermally destroyed.

Soil would be treated using one of two types of TDUs: a rotary dryer or thermal screw type. Rotary dryer types consist of cylinders that can be directly or indirectly fired, and thermal screw types consist of indirectly fired screw conveyors or augers. For purposes of the cost estimate, a mobile TDU would be brought on-site by a vendor to treat the soil. This eliminates the capital cost of purchasing a TDU that would only be used temporarily. The location of the TDU would be determined during the remedial design. The fuel source used for heating the soil would be natural gas or propane, with propane being more expensive.

Treatment rates vary widely depending on the type of TDU used and the soil characteristics. A general range is 10 to 30 tons/hour, with treatment rate being inversely proportional to the moisture and clay content of the soil. Rates have been reported

to be as low as 5 tons/hour or as high as 50 tons/hour The soil type at the site is anticipated to result in a treatment rate of 10 to 15 tons/hour, due to its relatively high clay and silt content, as well as moisture content. An estimated 7,800 tons of soil would be treated (assuming 1.5 tons per cubic yard). Treatment could be completed in an estimated 2 to 3 months, depending on TDU process schedules and operation and maintenance requirements.

Due to the predominant clay and silt content of the soil at the site, pretreatment will be necessary. For cost purposes, a shredder to be used to break down clumped clay/silt material was included as part of the TDU. The maximum size of material allowed in the TDU is generally 2 inches in diameter. Since clay will tend to clog the screen, periodic cleaning of the screen may be required. Since a significant portion of the soil to be treated would be from the saturated zone, some soil drying will be required to reduce the moisture content. A moisture content greater than approximately 20 percent can significantly impact the treatment rate and total cost. Drying can be accomplished by stockpiling the soil and allowing the soil to drain. The stockpile(s) would be covered to reduce the potential for VOC emissions. Addition of dry sand, fly ash, or hydrated lime can facilitate the disaggregation and drying process. For cost purposes, it is assumed that hydrated lime would be added to the stockpiled soil. For the estimated 7,800 tons of soil, approximately 26 tons of lime would be needed, assuming a usage rate of 300 tons of soil per ton of lime. However, suitability of additives would need to be evaluated to consider how they might change soil characteristics that could affect reuse.

Water would be added to the treated soil as it exits the TDU to control dust. The treated soil would be stockpiled on-site near the TDU for reuse.

The vapor treatment system for vapors carrying the desorbed VOCs typically involves particulate removal (e.g., wet scrubbers or fabric filters) and contaminant removal by condensation and carbon adsorption, thermal oxidation, or catalytic oxidation. Thermal oxidation followed by use of particulate filters is a technique used by a local vendor. For cost estimation purposes, thermal oxidation is assumed since use of carbon adsorption would incur additional costs to haul and regenerate the used carbon. The treated vapor might need to be cooled in a cooling tower prior to release to the atmosphere. In addition, a scrubber might need to be added to the thermal oxidizer off-gas to remove any VOC breakdown products of combustion from the vapor stream. The use of scrubbers is typically only required with higher concentrations of VOCs and also depends on the treatment requirements. Based on the experience of a local vendor, it is not anticipated that a scrubber will be required.

As a CERCLA remediation activity conducted entirely on-site, the use of a TDU at the site would not require a permit from SCAQMD. However, treated vapors released to the atmosphere would need to be handled in accordance with the substantive provisions of the SCAQMD regulations pertaining to point source emissions of VOCs. Local vendors typically employ a SCAQMD "various locations" permit for portable TDUs.

5.6.1.3 BUILDING DEMOLITION

Soil excavation under Alternative 4A would affect the same structure as Alternative 4. Building demolition would be conducted as described in Section 5.5.1.2, and demolition costs are presented in Table 5-11.

5.6.1.4 BACKFILLING OF EXCAVATIONS

The backfill criteria for Alternative 4A are identical to those for Alternative 4. Based on the estimates presented in Figure 5-18, the materials that would be available as excavation backfill would include approximately 8,700 cubic yards of soil with detectable but low concentrations of TCE and 1,2,3-TCP, along with 4,700 cubic yards of excavated soil with no detectable concentrations of VOCs. To the extent possible, only soil with reported concentrations of TCE and 1,2,3-TCP would be replaced below the water table. Soil with VOCs at concentrations exceeding the detection limits but below the 100 µg/kg TCE and 10 µg/kg 1,2,3-TCP action levels would be placed above the seasonal high water table, as illustrated on Figure 5-19.

Under Alternative 4, approximately 5,000 cubic yards of clean fill would be obtained from an off-site commercial source to bring the excavations to grade. However, under Alternative 4A, it is assumed that the soil treated with the TDU would be suitable for excavation backfill, which would reduce the volume of imported clean fill required. Soil treated using the TDU is not expected to have any remaining VOCs above the action levels required for use as backfill. Reported TDU desorption efficiencies of organic contaminants can exceed 99 percent, although it may be more difficult to achieve this percentage due to the predominant clays and silts at the site. Once treated, the soil would be tested to confirm the removal of VOCs to low or nondetectable levels.

5.6.1.5 EFFECTS OF BACKFILL WITH LOW LEVELS OF VOCs

As discussed in Sections 5.5.1.1 and 5.5.1.3, appropriate soil excavation criteria are 100 µg/kg for TCE and 10 µg/kg for 1,2,3-TCP. Soil with VOC concentrations that are less than these criteria would be used as backfill above the seasonal high water table (vadose zone). The vadose zone modeling results (using VLEACH) from the RI were used to evaluate the effects of VOCs in the vadose zone on groundwater quality (BNI 1997a). The modeling results presented in Table 5-7 indicate that the leachate from contaminated soil at the action levels would result in TCE and 1,2,3-TCP concentrations in groundwater that are near or below their site remediation goals of 5 and 0.6 µg/L, respectively. Groundwater modeling results are presented in Section 5.5.1.4.

5.6.1.6 DISPOSAL OF TREATED SOURCE MATERIALS

As noted in Section 3.3.3.6, backfilling or other beneficial reuse of soil treated at a TDU facility was determined to be the preferred means of disposal for this material. It is anticipated that the treated soil would not have any remaining contamination above the action levels required for use as backfill. For Alternative 4A, the preferred use is as

Table 5-11
Summary of Cost Estimate[a] for Alternative 4A

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering study/design/monitoring plan (3,700 hrs @ $85.00/hr)	$315,000			$315,000
Carbon adsorption treatment system (15 years) (includes equalization tank, prefilter, pumps, and controls)	$53,000			$53,000
GAC unit (average 15 years)		$61,400		$921,000
Groundwater Treatment (15 years)				
Install 18 extraction and 18 injection wells	$1,355,000			$1,355,000
Well O&M (average 15 years)		$51,400		$771,000
Piping	$309,000			$309,000
Removal of Source Materials				
Excavate, treat soil and backfill	$681,000			$681,000
Low-temperature thermal desorption	$645,000			$645,000
Install two monitoring wells	$26,000			$26,000
Building 16 demolition (8,000 square feet)	$152,000			$152,000
Electrical distribution	$126,000			$126,000
Monitoring and Reporting				
Performance monitoring (average 30 years) (includes groundwater and influent/effluent sample collection, analysis, water levels)		$50,800		$1,524,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$7,273,000**
Contingency (20%)[d]				$1,455,000
Escalation (base 01 January 2001)				$1,821,000
Total Cost				**$10,548,000**
Net Present Value of Alternative 4A (2002 $'s)				**$7,639,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect groundwater extraction for 15 years at IRP-13S; monitoring activities (annual and 5-year) continue for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports

Acronyms/Abbreviations:
GAC – granular activated carbon
IRP – Installation Restoration Program
O&M – operation and maintenance

backfill for the excavations at the site (Section 5.6.1.4), although other on-site beneficial uses could be considered. Backfill for the excavations would reduce the need for clean, imported material. Other potential beneficial uses include construction sites or backfill for other excavations. The treated soil would be tested to evaluate disposal options.

5.6.1.7 GROUNDWATER EXTRACTION

The groundwater extraction systems under Alternative 4A would be identical to those described for Alternative 4. Refer to Section 5.5.1.6 for a discussion of the groundwater extraction systems.

5.6.1.8 GROUNDWATER CONVEYANCE AND TREATMENT

Conveyance and treatment of groundwater for Alternative 4A would be identical to those for Alternative 4. Refer to Section 5.5.1.7 for a discussion of the groundwater conveyance and treatment systems and requirements.

5.6.1.9 INJECTION OF TREATED GROUNDWATER

Injection of treated groundwater for Alternative 4A will be identical to that for Alternative 4. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if reinjection is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, effective groundwater mounding geometries and injection inflow rates, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using percolation ponds, or use in wetlands, will also be evaluated. Refer to Section 5.5.1.8 for a discussion of the groundwater injection system and requirements.

5.6.1.10 PERFORMANCE MONITORING

Performance monitoring during the operating period for Alternative 4A would be identical to that for Alternative 4. An overview of the performance monitoring requirements for Alternative 4 is presented in Table 5-9. Details of the long-term groundwater monitoring program are presented in Section 5.5.1.9.

5.6.1.11 INSTITUTIONAL CONTROLS

Institutional controls are based on the groundwater treatment systems and the extent of the VOC plumes, and therefore the restrictions for Alternative 4A would be identical to those for Alternative 4. Refer to Section 5.5.1.10 for a detailed discussion of the institutional controls.

5.6.1.12 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data for Alternative 4A would be identical to those for Alternative 4. The reviews would be conducted every

5 years to determine whether the extraction wells were effectively containing the contaminated shallow groundwater and reducing VOC concentrations as expected. Refer to Section 5.5.1.11 for details on the periodic reviews.

5.6.2 Detailed Analysis

The Alternative 4A detailed analysis is identical to that for Alternative 4, except as it relates to on-site thermal treatment and disposition of the excavated source material. Alternative 4A was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.6.2.1 SHORT-TERM EFFECTIVENESS

Short-term effectiveness considerations for Alternative 4A are identical to those for Alternative 4, except for additional considerations pertaining to thermal treatment of soil. Short-term effectiveness considerations include short-term risks to workers associated with the remediation operations and potential impacts to the surrounding community, as discussed in Section 5.5.2.1.

Considerations pertaining to on-site thermal treatment, in addition to the soil excavation, transportation, and handling issues previously discussed, are as follows. Increased vehicular traffic on public roads and highways due to off-site transportation of excavated material would not be an issue, since on-site use of the soil is presumed. The health and safety plan and remedial action work plan would need to include minimizing short-term risks to workers and the surrounding community during mobilization of the TDU and during soil preparation and thermal treatment. Other additional short-term risks during on-site treatment would include potential exposure to VOC vapors during material handling and treatment and physical hazards associated with start-up and operation of the TDU.

The duration of the thermal treatment would be approximately 2 to 3 months. Since the soil treatment system would be a preassembled mobile unit, only minor on-site testing and equipment enhancements would likely be necessary to optimize the treatment process for site-specific conditions.

5.6.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

The long-term effectiveness and permanence of Alternative 4A would be identical to those for Alternative 4, as discussed in Section 5.5.2.2.

5.6.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

As with Alternative 4, Alternative 4A would accomplish a significant reduction in the toxicity, mobility, and volume of VOC-contaminated groundwater and source material (soils). An additional benefit of Alternative 4A is that thermal treatment of 5,200 cubic yards of soils with TCE and 1,2,3-TCP concentrations exceeding 100 and

10 μg/kg, respectively, would remove VOCs from these soils to low levels or below detection limits, enabling beneficial reuse of the soils. Reuse of treated soil for backfill would be subjected to the constraints discussed in Section 5.5.1.3. The desorbed VOCs in the treatment system vapor stream would be destroyed prior to discharge to the atmosphere. For groundwater, reduction in toxicity, mobility, or volume for Alternative 4A would be identical to that for Alternative 4. This is discussed in Section 5.5.2.3.

5.6.2.4 IMPLEMENTABILITY

Implementability of Alternative 4A would be generally identical to Alternative 4, which is discussed in Section 5.5.2.4. The differing component, soil treatment using a TDU, has been demonstrated to be feasible for the soil types found at the site, based on the long-term operation of the existing TDU for petroleum hydrocarbons. The technical components of a TDU are well established and have been widely used at other sites with TCE and related VOC contamination in soil. The equipment to be used is proven and reliable. Availability of a mobile TDU might be affected due to scheduling limitations by the vendors that supply mobile units in the region.

5.6.2.5 COST

Table 5-11 summarizes the cost estimate developed for Alternative 4A. The net present cost for aggressive groundwater extraction with on-site soil treatment would be approximately $7.6 million. Major cost elements include excavation and on-site treatment and beneficial use of source area soils, installation of the extraction wells and injection wells, and construction of the conveyance piping and treatment systems. Long-term monitoring of groundwater quality, sampling of the treatment plant influent and effluent, replacement of spent GAC, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that the groundwater extraction/treatment/injection systems would operate for 15 years. Performance monitoring would be conducted for 30 years.

The costs associated with excavation and on-site treatment and disposal of contaminated soils from the site would total approximately $1.3 million before inclusion of indirect costs, escalation, and contingencies. Source area soil excavation is the major reason Alternative 4A would entail significantly greater costs than Alternative 3, which also includes a groundwater extraction and treatment component (although on a smaller scale). As demonstrated by the modeling results presented in Appendix B, this soil removal is necessary for the aggressive groundwater extraction alternative to achieve site remediation goals within a reasonable time.

Backup and supporting details for the Alternative 4A cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.6.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 4A with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

Since the chemical-specific ARARs for Alternative 4A pertain to groundwater, they are identical to those identified for Alternative 4. Refer to Section 5.5.2.6 for a discussion of these ARARs.

Location-Specific ARARs

The primary activities under Alternative 4A that might trigger location-specific requirements are those related to the excavation of contaminated soils; installation of extraction, injection, and monitoring wells; and construction of the conveyance pipelines and a treatment facility. The additional activities regarding on-site thermal treatment are included in the ARARs already specified for Alternative 4. Refer to Section 5.5.2.6 for a discussion of location-specific ARARs.

Action-Specific ARARs

The major components of Alternative 4A that trigger action-specific ARARs are the generation of solid waste (excavated soil from source areas, soil cuttings from well installations, trench spoils, and spent GAC), on-site treatment of soil, extraction and treatment of contaminated groundwater containing VOCs, and injection of treated groundwater to the first and second WBZs.

Because Alternative 4A involves on-site thermal treatment and disposal of soil, other ARARs are triggered in addition to those specified for Alternative 4. The use of on-site thermal treatment is subject to RCRA requirements for hazardous waste specified in Cal. Code Regs. tit. 22, § 66265.370–383, with the exception of § 66265.382. If soil cuttings or excavated contaminated soil classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]) is proposed for on-site disposal, then the land disposal requirements (LDRs) of Cal. Code Regs. tit. 22, § 66268 would also be potential ARARs for treatment of the waste soil. The substantive portions of SCAQMD Rules 212, 1303, and 1401 identified as action-specific ARARs for Alternative 4A set technical requirements for addressing the potential atmospheric emissions of VOC-containing soil vapor that may be extracted by the VEE wells or desorbed by the TDU. Use of GAC to treat the soil vapor and a thermal oxidizer or GAC to treat the TDU vapors would satisfy the SCAQMD requirement to install best available control technology on sources potentially emitting toxic air pollutants, a category that includes some of the OU-1A COCs. Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements. Refer to Section 5.5.2.6 for a discussion of action-specific ARARs.

5.6.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 4A would protect human health and the environment in a manner identical to Alternative 4. Reuse of thermally treated soil as backfill at the site would be subjected to the criteria imposed on untreated soil, as described in Section 5.5.1.3. Details on overall protection of human health and the environment are discussed in Section 5.5.2.7

5.7 ALTERNATIVE 5 – PERMEABLE REACTION WALL

Alternative 5 features the use of an innovative *in situ* treatment technology—permeable reaction walls—to remediate contaminated groundwater at and downgradient from IRP-13S. Other components of this alternative include institutional controls in areas overlying the VOC plumes and downgradient migration pathways, long-term monitoring, and periodic reviews. Similar to Alternative 3, the overall objectives of the permeable reaction wall option would be to contain the VOC plumes, achieve significant reductions in VOC concentrations, and prevent human exposure to VOC-affected groundwater.

5.7.1 Description

Alternative 5 would include installation of *in situ* slurry wall/iron gate systems to remove VOCs from the first two WBZs of the shallow aquifer. The slurry walls would direct contaminated groundwater from upgradient areas through permeable sections of reactive iron in which VOCs would be degraded. Under Alternative 5, a permeable reaction wall would be placed near the downgradient margins of the plume within the first WBZ, extending vertically as needed to intercept VOC-affected groundwater in both the first and second WBZs. The walls would be keyed to the low-permeability soils beneath either the first or the second WBZ, depending on location. Low levels of existing VOC contamination downgradient of the walls would be remediated by natural attenuation. To reduce contaminant transport distances to the reactive media, iron walls would also be placed across the center of the VOC plumes. Figure 5-27 presents the conceptual layout of Alternative 5.

Permeable reaction wall technology offers a number of advantages at OU-1A. As a destructive treatment process, it would significantly and permanently reduce VOC contamination. TCE and 1,2,3-TCP would be degraded to nonchlorinated, nontoxic reaction products as groundwater flows through the reactive iron. The walls would be located to minimize downgradient VOC migration. The passive nature of the process would result in less complex O&M requirements compared to remediation by groundwater extraction and treatment in aboveground GAC systems. An additional advantage of this alternative is its low profile, which could possibly minimize the surface disruption caused by a long-term remedial action implemented concurrently with redevelopment of the Former MCAS Tustin property.

Alternative 5 would rely on natural groundwater flow to transport VOCs to the reactive wall sections. Therefore, restoration of the shallow aquifer would require many decades. Although VOCs would be degraded as groundwater passed through the permeable iron

walls, significant contamination would remain after 30 years in upgradient portions of the sand layers of the first and second WBZs. This alternative would not address ongoing groundwater contamination caused by the slow release of TCE from the source soils in the vadose zone. Furthermore, it would not prevent the potential downward migration of 1,2,3-TCP to the third WBZ through a localized lithologic discontinuity identified near the intersection of Cross Street and McCord Road.

Long-term performance monitoring would be performed to verify the effectiveness of the permeable reaction wall remedy, supported by detailed reviews every 5 years to evaluate its continued protectiveness. Deed restrictions would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes to restrict use of and prevent human contact with shallow groundwater.

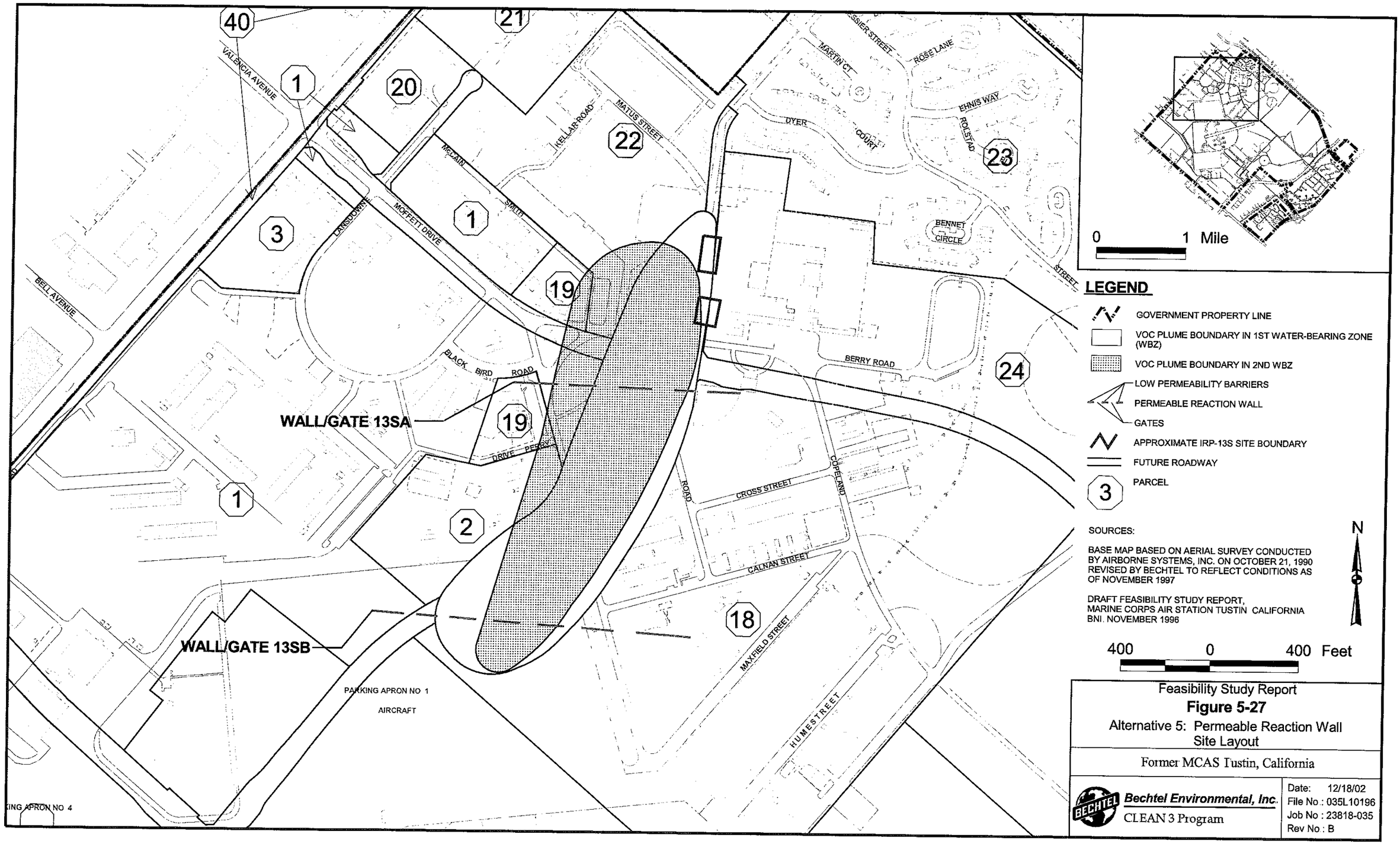
5.7.1.1 PERMEABLE REACTION WALL SYSTEM

Permeable reaction walls involve the construction of a bed of granular zero-valent iron perpendicular to the flow path of groundwater containing halogenated VOCs. This technology has been developed over the last decade. It has been used for groundwater remediation at TCE-contaminated sites in California and elsewhere in the United States, Canada, and Europe.

Available performance data and general site conditions indicate that this technology could be successfully implemented at OU-1A. Bench-scale treatability tests were completed in 1997 using samples of groundwater collected at nearby IRP-3 and IRP-12 sites. These studies demonstrated that VOCs in the shallow groundwater plume, including TCE and 1,2,3-TCP, could be successfully degraded by zero-valent iron at reaction rates comparable to those reported elsewhere in the literature (ETI 1998a, BNI 1998a). Appendix C provides additional background information on permeable reaction walls for VOC degradation and other significant findings from the bench-scale test.

In general, the bench-scale test proved that permeable reaction wall technology is feasible for this application. However, a number of site-specific constraints and uncertainties remain. Issues which must be addressed prior to full-scale implementation of permeable reaction walls include the long-term performance of the process, potential declines in iron reactivity and porosity due to chemical precipitation, and the lack of proven construction methods for wall installations deeper than about 45 feet bgs.

During a BCT meeting on 29 October 2002, the RAB for Former MCAS Tustin and the RWQCB stated their opposition to the application of this iron reactive wall technology at OU-1A. John Broderick, representing the RWQCB, stated that installation of reactive iron in the subsurface would likely generate by-products that would violate the Basin Plan and that the RWQCB would likely not accept Alternative 5. Dana Ogden, representing the city of Tustin, suggested eliminating Alternative 5 from the OU-1A FS altogether. Alternative 5 was retained for evaluation, however, to be consistent with the FS conducted for OU-1B and for further consideration as an innovative technology.


40
21
20
1
22
23
3
1
19
19
24
1
2
18
VALENCIA AVENUE
KELLAR ROAD
MATUS STREET
McCAIN
SMITH
LANSDOWNE
MOFFETT DRIVE
BELL AVENUE
BLACK BIRD ROAD
DRIVE
WALL/GATE 13SA
WALL/GATE 13SB
PARKING APRON NO 1
AIRCRAFT
MARTIN CT
ROSE LANE
DYER
COURT
EHNIS WAY
ROLSTAD
BENNET
CIRCLE
STREET
BERRY ROAD
CROSS STREET
COPELAND
ROAD
CALNAN STREET
MAXFIELD STREET
HUMESTREET
0
1 Mile
LEGEND
GOVERNMENT PROPERTY LINE
VOC PLUME BOUNDARY IN 1ST WATER-BEARING ZONE (WBZ)
VOC PLUME BOUNDARY IN 2ND WBZ
LOW PERMEABILITY BARRIERS
PERMEABLE REACTION WALL
GATES
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
SOURCES:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT, MARINE CORPS AIR STATION TUSTIN CALIFORNIA BNI. NOVEMBER 1996
N
400 0 400 Feet
Feasibility Study Report
Figure 5-27
Alternative 5: Permeable Reaction Wall Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/18/02
File No : 035L10196
Job No : 23818-035
Rev No : B

The conceptual layout described below and illustrated on Figure 5-27 was used to develop the cost estimate for the permeable reaction wall alternative The actual configuration of any full-scale system installed at OU-1A would be based on the pilot study plus other information developed during remedial design and may differ from the conceptual design presented in this FS Report

The thickness of zero-valent iron required at each treatment gate depends on groundwater velocity, the expected upgradient concentration of TCE and/or 1,2,3-TCP, and contaminant reaction rates as measured during the bench-scale test For this FS Report, it was assumed that 0 5 foot of reactive iron was the minimum thickness that could be reliably constructed Thick reactive iron sections are needed at OU-1A because 1,2,3-TCP degrades very slowly; therefore, it was assumed that the slurry walls would be 1-foot thick

The permeable iron gate sections would be installed to the required dimensions using continuous trenching techniques Native soils would be excavated and replaced with a granular iron product (-8 to +50 mesh size) available from a commercial supplier located in San Bernardino County The reactive iron layer would extend from the base of the trench upward to approximately 1 foot above the seasonal high water table The reactive material would be covered with a geotextile liner, followed by clean fill material (assumed to be native soil) to bring the trench to grade Figure 5-28 presents a schematic of the reactive wall components

Continuous trenching machines have been used for several years to install horizontal groundwater collection drains and impermeable barriers These machines allow simultaneous excavation and backfilling without an open trench Excavation is

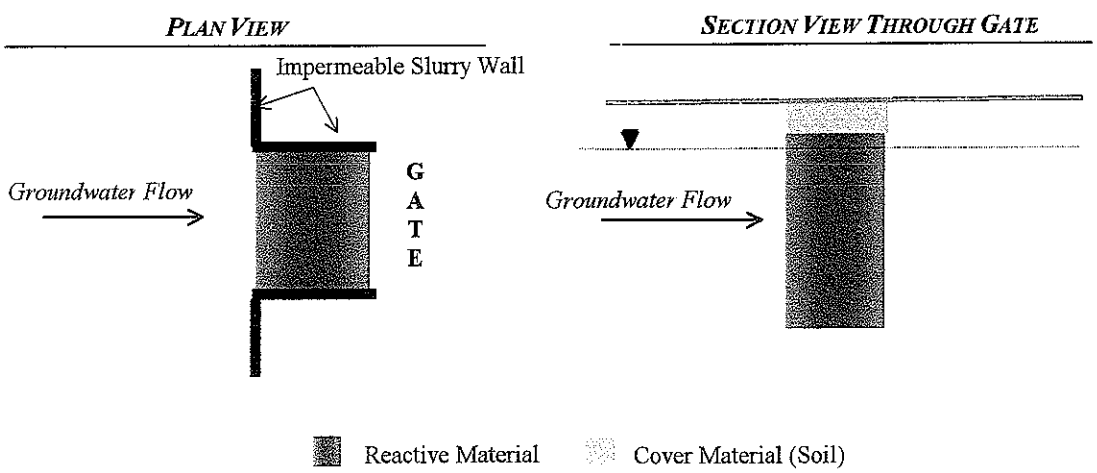


Figure 5-28
Schematic Diagram of Reactive Wall (Gate) Components

accomplished by a cutting chain immediately in front of a trench-box (boot), which extends the width and depth of the finished treatment zone. Both the cutting chain and the boot are attached to the trenching machine. As the trencher moves forward, iron is added to the boot to create the treatment zone.

According to ETI (1998b), continuous trenchers have been used to successfully install iron treatment walls at sites in New York, North Carolina, and Oregon. These projects have ranged from 1 foot to 2 feet in width and up to 35 feet to 45 feet deep. Construction contractors contacted during preparation of this FS Report stated that continuous trenching could be used to install reactive iron wall sections to the depths and widths required for remediation of the VOC plumes. For the purpose of this FS Report, it has been assumed that the permeable reaction wall alternative can be successfully built as proposed. However, it should be recognized that installation of the deep iron walls necessary to remediate VOCs in the second WBZ at IRP-13S would push the limits of available construction technology. Development of appropriate installation technique for the iron wall sections deeper than about 45 feet bgs would be a significant issue that would require resolution during remedial design.

The impermeable funnel sections required by this alternative would be constructed using a soil-bentonite mixture and conventional slurry wall installation techniques. Some of the slurry walls might be constructed in contaminated areas, in which case clean soil from elsewhere at Former MCAS Tustin would be used in the mixture to construct the wall.

Excavated soils removed from contaminated areas during construction of Alternative 5 would be stockpiled, tested to determine the appropriate waste classification, and transported to an off-site facility for treatment and/or disposal. None of the excavated soil is expected to exceed the characteristics of RCRA or non-RCRA hazardous waste. Details concerning the transport, treatment, and disposal of these materials would be as described for source removal activities under Alternative 4 in Sections 5.5.1.1 and 5.5.1.5.

Groundwater modeling was used to predict the performance of Alternative 5 as measured by removal of contaminant mass and reductions in concentrations of VOCs. Figure 5-29 shows the predicted concentrations of TCE entering the reactive wall at each of the gates at IRP-13S. With the assumed configuration of a single slurry wall/iron gate system at the downgradient margin of the plume in the first WBZ, the highest contaminant concentrations would not reach several of the reactive iron sections for 5 to 15 years. As shown on Figure 5-30, similar performance is expected for the reactive iron walls reduction of 1,2,3-TCP at IRP-13S. In all cases, VOC concentrations entering the walls (and therefore the rate of contaminant destruction) would be limited by the natural flow of groundwater. Remediation of the VOC plumes could only occur as quickly as VOCs were transported to the reactive iron under the influence of the prevailing hydraulic gradients in the shallow aquifer.

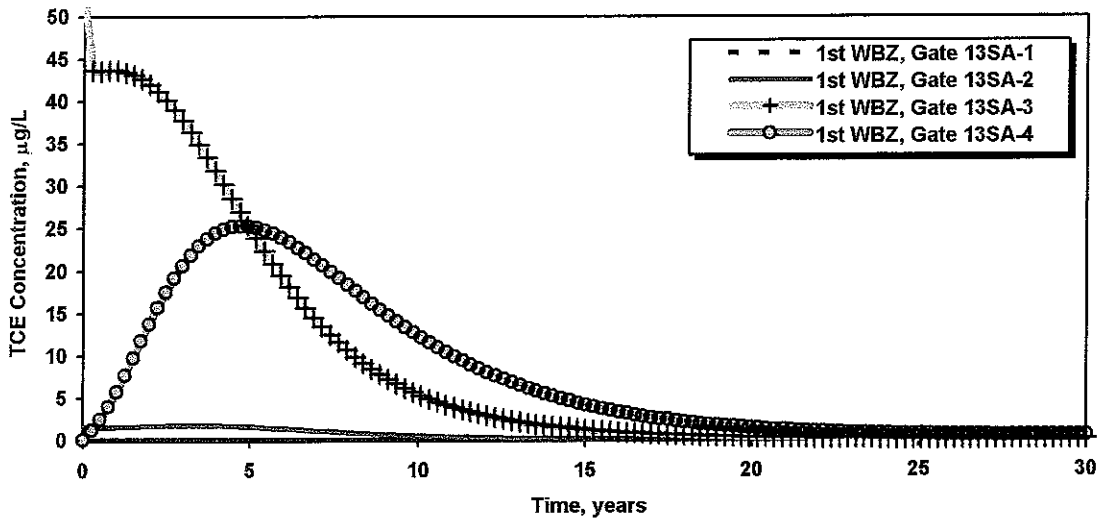


Figure 5-29
Predicted TCE Concentrations Entering Reactive Wall

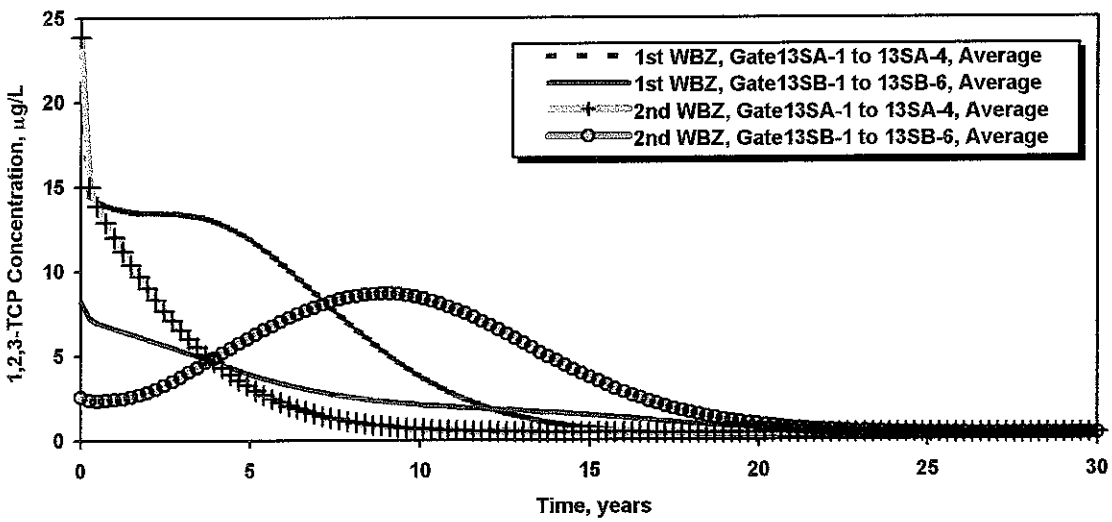


Figure 5-30
Predicted 1,2,3-TCP Concentrations Entering Reactive Wall

The reaction chemistry of the zero-valent iron process has potentially significant implications for the long-term O&M requirements associated with Alternative 5 (Focht et al. 1996). As groundwater passes through the reactive wall sections, iron corrodes and water is hydrolyzed. By-products of this reaction include hydrogen gas, ferrous ions, and hydroxide ions. The resulting pH increase may be sufficient to precipitate several minerals, including the hydroxides and carbonates of calcium, magnesium, and iron. This chemistry was confirmed during the 1997 bench test in which samples of OU-1A groundwater were passed through laboratory columns of granular iron. Under steady-state conditions, the groundwater samples increased from an initial pH 7.1 to values ranging from pH 8.7 to pH 9.2 (ETI 1998a). Significant reductions in calcium and carbonate alkalinity were observed, apparently from precipitation of calcium carbonate in the iron column (BNI 1998a).

As noted in Appendix C, process efficiency may be reduced as chemical precipitates coat the surface of the reactive media and possibly clog the pore space of the reaction walls. While laboratory tests indicate porosity losses of 2 to 15 percent per year as a result of chemical precipitation reactions, full-scale permeable reaction wall systems have operated for over 5 years without a decrease in performance (O'Hannesin and Gillham 1998, Sass et al. 1998, Vogan et al. 1998, Warner et al. 1998). Nevertheless, since reliable methods have not been demonstrated for removal of precipitates from an installed iron wall, the cost estimate developed for this FS Report assumed that the reactive iron media would have to be replaced once during the operating life of Alternative 5 due to irreversible chemical fouling. This replacement was assumed to occur 15 years after construction of the permeable reaction walls.

5.7.1.2 PERFORMANCE MONITORING

Performance monitoring for Alternative 5 would occur during the long-term operation of the full-scale system. Monitoring would be conducted to verify the effectiveness of the remedy and demonstrate that contaminated groundwater upgradient of the wall locations was being captured and directed to the reactive iron. Migration of the plume "tails" downgradient of the permeable reaction wall installations at IRP-13S would also be tracked. For the purpose of developing a cost estimate for this FS Report, the monitoring period was assumed to last 30 years. The actual monitoring period is likely to be much longer, since modeling results presented in Appendix B show that significant contamination would still remain after 30 years in the upgradient portions of the sand layers of the first and second WBZs. An overview of the performance monitoring requirements for Alternative 5 is presented in Table 5-12.

Sample collection to assess performance of the reactive wall sections is the major monitoring component associated with Alternative 5. It was assumed that groundwater monitoring wells would be installed upgradient and downgradient of each iron gate in both the first and second WBZs. Wells would be installed on 25-foot centers, based on the monitoring programs implemented at other sites where full-scale permeable reaction walls have been installed. Given the number and the lengths of the reactive wall sections

Table 5-12
Performance Monitoring for Permeable Reaction Walls

Type of Monitoring Data	Monitoring Locations	Purpose/Use of Data
Water levels	Upgradient/downgradient of slurry walls and reactive iron gates	Determine flow directions Confirm slurry wall performance
VOC concentrations in the shallow aquifer	Points upgradient/ downgradient of reactive iron gates and within VOC plumes	Confirm performance of reactive material Delineate areal and vertical extents of contamination Estimate remaining contaminant mass
Physical and chemical analyses of samples of iron media taken from reactive walls	Reactive iron gates	Assess proper operation of wall Determine need for rehabilitation/ replacement due to chemical precipitation

Acronym/Abbreviation:
VOC – volatile organic compound

proposed for remediation of VOCs at OU-1A, a total of 38 new monitoring wells would be required for this purpose.

The long-term groundwater monitoring program for Alternative 5 would also use a combination of existing and new wells to track the VOC plumes in areas away from the permeable reaction walls. It was assumed that two new groundwater monitoring wells would be installed, one well in each of the first and second WBZs at IRP-13S. In addition, it was assumed that four existing wells would be included in the groundwater monitoring plan.

Thus, for the purpose of this FS Report, a total of 42 wells would be monitored for Alternative 5, including the 38 new wells around the reactive wall sections and the 6 new and existing wells in the VOC plume areas. The actual number of monitoring wells to be sampled and the locations and specifications for any new monitoring wells (depth, screened interval, and well construction materials) would be determined during remedial design and documented in the long-term monitoring plan. This plan would also provide details concerning sampling procedures, target analytes, analytical methods, field and laboratory QA/QC, and reporting requirements. Well locations and surface completion methods would take accessibility into consideration, along with the need to minimize impacts on redevelopment of the Former MCAS Tustin property.

The frequency of groundwater monitoring would vary over time. Water levels would be measured quarterly. Groundwater samples for VOC analysis would be collected quarterly for the first 3 years after implementation of Alternative 5, semiannually for the next 7 years, and annually through the 30th year of the monitoring program assumed in this FS Report.

5.7.1.3 INSTITUTIONAL CONTROLS

Institutional controls are nonengineering mechanisms, particularly legal measures, designed to limit activities or access at a site to protect the selected remedy. Institutional controls fall into two broad categories, restrictions on future land use and provisions for access for future monitoring and maintenance. Proposed future land use is described in the MCAS Tustin SP. The SP indicates that the parcels at Former MCAS Tustin currently overlying the VOC plumes, as well as the downgradient parcels under which the plume is expected to migrate, will be redeveloped for residential, commercial, and recreational use (The Planning Center 1998).

Alternative 5 includes deed restrictions for redevelopment parcels overlying the VOC plumes as well as the downgradient redevelopment parcels under which the "tails" of the plume are expected to migrate (approximately 97 acres) (Figure 1-5). The land-use control objective within the RAOs is for protection of human health by preventing extraction of VOC-impacted shallow groundwater. Restrictions designed to limit inhalation of VOCs are not necessary as long as groundwater extraction is prohibited within the OU-1A plume boundaries (Appendix F). The deed restrictions include the following elements to achieve the land-use control RAO:

- prohibitions on the installation of public or private water supply wells in the shallow aquifer within the area of institutional controls
- prohibitions on the installation of underground utilities, including trenches, within the groundwater in the area requiring institutional controls without the review and approval by the DON and other regulatory agencies; improperly designed subsurface utilities, including the backfilled trenches, may create preferential pathways for the transport of contaminated groundwater and negatively impact the remedial alternative
- prohibitions on construction or other activities that would disturb or otherwise negatively impact the monitoring wells, slurry walls, and reactive iron gates without prior approval from the DON
- provisions to allow access to the DON and other regulatory agencies to install new monitoring wells and implement supplemental remedial measures in the future, if necessary
- provisions to allow access to the DON and other regulatory agencies to monitor the remedial action (i.e., monitoring wells, slurry walls, and reactive iron gates)
- requirements to notify the DON in advance of any plan to lease or transfer affected parcels
- requirements to notify the DON and other regulatory agencies in a timely manner of any change in site conditions that potentially compromises the remedy or endangers public health or the environment

The deed restrictions required for Alternative 5 would not hinder the development of the Former MCAS Tustin property, except for development over the iron walls. The iron walls are assumed to require replacement after 15 years. None of the expected land-use

scenarios on the affected parcels would require the installation of wells and use of groundwater from the shallow aquifer. The deed restrictions only require that wells installed in the regional aquifer be constructed with well screen depths and seals sufficient to prevent cross-contamination with the shallow aquifer. These restrictions will protect the selected remedy and will not affect development of the groundwater resource. Deed restrictions regarding the installation of underground utilities can be addressed with appropriate engineering controls. The time estimated for remediation, based on groundwater modeling, is greater than 30 years.

5.7.1.4 PERIODIC REVIEWS

Periodic reviews under Alternative 5 would involve a detailed analysis of the monitoring data to evaluate the continuing performance of the full-scale permeable reaction walls. According to ETI, a major factor potentially affecting process performance would be clogging due to chemical precipitation (ETI 1998a). Therefore, a primary objective of the periodic reviews would be to investigate whether significant clogging was occurring and to determine the need to rehabilitate or replace the reactive iron material.

Periodic reviews would also be the means to document progress toward site remediation goals and track migration of the plume "tails" in the first and second WBZs downgradient of the permeable reaction walls. The adequacy of the performance monitoring program would be assessed, with revisions suggested as necessary to meet project objectives. Modifications to the monitoring program might include the abandonment of some monitoring wells as portions of the VOC plumes are restored. Adjustments in monitoring frequency would also be made in response to field data.

Results of each periodic review would be documented in a summary report submitted by the DON to other regulatory agencies responsible for program oversight.

5.7.2 Detailed Analysis

Alternative 5 was analyzed in detail using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.7.2.1 SHORT-TERM EFFECTIVENESS

Implementation of Alternative 5 would entail large-scale construction activities at Former MCAS Tustin, with the potential to affect the surrounding community through noise and dust. Protective measures such as dust control and air monitoring would be implemented to minimize these impacts. Other contaminant-related impacts at the installation would be less likely since VOC-affected groundwater would not be brought to the surface. Transport of contaminated materials over public highways would also present short-term risks to other drivers and residents along transportation routes.

The greatest potential short-term risks to the community would be associated with increased vehicular traffic. As discussed in Section 5.5.2.1, this volume of truck traffic would be

negligible compared to overall traffic levels within the metropolitan Los Angeles area, especially when spread out over several months. However, Alternative 5 would entail the possibility of a vehicular accident potentially involving the release of contaminated material. Short-term transportation impacts would be minimized through use of a licensed commercial hauler required to follow all applicable federal, state, and local regulations dealing with transport of the soils removed from the station.

A rigorous health and safety plan and remedial action plan would have to be developed and successfully implemented to minimize risks to workers and the community during the soil excavation and handling associated with construction of the permeable reaction walls and installation of the monitoring wells. These plans would prescribe personal protection equipment as well as monitoring and mitigation measures needed to minimize short-term risks. Appropriate engineering and industrial hygiene controls would be required, such as dust suppression measures, perimeter monitoring, traffic safety planning, and contingency planning.

During operation of Alternative 5 over the long term, it might be necessary to replace the reactive material within the treatment gates. Replacement of the iron would present similar safety and health hazards as described above for the initial construction. Additional complications would be possible, however, depending on the timing of the iron replacement. As discussed in Section 5.7.1.1, some of the more highly contaminated groundwater might not arrive at the reactive wall sections for 10 years or more. If the arrival of this water were to coincide with replacement of the iron media, potential short-term risks to workers, and the importance of adhering to an appropriate health and safety plan, would increase.

Construction of the permeable reaction walls at IRP-13S would take approximately 1 year. Following construction, an initial round of testing would be completed over approximately 3 months. Assuming that the deed restrictions could be established concurrently with remedial design, the major components of Alternative 5 would be in place and operational approximately 3 years after the initial mobilization for the pilot study. At that point, the engineered systems of this remedy would effectively limit the further migration of the VOC plumes, except for the low-concentration plume "tails" downgradient of the permeable reaction walls. Combined with the institutional controls, this alternative would then begin to reduce the mass and concentration of VOCs in the subsurface while acting to prevent potential human exposure to contaminated shallow groundwater.

5.7.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 5 represents an application of permeable reaction wall technology under site conditions for which it has not been demonstrated. One critical technical issue concerns the hardness of the shallow groundwater at Former MCAS Tustin, which increases the likelihood and magnitude of potential mineral precipitation on the iron media. Another involves the need to extend relatively thick (5 to 6 feet) iron wall sections to

approximately 75 feet bgs, deeper than any full-scale applications reported in the literature to date.

Alternative 5 is intended to contain and ultimately remediate the VOC plumes by reducing contaminant concentrations in shallow groundwater to the site cleanup goals established in Section 2.5. This objective would be achieved gradually as contaminated groundwater upgradient of the walls is transported to the reactive iron while the downgradient plume "tails" are attenuated by natural processes such as dilution, dispersion, and adsorption. Modeling was performed to evaluate capture of the VOC plumes by the slurry walls, channeling of contaminated groundwater through the reactive wall sections, and natural attenuation of the downgradient VOCs over a 30-year period.

Results of the modeling simulation are depicted on Figures 5-31 and 5-32. These figures illustrate that the permeable reaction wall configurations developed for Alternative 5 would be effective at directing most of the upgradient VOC-affected groundwater to the reactive iron.

After 30 years of operation, TCE and 1,2,3-TCP concentrations upgradient of the permeable reaction walls would be much lower than at present. However, VOC contamination exceeding site remediation goals would generally remain within the footprint of the VOC plumes, as natural groundwater flow would move VOCs to the reactive iron relatively slowly. The modeling results showed that only 1,2,3-TCP in the most upgradient portion of the VOC plumes would be slightly above site remediation goals after 30 years. Residual risks associated with the VOC plumes would gradually decline under Alternative 5, but would remain elevated until the upgradient, more highly contaminated groundwater flowed through the permeable reaction walls. The magnitude of this decline is illustrated on Figures 5-33 and 5-34, which plot predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs.

Substantial reductions in VOC concentrations (and therefore risk reductions) are expected after installation of the permeable reaction walls, especially during the first 10 years. From trends presented in Figures 5-33 and 5-34, predicted maximum concentrations of TCE and 1,2,3-TCP in shallow groundwater would exceed site cleanup goals for many decades under Alternative 5

Based on concentration trends presented in Figure 5-33 and 5-34, maximum predicted concentrations of TCE and 1,2,3-TCP would exceed their site remediation goals of 5 and 0.6 µg/L, respectively, after 30 years. Except for 1,2,3-TCP in the first WBZ, maximum concentrations of VOCs in groundwater after 30 years under Alternative 5 are expected to occur upgradient of the permeable reaction walls. These contaminants would eventually be transported to the reactive iron and degraded at some time beyond the period considered in this FS Report. Extrapolation of the trends in Figure 5-33 suggests that an additional 30 to 60 years would be required to reduce TCE concentrations to less than 5 µg/L throughout the current extent of the VOC plumes.

Because of natural attenuation processes within the shallow aquifer, residual contamination downgradient of the permeable reaction walls after 30 years would also be

eventually reduced to the cleanup goals. Migration of these plume remnants is not expected beyond the station boundaries.

As with Alternatives 1 and 2, Alternative 5 does not employ active measures to reverse the potential downward migration of 1,2,3-TCP to the third WBZ in a localized area downgradient of IRP-13S. Alternative 5 would entail monitoring in the third WBZ to evaluate this concern. However, the potential for contamination of the deeper regional aquifer would remain, detracting from the long-term effectiveness of permeable reaction walls in this alternative.

Deed restrictions would be used under Alternative 5 to prevent future human exposures to VOC-affected groundwater in the areas of existing contamination as well as along the downgradient VOC migration pathways within the boundaries of the Former MCAS Tustin property. Deed restrictions are expected to be effective and reliable methods of controlling health risks in on-station areas actually or potentially impacted by the VOC plumes. The long-term effectiveness of these measures would be contingent upon their continued enforcement, which would be the responsibility of the DON and DTSC.

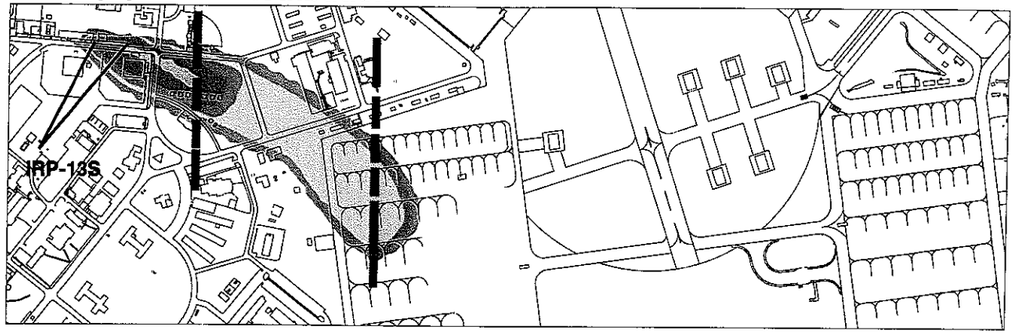
Residuals in the form of spent (nonreactive) iron could possibly be generated if the reactive wall sections had to be replaced some years after the initial construction. Because this material would be a solid waste, it would have to be characterized prior to transport off-site. While it is unlikely that the spent iron would be classified as a hazardous waste, management of this material would comply with RCRA and California waste management regulations. Therefore, residual risks associated with the spent iron are considered negligible.

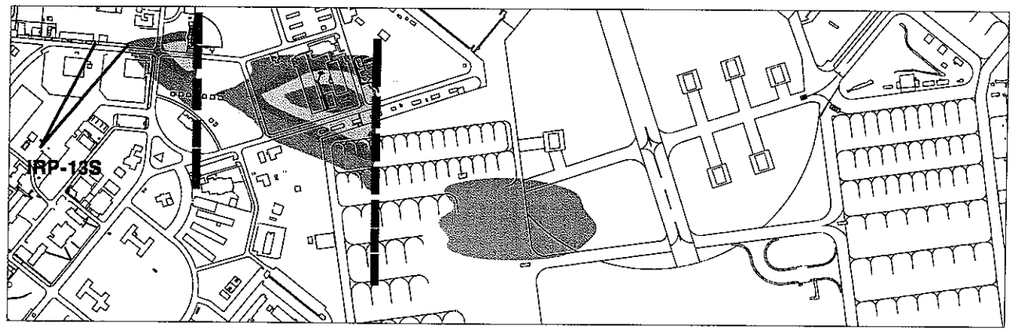
The principal long-term management activity under Alternative 5 would involve verifying the continued effectiveness of the permeable reaction walls through the performance monitoring program discussed in Section 5.7.1.2. Monitoring would include collecting hydraulic head data (to show control of the VOC plumes and evaluate flow through the reactive wall sections) and groundwater sampling (to demonstrate successful degradation of TCE, 1,2,3-TCP, and other site-related contaminants).

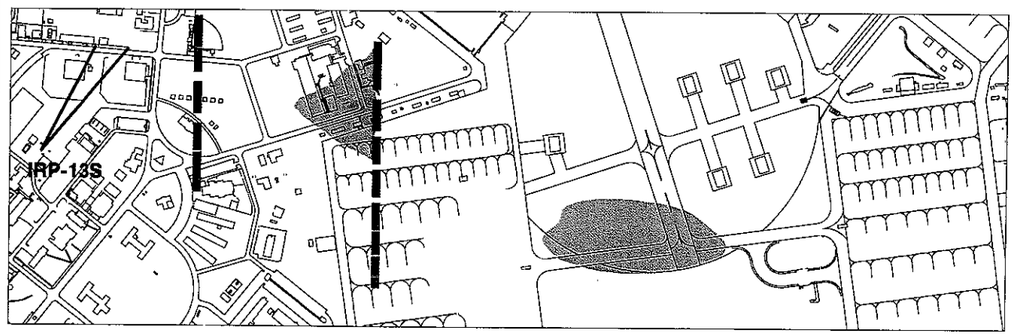
5.7.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

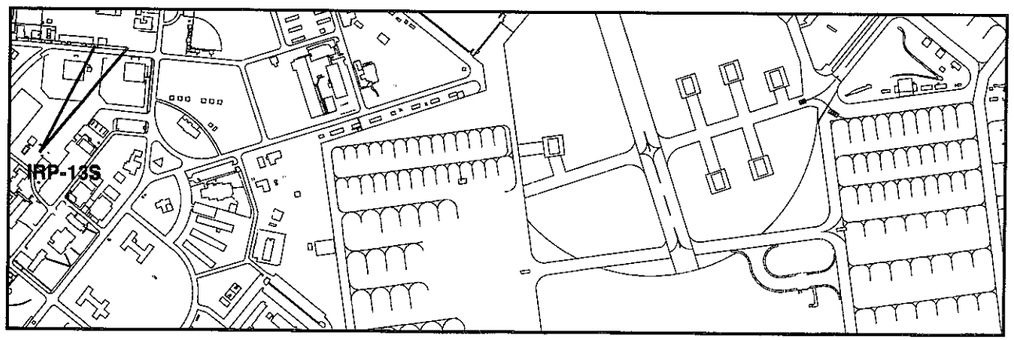
Over time, Alternative 5 would significantly reduce the toxicity, mobility, and volume of the OU-1A groundwater contaminants. Chemical reactions occurring within the iron would remove VOCs from groundwater passing through the permeable wall sections. According to the modeling results presented in Appendix B, operation of the permeable reaction walls for 30 years would remove approximately 45 percent of the TCE mass and 60 percent of the 1,2,3-TCP mass at and downgradient of IRP-13S. As shown on Figures 5-33 and 5-34, maximum VOC concentrations would be reduced by factors of 50 to more than 99 percent, thereby representing a significant reduction in the toxicity of the VOC plumes.

1,2,3-TCP Distribution

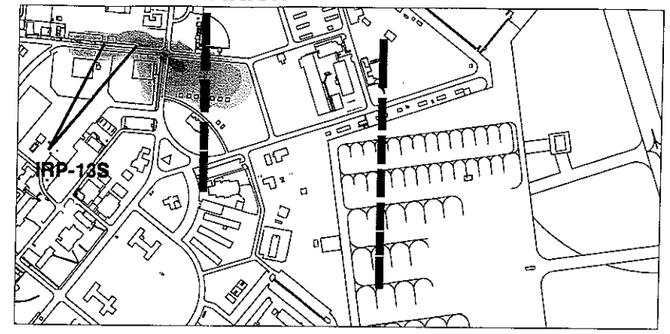




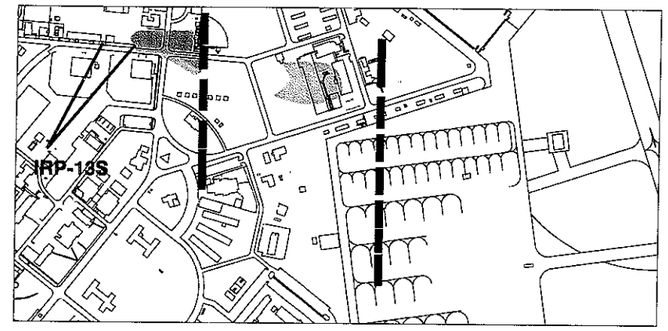




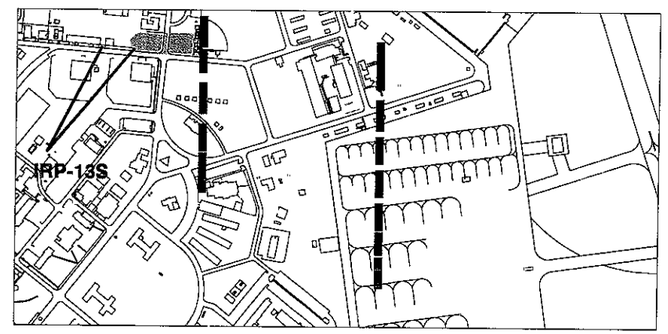
TCE Distribution



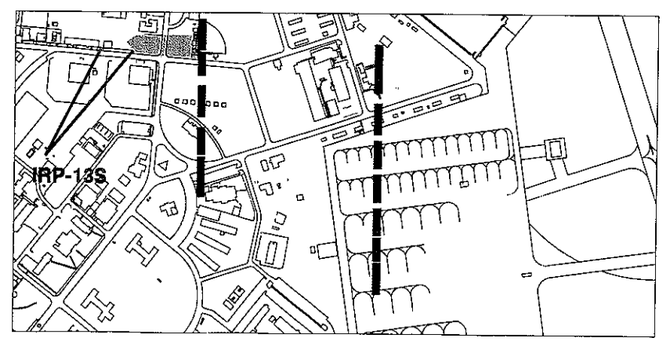
Current Conditions



After 10 Years

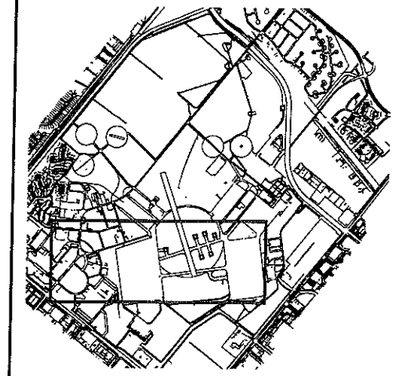


After 20 Years

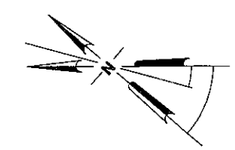


After 30 Years

Alternative 5: Permeable Reaction Wall



1,2,3-TCP	TCE
1 to 5 ug/L	5 to 10 ug/L
5 to 10 ug/L	10 to 20 ug/L
10 to 20 ug/L	20 to 50 ug/L
20 to 50 ug/L	50 to 100 ug/L
50 to 100 ug/L	100 to 200 ug/L
> 100 ug/L	200 to 500 ug/L
	500 to 1000 ug/L
	1000 to 2000 ug/L
	2000 to 5000 ug/L
	> 5000 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-31
Alternative 5: Permeable Reaction Wall
Simulated TCE and 1,2,3-TCP
Concentrations in the 1st WBZ at IRP-13S

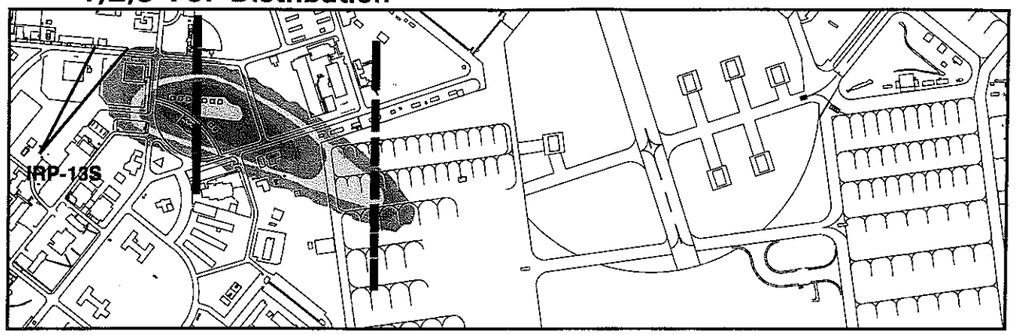
Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

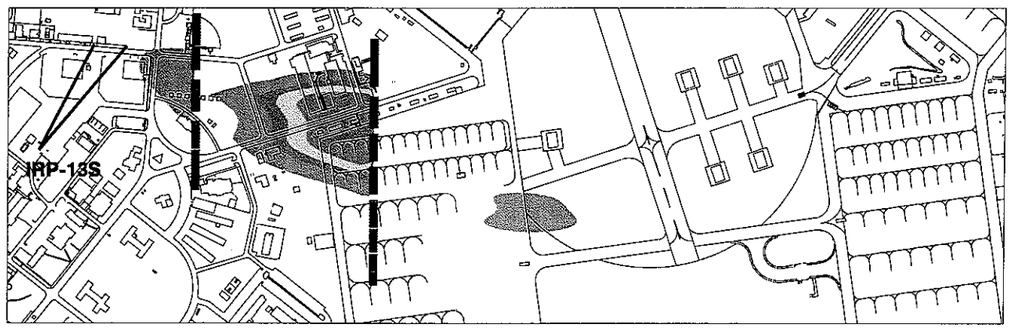
Date: 01/23/03
File No. 035L8618
Job No.:23818-035

gwm72alt5lfs 01/23/03 /f/tustin/tustinsun

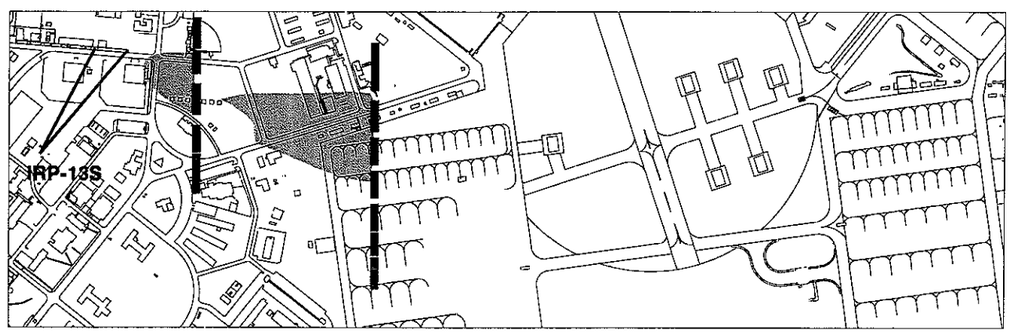
1,2,3-TCP Distribution



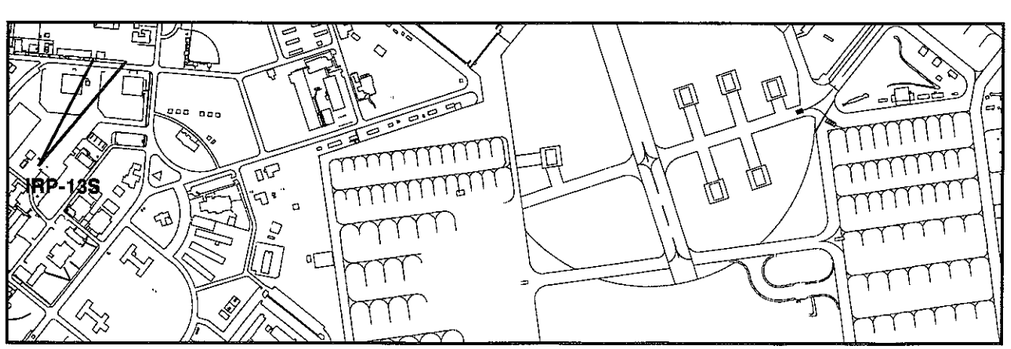
Current Conditions



After 10 Years

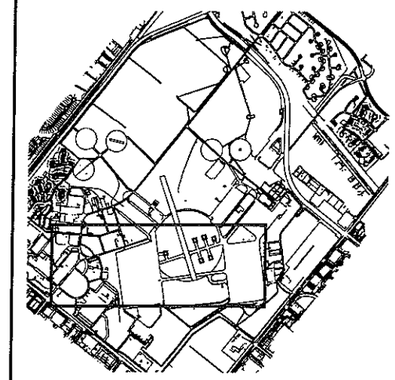


After 20 Years



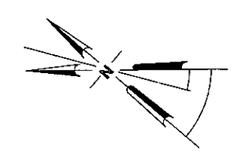
After 30 Years

Alternative 5: Permeable Reaction Wall



1,2,3-TCP

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L



0 450 900 1350 1800

SCALE IN FEET

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

Feasibility Study Report
Figure 5-32
Alternative 5: Permeable Reaction Wall
Simulated 1,2,3-TCP
Concentrations in the 2nd WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 01/23/03
File No 035L8619
Job No.:23818-035

gwm72alt52fs 01/23/03 /f/tustin/tustinsun

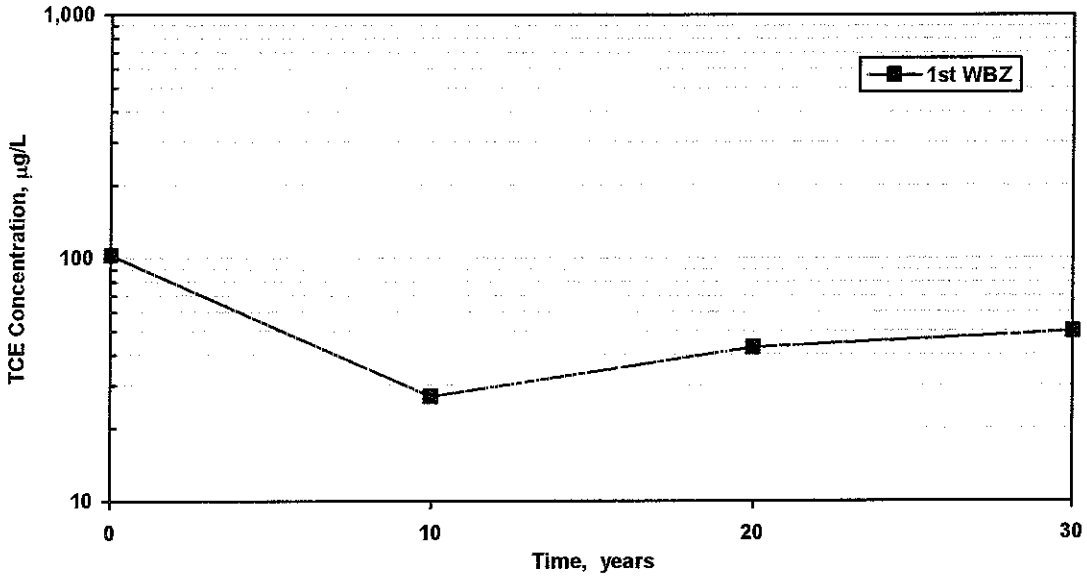


Figure 5-33
Predicted Maximum TCE Concentrations Under Alternative 5

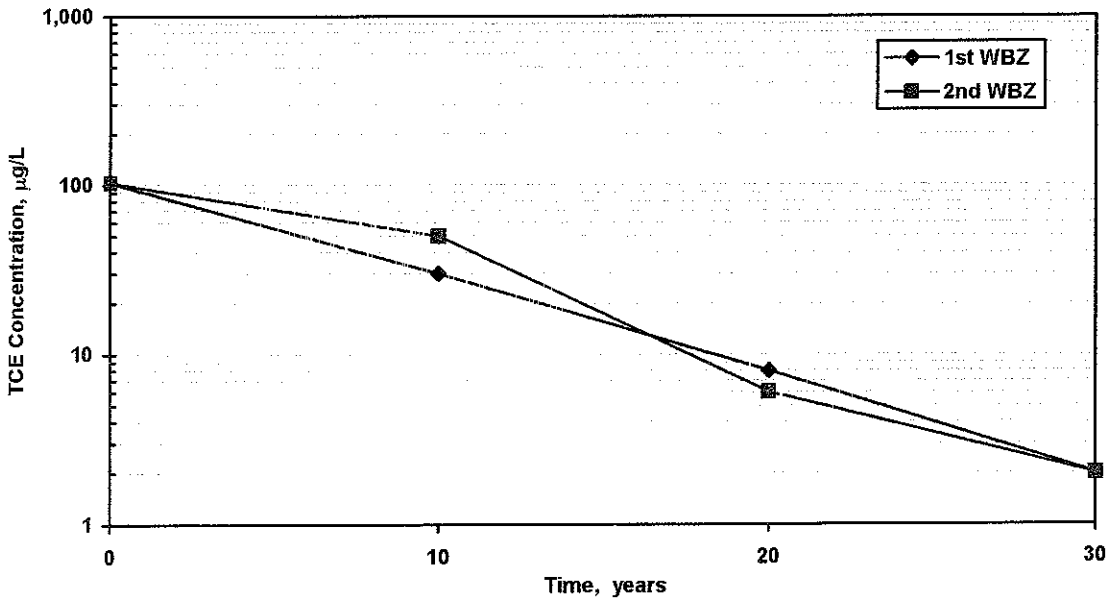


Figure 5-34
Predicted Maximum 1,2,3-TCP Concentrations Under Alternative 5

Halogenated VOCs such as TCE and 1,2,3-TCP would be degraded to nonhalogenated, nontoxic compounds by the reactive iron. Destruction of these VOCs would be assured by providing adequate residence time for the contaminated groundwater within the permeable wall sections. For this FS Report, sizing of the permeable reaction walls (and therefore groundwater residence time) was based on reaction rate constants determined from the 1997 bench-scale test performed with water samples from the VOC plume (ETI 1998a, BNI 1998a). A 50 percent margin of safety was included in the conceptual design of Alternative 5.

Using the assumed funnel and gate configuration, the mobility of the VOC plumes would be substantially controlled. The slurry walls would direct upgradient contaminated groundwater toward and through the reactive iron. Concerns about groundwater movement around the edges of the slurry walls or migration of the downgradient plume "tails" could be addressed during remedial design by making slight modifications to the permeable reaction wall configurations presented in this FS Report.

5.7.2.4 IMPLEMENTABILITY

Installation of permeable reaction walls at OU-1A would present a number of technical and administrative challenges. The technical uncertainties would be reduced to some degree by successful completion of a pilot test at Plume 12W at OU-1B prior to implementation of the full remedy. The implementability of Alternative 5 is contingent upon securing the services of a knowledgeable process vendor (currently limited to one company, ETI) and a construction contractor with the requisite experience and equipment to install relatively thick (5 to 6 feet) iron wall sections to depths of 75 feet bgs. Design of both the pilot- and full-scale systems would require extensive consultation with the process vendor and the construction contractor to assure the successful implementation of permeable reaction walls at OU-1A.

Construction of the slurry walls and monitoring wells would involve standard remedial construction techniques. However, installation of the reactive iron walls would be more complicated, particularly for those gates extending into the second WBZ. Iron walls have not been constructed to the depth needed to capture and treat all VOC-affected shallow groundwater at OU-1A, and there is some uncertainty regarding the constructability of all the components required by Alternative 5.

The operational reliability of the permeable reaction walls should be high, as this technology requires no energy input or mechanical systems to operate. Over time, excessive chemical precipitation might decrease the reactivity and/or porosity of the iron medium, which in turn might affect contaminant degradation rates. Monitoring activities would include methods for tracking chemical precipitation and other geochemical processes that might impact flow through or VOC degradation within the wall. Overall, the performance of this remedy would be readily measured through a conventional monitoring program.

A major concern with the selection of this technology is that there is only one experienced process vendor available to market the technology. While several suppliers

market commercial iron products meeting the required specifications, the number of contractors potentially capable of constructing the deeper iron walls may also be limited. The contractual and administrative complications associated with a sole-source process procurement must therefore be considered when evaluating the implementability of Alternative 5. In addition, the ability of the DON to obtain competitive construction bids is not assured, as it would be for more conventional technologies such as groundwater extraction and GAC treatment.

From an administrative viewpoint, the permeable reaction wall alternative may be attractive because it entails no aboveground structures or ongoing surface operations. However, the deed restrictions that would be instituted as part of Alternative 5 could possibly complicate future redevelopment of the Former MCAS Tustin property, at least on those parcels overlying the slurry walls and reactive iron walls. These areas could be used for a variety of purposes, including roadways, parks, recreation areas, parking lots, or storage areas, but the erection of permanent structures would be prohibited because of potential interference with the DON's access needs as well as threats to the physical integrity of the subsurface remediation systems. Deed restrictions on other redevelopment parcels at Former MCAS Tustin would generally prohibit the installation of public or private water supply wells in the shallow aquifer, protect the monitoring wells, and assure the DON access for sample collection and maintenance. These conditions should not be excessively burdensome for the reasons presented in Section 5.3.1.1.

During a BCT meeting on 29 October 2002, the RAB for Former MCAS Tustin and the RWQCB stated their opposition to the application of this iron reactive wall technology at OU-1A. John Broderick, representing the RWQCB, stated that installation of reactive iron in the subsurface would likely generate by-products that would violate the Basin Plan and that the RWQCB would likely not accept Alternative 5. Dana Ogden, representing the city of Tustin, suggested eliminating Alternative 5 from the OU-1A FS altogether. Alternative 5 was retained for evaluation, however, to be consistent with the FS conducted for OU-1B and for further consideration as an innovative technology.

The deed restrictions under Alternative 5 would most likely remain in force beyond the 30-year period of operation considered in this FS Report. Implementation of this alternative would therefore require administrative coordination with state and local agencies to enforce the deed restrictions.

5.7.2.5 COST

Table 5-13 summarizes the cost estimate developed for Alternative 5. The net present cost for permeable reaction walls as configured in this FS Report would be approximately $19 million. Major capital cost elements include construction of the iron walls, transportation and off-site disposal of contaminated soils removed during the initial construction, the licensing fee paid to the process vendor, and installation of the monitoring wells. The largest O&M cost components are those related to the assumed replacement of the reactive iron media 15 years after implementation of the full-scale permeable reaction wall system. Long-term monitoring of groundwater quality around

Table 5-13
Summary of Cost Estimate[a] for Alternative 5

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering study/design/monitoring plan (1,500 hours @ $85.00/hour)	$170,000			$170,000
Construction of reaction wall (includes licensing fee [15% of construction and iron cost], transport, and disposal of contaminated soil)	$9,415,000			$9,415,000
Reaction wall O&M			$6,853,000	$6,853,000
Monitoring and Reporting				
Install 38 monitoring wells	$430,000			$430,000
Performance monitoring (average 30 years) (includes sample collection, analysis, water levels)		$81,733		$2,452,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$19,716,000**
Contingency (20%)[d]				$3,943,000
Escalation (base 01 January 2001)				$7,529,000
Total Cost				**$31,188,000**
Net Present Value of Alternative 5 (2002 $'s)				**$19,036,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect monitoring activities (annual and 5-year) for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports

Acronym/Abbreviation:
O&M – operation and maintenance

the permeable reaction walls would also be a significant ongoing O&M expense. For the purpose of this estimate, it was assumed that the monitoring program would be conducted for a 30-year period.

Backup and supporting details for the Alternative 5 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.7.2.6 COMPLIANCE WITH ARARs

The major components of Alternative 5 that trigger action-specific ARARs are the installation and development of monitoring wells along with the excavation of soil for and limited depth of construction of the slurry walls and reactive iron gates. Long-term maintenance could include the periodic removal and replacement of spent (nonreactive) iron. These activities would generate solid wastes requiring characterization and appropriate management under RCRA and related state hazardous waste regulations. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

The trends evident on Figures 5-33 and 5-34 suggest that the permeable reaction wall alternative would eventually comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. However, similar to Alternative 3, compliance would be gradual and over an extended period of time. Contamination would remain above regulatory- and health-based limits for several decades within upgradient portions of the plume as TCE- and 1,2,3-TCP-affected groundwater slowly migrated toward the reactive iron. Downgradient of the permeable reaction walls, migration of the low concentration plume "tails" is not expected to be significant. Residual contamination migration in the shallow groundwater would be attenuated over time by natural processes. It could be eliminated entirely during final remedial design by slightly modifying the permeable reaction wall configurations presented in this FS Report.

Chemical-specific ARARs that would eventually be met in the first and second WBZs through implementation of Alternative 5 include the following:

- **Federal:** SDWA MCL (40 C.F.R. § 141.61[a]) for TCE; RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); CWA of 1977 (40 C.F.R. § 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs. tit. 22, §§ 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])
- **State:** Substantive portions of the beneficial uses and water quality objectives in the WQCP for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2 in Appendix A; and DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261.22[a][4], and 66261.24[a][2]–[8])

The persistence of VOC contamination would prevent beneficial use of shallow groundwater within areas currently overlying the VOC plumes as well as the downgradient migration pathways on the Former MCAS Tustin redevelopment parcels. Deed restrictions would remain in effect beyond the 30-year period considered in this FS Report. No such restrictions on beneficial use would occur for any portion of the deeper Irvine Pressure Subbasin (regional aquifer) underlying the installation.

Location-Specific ARARs

The primary activities under Alternative 5 that may trigger location-specific requirements would be those related to installation of the pilot- and full-scale permeable reaction wall systems and the monitoring wells. Construction of the full-scale systems at OU-1A would entail a much larger construction effort. The final design of Alternative 5 would specify procedures and mitigation measures to avoid impacts to these structures during installation of the slurry walls and reactive iron gates. Otherwise, neither the construction nor the long-term operation of Alternative 5 is expected to complicate compliance with location-specific ARARs.

Alternative 5 would be designed and implemented to meet all location-based requirements, which are identified as ARARs in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

The major components of Alternative 5 that trigger action-specific ARARs are the excavation of soil for construction of the slurry walls and reactive iron gates. Excess soil would also be generated during installation of the monitoring wells. Some excavations and monitoring well installations might occur in areas with contaminated soil. Future O&M for this alternative could include removal of spent (nonreactive) iron. All these activities would generate solid wastes requiring characterization and proper treatment and/or disposal.

As identified in Appendix A (Section A4.5), the action-specific requirements for permeable reaction walls include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs., tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34); groundwater monitoring (Cal. Code Regs., tit. 22, § 66264.91[a] and [c], 66264.97, 66264.98, and 66264.100[a] and [b]); and as specified in Table A4-1 in Appendix A
- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); antidegradation provisions of SWRCB Resolution No.68-16 (SWRCB 1968); California Civil Code requirements for land-use controls (Cal. Civ. Code

§ 1471); California Health and Safety Code requirements for institutional controls (Cal. Health & Safety Code §§ 25202.5, 25222.1, and 25233[c]); and substantive provisions of SCAQMD Rules 401, 403, 404, and 405 as delineated in Table A4-2 in Appendix A

Activities under Alternative 5 that produce solid waste (excavated soil, soil cuttings, and spent iron) would be implemented in a manner compliant with federal and state action-specific ARARs at Cal. Code Regs. tit. 22, § 66262. These residuals would be characterized using criteria for the identification of RCRA and non-RCRA hazardous waste. If any of these wastes were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the hazardous waste requirements of Cal. Code Regs. tit. 22, §§ 66262 and 66264 would also be potential ARARs for activities involving management of the waste for off-site disposal. Implementing Alternative 5 in compliance with these requirements would not be expected to present significant complications from a technical or administrative viewpoint.

Alternative 5 would comply with the Basin Plan requirements to maintain beneficial uses and meet water quality objectives for groundwater in the Irvine Pressure Subbasin (regional aquifer) by limiting further migration of contaminated groundwater and *in situ* treatment.

Performance goals for the *in situ* treatment of the VOC plumes would be based on reducing 1,2,3-TCP, TCE, and other site-related VOC contaminants to the remediation goals established in Section 2.5. This would assure compliance with the narrative water quality objective for surface water provided in the Basin Plan.

Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements.

The long-term performance of the remedial process involved in Alternative 5 has not been proven, and construction techniques need to be resolved for proposed installation depths below 45 feet bgs. The RWQCB and local citizenry consider the use of permeable reactive gate technology using reactive iron to be potentially inappropriate for remedial actions at OU-1A.

Although Alternative 5 could be designed and implemented to comply with all of the federal and state action-specific requirements identified, some uncertainty remains regarding ease of implementability and acceptance.

5.7.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Overall protection of human health and the environment is considered fair for Alternative 5. This option uses an innovative technology for *in situ* remediation of the VOC-affected shallow groundwater at and downgradient of IRP-13S. It employs a destructive treatment process offering a permanent solution to groundwater contamination problems at OU-1A. Alternative 5 would eventually comply with all identified ARARs, reduce potential risk to human health and the environment, and gradually achieve the site remediation goals established in Section 2.5. Implementation and enforcement of

institutional controls should effectively prevent human exposure to contaminated shallow groundwater until cleanup goals are attained. Over time, concentrations of TCE and 1,2,3-TCP, along with the associated risks to potential residential receptors, would decline due to the destruction of contaminant mass by the reactive iron. Performance monitoring and periodic reviews would verify and track the overall performance of the remedy.

Alternative 5 represents an extension of permeable reaction wall technology in that it has not been demonstrated at sites with the elevated hardness of the OU-1A groundwater. Iron walls have not been installed at the depths required to address contamination in the second WBZ at IRP-13S. Bench-scale data indicate that 1,2,3-TCP can be successfully degraded by zero-valent iron, but full-scale permeable reaction wall applications have not been reported for remediation of this VOC. Although this is not surprising, since 1,2,3-TCP is not often encountered as a groundwater contaminant, it does add additional technical uncertainty to Alternative 5.

In the full-scale application, permeable reaction walls would be placed at the downgradient margins of the VOC plumes and in the middle of the VOC plumes in the first and second WBZs. If the walls work as well as reported at other sites (Section 3.3.2.5 and Appendix C), TCE, 1,2,3-TCP, and other chlorinated VOCs in groundwater passing through the reactive iron would be effectively degraded to nontoxic by-products.

No further degradation of groundwater quality in the first two WBZs of the shallow aquifer would occur upgradient of the permeable reaction walls. Downgradient on-site migration of the low concentration plume "tails" is not expected to be significant. This migration would be attenuated over time by natural processes and is not expected to reach Barranca Channel. Concerns about potential downgradient migration under Alternative 5 could be eliminated entirely during final remedial design by slightly modifying the permeable reaction wall configurations presented in this FS Report. However, since Alternative 5 uses an inherently passive process, it would not provide any measures to reverse the potential downward migration of 1,2,3-TCP to the third WBZ in a localized portion of the IRP-13S plume.

During a BCT meeting on 29 October 2002, the RAB for Former MCAS Tustin and the RWQCB stated their opposition to the application of this iron reactive wall technology at OU-1A. John Broderick, representing the RWQCB, stated that installation of reactive iron in the subsurface would likely generate by-products that would violate the Basin Plan and that the RWQCB would likely not accept Alternative 5. Dana Ogden, representing the city of Tustin, suggested eliminating Alternative 5 from the OU-1A FS altogether. Alternative 5 was retained for evaluation, however, to be consistent with the FS conducted for OU-1B and for further consideration as an innovative technology.

Another disadvantage to Alternative 5 is that it must be implemented and remain functional for a potentially significant length of time to completely remediate the VOC plumes. Modeling completed for this FS Report indicates that the permeable reaction walls would have to operate for several decades beyond the 30-year period considered in

this FS Report to achieve site remediation goals for TCE and 1,2,3-TCP. A prolonged period of operation increases costs as well as the chances that unforeseen problems, such as gradual deterioration of the reactive iron or failure to enforce institutional controls, could reduce the overall protectiveness of Alternative 5.

5.8 ALTERNATIVE 6 – VACUUM-ENHANCED EXTRACTION WITH OFF-SITE SOIL DISPOSAL

Alternative 6, VEE with off-site soil disposal, is intended to contain the VOC plumes within the boundaries of the Former MCAS Tustin property while attempting to shorten the time required to remediate VOC-affected groundwater. A network of VEE wells would be established to remove contaminated groundwater in the first WBZ at and downgradient of IRP-13S. Other components of this alternative include removal of VOC-contaminated soils from the source areas at IRP-13S, conventional groundwater extraction in the second WBZ, treatment and discharge of extracted groundwater, institutional controls, long-term monitoring, and periodic reviews.

5.8.1 Description

Alternative 6 is a refinement of Alternative 4. A high vacuum would be imposed on the groundwater extraction wells completed in the first WBZ at the site. The purpose of the VEE system would be to increase the groundwater extraction rate, and thus the rate of VOC removal, from the sand layer of the first WBZ. Additional contaminants would be removed with any soil vapor extracted by the vacuum system as the groundwater table is lowered near the VEE wells and VOCs are stripped from newly exposed soil. Conventional groundwater extraction would be used to remove dissolved contaminants from the second WBZ. Operation of the extraction wells in the upper two WBZs would eliminate concerns related to the potential downgradient migration of the VOC plumes toward off-station properties as well as the threat of future VOC discharges to Barranca Channel. Additionally, groundwater extraction in the second WBZ would maintain a constant upward hydraulic gradient from the third WBZ, thereby eliminating the potential for the localized, downward migration of 1,2,3-TCP identified during a field investigation completed at Former MCAS Tustin in 1998 (BNI 1999c).

The extracted groundwater would be treated by GAC to remove organic contaminants. One aboveground treatment facility would be constructed near the location of the active TCRA treatment system. Treated groundwater would be discharged to a city of Tustin storm drain eventually emptying into Peters Canyon Channel. Any soil vapor extracted by the VEE wells would be treated by GAC adsorption prior to release to the ambient air.

Alternative 6 would also include mechanical excavation of VOC-affected soils in the source areas at IRP-13S. Long-term performance monitoring would track the progress of remediation, supported by detailed reviews every 5 years to evaluate remediation's continued protectiveness. Deed restrictions would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes to prohibit shallow groundwater use, effectively preventing human exposure to contaminated groundwater.

Figure 5-35 presents the site layout for Alternative 6. Individual components of the VEE alternative are discussed in greater detail below.

5.8.1.1 EXCAVATION OF SOURCE MATERIAL

Under Alternative 6, vadose soil containing elevated TCE concentrations would be removed at MWA-18, as would VOC-contaminated soil from the upper confining clays of the first WBZ. The rationale for removing these soils, as discussed for Alternative 4 in Section 5.5.1.1, would be to eliminate chronic sources of low-level VOC contamination to the sand layer of the first WBZ. Modeling results presented in Appendix B show that these sources would be especially significant if groundwater were to be extracted from the first WBZ.

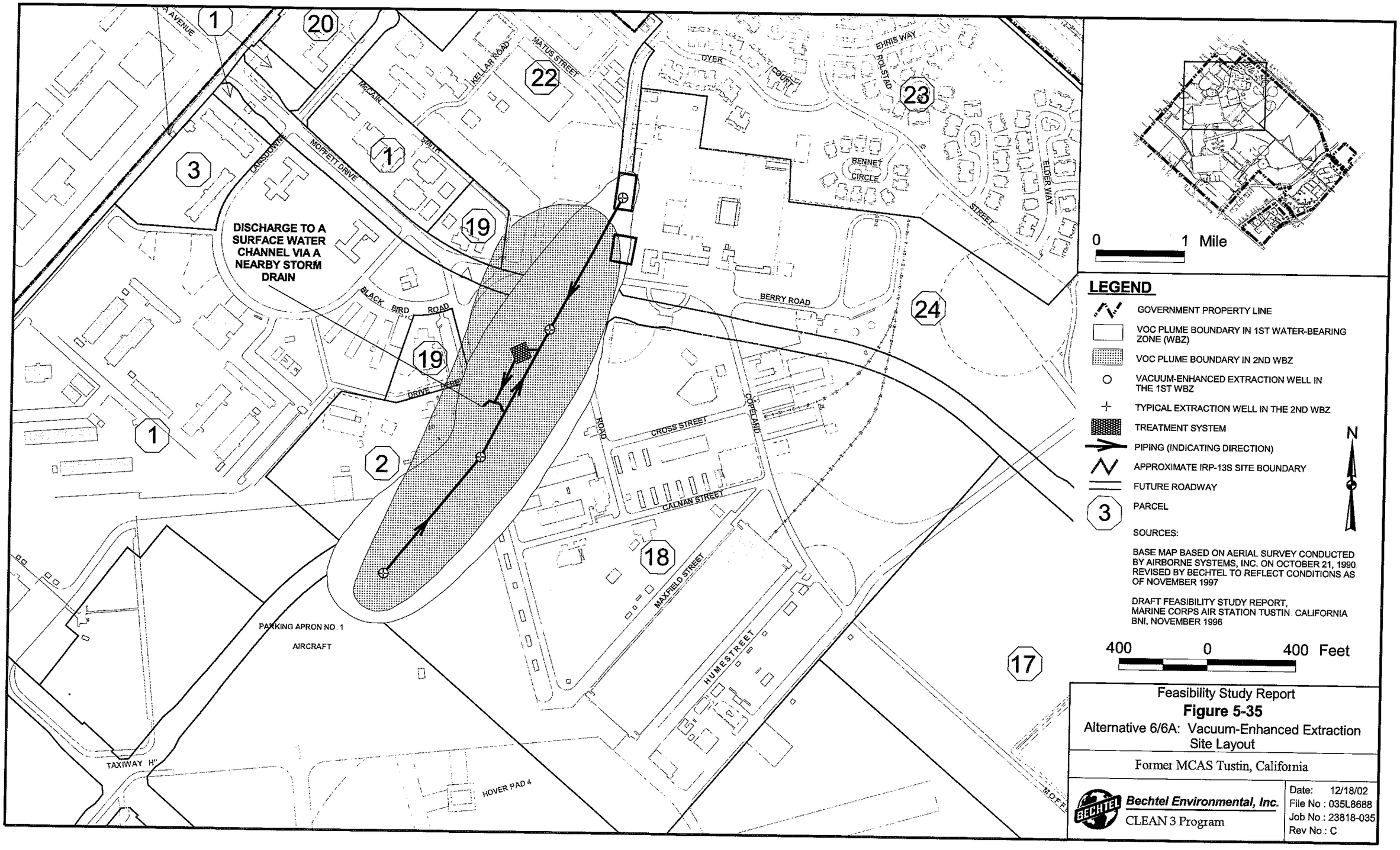
Soil excavation criteria for TCE and 1,2,3-TCP would remain at 100 and 10 μg/kg, respectively. Confirmation samples would be collected at the bottom of each excavation to demonstrate removal of all contaminated soil exceeding these criteria.

The areas and depths to be excavated under Alternative 6 would be the same as for Alternative 4. A total of 18,600 cubic yards of soil would be excavated using sheet piling and construction dewatering. As with Alternative 4, the excavated soils would be segregated into three groups based on VOC concentrations. This would minimize the volume of material for off-site disposal and facilitate reuse of the cleaner soil fractions as backfill. Figure 5-18 shows the volume of excavated soil estimated for Alternative 6, which would be identical to that for Alternative 4.

A temporary storage area with a liner, a berm, and leachate collection, run-on diversion, and dust control features would be constructed for the soil stockpiles at the site. The stockpiled material would be tested to determine its classification under both federal and California hazardous waste management regulations. Based on data from the RI (BNI 1997a), it was assumed for the purpose of this FS Report that none of the excavated soil at OU-1A would be classified as RCRA or non-RCRA hazardous waste.

After confirmation of the appropriate waste classification, soil with reported TCE or TCP at concentrations exceeding 100 or 10 μg/kg, respectively, would be transported in trucks to a permitted Class II landfill and disposed as nonhazardous solid waste. Approximately 5,200 cubic yards of soil would be shipped off-site for disposal. It was further assumed that approximately 13,400 cubic yards of soil from the other two categories, containing either not reported or low concentrations of TCE (up to 100 μg/kg) and/or 1,2,3-TCP (up to 10 μg/kg), would be backfilled directly into the excavations.

Dewatering of the excavations would be required, since the target soils are below the water table at the site. Water pumped out of the excavations and collected from the temporary soil storage areas would be stored in Baker-type tanks and treated using mobile GAC units. The treated water would be reused on-site for dust control or irrigation.


DISCHARGE TO A SURFACE WATER CHANNEL VIA A NEARBY STORM DRAIN
LANSDOWNE
MOFFETT DRIVE
MCCAIN
SMITH
KELLAR ROAD
MATUS STREET
DYER
COURT
EHRIS WAY
ROLSTAD
BENNET CIRCLE
ELDER WAY
STREET
BERRY ROAD
BLACK BIRD ROAD
DRIVE EAST
CROSS STREET
COPELAND
ROAD
CALNAN STREET
MAXFIELD STREET
HUMESTREET
PARKING APRON NO. 1
AIRCRAFT
TAXIWAY "H"
HOVER PAD 4
1
2
3
17
18
19
20
22
23
24
0
1 Mile
LEGEND
GOVERNMENT PROPERTY LINE
VOC PLUME BOUNDARY IN 1ST WATER-BEARING ZONE (WBZ)
VOC PLUME BOUNDARY IN 2ND WBZ
VACUUM-ENHANCED EXTRACTION WELL IN THE 1ST WBZ
TYPICAL EXTRACTION WELL IN THE 2ND WBZ
TREATMENT SYSTEM
PIPING (INDICATING DIRECTION)
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
SOURCES:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997
DRAFT FEASIBILITY STUDY REPORT, MARINE CORPS AIR STATION TUSTIN, CALIFORNIA BNI, NOVEMBER 1996
N
400 0 400 Feet
Feasibility Study Report
Figure 5-35
Alternative 6/6A: Vacuum-Enhanced Extraction Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/18/02
File No.: 035L8688
Job No.: 23818-035
Rev No.: C

5.8.1.2 BUILDING DEMOLITION

Soil excavation under Alternative 6 would affect the same structure discussed in Section 5.5.1.2 for Alternative 4. For the purpose of developing a cost estimate in this FS Report, it was assumed that Building 16 at IRP-13S would be demolished. However, based on previous asbestos surveys, Building 16 contains varying amounts of ACM. The presence of ACM in Building 16 will significantly increase the demolition costs. The costs are discussed in Section 5.8.2.5.

5.8.1.3 BACKFILLING OF EXCAVATIONS

Backfilling of the excavations under Alternative 6 would be as described in Section 5.5.1.3 for Alternative 4. Approximately 5,200 cubic yards of clean fill, assumed to be ungraded sand, would be brought to the site from an off-site commercial source. This sand would be used as excavation backfill, along with approximately 13,400 cubic yards of material excavated at OU-1A. Prior to reuse as backfill, the excavated native material would be tested to show that concentrations of TCE and 1,2,3-TCP were below 100 and 10 µg/kg, respectively. To the extent possible, only soil with not reported concentrations of TCE and 1,2,3-TCP would be replaced below the water table. Soil with VOCs exceeding the detection limits but below the 100 µg/kg TCE and 10 µg/kg 1,2,3-TCP action levels would be placed above the seasonal high water table, as illustrated on Figure 5-19.

5.8.1.4 EFFECTS OF BACKFILL WITH LOW LEVELS OF VOCs

As discussed in Sections 5.5.1.1 and 5.5.1.3, appropriate soil excavation criteria for TCE and 1,2,3-TCP are 100 and 10 µg/kg, respectively. Soil with VOCs at concentrations that are less than these values would be used as backfill placed above the seasonal high water table (vadose zone). VLEACH modeling results from the RI were reexamined to evaluate the effects on groundwater from backfilled soils with VOCs at these low concentrations. The modeling indicated that the leachate from vadose zone backfill would result in TCE and 1,2,3-TCP in groundwater at concentrations that are near or below their respective site remediation goals of 5 and 0.6 µg/L (Tables 2-5 and 5-7). Details on the reexamination of these data are presented in the discussion for Alternative 4 (Section 5.5).

5.8.1.5 OFF-SITE DISPOSAL OF SOURCE MATERIALS

Under Alternative 6, approximately 5,200 cubic yards of VOC-contaminated soil would be transported to a permitted Class II landfill. A licensed waste hauler would be used for these shipments. A commercial Class II landfill in northern Los Angeles County, located approximately 100 miles from the site, was selected as a representative facility for the purpose of developing a cost estimate for this FS Report. The actual landfill to be used would be determined during detailed design on the basis of competitive bids. In conjunction with the final design effort, U.S. EPA must also determine that the Class II landfill ultimately selected for off-site disposal of OU-1A soils is qualified to receive

waste from a CERCLA site per 40 C.F.R. § 300.440. Details on the off-site disposal of source material soils under Alternative 6 would be identical to those for Alternative 4, discussed in Section 5.5.1.5.

5.8.1.6 GROUNDWATER EXTRACTION

VEE wells (operating at a vacuum between 0.3 and 0.4 atmosphere) would be installed under Alternative 6 to remediate VOC-affected groundwater in the first WBZ. For this FS Report, it was assumed that conventional extraction wells would be installed in the second WBZ. However, the possibility of using VEE wells in the second WBZ would also be evaluated during the remedial design. Groundwater extraction in the second WBZ, whether by conventional wells or VEE, would be designed to maintain a constant upward hydraulic gradient from the third WBZ and eliminate the potential for farther downward migration of 1,2,3-TCP in a localized area near the intersection of Cross Street and McCord Road.

The extraction well network illustrated in Figure 5-35 would contain all VOC-contaminated groundwater within existing plume boundaries in both the first and second WBZs.

The number of extraction wells, well locations, and pumping rates required by Alternative 6 were determined based on aquifer tests, geologic cross-sections, and groundwater monitoring completed for the RI and the RFA (BNI 1997a,b). Groundwater modeling was used to optimize the conceptual design of the groundwater extraction system, as detailed in Appendix B.

A total of eight groundwater extraction wells would be required under Alternative 6, including four VEE wells in the first WBZ and four conventional extraction wells in the second WBZ. Table 5-14 summarizes the proposed completion depths and pumping rates for these wells. As shown on Figure 5-35, extraction wells would be located along the centerlines of the VOC plumes, with at least one well placed near the portion of each plume with the highest VOC concentrations. Actual extraction well locations and depths would be determined during remedial design.

Groundwater modeling results indicate that the groundwater extraction wells would produce a combined 72 gpm (48 gpm from the first WBZ and 24 gpm from the second WBZ), equivalent to an influent flow rate of approximately 104,000 gpd to the treatment system discussed in Section 5.8.1.6. Actual production rates may vary from these estimates due to the heterogeneity of the shallow aquifer. This issue would be addressed through groundwater extraction tests conducted at the proposed well locations during remedial design.

Figure 5-36 presents a schematic conceptual design of the type of VEE well that would be installed in the first WBZ under Alternative 6. Each well would be completed as a 6-inch-diameter, production-type water well. For cost estimation purposes, it was assumed that the wells would be constructed using stainless steel casings and well screens. The actual materials of construction would be determined during remedial

Table 5-14
Extraction Well Details for Vacuum-Enhanced Extraction

Water-Bearing Zone	Number of Wells	Completion Depth* (feet bgs)	PUMPING RATE (gpm)	
			Each Well	Combined
First	4	30–34	12	48
Second	4	55–60	6	24
Total	8	N/A	N/A	72

Note:
* completion depths shown are estimated; actual depths would vary depending on conditions encountered at each location

Acronyms/Abbreviations:
bgs – below ground surface
gpm – gallons per minute
N/A – not applicable

design. A sand pack would be placed around each screen. The annular space between the screened interval and ground surface would be sealed with grout. The wells would be completed with dedicated submersible pumps along with the necessary piping and electrical controls.

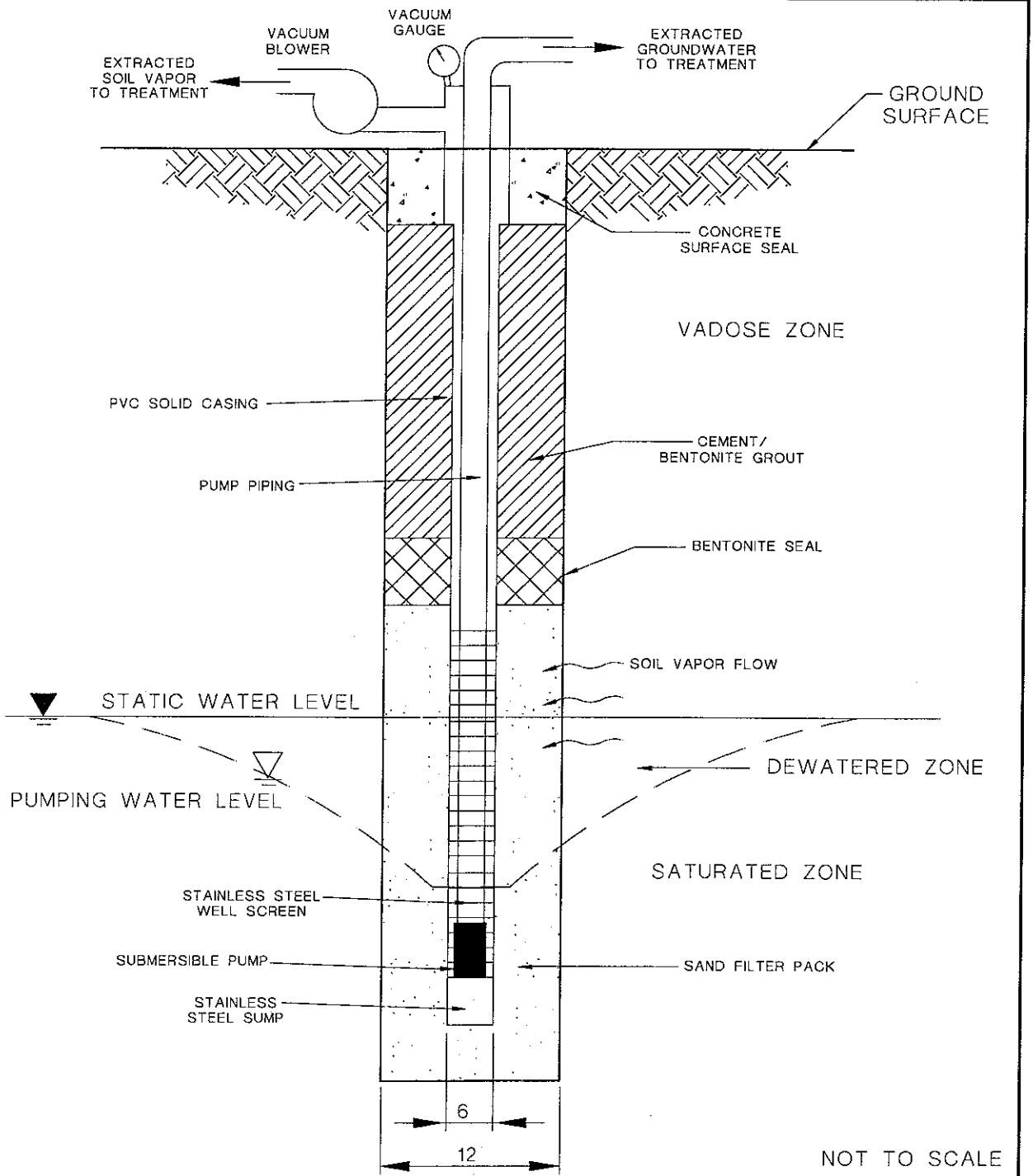
Liquid-ring pumps installed at the treatment facility would produce the vacuum required by the VEE wells. Each wellhead would be connected to the vacuum source by a buried piping network. A total of approximately 1,700 feet of vacuum distribution piping would be required by Alternative 6.

Installation and completion of the extraction wells would be in accordance with the substantive requirements of Orange County Ordinance No. 2607. In addition, the wells would be constructed to meet DWR specifications and safety and health standards (DWR 1991).

The VEE and conventional groundwater extraction wells would continue to operate until VOC concentrations in the sand layers of the first two WBZs approach asymptotic levels. Based on the modeling described in Appendix B, extraction is expected to continue for 15 years. Extraction for longer periods would not result in significant additional contaminant reduction, as illustrated in Figures 5-37 and 5-38. After the extraction systems are shut down, natural attenuation processes would continue to reduce residual VOCs to site cleanup goals.

5.8.1.7 GROUNDWATER CONVEYANCE AND TREATMENT

With all extraction wells operating, Alternative 6 would yield nearly 38 million gallons of water per year. The total volume of groundwater to be managed by this alternative would be approximately 0.5 billion gallons, assuming that the extraction system operates for 15 years. Extracted groundwater would be delivered to the treatment facility via buried



Feasibility Study Report

Figure 5-36

Typical Vacuum-Enhanced Extraction Well

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/16/02
File No: 035X8687
Job No: 23818-035
Rev No: B

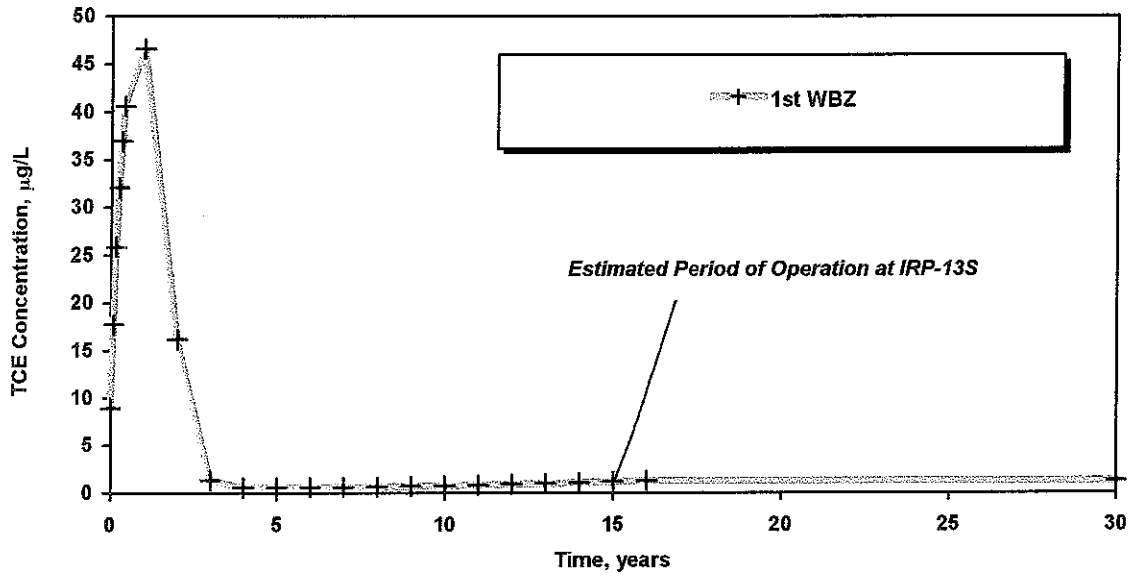


Figure 5-37
Predicted TCE Concentrations in Vacuum-Enhanced Extraction Wells

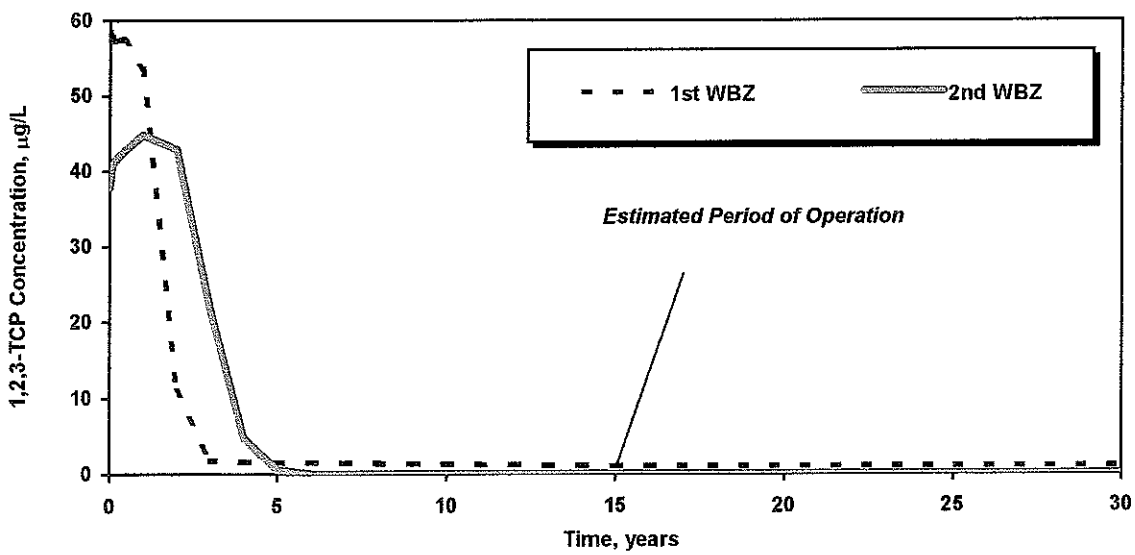


Figure 5-38
Predicted 1,2,3-TCP Concentrations in Vacuum-Enhanced Extraction Wells

pipelines installed according to applicable city of Tustin codes. Approximately 1,700 feet of double-walled conveyance piping would be required by Alternative 6.

A groundwater treatment facility would be constructed, as shown on Figure 5-35. The treatment plant would consist of an equalization tank, cartridge filters, modular GAC units, and associated pumps, piping, and controls. Two-stage GAC adsorption would be employed to reduce the OU-1A COCs to their site remediation goals (Section 2.5) before discharge. Selection of GAC as the preferred process option for removing VOCs from groundwater is documented in Sections 3.3.2.7 and 5.4.1.2.

Capacity of the equalization tank would be 20,000 gallons at the treatment plant. The tank would be sized to hold approximately 4 hours of flow with all wells operating. The equalization tank would be used to prevent flow surges due to cyclic operation of the pumps in the individual extraction wells. Such surges may affect the performance of the GAC adsorbers if not properly controlled. The tanks would be equipped with level control switches to shut down the extraction wells if necessary to prevent overflows.

Sample taps would be provided so that the effluent at the treatment plant could be monitored against discharge requirements. Samples could also be obtained from the equalization tank effluent and between the GAC vessels to monitor the performance of individual carbon units and determine when to replace spent GAC in the lead adsorber.

Groundwater modeling was used to predict influent TCE and 1,2,3-TCP concentrations to the treatment plant, as shown on Figures 5-37 and 5-38. Other VOCs are at much lower concentrations in the VOC plumes and would be expected to decline with time in the extracted groundwater in a similar manner. Maximum influent concentrations from the flow-weighted design for TCE and 1,2,3-TCP are 47 and 59 μg/L, respectively.

Using the predicted groundwater extraction rates and design influent VOC concentrations, an estimated carbon usage rate of 0.237 pound per thousand gallons treated was calculated for the first year of operation at the treatment facility. This is equivalent to 9,000 pounds of GAC annually.

Operation of the treatment facility for 15 years (the basis for the FS cost estimate) would produce a maximum of 135,000 pounds of spent GAC. The maximum VOC loading on the GAC is anticipated to be less than 4 percent by weight. Regeneration or disposal of the spent carbon would be the responsibility of the GAC supplier under a long-term service contract. For purposes of this FS Report, it was assumed that spent GAC would be transported off-site for regeneration, which is the typical practice on groundwater remediation projects. Prior to shipment from the site, the spent GAC would be tested to determine its waste classification (nonhazardous, RCRA hazardous, and/or non-RCRA hazardous). Characterization, packaging, and transport of this material would be in accordance with DOT, U.S. EPA, and DTSC requirements.

GAC would also be used to remove VOCs from any soil vapor recovered by the VEE wells prior to emission to the ambient air. Modular GAC canisters would be connected to the exhaust side of the liquid ring vacuum pumps at the treatment facility. Modeling results presented in Appendix B predict that 0.9 scfm of soil vapor would be recovered

from the VEE wells. Assuming these flow rates and the model-based predictions for vapor-phase VOC concentrations, the maximum spent GAC generation rate for soil vapor treatment is expected to be less than 200 pounds per year. Replacement of the modular canisters and regeneration of the spent GAC from vapor-phase treatment would also be the responsibility of the carbon supplier under a long-term service contract.

The results of a recent pilot test at a nearby site (IRP-3) suggest that vapor flow in the VEE wells is unlikely because residual moisture in the upper clay layer of the first WBZ would act as an effective barrier to air circulation from the surface (BNI 1999a). However, it was determined that provisions to treat VOC-containing vapors should be included for Alternative 6, since modeling results indicate that soil vapor extraction is theoretically possible. This issue would be resolved during final design if VEE is selected as the OU-1A remedial alternative.

5.8.1.8 GROUNDWATER DISPOSAL

Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel. The eventual discharge of water to Peters Canyon Channel would comply with substantive ARARs for surface water discharges. Groundwater disposal for Alternative 6 would be identical to that for Alternative 3, hydraulic containment. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if discharge to the storm drain system is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated. Permitting issues for these discharges are discussed in detail in Section 2.3 and Appendix A (Section A4.6.2).

5.8.1.9 PERFORMANCE MONITORING

Performance monitoring during the operating period for Alternative 6 (expected to be 15 years) would verify capture of the plume, monitor changes in the distribution and magnitude of TCE and 1,2,3-TCP contamination within the shallow aquifer, and demonstrate successful treatment of the extracted groundwater prior to discharge. An overview of the performance monitoring requirements for Alternative 6 is presented in Table 5-15. After active operations cease, monitoring would continue to track migration of the remnants of the VOC plumes in the first and second WBZs. Over time, residual TCE and 1,2,3-TCP concentrations would slowly attenuate due to naturally occurring processes such as dilution, dispersion, and adsorption. For purposes of this FS Report, the postoperational monitoring period was assumed to last through the 30th year after remediation begins, or for 15 years after groundwater extraction ceases at the site. The actual length of the operational and postoperational monitoring periods would be dictated by field conditions.

Table 5-15
Performance Monitoring for Vacuum-Enhanced Extraction

Type of Monitoring Data	Monitoring Locations	Purpose/Use of Data
Water levels	Monitoring wells throughout and around the VOC plumes	Prepare potentiometric surface maps and hydrographs Determine horizontal and vertical hydraulic gradients Confirm capture zones
VOC concentrations in the shallow aquifer	Monitoring wells throughout and around the VOC plumes	Delineate areal and vertical extents of contamination Confirm remediation of plume and assess progress toward cleanup goals Estimate remaining contaminant mass
VOC concentrations in extracted groundwater	Extraction wells and equalization tank effluent	Estimate cumulative mass of VOCs removed from aquifer Characterize extracted groundwater from individual wells and combined treatment plant influent with respect to RCRA and non-RCRA hazardous waste criteria Determine when extraction should cease because contaminants have reached asymptotic levels
VOC concentrations in treatment plant effluent	Effluent lines from GAC vessels	Assess performance of treatment system Demonstrate compliance with discharge requirements
VOC concentrations in treated soil vapor	Vapor discharge from modular GAC units downstream of vacuum pumps	Demonstrate compliance with air emissions requirements
Flow rates	Extraction wells and various points in treatment system	Confirm that extraction and treatment systems are operating to specifications
Other operational parameters (e g., water line pressures, vacuum at VEE wellheads)	Various locations	As needed to assess proper operation or incipient failure of pumps and filters

Acronyms/Abbreviations:
GAC – granular activated carbon
RCRA – Resource Conservation and Recovery Act
VEE – vacuum-enhanced extraction
VOC – volatile organic compound

As noted in Appendix B, it was not possible to model the long-term migration of the VOC plume remnants after active groundwater extraction ceases under Alternative 6. However, the model results do show that the residual VOC mass would be less than Alternative 4 in both the first and second WBZs. Therefore, it can be concluded that VOC migration during the postoperational monitoring period for the VEE alternative would be no greater, and probably less, than that predicted for the aggressive groundwater extraction alternative. In both cases, residual TCE and 1,2,3-TCP in groundwater are not expected to migrate significantly beyond existing plume boundaries at concentrations exceeding site cleanup goals. The long-term groundwater monitoring program for Alternative 6 was developed on this basis.

The long-term groundwater monitoring program would use a combination of existing and new wells. For the purpose of developing a cost estimate, it was assumed that two new groundwater monitoring wells would be installed, one each in the first and second WBZs. In addition, it was assumed that four existing wells would be included in the groundwater monitoring plan. Thus, a total of six wells would be monitored for Alternative 6. The actual number of monitoring wells to be sampled and the locations and specifications for any new monitoring wells (depth, screened interval, and well construction materials) would be determined during remedial design and documented in the long-term monitoring plan. This plan would also provide details concerning sampling procedures, target analytes, analytical methods, field and laboratory QA/QC, and reporting requirements. Well locations and surface completion methods would take accessibility into consideration, along with the need to minimize impacts on redevelopment of the Former MCAS Tustin property.

The frequency of groundwater monitoring would vary over time. During the initial stages of system start-up and equilibration, monitoring of water levels in the extraction wells would be on a near-continuous basis using pressure transducers and data loggers. This initial period of monitoring was assumed to extend no more than 2 weeks, after which water level monitoring would switch sequentially to daily, weekly, monthly, and finally quarterly measurements. Groundwater samples for VOC analysis would be collected quarterly for the first 3 years after implementation of Alternative 6, semiannually for the next 7 years, and annually through the 30th year.

VOC samples for performance monitoring at each treatment plant would be collected monthly from the equalization tank effluent, lead GAC vessel effluent, and the final effluent. Additional effluent monitoring (e.g., for parameters such as toxicity or metals) would be conducted as required to satisfy discharge requirements. It was assumed that treated soil vapor would be tested monthly for VOCs. Total extraction rates and line pressures would also be recorded for both the liquid and vapor streams. The specifics of the treatment plant performance monitoring activities would be determined during remedial design and documented in the long-term monitoring plan.

5.8.1.10 INSTITUTIONAL CONTROLS

Institutional controls are nonengineering mechanisms, particularly legal measures, designed to limit activities or access at a site to protect the selected remedy. Institutional controls fall into two broad categories, restrictions on future land use and provisions for access for future monitoring and maintenance. Proposed future land use is described in the MCAS Tustin SP. The SP indicates that the parcels at Former MCAS Tustin currently overlying the VOC plumes, as well as the downgradient parcels under which the plume is expected to migrate, will be redeveloped for residential, commercial, and recreational use (The Planning Center 1998).

Alternative 6 includes deed restrictions for parcels overlying the VOC plumes (approximately 44 acres), plus an approximately 200-foot buffer zone surrounding the plume and the alignment of the conveyance piping connecting the extraction wells to the treatment system, the treatment system compound, and the discharge location (Figure 1-5). The land-use control objective within the RAOs is for protection of human health by preventing extraction of VOC-impacted shallow groundwater. Restrictions designed to limit inhalation of VOCs are not necessary as long as groundwater extraction is prohibited within the OU-1A plume boundaries (Appendix F). The deed restrictions would include the following elements to achieve the land-use control RAO:

- prohibitions on the installation of public or private water supply wells in the shallow aquifer within the area of institutional controls
- prohibitions on the installation of underground utilities, including trenches, within the groundwater in the area requiring institutional controls without the review and approval by the DON and other regulatory agencies; improperly designed subsurface utilities, including the backfilled trenches, may create preferential pathways for the transport of contaminated groundwater and negatively impact the remedial alternative
- prohibitions on construction or other activities that would disturb or otherwise negatively impact the monitoring wells, extraction wells, treatment system, conveyance piping, or the discharge structure without prior approval from the DON
- provisions to allow access to the DON and other regulatory agencies to install new monitoring wells and implement supplemental remedial measures in the future, if necessary
- provisions to allow access to the DON and other regulatory agencies to monitor the remedial action (i.e., the monitoring wells, extraction wells, conveyance piping, treatment system, and discharge structure)
- requirements to notify the DON in advance of any plan to lease or transfer affected parcels
- requirements to notify the DON and regulatory agencies in a timely manner of any change in site conditions that potentially compromises the remedy or endangers public health or the environment

The deed restrictions required for Alternative 6 would not hinder the development of the Former MCAS Tustin property. None of the expected land-use scenarios for the affected parcels would require the installation of wells and use of groundwater from the shallow aquifer. The deed restrictions only require that wells installed in the regional aquifer are constructed with well screen depths and seals sufficient to prevent cross-contamination with the shallow aquifer. These restrictions will protect the selected remedy and will not affect development of the groundwater resource. Deed restrictions regarding the installation of underground utilities can be addressed with appropriate engineering controls. The time estimated for remediation, based on groundwater modeling, is greater than 30 years.

5.8.1.11 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data would be conducted every 5 years to determine whether the extraction wells were effectively capturing the contaminated shallow groundwater and reducing VOC concentrations as expected. If satisfactory progress toward site remediation goals was not being demonstrated, it might be necessary to modify the design and/or operation of the groundwater extraction systems. Possible modifications might include relocating extraction wells, adding extraction wells, or adjusting pumping rates.

These 5-year reviews would also assess the adequacy of the performance monitoring program and suggest revisions as necessary to meet project objectives. Modifications might include the abandonment of some monitoring wells as portions of the VOC plumes are restored. Adjustments in monitoring frequency would also be made in response to field data.

Results of each periodic review would be documented in a summary report submitted by the DON to the regulatory agencies responsible for program oversight.

5.8.2 Detailed Analysis

Alternative 6 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.8.2.1 SHORT-TERM EFFECTIVENESS

The greatest short-term risks during implementation of Alternative 6 would occur to workers and the surrounding community during excavation and handling of contaminated soils at the site. Workers involved in these activities may also be exposed to contaminated groundwater, since the excavations would extend below the water table. Potential impacts to the surrounding community may occur as a result of a relatively large-scale excavation project and its associated noise, dust, and vehicular traffic. Transport of contaminated materials over public highways would present short-term risks to other drivers and residents along transportation routes.

The greatest potential short-term risks to the community would be associated with the increased vehicular traffic. As noted in Section 5.5.2.1, approximately 650 truck trips (650 round trips are equivalent to 1,300 trips total) would be required to transport 5,200 cubic yards of contaminated soils from the site to an off-site Class II landfill. For this reason, Alternative 6 would entail the possibility of a vehicular accident potentially involving the release of contaminated material. Short-term transportation impacts would be minimized through use of a licensed commercial hauler required to follow all applicable federal, state, and local regulations dealing with transport of the soils removed from the station.

A rigorous health and safety plan and remedial action work plan would have to be developed and successfully implemented to minimize short-term risks to workers and the surrounding community during soil excavation and handling. These plans would prescribe personal protection equipment as well as monitoring and mitigation measures needed to minimize risks. Appropriate engineering and industrial hygiene controls would be required, such as dust suppression measures, perimeter monitoring, traffic safety planning, spill prevention, and contingency planning.

Other short-term risks during implementation of Alternative 6 would include potential exposure to contaminated groundwater and soil during installation of the extraction system, pipelines, and monitoring wells. Additional construction work would include assembly of the treatment facility and associated piping, instrumentation, mechanical systems, and electrical controls. Potential short-term impacts from these activities would be controlled through the site-specific health and safety plan and remedial action work plan.

Short-term risks would also be associated with the start-up of the extraction wells and the treatment facility as these activities would entail management of VOC-contaminated groundwater in otherwise untested systems. Potential impacts from inadvertent releases would be controlled through a spill prevention plan developed prior to construction. This plan would identify procedures for rapid spill response and cleanup as well as measures to prevent or contain releases. Impacts on the community or on-site workers would be minimal under these circumstances.

The duration of the soil excavation, well installation, and treatment facility construction activities under Alternative 6 would be approximately 6 months. Following construction, the system would be tested to confirm the performance of each component before long-term operations commenced. This initial "shake-down" period should last no more than 3 months. Assuming that the deed restrictions could be established concurrently with remedial design, the major components of Alternative 6 would be in place approximately 9 months after mobilization for field construction. At that point, the engineered remediation systems of this remedy would effectively limit the further migration of the VOC plumes. Combined with the institutional controls, Alternative 6 would then begin to reduce the mass and concentration of VOCs in the subsurface. At the same time, it would act to prevent potential human exposure to contaminated shallow groundwater and the off-station migration of TCE and 1,2,3-TCP.

5.8.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 6 would be designed and implemented to contain VOC-affected groundwater within the boundaries of the Former MCAS Tustin property while reducing contaminant concentrations in the first and second WBZs to the site remediation goals established in Section 2.5. Similar to Alternative 4, this alternative would constitute an aggressive program to remediate site-related subsurface contamination. Proven, conventional technologies would be used to remediate both contaminated soils and groundwater, supplemented by VEE in the first WBZ. As discussed in Section 3.3.2.6, VEE is a recent modification of conventional groundwater extraction technology that appears to be particularly well-suited for the hydrogeologic conditions and COCs associated with the VOC plumes. When all components have been successfully implemented, Alternative 6 would be an effective, permanent means to address the plume at and downgradient of IRP-13S.

As with Alternative 4, there are potentially significant technical issues related to the subsurface conditions at the site that could complicate realization of site cleanup goals under this VEE alternative. Major complications could arise from the heterogeneous, anisotropic nature of the shallow aquifer and the presence of potentially significant quantities of contamination in fine-grained, low-permeability clay layers. As noted in Section 2.6, these low-permeability zones cannot easily be remediated. Extraction from the sand layers of the first two WBZs would not significantly reduce VOC concentrations in the clays. In some cases, adsorbed VOCs in the lower confining clay layer of the first WBZ may actually serve as a continuing source of contamination to other, more transmissive portions of the shallow aquifer. The impact of site heterogeneity and other characteristics will not be known until the VEE and conventional groundwater extraction systems under Alternative 6 have been installed and operated for a period of time, perhaps a year or more.

Computer modeling of Alternative 6 is discussed in Appendix B. Results of the simulations are depicted on Figures 5-39 and 5-40. These figures indicate that the proposed network of extraction wells should remove most of the TCE and 1,2,3-TCP contamination in the sand layers of the first two WBZs during the 15-year period of active groundwater extraction. After the extraction systems are shut down, the plume remnants would be attenuated by natural processes (dilution, dispersion, and adsorption) and should not migrate significantly beyond the existing areas of contamination at concentrations exceeding site cleanup goals. As discussed in Section 5.8.1.8, migration of residual VOCs during the postoperational period under the VEE alternative should be no greater, and probably would be less, than that predicted for the aggressive groundwater extraction alternative illustrated on Figures 5-23 and 5-24.

Alternative 6 would also eliminate concerns about the potential off-station migration of VOC-contaminated groundwater discharged to Barranca Channel. Additionally, groundwater extraction from the second WBZ would be designed to maintain a constant upward hydraulic gradient from the third WBZ, thereby eliminating the potential for the

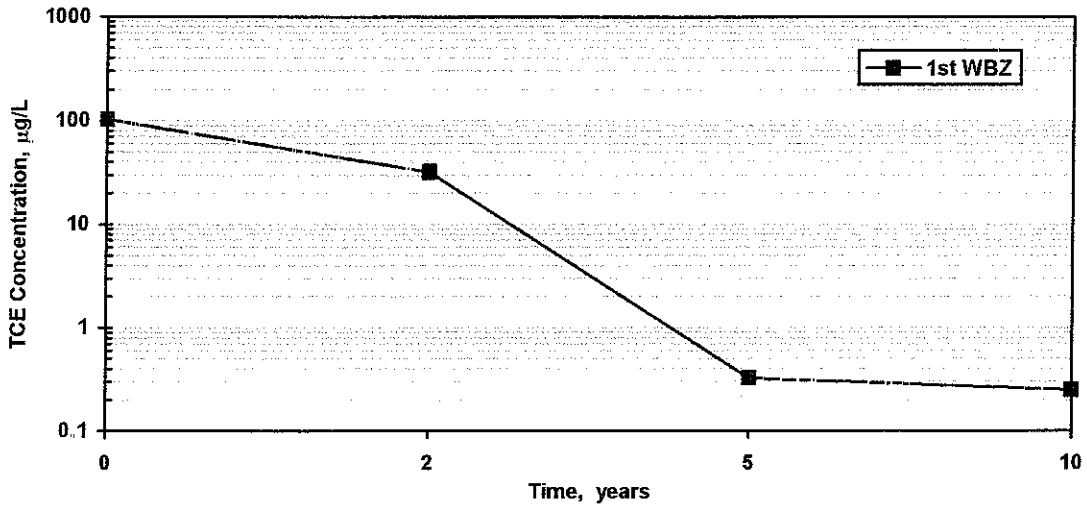


Figure 5-39
Predicted Maximum TCE Concentrations
Under Vacuum-Enhanced Extraction

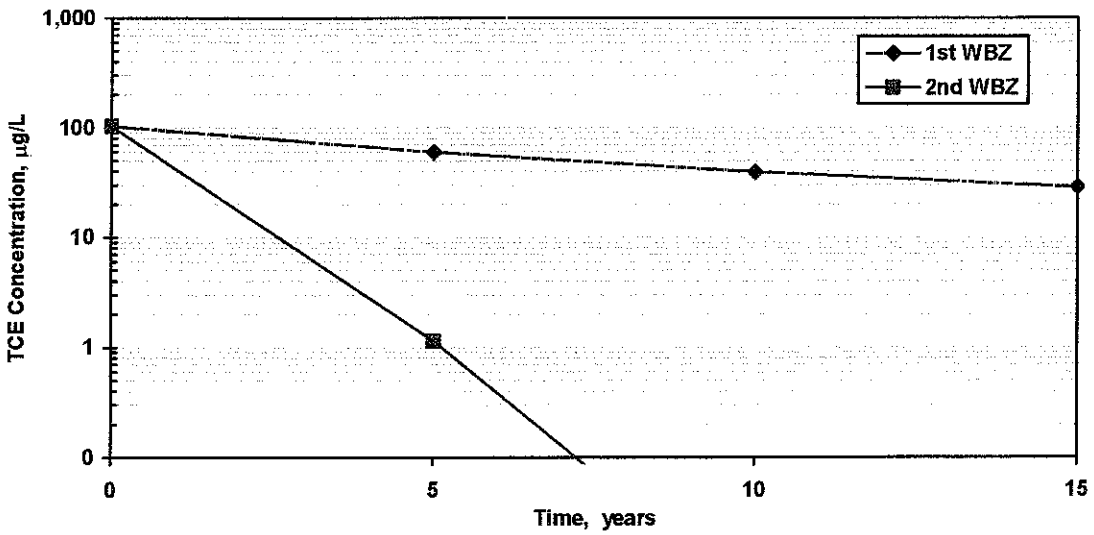


Figure 5-40
Predicted Maximum 1,2,3-TCP Concentrations
Under Vacuum-Enhanced Extraction

localized, downward migration of 1,2,3-TCP first identified during a field investigation completed at MCAS Tustin in 1998 (BNI 1999c).

Under Alternative 6, extracted groundwater would be treated using GAC adsorption, identified by U.S. EPA as a proven and effective method for removing TCE and other chlorinated VOCs from water (U.S. EPA 1996b). All components of the treatment, discharge, and monitoring systems required by this alternative have been extensively implemented for groundwater remediation at other sites, including the TCRA system at IRP-13S, demonstrating a high degree of long-term operational reliability.

Residual risks associated with the VOC plumes would be expected to decline as VOC-contaminated water is withdrawn from the shallow aquifer. The magnitude of this decline is illustrated on Figures 5-39 and 5-40, which plot predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs. Substantial VOC concentration reductions (and therefore risk reductions) are expected during the initial 15 years of groundwater extraction.

Based on trends presented on Figure 5-39, predicted maximum concentrations of TCE in the first WBZ would fall below the site remediation goal of 5.0 μg/L within 5 years. Predicted maximum concentrations of 1,2,3-TCP would fall below the site remediation goal of 0.6 μg/L in the second WBZ within approximately 8 years. Active groundwater extraction would continue until significant additional contaminant reduction could no longer be achieved, as discussed in Section 5.8.1.5. Because of natural attenuation processes within the shallow aquifer, it would be possible to leave residual TCE contamination in other portions of the VOC plumes at concentrations slightly exceeding the cleanup goal. The remaining TCE contamination is not expected to migrate significantly beyond the existing plume boundaries once the extraction wells cease operating. However, the maximum 1,2,3-TCP concentration remaining in the first WBZ would still be relatively high when groundwater extraction is halted after 15 years. At 29 μg/L, this residual 1,2,3-TCP concentration in the first WBZ would probably take many decades to decline below 0.6 μg/L as a result of natural attenuation processes.

The groundwater modeling analysis presented in Appendix B suggests vertical migration from the lower clay as the cause of the high 1,2,3-TCP residual in the sand layer of the first WBZ when groundwater extraction ceases under Alternative 6. The VEE wells in the first WBZ, operating at 12 gpm each, appear to induce an upward flux of 1,2,3-TCP from the more highly contaminated clays. While this flux might be reduced by optimizing the extraction rate during remedial design, the results presented on Figure 5-40 indicate that application of VEE might not be technically appropriate at the site.

Deed restrictions would be used under Alternative 6 to prevent future human exposures to VOC-affected groundwater within the area of contamination through restriction of groundwater use. Deed restrictions are expected to be effective and reliable methods of controlling health risks in areas impacted by the VOC plumes. Furthermore, by preventing further expansion of the plumes beyond their current limits, Alternative 6

reduces the area over which deed restrictions must be applied to approximately 54.1 acres. The long-term effectiveness of these measures would be contingent upon their continued enforcement.

Residuals generated by the treatment system under Alternative 6 would consist of an estimated 9,000 pounds of spent GAC per year. Spent GAC, which would be managed by the carbon supplier under a long-term service contract, would be taken off-site for regeneration or disposal. Because this material would be a solid waste which might contain relatively high concentrations of TCE and other VOCs, it would have to be characterized prior to transport off-site. Long-term management of spent GAC would be in accordance with RCRA and California waste management regulations. Therefore, residual risks associated with the spent carbon are considered negligible.

5.8.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 6 would accomplish a significant reduction in the toxicity, mobility, and volume of VOC-contaminated groundwater and source material (soils). Excavation of soils with TCE and 1,2,3-TCP at concentrations exceeding 100 and 10 µg/kg, respectively, would result in removing approximately 5,200 cubic yards of VOC-affected material to a secure Class II landfill in compliance with 40 C.F.R. § 300.440. Long-term operation of the VEE and conventional groundwater extraction system is also expected to accomplish a potentially significant reduction in the volume and mass of subsurface VOCs. According to the modeling results presented in Appendix B, soil excavation and operation of the extraction systems for 15 years would remove over 90 percent of the TCE mass and approximately 80 percent of 1,2,3-TCP mass at and downgradient of IRP-13S.

Groundwater extraction in the first two WBZs would substantially reduce the potential lateral and vertical migration of the VOC contaminants in shallow groundwater. As shown on Figures 5-39 and 5-40, maximum TCE and 1,2,3-TCP concentrations would decline from existing levels by factors of 70 percent to greater than 99 percent during the operating period of the extraction systems, representing a significant reduction in the toxicity associated with the VOC plumes.

As stated in Sections 2.6 and 5.7.2.2, remediation of VOC contamination is a complex process in a heterogeneous aquifer such as the shallow groundwater system at Former MCAS Tustin. The potential for successful cleanup can best be evaluated once a remediation system has been installed and operated. It is technically infeasible to remove all contamination from the VOC plumes given the prevalence of fine-grained materials, the propensity of organic contaminants to partition between the adsorbed and dissolved phases, and other factors that limit contaminant recovery. Therefore, while Alternative 6 should effectively remove nearly all of the mobile contamination in the first two WBZs, the extent to which the residual, immobile VOCs would continue to affect the aquifer over the long term remains unknown. Modeling-based predictions indicate that VOC concentrations within portions of the VOC plume areas would still exceed site

remediation goals when the groundwater extraction systems cease operating in 15 years. Remediation of these plume residuals by natural attenuation during the postoperational period would probably take several decades beyond the 30-year period considered in this FS Report.

The extracted groundwater and vapor under Alternative 6 would be treated using GAC. Dissolved and vapor-phase contaminants would be transferred to a solid phase (i.e., carbon). The spent GAC would most likely be regenerated in a high-temperature furnace at a permitted off-site facility operated by the carbon supplier. The adsorbed VOCs would be destroyed during the carbon regeneration process.

5.8.2.4 IMPLEMENTABILITY

Alternative 6 would be readily implemented, with no anticipated difficulties in reliability or scheduling. Most of the technical components of this alternative are well established, including soil excavation and landfill disposal, conventional groundwater extraction, GAC treatment, and long-term monitoring. These technologies have been widely used at other sites with TCE and related VOC contamination in the subsurface.

The use of VEE to capture VOC-affected groundwater in the first WBZ would be more innovative, raising several technical uncertainties. Reducing TCE to the low concentrations shown on Figure 5-39 depends on the ability of VEE to extract 12 gpm per well from the first WBZ. The modeling results presented in Appendix B suggest that groundwater extraction at these rates is possible using an applied vacuum of 0.35 atmosphere. However, a recent VEE field test at an average applied vacuum of 0.37 atmosphere could not sustain an extraction rate of more than 5 gpm from a well completed in the first WBZ at nearby IRP-3 (BNI 1999a).

The equipment and construction methods to be used under Alternative 6 are proven, reliable, and readily available. In addition, multiple vendors are available to supply, at competitive prices, the equipment and services necessary for the groundwater extraction, monitoring, and treatment systems of this alternative.

The deed restrictions that would be instituted as part of Alternative 6 are not expected to prevent or unnecessarily complicate future redevelopment of the Former MCAS Tustin property. The reasoning supporting this conclusion is presented in Section 5.3.1.1. The deed restrictions under Alternative 6 would most likely remain in force beyond the 30-year period considered in this FS Report, perhaps for many additional decades. Implementation of this alternative would therefore require administrative coordination with state and local agencies to enforce the deed restrictions.

Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel. The discharge of water to this channel would comply with substantive ARARs for surface water discharges.

The DON has reviewed the need to obtain an NPDES permit for the discharge of treated water to Peters Canyon Channel and has determined that such a permit would not be necessary. A discussion of this determination is presented in Section 5.4.1.3.

5.8.2.5 COST

Table 5-16 summarizes the cost estimate developed for Alternative 6. The net present cost for the VEE alternative would be approximately $6.4 million, essentially equivalent to Alternative 4 considering the -30 to +50 percent estimation accuracy used in this FS Report.

The estimated cost of Alternative 6 could increase by $0.5 million, to approximately $6.9 million, if additional VEE wells are required to contain the VOC plumes and obtain the desired groundwater extraction rate in the first WBZ. As noted in Section 5.8.2.4, results of a recent VEE field test at IRP-3 (BNI 1999a) suggest that groundwater extraction at 12 gpm per well, as estimated by the model presented in Appendix B, may not be achievable in practice.

Major cost elements of Alternative 6 include excavation and off-site disposal of source area soils, installation of the conventional extraction wells and VEE wells, and construction of the conveyance piping and treatment systems. Long-term monitoring of groundwater quality, sampling of the treatment plant influent and effluent, replacement of spent GAC, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that the groundwater extraction and treatment systems would operate for 15 years. Performance monitoring would be conducted for 30 years.

Backup and supporting details for the Alternative 6 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.8.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 6 with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

The VEE alternative would be designed and implemented to comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. Figures 5-39 and 5-40 show that significant progress toward these ARARs would be made by groundwater extraction systems operating for 15 years. Based on trends shown in Figure 5-39, predicted maximum concentrations of TCE in the first WBZ would fall below the site remediation goal of 5.0 µg/L within 5 years. Predicted maximum concentrations of 1,2,3-TCP would fall below the site remediation goal of 0.6 µg/L in the second WBZ within approximately 8 years.

After the extraction wells are shut off, expansion of the plume remnants is not expected to be significant. During the postoperational period, VOCs are not expected to migrate beyond the station boundaries at concentrations exceeding the site cleanup objectives.

Table 5-16
Summary of Cost Estimate[a] for Alternative 6

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering/design/monitoring plan (3,000 hours @ $85 00/hour)	$255,000			$255,000
Carbon adsorption treatment system (15 years) (includes equalization tank, prefilter, pumps, and controls)	$53,000			$53,000
GAC Unit O&M (average 15 years)		$13,567		$407,000
Modular GAC unit to treat off-gas	$2,000			$2,000
Modular GAC O&M (average 15 years)		$1,833		$55,000
Groundwater Treatment (15 years)				
Install eight extraction wells (four VEE wells is first WBZ and four traditional extraction wells in second WBZ)	$302,000			$302,000
Wells O&M (average 15 years)		$9,800		$294,000
Piping	$131,000			$131,000
Removal of Source Materials				
Excavate and disposal of soil off-site	$2,049,000			$2,049,000
Install two monitoring wells	$26,000			$26,000
Building 16 demolition (8,000 square feet)	$152,000			$152,000
Electrical distribution	$47,000			$47,000
Monitoring and Reporting				
Performance monitoring (average 30 years) (includes groundwater and influent/effluent sample collection, analysis, water levels)		$65,300		$1,959,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$6,129,000**
Contingency (20%)[d]				$1,226,000
Escalation (Base 01 January 2001)				$1,598,000
Total Cost				**$8,953,000**
Net Present Value of Alternative 6 (2002 $'s)				**$6,403,000[e]**

(table continues)

Table 5-16 (continued)

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect groundwater extraction for 15 years at IRP-13S; monitoring activities (annual and 5-year) continue for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs are not incurred on studies, plans, and reports
[e] net present cost could increase by up to $0.5 million if additional VEE wells are required; actual extraction rates in the first WBZ could be as low as 7 gpm per well, as obtained in a recent VEE field test (BNI 1999a), rather than the 12 gpm per well estimated by the model presented in Appendix B

Acronyms/Abbreviations:
GAC – granular activated carbon
gpm – gallons per minute
IRP – Installation Restoration Program
O&M – operation and maintenance
VEE – vacuum-enhanced extraction
WBZ – water-bearing zone

Chemical-specific requirements that would be met through implementation of Alternative 6 include the following:

- **Federal:** SDWA MCL (40 C.F.R. §141.61[a]) for TCE; RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); CWA of 1977 (40 C.F.R. § 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs. tit. 22, § 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])
- **State:** Substantive portions of the beneficial uses and water quality objectives in the WQCP for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2 of Appendix A; and DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261.22[a][4], and 66261.24[a][2]-[8])

The persistence of VOC contamination within the plume areas would prevent beneficial use of shallow groundwater on approximately 44 acres of the Former MCAS Tustin property. These restrictions would remain in effect for several decades beyond the 30-year period considered in this FS Report for the areas overlying the VOC plume in the first WBZ. No such restrictions on beneficial use would occur on adjacent off-site properties or for any portion of the deeper Irvine Pressure Subbasin (regional aquifer) underlying the station.

Location-Specific ARARs

The primary activities under Alternative 6 that may trigger location-specific requirements are those related to the excavation of contaminated soils, installation of extraction wells and monitoring wells, construction of the treatment facility, and installation of pipelines for extracted groundwater, treated groundwater, and vacuum distribution. Given the limited size of the treatment facility and related appurtenances, the "footprint" associated with Alternative 6 is expected to be small. Approximately 3,100 feet of trenching (less

than 4 feet deep) would be required to install the piping for extracted and treated groundwater as well as the vacuum distribution systems. Otherwise, none of the groundwater-related remedial systems would involve major construction, earthwork, or drainage manipulation activities of the type most likely to complicate compliance with location-specific ARARs.

Alternative 6 would be designed and implemented to meet all location-based requirements, which are identified as ARARs in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

The major components of Alternative 6 that trigger action-specific ARARs are the generation of solid waste (excavated soil from the source area, soil cuttings from well installations, trench spoils, and spent GAC), extraction and treatment of contaminated groundwater containing VOCs, eventual discharge of treated groundwater to Peters Canyon Channel, and potential emissions of treated soil vapor that may contain VOCs. As identified in Appendix A (Section A4.6.2), the action-specific requirements for the VEE alternative include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs. tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34); groundwater monitoring (Cal. Code Regs. tit. 22, § 66264.91[a] and [c], 66264.97, 66264.98, and 66264.100[a] and [b]); secondary containment for piping (Cal. Code Regs. tit. 22, § 66264.193 [a], [b], [c], and [f]); Clean Air Act (CAA) requirements regarding use of equipment for controlling air pollution (SCAQMD Rule 212), the emissions of halogenated VOCs (SCAQMD Rule 1303), and the emissions of carcinogenic air contaminants (SCAQMD Rule 1401); RCRA requirements for thermal treatment of hazardous waste (Cal. Code Regs. tit. 22, § 66265.370–383 with the exception of § 66265.382); and Criteria for Classification of Solid Waste Disposal Facilities and Practices regulations with regards to solid waste disposal (40 C.F.R. § 257.3-4 and Appendix I) as specified in Table A4-1 in Appendix A

- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); antidegradation provisions of SWRCB Resolution No. 68-16 (SWRCB 1968); California Civil Code requirements for land-use controls (Cal. Civ. Code § 1471), and California Health and Safety Code requirements for institutional controls (Cal Health & Safety Code §§ 25202.5, 25222.1, and 25233[c]) and substantive provisions of SCAQMD Rules 212, 1303, 401(b)(1)(A), 403, 404, 405, and 1401

All activities under Alternative 6 that produce solid waste (excavated soil, soil cuttings, trench spoils, and spent GAC) would be implemented in a manner compliant with federal and state action-specific ARARs at Cal. Code Regs. tit. 22, § 66262.

These residuals would be characterized with respect to criteria for the identification of RCRA and non-RCRA hazardous waste. If any of these wastes were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the hazardous waste requirements of Cal. Code Regs. tit. 22, §§ 66262 and 66264 would also be potential ARARs for activities involving management of the waste for off-site disposal. Implementing Alternative 6 in compliance with these requirements would not be expected to present significant complications from a technical or administrative viewpoint.

Another action-specific consideration for Alternative 6 regards classification of the extracted groundwater under RCRA. As noted in Appendix A (Section A1.4.1), none of the groundwater samples collected from the first and second WBZs during the RI had TCE concentrations greater than the 500 μg/L, the limit established for designation as a RCRA characteristic hazardous waste. Based on the modeling described in Appendix B, it is predicted that maximum TCE concentrations in the extracted groundwater for Alternative 6 would be less than the 500 μg/L RCRA threshold (Figure 5-39). More accurate estimates of expected TCE concentrations in the extracted groundwater would be obtained during remedial design. If groundwater from the wells were classified as hazardous waste, then the requirements of Cal. Code Regs. tit. 22, § 66264 would be potential ARARs for portions of the extraction and treatment systems. The design of the groundwater treatment facility would also have to be modified slightly to include secondary containment. TCE concentrations below the RCRA limits would not trigger any hazardous waste management ARARs. RCRA hazardous waste criteria have not been set for 1,2,3-TCP.

Alternative 6 would comply with Basin Plan requirements to maintain beneficial uses and meet water quality objectives for groundwater in the Irvine Pressure Subbasin (regional aquifer) by limiting further migration of contaminated groundwater and *ex situ* treatment. During the first 15 years of groundwater extraction, significant progress would be made toward attaining these goals in the shallow aquifer system underlying Former MCAS Tustin. Although the predicted concentrations of TCE in the first WBZ would fall below the site remediation goal of 5.0 μg/L within 5 years, the predicted concentrations of 1,2,3-TCP may still exceed the remediation goal of 0.6 μg/L in the second WBZ after the groundwater extraction and treatment system has achieved its maximum effectiveness and is terminated. From this point, remediation by natural attenuation is expected to be effective at reducing 1,2,3-TCP concentrations to below the remediation goal, although it may take a few decades. Several additional decades may be necessary to reduce 1,2,3-TCP to less than 0.6 μg/L in the first WBZ.

Performance goals for treatment of the extracted groundwater would be based on reducing TCE, 1,2,3-TCP, and other site-related VOC contaminants to levels acceptable for discharge. The NPDES general permit discharge limits would be used as TBC

guidance for conducting on-site discharge of treated groundwater in compliance with the beneficial uses and WQOs for the surface water provided in the Basin Plan. The DON and RWQCB have "agreed to disagree" concerning the applicability of the permit exclusion of CERCLA Section 121(e). Consistent with this agree-to-disagree compromise, the DON maintains that surface water discharge related to OU-1A remedial action is exempt from such permit requirements, but the DON agrees to comply with the substantive requirements of the permit as a means of ensuring compliance with the substantive provisions of the WQCP and other state ARARs as provided by Section 121(d) of CERCLA. Performance monitoring requirements would be submitted for regulatory agency review in the Operation and Maintenance Plan.

The substantive portions of the SCAQMD rules identified as action-specific ARARs for Alternative 6 set technical requirements for addressing the potential atmospheric emissions of VOC-containing soil vapor that may be extracted by the VEE wells. Use of GAC to treat the extracted vapor would satisfy the SCAQMD requirement to install best available control technology on sources potentially emitting toxic air pollutants, a category which includes some of the OU-1A COCs. Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements.

5.8.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 6 would protect human health and the environment. This alternative would use a combination of proven and innovative technologies to remove contaminant source material and remediate VOC-affected groundwater at and downgradient of IRP-13S. The VEE option would provide a permanent solution to shallow groundwater contamination at OU-1A, reduce potential risk to human health and the environment, comply with ARARs, and achieve site remediation goals as quickly as possible for all affected areas except the first WBZ. Alternative 6 would also prevent significant downgradient migration of the VOC plumes, control the threat to water quality in the third WBZ and the deeper regional aquifer at IRP-13S, prevent or limit movement of contaminated groundwater onto adjacent properties, and eliminate potential ecological impacts associated with future releases of VOCs to Barranca Channel. Treatment of the extracted groundwater using GAC, a well-established process, would remove VOCs to concentrations acceptable for discharge to surface water (to a future city of Tustin storm drain along Armstrong Avenue and eventually into Peters Canyon Channel). Implementation and enforcement of institutional controls should effectively prevent human exposure to VOC-affected shallow groundwater until cleanup goals are achieved. The deed restrictions required by this alternative would be limited to approximately 44 acres overlying the existing areas of OU-1A contamination. Over time, concentrations of TCE and 1,2,3-TCP in shallow groundwater along with risks to potential residential receptors would decline due to the removal of contaminant mass by the extraction wells. Performance monitoring and periodic reviews would verify and track the overall performance of the remedy.

Groundwater modeling results indicate that source removal combined with a 15-year groundwater extraction, treatment, and discharge program should remove most of the contaminant mass in the subsurface. During the postextraction period, natural attenuation processes would prevent significant migration of VOCs beyond the existing plume boundaries at concentrations exceeding site cleanup goals. Contamination would not migrate beyond the Former MCAS Tustin property boundary. Although Alternative 6 is not designed to remove all contamination from the subsurface, it does address the most highly contaminated materials in the upper confining layer of the first WBZ as well as that portion of the contaminant mass that is most mobile (i.e., VOCs within the transmissive sand layers of the first and second WBZs).

An assessment of the protectiveness of Alternative 6 must consider the uncertainty associated with aquifer restoration by extraction, especially VEE. Conclusions regarding the performance of this option are based almost entirely on modeling projections. Actual performance of a full-scale extraction system at the site may be different. In particular, the VEE wells may not be able to sustain the groundwater extraction rates predicted by the model. As a result, implementation of Alternative 6 may entail either greater costs (to install more wells) or more time (due to less water removal) than the estimates presented in this FS Report.

It is also important to note that the uncertainties surrounding Alternative 6 are limited primarily to the effectiveness of groundwater extraction (either by VEE or conventional wells) as a method of aquifer restoration. There is a high degree of confidence that the extraction wells would effectively contain the VOC plumes, that source removal would reduce the migration of VOCs to the permeable sand layers of the first and second WBZs, that monitoring and periodic reviews would allow for ongoing evaluation and adjustment of the remedy, and that deed restrictions would reliably prevent potential human exposure to contaminated groundwater. For these reasons, Alternative 6 would be protective in an overall sense.

5.9 ALTERNATIVE 6A – VACUUM-ENHANCED EXTRACTION WITH ON-SITE SOIL TREATMENT

Alternative 6A is identical to Alternative 6 in all aspects except for the disposal of excavated source soils, which would be treated on-site using a TDU instead of being disposed at an off-site landfill.

VEE is intended to contain the VOC plumes within the boundaries of the Former MCAS Tustin property while attempting to shorten the time required to remediate VOC-affected groundwater. A network of VEE wells would be established to remove contaminated groundwater in the first WBZ at and downgradient of IRP-13S. Other components of this alternative include removal of VOC-contaminated soils from the source areas, conventional groundwater extraction in the second WBZ, treatment and discharge of extracted groundwater, institutional controls, long-term monitoring, and periodic reviews.

5.9.1 Description

Alternative 6A is a refinement of Alternative 6, which is a refinement of Alternative 4. Alternative 6A includes on-site treatment and disposal of VOC-contaminated soils, instead of off-site disposal as described for Alternative 6. All other aspects of Alternatives 6 and 6A are identical.

Under Alternative 6A, a high vacuum would be imposed on the groundwater extraction wells completed in the first WBZ to increase the groundwater extraction rate, and thus the rate of VOC removal from the sand layer of the first WBZ. Additional contaminants would be removed with any soil vapor extracted by the vacuum system as the groundwater table is lowered in the vicinity of the VEE wells and VOCs are stripped from newly exposed soil. A conventional groundwater extraction system would be installed to remove dissolved contaminants from the second WBZ. Operation of the extraction wells in the upper two WBZs would eliminate concerns related to the potential downgradient migration of the VOC plumes toward off-site properties as well as the threat of future VOC discharges to Barranca Channel. Additionally, groundwater extraction in the second WBZ would maintain a constant upward hydraulic gradient from the third WBZ, thereby eliminating the potential for the localized, potential downward migration of 1,2,3-TCP identified during a field investigation completed at MCAS Tustin in 1998 (BNI 1999c).

Figure 5-35 presents the conceptual site layout for Alternative 6A. Individual components of this VEE alternative are discussed in greater detail in the subsections of Section 5.8.

5.9.1.1 EXCAVATION OF SOURCE MATERIAL

The areas and depths to be excavated under Alternative 6A would be the same as those for Alternatives 4, 4A, and 6. These areas are shown on Figure 5-17. Stockpiled soil would be segregated into three stockpiles, according to expected TCE and 1,2,3-TCP concentrations as described in Alternative 4. Figure 5-18 shows the volume of excavated soil estimated in each category. Details on source material excavation are presented in Section 5.5, Alternative 4.

After confirmation of the appropriate waste classification, soil from the stockpile with the highest VOC concentrations would be treated on-site in a TDU and reused as excavation backfill. The treatment and disposal of approximately 5,200 cubic yards of excavated soil are further discussed in subsequent sections.

5.9.1.2 TREATMENT OF SOURCE MATERIAL

Treatment of excavated source material (soils) under Alternative 6A would be identical to that for Alternative 4A. Excavated source soils with TCE or 1,2,3-TCP at concentrations exceeding 100 or 10 µg/kg, respectively, would be treated using a TDU. Thermal desorption is a physical process in which soil is heated to temperatures between 200 and 1,000 °F, causing VOCs to vaporize from the soil matrix. A carrier gas or vacuum system

transports the volatilized water and organics to a vapor treatment system where the contaminants are thermally destroyed.

Soil would be treated using one of two types of TDUs: a rotary dryer or thermal screw type. Rotary dryer TDUs consist of cylinders that can be directly or indirectly fired, while thermal screw TDUs consist of indirectly fired screw conveyors or augers. For purposes of the cost estimate, a mobile TDU would be brought on-site by a vendor to treat the soil. This eliminates the capital cost of purchasing a TDU that would only be used temporarily. The location of the TDU would be determined during the remedial design. The fuel source used for heating the soil would be natural gas or propane, with propane being more expensive.

Treatment rates vary widely depending on the type of TDU used and the soil characteristics. A general range is 10 to 30 tons/hour, with treatment rate being inversely proportional to the moisture and clay content of the soil. Rates have been reported to be as low as 5 tons/hour or as high as 50 tons/hour. The soil type at the site is anticipated to result in a treatment rate of 10 to 15 tons/hour, due to its relatively high clay, silt, and moisture content. An estimated 7,800 tons of soil would be treated (assuming 1.5 tons per cubic yard). Treatment could be completed in an estimated 2 to 3 months, depending on TDU process schedules and operation and maintenance requirements.

Due to the predominant clay and silt content of the soil at the site, pretreatment is anticipated to be necessary. For cost purposes, a shredder to be used to break down clumped clay/silt material was included as part of the TDU. The maximum size of material allowed in the TDU is generally 2 inches in diameter. Since clay will tend to clog the screen, periodic cleaning of the screen may be required. Since a significant portion of the soil to be treated would be from the saturated zone, some soil drying would be required to reduce the moisture content. A moisture content greater than approximately 20 percent can significantly impact the treatment rate and total cost. Drying can be accomplished by stockpiling the soil and allowing it to drain. The stockpile(s) would be covered to reduce the potential for VOC emissions. Addition of dry sand, fly ash, or hydrated lime can facilitate the disaggregation and drying process. For cost purposes, it is assumed that hydrated lime would be added to the stockpiled soil. For the estimated 7,800 tons of soil, approximately 26 tons of lime would be needed, assuming a usage rate of 300 tons of soil per ton of lime. However, the suitability of additives would need to be evaluated to consider how they might change soil characteristics that could affect reuse.

Water would be added to the treated soil as it exits the TDU to control dust. The treated soil would be stockpiled on-site near the TDU for reuse.

The vapor treatment system for the vapors carrying the desorbed VOCs typically involves particulate removal (e.g., wet scrubbers or fabric filters) and contaminant removal by condensation and carbon adsorption, thermal oxidation, or catalytic oxidation. Thermal oxidation followed by use of particulate filters is a technique used by a local vendor. For cost estimation purposes, thermal oxidation is assumed since use of carbon adsorption would incur additional costs to haul and regenerate the used carbon. The treated vapor

might need to be cooled in a cooling tower prior to being released to the atmosphere. In addition, a scrubber might need to be added to the thermal oxidizer exhaust to remove any VOC breakdown products of combustion from the vapor stream. The use of scrubbers is typically only required with higher concentrations of VOCs and also depends on treatment requirements. Based on the experience of a local vendor, it is not anticipated that a scrubber would be required.

As a CERCLA remediation activity conducted entirely on-site, the use of a TDU at the site would not require a permit from SCAQMD. However, treated vapors released to the atmosphere would need to be handled in accordance with the substantive provisions of the SCAQMD regulations pertaining to point source emissions of VOCs. Local vendors typically employ a SCAQMD "various locations" permit for portable TDUs.

5.9.1.3 BUILDING DEMOLITION

Soil excavation under Alternative 6A would affect the same structure as that for Alternatives 6 and 4. Building demolition would be conducted as described in Sections 5.5.1.2 and 5.5.8.2.

5.9.1.4 BACKFILLING OF EXCAVATIONS

The backfill criteria for Alternative 6A are identical to those for Alternative 4. Based on the estimates presented in Figure 5-27, the materials that would be available as excavation backfill would include approximately 8,700 cubic yards of soil removed from the site containing detectable but low concentrations of TCE and 1,2,3-TCP, along with 4,700 cubic yards of excavated soil having no reported VOC contamination. To the extent possible, only soil with no reported concentrations of TCE and 1,2,3-TCP would be replaced below the water table. Soil with VOCs at concentrations exceeding the detection limits but below the 100 μg/kg TCE and 10 μg/kg 1,2,3-TCP action levels would be placed above the seasonal high water table, as illustrated on Figure 5-28.

Under Alternative 6, approximately 5,200 cubic yards of clean fill would be obtained from an off-site commercial source to backfill the excavations to grade. However, under Alternative 6A, it is assumed that the soil treated with the TDU will be suitable for excavation backfill, which would reduce the volume of imported clean fill required. Soil treated using the TDU is not expected to have any remaining VOCs above the action levels required for use as backfill. Reported TDU desorption efficiencies of organic contaminants can be greater than 99 percent, although it may be more difficult to achieve this percentage due to the predominant clays and silts at the site. Once treated, the soil would be tested to confirm the removal of VOCs to low or not reported levels.

5.9.1.5 EFFECTS OF BACKFILL WITH LOW LEVELS OF VOCs

As discussed in Sections 5.5.1.1 and 5.5.1.3, appropriate soil excavation criteria for TCE and 1,2,3-TCP are 100 and 10 μg/kg, respectively, and soil with VOCs at concentrations that are less than these values would be used as backfill above the seasonal high water table (vadose zone). The vadose zone modeling (VLEACH) results from the RI were

used to evaluate the effects of VOCs in the vadose zone on groundwater quality. The modeling results shown in Table 5-7 indicate that the leachate from contaminated soil at the action levels would result in TCE and 1,2,3-TCP concentrations in groundwater that are near or below their respective site remediation goals of 5 µg/L and 0.6 µg/L. Modeling results are presented in Section 5.5.1.4.

5.9.1.6 DISPOSAL OF TREATED SOURCE MATERIALS

As noted in Section 3.3.3.6, backfilling or other beneficial reuse of soil treated using a TDU was determined to be the preferred means of disposal for this material. It is anticipated that the treated soil would not have any remaining contamination above the action levels that would prohibit its use as backfill. For Alternative 6A, the preferred use is as backfill for the excavations at the site, although other beneficial uses could be considered. Backfill for the excavations would reduce the need for clean, imported material. Other potential beneficial uses include use at construction sites or backfill for other excavations.

5.9.1.7 GROUNDWATER EXTRACTION

The VEE system under Alternative 6A would be identical to that described for Alternative 6. Refer to Section 5.8.1.6 for a description of the groundwater extraction system.

5.9.1.8 GROUNDWATER CONVEYANCE AND TREATMENT

Conveyance and treatment of groundwater for Alternative 6A would be identical to those for Alternative 6. Refer to Section 5.8.1.7 for a discussion of the groundwater conveyance and treatment systems and requirements.

5.9.1.9 GROUNDWATER DISPOSAL

Groundwater disposal for Alternative 6A would be identical to that for Alternative 3, hydraulic containment. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if reinjection is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated. Permitting issues for these discharges are discussed in detail in Section 2.3 and Appendix A (Section A4.6.2).

5.9.1.10 PERFORMANCE MONITORING

Performance monitoring during the operating period for Alternative 6A would be identical to that for Alternative 6. An overview of the performance monitoring

requirements for Alternative 6 is presented in Table 5-15. Details of the long-term groundwater monitoring program are presented in Section 5.8.1.9.

5.9.1.11 INSTITUTIONAL CONTROLS

Institutional controls are based on the groundwater treatment systems and the extent of the VOC plumes, and therefore the restrictions for Alternative 6A would be identical to those for Alternative 6. Refer to Section 5.8.1.10 for a detailed discussion of the institutional controls.

5.9.1.12 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data for Alternative 6A would be identical to those for Alternative 6. Reviews would be conducted every 5 years to determine whether the extraction wells were effectively containing the contaminated shallow groundwater and reducing VOC concentrations as expected. Refer to Section 5.8.1.11 for details on the periodic reviews.

5.9.2 Detailed Analysis

Alternative 6 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.9.2.1 SHORT-TERM EFFECTIVENESS

Short-term effectiveness considerations for Alternative 6A are identical to those for Alternative 6, except for additional considerations pertaining to thermal treatment of soil. Short-term effectiveness considerations include short-term risks to workers associated with the remediation operations and potential impacts to the surrounding community, as discussed in Section 5.8.2.1.

Considerations pertaining to on-site thermal treatment, in addition to the soil excavation, transportation, and handling issues previously discussed, are as follows. Increased vehicular traffic on public roads and highways due to off-site transportation of excavated material would not be an issue, since on-site use of the soil is presumed. The health and safety plan and remedial action work plan would need to include minimizing short-term risks to workers and the surrounding community during mobilization of the TDU and during soil preparation and thermal treatment. Other additional short-term risks during on-site treatment would include potential exposure to VOC vapors during material handling and treatment and physical hazards associated with start-up and operation of the TDU.

The duration of the thermal treatment would be approximately 2 to 3 months. Since the soil treatment system would be a preassembled mobile unit, only minor on-site testing and equipment enhancements would likely be necessary to optimize the treatment process for site-specific conditions.

5.9.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

The long-term effectiveness and permanence of Alternative 6A would be identical to those of Alternative 6, as discussed in Section 5.8.2.2.

5.9.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

As with Alternative 6, Alternative 6A would accomplish a significant reduction in the toxicity, mobility, and volume of VOC-contaminated groundwater and source material (soils). An additional benefit of Alternative 6A is that thermal treatment of 5,200 cubic yards of soils with TCE and 1,2,3-TCP at concentrations exceeding 100 and 10 µg/kg, respectively, would remove VOCs from these soils to low levels or below detection limits, enabling beneficial reuse of the soils. Reuse of treated soil for backfill would be subjected to the constraints discussed in Section 5.5.1.3. VOCs desorbed in the treatment system vapor stream would be destroyed prior to discharge to the atmosphere. For groundwater, reduction in toxicity, mobility, or volume for Alternative 6A would be identical to that for Alternative 6. This is discussed in Section 5.8.2.3.

5.9.2.4 IMPLEMENTABILITY

Implementability of Alternative 6A would be almost identical to that of Alternative 6, which is discussed in Section 5.8.2.4. The differing component, soil treatment using a TDU, has been demonstrated to be feasible for the soil types found at the site, based on the long-term operation of the existing TDU for petroleum hydrocarbons. The technical components of a TDU are well established and have been widely used at other sites with TCE and related VOC contamination in soil. The equipment that would be used is proven and reliable. Availability of a mobile TDU might be affected due to scheduling limitations by the vendors which supply mobile units in the region.

5.9.2.5 COST

Table 5-17 summarizes the cost estimate developed for Alternative 6A. The net present cost for the VEE alternative with on-site soil treatment would be approximately $5.6 million, essentially equivalent to Alternative 4A considering the -30 to +50 percent estimation accuracy used in this FS Report.

The estimated net present cost of Alternative 6A could increase by $0.5 million to approximately $6.1 million if additional VEE wells are required to contain the VOC plumes and obtain the desired groundwater extraction rate in the first WBZ. As noted in Section 5.8.2.4, results of a recent VEE field test at nearby IRP-3 (BNI 1999a) suggest that groundwater extraction at 12 gpm per well, as estimated by the model presented in Appendix B, may not be sustainable in practice.

Major cost elements of Alternative 6A include excavation and on-site treatment and disposition of source area soils, installation of the conventional extraction wells and VEE wells, and construction of the conveyance piping and treatment systems. Long-term

Table 5-17
Summary of Cost Estimate[a] for Alternative 6A

Description	Capital Cost	O&M COSTS Annual Average	O&M COSTS 5th Year	Total Costs[b]
Engineering/design/monitoring plan (3,200 hours @ $85.00/hour)	$272,000			$272,000
Carbon adsorption treatment system (15 years) (includes equalization tank, prefilter, pumps, and controls)	$53,000			$53,000
GAC unit O&M (average 15 years)		$27,133		$407,000
Modular GAC unit to treat off-gas	$2,000			$2,000
Modular GAC O&M (15 years)		$3,667		$55,000
Groundwater Treatment (15 years)				
Install eight extraction wells (four VEE wells is first WBZ and four traditional extraction wells in second WBZ)	$302,000			$302,000
Wells O&M (average 15 years)		$19,600		$294,000
Piping	$131,000			$131,000
Removal of Source Materials				
Excavate, treat and backfill	$681,000			$681,000
Low-temperature thermal desorption system	$645,000			$645,000
Install two monitoring wells	$26,000			$26,000
Building 16 demolition (8,000 square feet)	$152,000			$152,000
Electrical distribution	$47,000			$47,000
Monitoring and Reporting				
Performance monitoring (average 30 years) (includes groundwater and influent/effluent sample collection, analysis, water levels)		$65,300		$1,959,000
Annual monitoring report		$10,000[c]		$240,000
5-year review			$26,000	$156,000
Total				**$5,422,000**
Contingency (20%)[d]				$1,085,000
Escalation (Base 01 January 2001)				$1,547,000
Total Cost				**$8,054,000**
Net Present Value of Alternative 6A (2002 $'s)				**$5,563,000[e]**

(table continues)

Table 5-17 (continued)

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect groundwater extraction for 15 years at IRP-13S; monitoring activities (annual and 5-year) continue for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports
[e] net present cost could increase by up to $0.5 million if additional VEE wells are required; actual extraction rates in the first WBZ could be as low as 7 gpm per well, as obtained in a recent VEE field test (BNI 1999a), rather than the 12 gpm per well estimated by the model presented in Appendix B

Acronyms/Abbreviations:
GAC – granular activated carbon
gpm – gallons per minute
IRP – Installation Restoration Program
O&M – operation and maintenance
VEE – vacuum-enhanced extraction
WBZ – water-bearing zone

monitoring of groundwater quality, sampling of the treatment plant influent and effluent, replacement of spent GAC, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that the groundwater extraction and treatment systems would operate 15 years. Performance monitoring would be conducted for 30 years.

Backup and supporting details for the Alternative 6A cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.9.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 6A with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

Since the chemical-specific ARARs for Alternative 6A pertain to groundwater, they are identical to those for Alternative 6. Refer to Section 5.8.2.6 for a discussion of these ARARs.

Location-Specific ARARs

The primary activities under Alternative 6A that might trigger location-specific requirements are those related to the excavation of contaminated soils; installation of extraction, injection, and monitoring wells; and construction of the conveyance pipelines and treatment plants. The additional activities due to on-site thermal treatment fall under the ARARs already specified for Alternative 4A. Refer to Section 5.8.2.6 for a discussion of location-specific ARARs.

Action-Specific ARARs

The major components of Alternative 6A that trigger action-specific ARARs are the generation of solid waste (excavated soil from the source areas, soil cuttings from well installations, trench spoils, and spent GAC), on-site treatment of soil, extraction and treatment of contaminated groundwater containing VOCs, the discharge of treated groundwater into a city of Tustin storm drain eventually emptying into Peters Canyon Channel, and potential emissions of treated soil vapor that might contain VOCs.

Because Alternative 6A involves on-site thermal treatment and disposal of soil, other ARARs are triggered in addition to those specified for Alternative 6. The use of on-site thermal treatment is subject to RCRA requirements for hazardous waste specified in Cal. Code Regs. tit. 22, § 66265.370–383, with the exception of § 66265.382. If soil cuttings or excavated contaminated soil were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]) and were proposed for on-site disposal, then the LDRs of Cal. Code Regs. tit. 22, § 66268 would also be potential ARARs for treatment of the waste soil. The substantive portions of the SCAQMD rules identified as action-specific ARARs for Alternative 6 set technical requirements for addressing the potential atmospheric emissions of VOC-containing soil vapor that might be extracted by the VEE wells or desorbed in the TDU. Use of GAC to treat the VEE well soil vapor and a thermal oxidizer or GAC to treat the TDU vapors would satisfy the SCAQMD requirement to install best available control technology on sources potentially emitting toxic air pollutants, a category which includes some of the OU-1A COCs. Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements. Refer to Section 5.8.2.6 for a discussion of action-specific ARARs.

5.9.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 6A would protect human health and the environment in a manner identical to Alternative 6. Reuse of thermally treated soil as backfill at the site would be subjected to the criteria imposed on untreated soil, as described in Section 5.6.1.3. Details on overall protection of human health and the environment are discussed in Section 5.8.2.7.

5.10 ALTERNATIVE 7 – HYDRAULIC CONTAINMENT WITH HOT SPOT REMOVAL

Alternative 7 is an enhancement or optimization of Alternative 3 that combines groundwater extraction and limited source soil excavation of hot spots with the hydraulic containment described under Alternative 3. In addition to four hydraulic containment wells that would operate for the duration of the remedy, one hot spot groundwater extraction well would operate in the central portion of the VOC plume for approximately 6 years. Treated groundwater would be discharged to a city of Tustin storm drain and ultimately to Peters Canyon Channel. Hot spot soil would be excavated and treated on-site using a TDU. Hot spot groundwater and soil removal optimizes hydraulic

containment by reducing the time required to attain the cleanup goals established for the site.

5.10.1 Description

Alternative 7 combines hydraulic containment with soil and groundwater hot spot removal. Contaminated soil would be excavated and treated on-site with a TDU. Treated soil would be used as excavation backfill. Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel. Long-term performance monitoring would verify the effectiveness of the remedial action, supported by detailed reviews at 5-year intervals to evaluate its continued protectiveness. Deed restrictions to prevent groundwater use would be placed on the redevelopment parcels at Former MCAS Tustin that overlie the VOC plumes and an approximately 200-foot buffer zone surrounding the plumes, effectively preventing human exposure to contaminated groundwater.

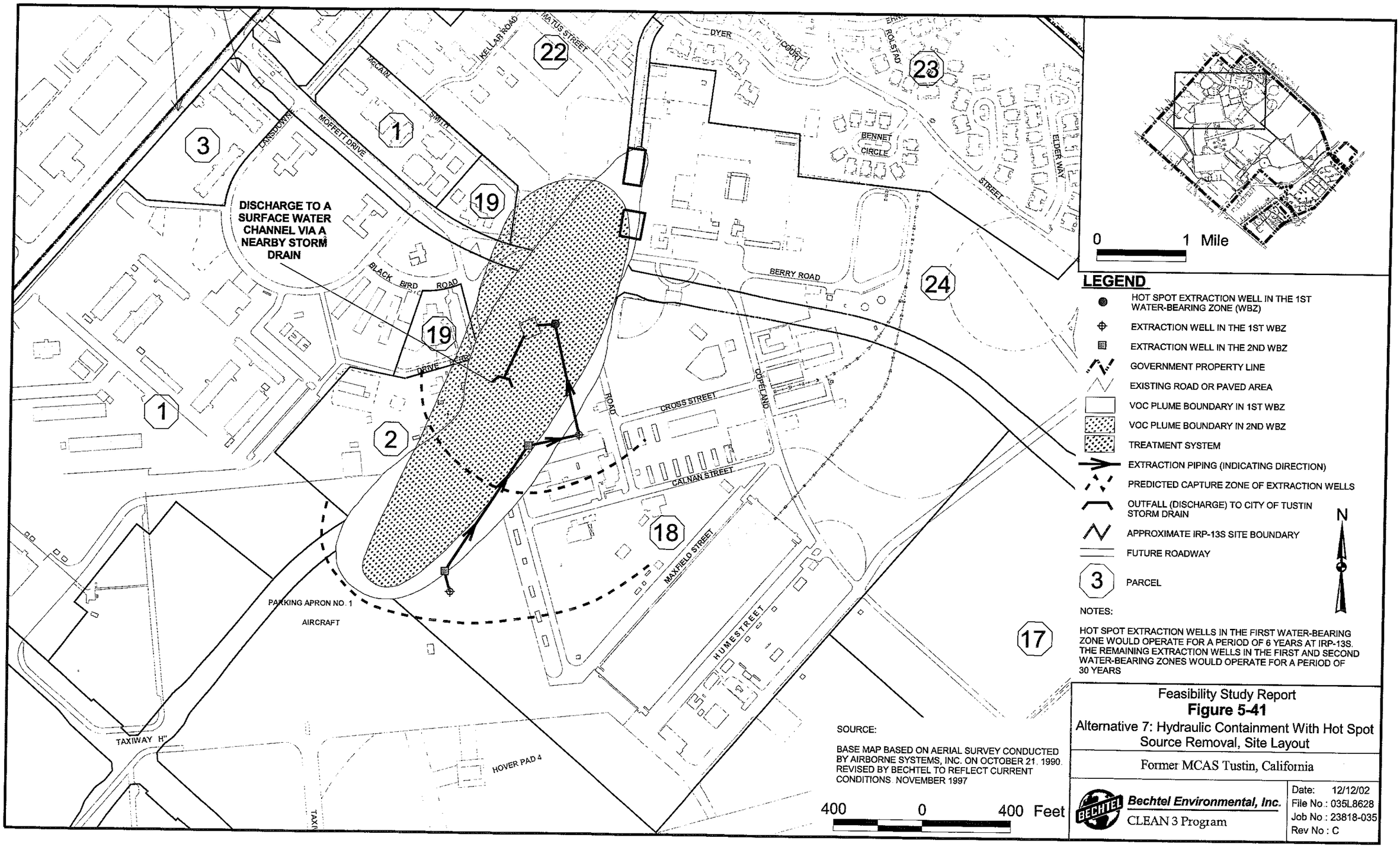
A conceptual site layout depicting the surface components of Alternative 7 is illustrated on Figure 5-41. Descriptions of the major components of Alternative 7 are presented below.

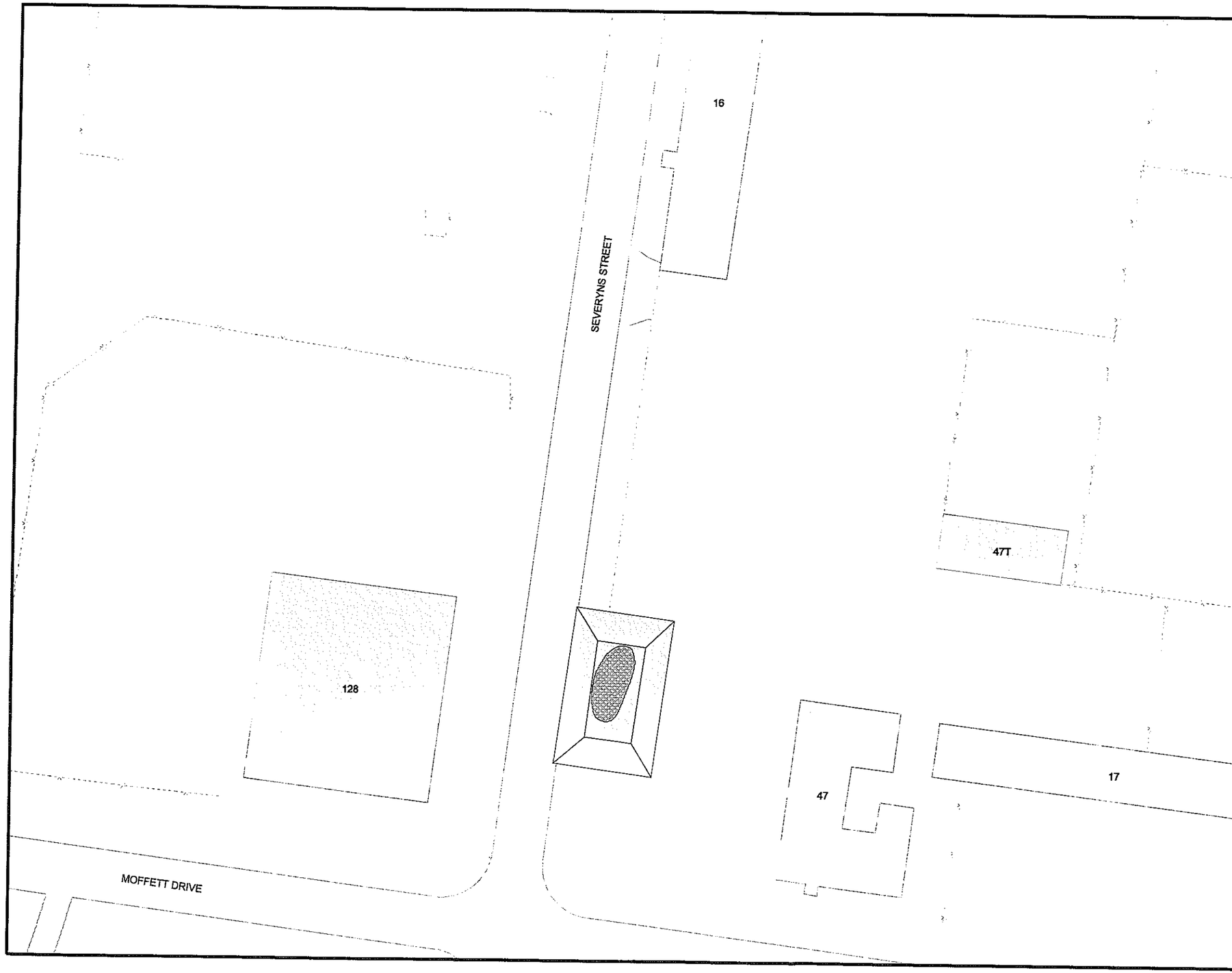
5.10.1.1 SOIL HOT SPOT EXCAVATION

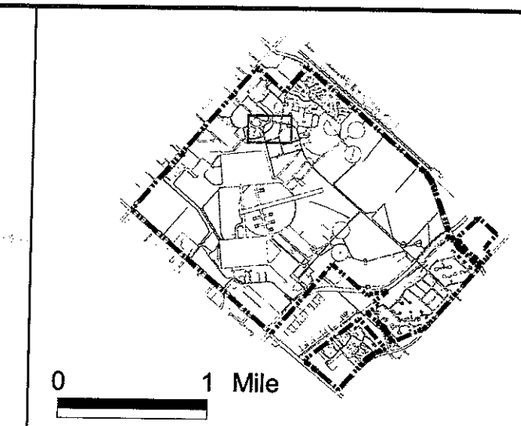
Under Alternative 7, soil containing elevated concentrations of TCE would be removed from the vadose zone and upper confining layer of the first WBZ. The rationale for excavating these soils is to eliminate potential sources of low-level VOC contamination (at or exceeding the MCL) to groundwater of the first WBZ.

Groundwater modeling results indicate that excavation of VOC-affected soils from the upper clay layer at the site markedly increases the effectiveness of hydraulic containment. The modeling results indicate that soils left in place with TCE and/or 1,2,3-TCP at concentrations exceeding 400 and 100 µg/kg, respectively, would result in a continuing source of contamination to groundwater at concentrations exceeding the site remediation goals established for these chemicals. Soils contaminated with 1,2,3-TCP at concentrations exceeding the excavation criteria of 100 µg/kg were not reported at the site. The soils targeted for excavation would be soils in those portions of the vadose zone and upper confining layer of the first WBZ with TCE at concentrations above approximately 400 µg/kg. These target soils generally occur at depths of approximately 3 to 15 feet bgs. Excavation of target soils would by necessity also remove clean overburden and the less contaminated soils that overly the upper confining clay layer. The development of soil excavation criteria for Alternative 7 is explained in greater detail in Appendices B and E.

Under Alternative 7, a total of approximately 2,450 cubic yards of soil would be excavated from one area at IRP-13S (Figure 5-42). Appendix E presents estimates of the soil volumes that would be excavated to a maximum total depth of approximately 15 feet bgs using an open cut excavation technique with a slope factor of 1:1. Available data were sufficient to estimate soil excavation volumes for this FS Report and are considered adequate for conceptual design (BNI 1997b, 1998a).


DISCHARGE TO A SURFACE WATER CHANNEL VIA A NEARBY STORM DRAIN
LANSDOWNE
MOFFETT DRIVE
MCCLAIN
SMITH
KELLAR ROAD
HATUS STREET
DYER
COURT
ROLSTAD
BENNET CIRCLE
ELDER WAY
STREET
BERRY ROAD
BLACK BIRD ROAD
DRIVE
CROSS STREET
COPELAND
ROAD
CALNAN STREET
MAXFIELD STREET
HUMESTREET
PARKING APRON NO. 1
AIRCRAFT
TAXIWAY H"
HOVER PAD 4
1
2
3
17
18
19
22
23
24
0
1 Mile
LEGEND
HOT SPOT EXTRACTION WELL IN THE 1ST WATER-BEARING ZONE (WBZ)
EXTRACTION WELL IN THE 1ST WBZ
EXTRACTION WELL IN THE 2ND WBZ
GOVERNMENT PROPERTY LINE
EXISTING ROAD OR PAVED AREA
VOC PLUME BOUNDARY IN 1ST WBZ
VOC PLUME BOUNDARY IN 2ND WBZ
TREATMENT SYSTEM
EXTRACTION PIPING (INDICATING DIRECTION)
PREDICTED CAPTURE ZONE OF EXTRACTION WELLS
OUTFALL (DISCHARGE) TO CITY OF TUSTIN STORM DRAIN
APPROXIMATE IRP-13S SITE BOUNDARY
FUTURE ROADWAY
PARCEL
N
NOTES:
HOT SPOT EXTRACTION WELLS IN THE FIRST WATER-BEARING ZONE WOULD OPERATE FOR A PERIOD OF 6 YEARS AT IRP-13S. THE REMAINING EXTRACTION WELLS IN THE FIRST AND SECOND WATER-BEARING ZONES WOULD OPERATE FOR A PERIOD OF 30 YEARS
SOURCE:
BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990. REVISED BY BECHTEL TO REFLECT CURRENT CONDITIONS. NOVEMBER 1997
400
0
400 Feet
Feasibility Study Report
Figure 5-41
Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Site Layout
Former MCAS Tustin, California
Bechtel Environmental, Inc.
CLEAN 3 Program
Date: 12/12/02
File No.: 035L8628
Job No.: 23818-035
Rev No.: C





LEGEND

- > 400 ug/kg TCE
- EXCAVATION LIMITS
- FUTURE ROADWAY

NOTES:

AREA OF EXCAVATION INCLUDES ALL TCE CONTAMINATION > 400 ug/kg

EXCAVATION AREA IS APPROXIMATE ASSUMING A 1:1 CUT SLOPE TO A MAXIMUM DEPTH OF 15 FT BGS

SOURCE:

BASE MAP BASED ON AERIAL SURVEY CONDUCTED BY AIRBORNE SYSTEMS, INC. ON OCTOBER 21, 1990 REVISED BY BECHTEL TO REFLECT CONDITIONS AS OF NOVEMBER 1997

N

60 0 60 Feet

Feasibility Study Report
Figure 5-42
Alternative 7: Extent of TCE Soil Contamination > 400 ug/kg and Excavation Areas at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

Date: 12/12/02
File No : 035L8689
Job No : 23818-035
Rev No : D

Soil samples would be collected from the sidewalls of each excavation to guide the excavation and document the effectiveness of the excavation. Analytical results would be obtained quickly, either by requesting 24-hour turnaround at an off-site laboratory or through use of an on-site field laboratory. This procedure would minimize the time that the excavation would have to remain open and reduce the volume of infiltrated groundwater requiring management by the excavation contractor.

Soil excavated at the site would be segregated into three stockpiles according to expected TCE concentrations. Management of excavated soil in this manner would minimize the volume of material selected for treatment using the TDU and would facilitate reuse of the cleaner soil fractions as excavation backfill. One soil stockpile would include all material with expected TCE concentrations exceeding 100 µg/kg. The second stockpile would contain soils with detectable but low VOC concentrations, i.e., material with TCE at concentrations that do not exceed 100 µg/kg. The third stockpile would contain soil with no reported concentrations of TCE. Figure 5-43 presents estimated volumes of soil expected in each of the three stockpiles.

A temporary storage area with a liner, berm, leachate collection system, run-on diversion, and dust control features would be constructed for the stockpiled soil at the site. The stockpiled material would be tested to determine its classification under both federal and California hazardous waste management regulations. Based on data obtained during the RI, it was assumed that none of the soil excavated at IRP-13S would be classified as RCRA or non-RCRA hazardous waste.

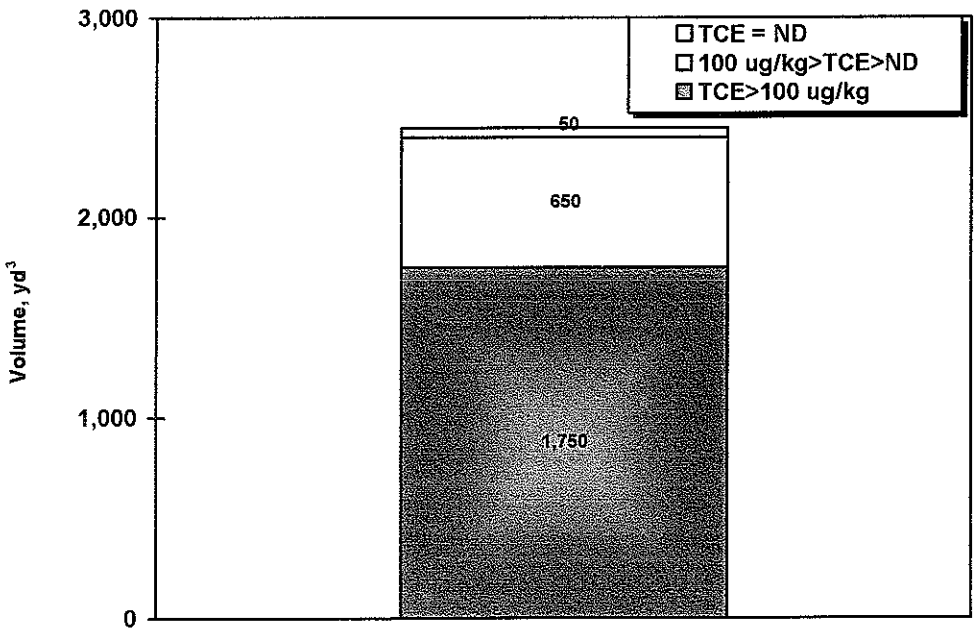


Figure 5-43
Volume of Soil to Be Excavated Under Alternative 7

After confirming the appropriate waste classification, approximately 1,750 cubic yards soil from the stockpile with the highest VOC concentrations (exceeding 100 µg/kg) would be treated on-site using a TDU and then be reused as excavation backfill, as needed. The treatment and subsequent disposal of soil are discussed further in following sections. Clean, treated soil and soil with TCE at concentrations below 100 µg/kg are proposed for use as backfill above the water table.

Construction dewatering is also anticipated to be necessary, as the excavation is planned to extend below the water table to the top of the sand layer in the first WBZ. The cost estimate for Alternative 7 was developed on the basis that the water pumped out of the excavations and collected from the temporary soil storage areas would be stored in Baker-type tanks and treated using mobile GAC units. The treated water could then be reused on-site for dust control or to add moisture to the thermally treated soil.

5.10.1.2 TREATMENT OF SOURCE MATERIAL

Stockpiled hot spot soils with TCE at concentrations exceeding 100 µg/kg would be treated using a TDU. A description of thermal desorption and treatment processes, including the types and treatment rates of TDUs that are anticipated to be used, is presented in Section 5.6.1.2. For purposes of the cost estimate, it was assumed that a mobile TDU would be brought on-site by a local vendor. The location of the TDU would be determined during the remedial design. Based on an estimated 2,600 tons of soil expected to be treated (assuming 1.5 tons per cubic yard), and an anticipated treatment rate on the order of 10 to 15 tons/hour, treatment could be completed in an estimated 1 to 2 months, depending on TDU process schedules and operation and maintenance requirements. After treatment, TCE concentration in soil will be reduced to below the detection limit, approximately 5.0 µg/kg.

As previously described in Section 5.6.1.2, based on the predominance of clay and silt in soils at the site, pretreatment of soil is assumed to be necessary. For purposes of cost estimation, pretreatment was assumed to include a shredder to be used as part of the TDU to break down clumped clay/silt material in the soils, and hydrated lime was assumed to be used as an additive to reduce soil moisture content. For the estimated total of 2,600 tons of soil requiring treatment, approximately 9 tons of lime would be needed for pretreatment, assuming a usage rate of 300 tons of soil per ton of lime. However, the suitability of additives should be evaluated to indicate how the characteristics of soil may change and thereby potentially affect its reuse. Water would be added to the treated soil as it exits the TDU to control dust. The treated soil would be stockpiled on-site near the TDU to await reuse.

The vapor treatment system for the vapors carrying the described VOCs is described in Section 5.6.1.2. For cost estimation purposes, thermal oxidation was assumed and, depending on the treatment requirements, a scrubber and cooling tower may be needed.

As a CERCLA remediation activity that would be conducted entirely on-site, the use of a TDU at OU-1A would not require a permit from SCAQMD. However, treated vapors released to the atmosphere would need to comply with the substantive provisions of the

SCAQMD regulations pertaining to point source emissions of VOCs. Local vendors typically employ a SCAQMD "various locations" permit for portable TDUs.

5.10.1.3 BUILDING DEMOLITION

No structures exist over the area that would be excavated under Alternative 7; therefore, no building demolition would be required.

5.10.1.4 BACKFILLING OF EXCAVATIONS

It is anticipated that excavation of hot spot soils under Alternative 7 would extend beneath the water table. Based on the estimates summarized in Figure 5-43, materials that would be available as excavation backfill would include approximately 50 cubic yards of excavated soil with no reportable TCE, approximately 650 cubic yards of soil with TCE at concentrations less than 100 µg/kg, and approximately 1,750 cubic yards of soil treated with the TDU. The excavated and treated soil would be stockpiled at the site and placed back to the same excavation level so that activities are kept within the same area of contamination.

Under Alternative 7, clean fill consisting of sand or gravel would be obtained from an off-site commercial source and used as backfill in the bottom 4 feet of the excavation. Only soil with no reported concentrations of TCE would be placed below the seasonal high-water table, as illustrated on Figure 5-44. A geotextile liner would be placed above the clean fill and the seasonal high-water table with the intent to prevent desorption of VOCs from the soil into the groundwater.

5.10.1.5 EFFECT OF BACKFILL WITH LOW LEVELS OF VOCs

Groundwater modeling results indicate that the use of soil with low-level concentrations of TCE (less than 100 µg/kg) as backfill above the water table would result in TCE in groundwater at concentrations near or below the MCL of 5 µg/l.

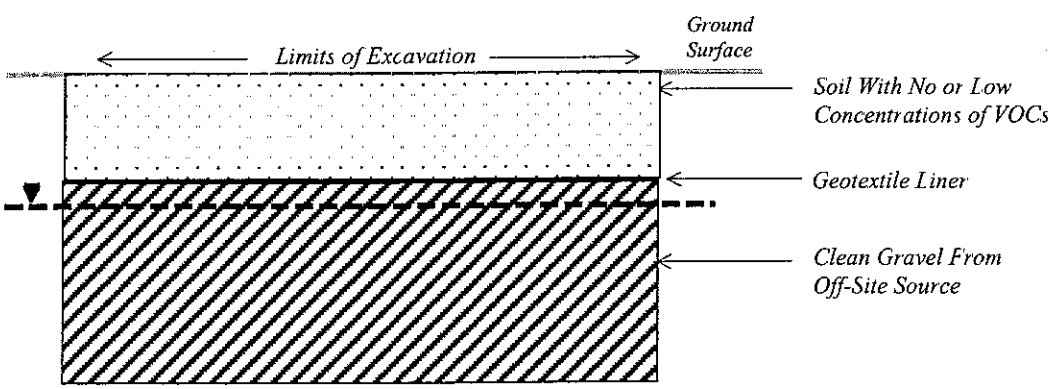


Figure 5-44
Backfilling of Excavation Following Hot Spot Source Removal

5.10.1.6 DISPOSAL OF TREATED SOURCE MATERIALS

Backfilling or other beneficial reuse of soil treated at a TDU facility was determined to be the preferred means for disposal of this material. It is anticipated that the treated soil would not have any remaining VOC contamination exceeding the action levels (100 µg/kg for TCE) for use as backfill. For Alternative 7, the preferred reuse of treated soil is for backfill, although other on-site beneficial uses could be considered. Other potential beneficial uses include construction sites or backfill for other excavations. Testing of the treated soil will be performed to evaluate reuse options.

5.10.1.7 GROUNDWATER EXTRACTION

Groundwater extraction under Alternative 7 would include two wells installed in each of the first and second WBZs for hydraulic containment and one hot spot extraction well installed in the first WBZ. The hot spot extraction well would be located near the highest VOC concentrations in the IRP-13S plume and would operate for a period of approximately 6 years. The four hydraulic containment wells would operate for 30 years. Operation of the hydraulic containment and hot spot wells would create cones of depression that would capture contamination from the leading margins and from the central portions of the plumes that would prevent any additional horizontal or vertical migration of VOCs in the upper two WBZs.

The number of extraction wells, well locations, pumping rates, and duration proposed under Alternative 7 were estimated based on groundwater modeling that relied upon aquifer tests, geologic cross-sections, and groundwater monitoring completed for the RI and the RFA (BNI 1997a,b). This information was used as input to simulate the hydraulic containment with hot spot removal option, as described in Appendix B.

Based on groundwater modeling results, a total of 5 groundwater extraction wells would be required under Alternative 7. Figure 5-41 summarizes proposed locations for the hydraulic containment and hot spot extraction wells. Table 5-18 summarizes the proposed completion depths, pumping rates, and duration for these wells. The actual extraction well locations and completion depths would be determined during remedial design. As extraction wells are installed and tested, groundwater extraction rates and capture zones would be compared to the simulated extraction rates and capture zones. Based on this evaluation, the extraction well field would be fine-tuned, as necessary, to meet the objectives of Alternative 7.

The methods and materials that would be used for installation and completion of extraction wells under Alternative 7 would be identical to those described for Alternative 3. Refer to Section 5.4.1.1 for a discussion of extraction well installation methods and well completion details.

Based on the modeling results, operation of the four hydraulic containment wells located in the first two WBZs would act as a hydraulic barrier to capture the leading edge of contamination and prevent further migration of VOCs in the upper two WBZs

Table 5-18
Extraction Well Details for Hydraulic Containment With Hot Spot Removal

WBZ	Number of Wells	Completion Depth[a] (feet bgs)	PUMPING RATE		
			Hot Spot Wells (gpm)	Containment Wells (gpm)	Combined (gpm)
First	2	30–34	N/A	6[b]	N/A
First	1	30–34	6	N/A	N/A
Second	2	55–60	N/A	6[b]	N/A
Total	**5**	**N/A**	**6[c] (b)**	**12**	**18/12[d]**

Notes:
[a] completion depths shown are estimated; actual depths would vary depending on conditions encountered at each location
[b] two containment wells would operate at 3 gpm each
[c] this well would operate for approximately 6 years after implementation of remedial alternative
[d] the total combined pumping rate would be 18 gpm for years 0 to 6 and 12 gpm for years 6 to 30

Acronyms/Abbreviations:
bgs – below ground surface
gpm – gallons per minute
N/A – not applicable
WBZ – water-bearing zone

(Figures 5-45 and 5-46). For the purpose of cost estimation, it was assumed that the groundwater extraction system would operate for 30 years as described below. After the extraction system is shut down, natural processes would continue to reduce residual VOCs to site cleanup goals.

Operation of the hot spot groundwater extraction well located in the first WBZ in the backfilled excavations would act to capture groundwater with the highest VOC concentrations. Based on groundwater modeling results, this hot spot well would continue to operate until concentrations of 1,2,3-TCP in the groundwater extracted from the sand layer in the first WBZ approaches an asymptotic level. It is anticipated that hot spot groundwater extraction would continue for approximately 6 years at IRP-13S as extraction for longer periods would not result in significant contaminant reduction, as illustrated in Figure 5-47.

Table 5-18 summarizes operational periods and pumping rates for groundwater extraction wells required under Alternative 7. Assuming a combined extraction rate of 18 gpm for the first six years of operation (12 gpm from the first WBZ and 6 gpm from the second WBZ), the extraction system would produce approximately 26,000 gpd of extracted groundwater for treatment and disposal. Assuming a combined extraction rate of 12 gpm for years 6 to 30 (6 gpm from the first WBZ and 6 gpm from the second WBZ), approximately 17,300 gpd would be produced.

Groundwater extraction rates presented in Table 5-18 were estimated through groundwater modeling of the hydraulic containment with hot spot removal alternative, as

discussed in Appendix B. The steady-state drawdown attained in each WBZ is predicted to establish capture zones of sufficient width to contain hot spot groundwater in the central portion of the VOC plume and also to contain the leading edge of the VOC plume, as shown on Figures 5-45 and 5-46. Actual extraction rates and drawdowns may vary from these estimates due to the heterogeneity of the shallow aquifer and the uncertainties associated with groundwater modeling. This issue would be addressed through evaluation of performance monitoring data collected from the TCRA system currently in operation at OU-1A and through groundwater extraction tests that would be conducted at the proposed well locations during remedial design.

5.10.1.8 GROUNDWATER CONVEYANCE AND TREATMENT

For the purpose of developing a cost estimate, it was assumed that the groundwater extraction and treatment system would operate for 30 years. The five groundwater extraction wells installed under Alternative 7 would yield nearly 9.5 million gallons of water per year for the first 6 years, and 6.3 million gallons of water per year for years 6 to 30. The cumulative volume of water to be managed over a 30-year period would be approximately 208 million gallons.

Groundwater would be pumped from the extraction wells and delivered to a treatment system that would be constructed near the location of the existing TCRA treatment system. Approximately 1,600 feet of double-walled conveyance piping would be required. The conceptual location and operation of the groundwater treatment plant for Alternative 7, illustrated in Figure 5-41, would be identical to those described for Alternative 3.

Preliminary specifications for the GAC treatment system were developed based on discussions with equipment vendors and on the anticipated flows and VOC concentrations for the groundwater to be extracted under Alternative 7. Predicted maximum concentrations of TCE and 1,2,3-TCP in the extraction wells over time are shown on Figures 5-47 and 5-48. Other VOCs occur in groundwater at much lower concentrations than the primary OU-1A contaminants, TCE and 1,2,3-TCP, and would also be expected to decline with time in the extracted groundwater.

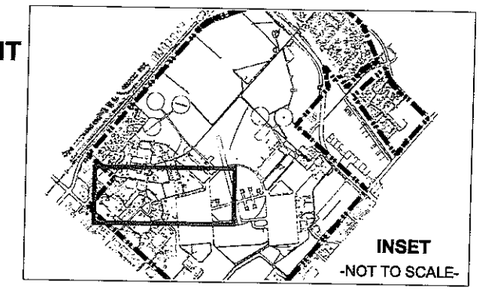
Using the predicted groundwater extraction rates and design concentrations for TCE and 1,2,3-TCP, an estimated carbon usage rate of 0.087 pound per thousand gallons was calculated for the first 6 years of operation and 0.076 pound per thousand gallons for years 6 to 30 of operation. This equates to an annual GAC consumption of approximately 900 pounds for the first 6 years, and approximately 500 pounds for years 6 to 30.

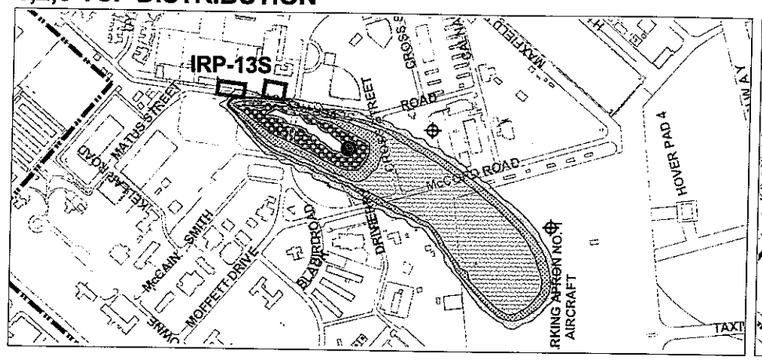
Thirty years of operation (the basis for the FS cost estimate) would produce a maximum of approximately 16,500 pounds of spent GAC. The maximum VOC loading on the GAC removed from the treatment facility is anticipated to be less than 1 percent by weight. Regeneration or disposal of the spent GAC would be the responsibility of the GAC supplier under a long-term service contract. For purposes of this FS Report, it was assumed that spent GAC would be taken off-site for regeneration, which is the typical

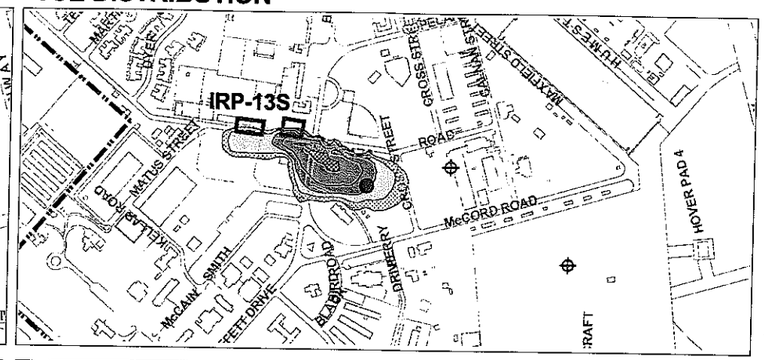
1,2,3-TCP DISTRIBUTION

TCE DISTRIBUTION

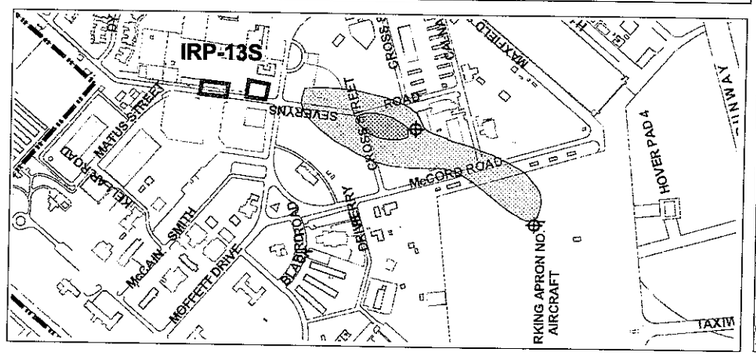
ALTERNATIVE 7: HYDRAULIC CONTAINMENT WITH HOT SPOT SOURCE REMOVAL

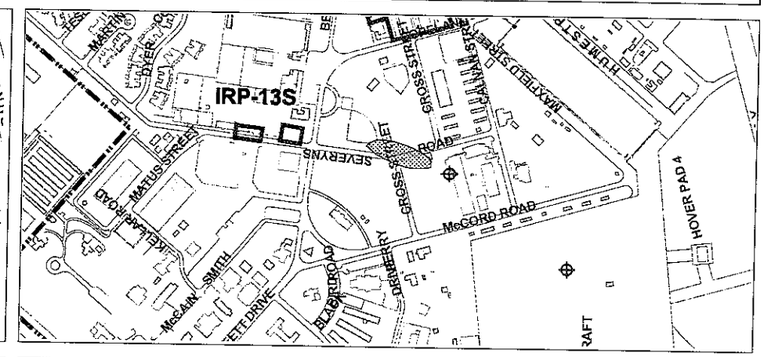




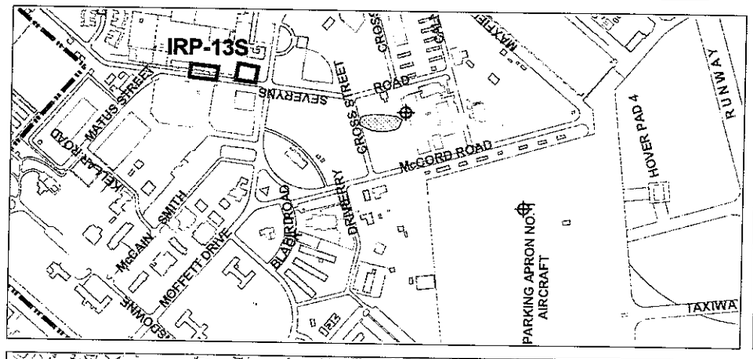


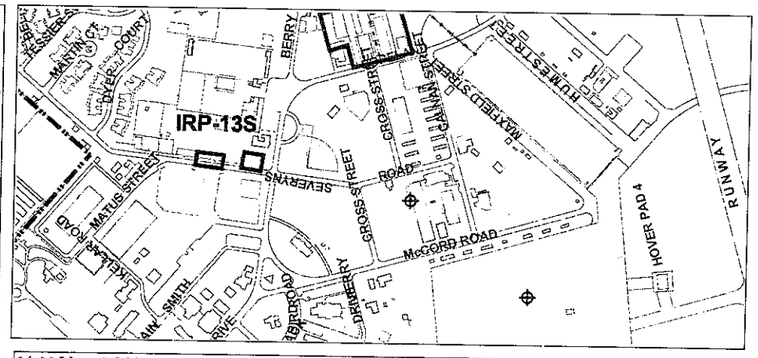
CURRENT CONDITIONS



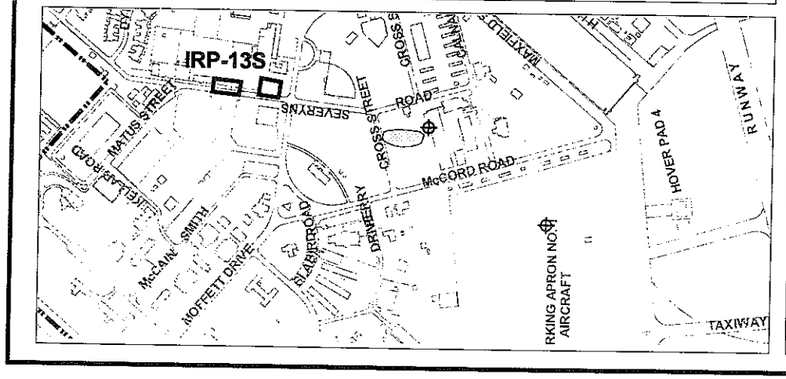


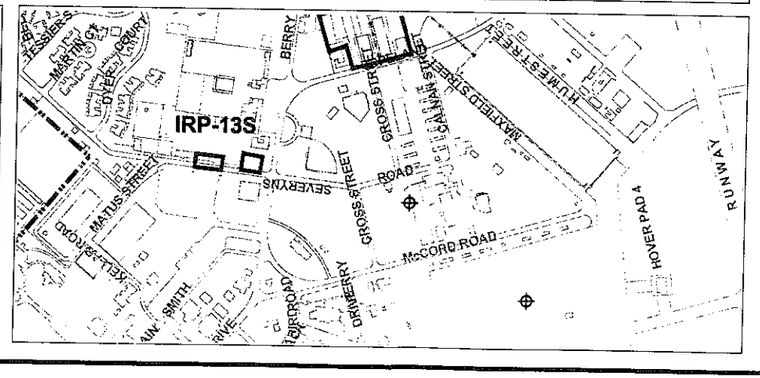
AFTER 10 YEARS





AFTER 20 YEARS





AFTER 30 YEARS

LEGEND

- HOT SPOT EXTRACTION WELL IN THE 1ST WATER-BEARING ZONE (WBZ)
- EXTRACTION WELL IN THE 1ST WBZ
- GOVERNMENT PROPERTY LINE
- EXISTING ROAD OR PAVED AREA
- BUILDING OR STRUCTURE
- RAILROAD
- FENCE

TCE CONCENTRATION IN GROUNDWATER:

- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- 100 to 200 ug/L
- 200 to 500 ug/L
- 500 to 1000 ug/L
- 1000 to 2000 ug/L
- 2000 to 5000 ug/L
- > 5000 ug/L

1,2,3-TCP CONCENTRATION IN GROUNDWATER:

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L

N

900 0 900 Feet

Feasibility Study Report

Figure 5-45

Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Simulated TCE and 1,2,3-TCP Concentrations in the 1st WBZ at IRP-13S

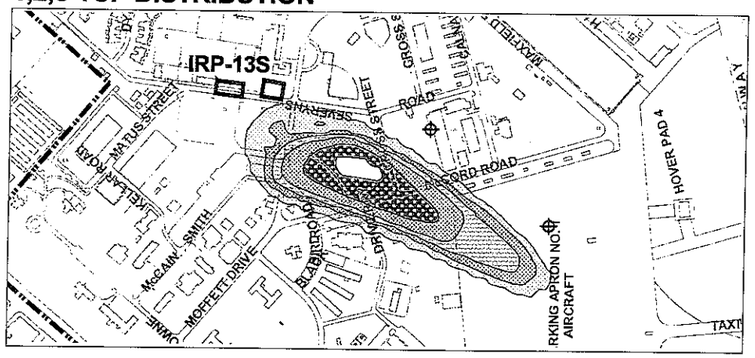
Former MCAS Tustin, California

Bechtel Environmental, Inc.
CLEAN 3 Program

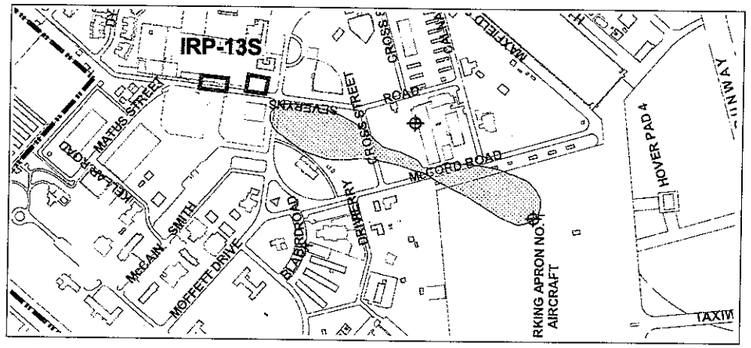
Date: 12/19/02
File No : 035L8622
Job No : 23818-035
Rev No : C

1,2,3-TCP DISTRIBUTION

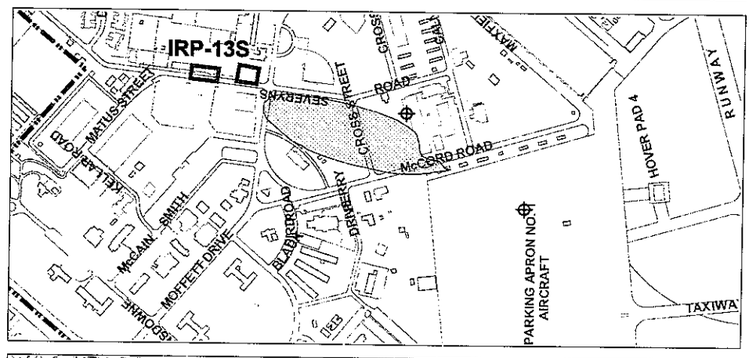
ALTERNATIVE 7: HYDRAULIC CONTAINMENT WITH HOT SPOT SOURCE REMOVAL



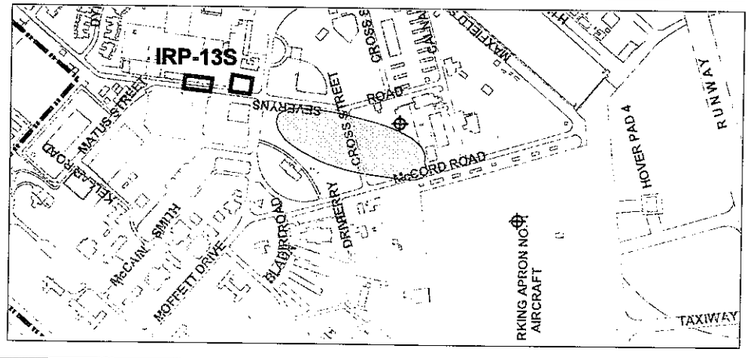
CURRENT CONDITIONS



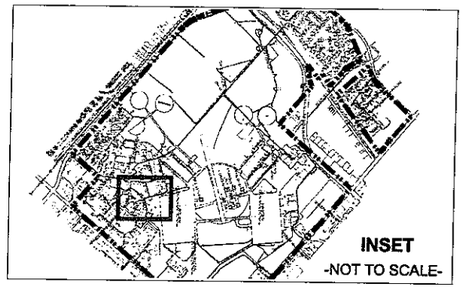
AFTER 10 YEARS



AFTER 20 YEARS



AFTER 30 YEARS



LEGEND

- EXTRACTION WELL IN THE 2ND WATER-BEARING ZONE (WBZ)
- GOVERNMENT PROPERTY LINE
- EXISTING ROAD OR PAVED AREA
- BUILDING OR STRUCTURE
- RAILROAD
- FENCE

1,2,3-TCP CONCENTRATION IN GROUNDWATER:

- 1 to 5 ug/L
- 5 to 10 ug/L
- 10 to 20 ug/L
- 20 to 50 ug/L
- 50 to 100 ug/L
- > 100 ug/L

N

900 0 900 Feet

Feasibility Study Report

Figure 5-46

Alternative 7: Hydraulic Containment With Hot Spot Source Removal, Simulated 1,2,3-TCP Concentrations in the 2nd WBZ at IRP-13S

Former MCAS Tustin, California

Bechtel Environmental, Inc.

CLEAN 3 Program

Date: 12/19/02
File No : 035L8623
Job No : 23818-035
Rev No : C

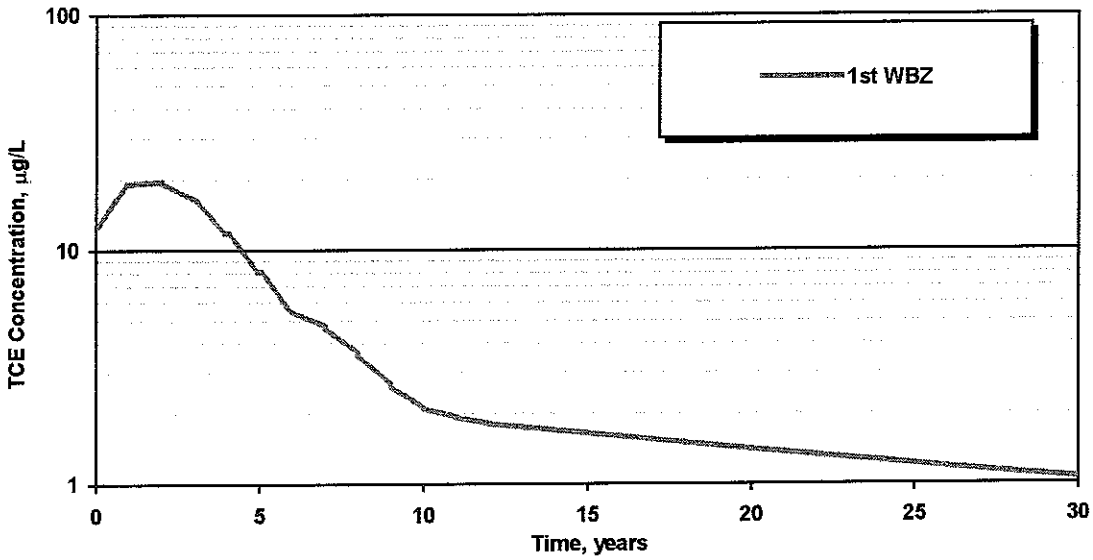


Figure 5-47
Predicted TCE Concentrations
in Extraction Wells Under Alternative 7

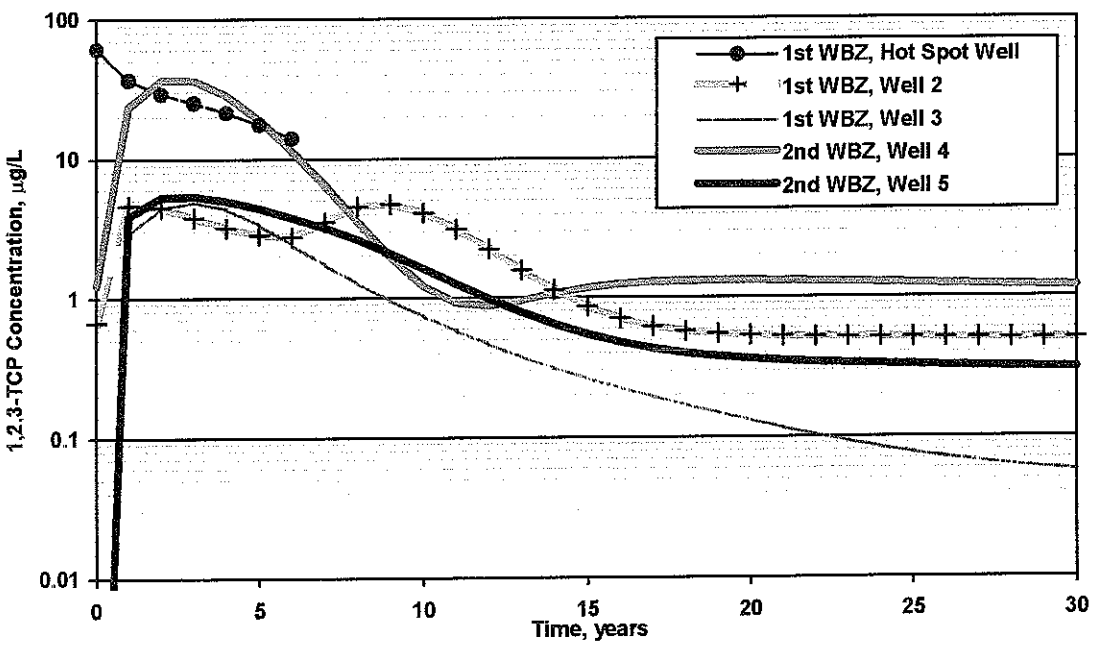


Figure 5-48
Predicted 1,2,3-TCP Concentrations
in Extraction Wells Under Alternative 7

practice on groundwater remediation projects. Prior to shipment from the site, the spent GAC would be tested to determine its waste classification (nonhazardous, RCRA hazardous, and/or non-RCRA hazardous). Characterization, packaging, and transport of this material would be in accordance with DOT, U.S. EPA, and DTSC requirements.

5.10.1.9 GROUNDWATER DISPOSAL

Treated water from the treatment system would be discharged to a city of Tustin storm drain, ultimately discharging into Peters Canyon Channel. The eventual discharge of water to Peters Canyon Channel would comply with substantive ARARs for surface water discharges. Groundwater disposal for Alternative 7 would be identical to that for Alternative 3, hydraulic containment. Disposal options for treated groundwater will be reevaluated in the remedial design to determine if discharge to the storm drain system is the most technically feasible and cost-effective method for disposal. The reevaluation will consider additional factors such as local hydrogeology, substantive regulations, regulatory/public input, and TMDL discharge limits for chemicals (including selenium). Other potential public uses for treated groundwater, such as "purple" water irrigation, groundwater recharge using reinjection or percolation ponds, or use in wetlands, will also be evaluated. Refer to Section 5.4.1.3 for a discussion of groundwater disposal. Permitting issues for these discharges are discussed in detail in Section 2.3 and Appendix A (Section A4.6.2).

5.10.1.10 PERFORMANCE MONITORING

Performance monitoring during implementation of Alternative 7 would be similar to that described under Alternative 3. Performance monitoring would be used to optimize operation of the extraction system, track mass removal, verify containment of the VOC plumes, and demonstrate successful treatment of the extracted groundwater prior to discharge. Monitoring would include water-level measurements as well as the collection and analysis of samples from wells placed within the plume areas. Process streams within the treatment plant would also be tested. The overall approach to monitoring for Alternative 7 is consistent with that presented in U.S. EPA technical guidance (U.S. EPA 1994c). A summary of proposed performance monitoring anticipated for Alternative 7 is presented in Table 5-19.

The long-term groundwater monitoring program for Alternative 7 would be identical to that described under Alternative 3. For the purpose of developing a cost estimate, it was assumed that two new groundwater monitoring wells would be installed, one well in each WBZ at IRP-13S. In addition, it was assumed that four existing wells would be included in the groundwater monitoring plan. Thus, a total of six wells would be monitored for Alternative 7. The actual number of monitoring wells to be sampled and the locations and specifications for any new monitoring wells (depth, screened interval, and well construction materials) would be determined during remedial design and documented in the long-term monitoring plan. This plan would also provide details concerning sampling procedures, target analytes, analytical methods, field and laboratory

Table 5-19
Performance Monitoring for Hydraulic Containment with Hot Spot Removal

Type of Monitoring Data	Monitoring Locations	Purpose/Use of Data
Water levels	Monitoring wells throughout and around the VOC plumes	Prepare potentiometric surface maps and hydrographs Determine horizontal and vertical hydraulic gradients Confirm capture zones (containment of plume)
VOC concentrations in the shallow aquifer	Monitoring wells throughout and around the VOC plumes	Delineate areal and vertical extent of contamination Confirm containment of plume
VOC concentrations in extracted groundwater	Extraction wells and equalization tank effluent	Estimate cumulative mass of VOCs removed from aquifer Characterize extracted groundwater from individual wells and combined treatment plant influent with respect to RCRA and non-RCRA hazardous waste criteria
VOC concentrations in treatment plant effluent	Effluent lines from GAC vessels	Assess performance of treatment system Demonstrate compliance with discharge requirements
Flow rates	Extraction wells and various points in treatment system	Confirm that extraction and treatment systems are operating to specifications
Other operational parameters (e.g , waterline pressures)	Various locations	As needed to assess proper operation or incipient failure of pumps and filters

Acronyms/Abbreviations:
GAC – granular activated carbon
RCRA – Resource Conservation and Recovery Act
VOC – volatile organic compound

QA/QC, and reporting requirements. Well locations and surface completion methods would take accessibility into consideration, along with the need to minimize impacts on redevelopment of the Former MCAS Tustin property.

5.10.1.11 INSTITUTIONAL CONTROLS

The area that requires deed restrictions is based on the extent of the VOC plumes, and therefore institutional controls for Alternative 7 will be almost identical to those for Alternative 3. Refer to Section 5.4.1.5 for a detailed discussion of the institutional controls.

5.10.1.12 PERIODIC REVIEWS

Periodic reviews involving a detailed analysis of the groundwater data under Alternative 7 would be identical to those under Alternative 3. The reviews would be conducted every 5 years to determine whether the extraction wells were effectively containing the contaminated shallow groundwater and reducing VOC concentrations as expected. Refer to Section 5.4.1.6 for details on the periodic reviews.

5.10.2 Detailed Analysis

The detailed analysis for Alternative 7 is similar to that for Alternative 3, except as it relates to excavation of hot spot source soils and on-site thermal treatment and disposition of the excavated source material. Alternative 7 was analyzed using the CERCLA evaluation criteria identified in Section 5.1. The order in which these criteria are addressed has been modified to facilitate the discussion presented in the following subsections.

5.10.2.1 SHORT-TERM EFFECTIVENESS

Short-term effectiveness considerations for Alternative 7 are similar to those for Alternative 3 owing to the efficiency of hydraulic containment. Alternative 7 adds effectiveness from the extraction of hot spot groundwater and excavation and thermal treatment of contaminated soil.

The greatest short-term risks during implementation of Alternative 7 would occur to workers and the surrounding community during excavation and handling and treatment of contaminated soils at IRP-13S. Workers involved in these activities may also be exposed to contaminated groundwater, since the excavations would extend below the water table.

The health and safety plan and remedial action work plan would need to include minimizing short-term risks to workers and the surrounding community during soil excavation activities, mobilization of the TDU, and soil preparation and thermal treatment. Short-term risks associated with on-site treatment of soil would include potential exposure to VOC vapors during material handling and treatment and physical hazards associated with start-up and operation of the TDU. These plans would prescribe personal protection equipment as well as monitoring and mitigation measures needed to minimize risks. Appropriate engineering and industrial hygiene controls would be

required, such as dust suppression measures, perimeter monitoring, traffic safety planning, spill prevention, and contingency planning.

Short-term risks are associated with installation of the groundwater extraction system, conveyance pipelines, and monitoring wells, as well as the start-up of the extraction wells and treatment plants, as these activities would entail management of VOC-contaminated groundwater in otherwise untested systems. Potential impacts from inadvertent releases would be controlled through a spill prevention plan developed prior to construction. This plan would identify procedures for rapid spill response and cleanup as well as measures to prevent or contain releases. Impacts on the community or on-site workers would be minimal under these circumstances.

The duration of the soil excavation and treatment, well installation, and groundwater treatment plant construction activities would be approximately 6 months. Following construction, the system would be tested to confirm the performance of each component before long-term operations commenced. This initial "shake-down" period should last no more than 3 months. Assuming that the deed restrictions could be established concurrently with remedial design, the major components of Alternative 7 would be in place approximately 9 months after mobilization for field construction. At that point, the combination of institutional controls and engineered remediation systems of this remedy would effectively limit the further migration of the VOC plumes, while significantly reducing the mass and concentration of VOCs in the subsurface along with the potential for human exposure to contaminated shallow groundwater.

5.10.2.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 7 is intended to contain the VOC plumes within the limits of the existing areas of contamination on the Former MCAS Tustin property, similar to that described under Alternative 3 in Section 5.4.2.2. In addition, Alternative 7 is intended to achieve significant reductions in contaminant mass and concentrations in the first WBZ earlier than would be expected under Alternative 3. Groundwater modeling presented in Appendix B shows that a small number of strategically-placed extraction wells is sufficient to meet these objectives.

Results from the modeling simulation are presented on Figures 5-45 and 5-46. These figures show that TCE and 1,2,3-TCP in groundwater would not migrate beyond the current existing downgradient margins of the plumes in the sand layers of the first and second WBZs. This would eliminate concerns regarding the potential off-site migration of contaminated groundwater. Alternative 7 accomplishes significant reductions in both concentration and mass as the VOC plumes are captured by the groundwater extraction system.

The groundwater to be extracted by hot spot groundwater extraction and hydraulic containment wells would be treated using GAC adsorption, a process identified by U.S. EPA as a proven and effective method for removing TCE, 1,2,3-TCP, and other chlorinated VOCs from water (U.S. EPA 1996b). All components of the extraction, treatment, and monitoring systems required by Alternative 7 have been implemented for

groundwater remediation at many other sites, demonstrating a high degree of long-term operational reliability.

Residual risks associated with the VOC plumes would be expected to decline as VOC-contaminated water is withdrawn from the shallow aquifer. The magnitude of this decline is illustrated on Figures 5-49 and 5-50, which plot predicted maximum TCE and 1,2,3-TCP concentrations in the sand layers of the first and second WBZs. Substantial VOC concentration reductions (and therefore risk reductions) are expected during the initial 15 years of hydraulic containment. Within 15 years under Alternative 7, maximum predicted concentrations of TCE would fall below the site remediation goal of 5 μg/L (Figure 5-49). Based on trends presented in Figure 5-50, predicted maximum concentrations of 1,2,3-TCP in the first and second WBZs would still exceed the site remediation goal of 0.6 μg/L after more than 60 years under Alternative 7.

Institutional controls for Alternative 7, including deed restrictions to prevent use of shallow groundwater, would be identical to those described for Alternative 3.

Residuals generated by the treatment system under Alternative 7 would consist of an estimated 5,000 pounds of spent GAC for the first 6 years, and approximately 11,500 pounds for the following 24 years. Spent GAC, which would be managed by the carbon supplier under a long-term service contract, would be taken off-site for regeneration or disposal. Because this material would be a solid waste that might contain relatively high concentrations of TCE and other VOCs, it would have to be characterized prior to transport off-site. Long-term management of spent GAC would be performed in accordance with RCRA and California waste management regulations. Therefore, residual risks associated with the spent carbon are considered negligible.

5.10.2.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 7 would accomplish a significant reduction in the toxicity, mobility, and volume of VOC-contaminated groundwater and source material (soils). Alternative 7 would eliminate contaminant mobility by capturing the VOC plumes and by preventing further VOC migration either laterally or vertically. Long-term operation of the groundwater extraction system is also expected to accomplish a potentially significant reduction in the volume and mass of subsurface contamination. According to the modeling results presented in Appendix B, hydraulic containment for 30 years would remove, on a mass basis, over 73 percent of the TCE and over 65 percent of the 1,2,3-TCP currently estimated to be in the VOC plumes. As shown in Figures 5-49 and 5-50, predicted maximum 1,2,3-TCP and TCE concentrations under Alternative 7 would decline from existing values by factors greater than 98 percent over 30 years, representing a significant reduction in the toxicity of the VOC plumes.

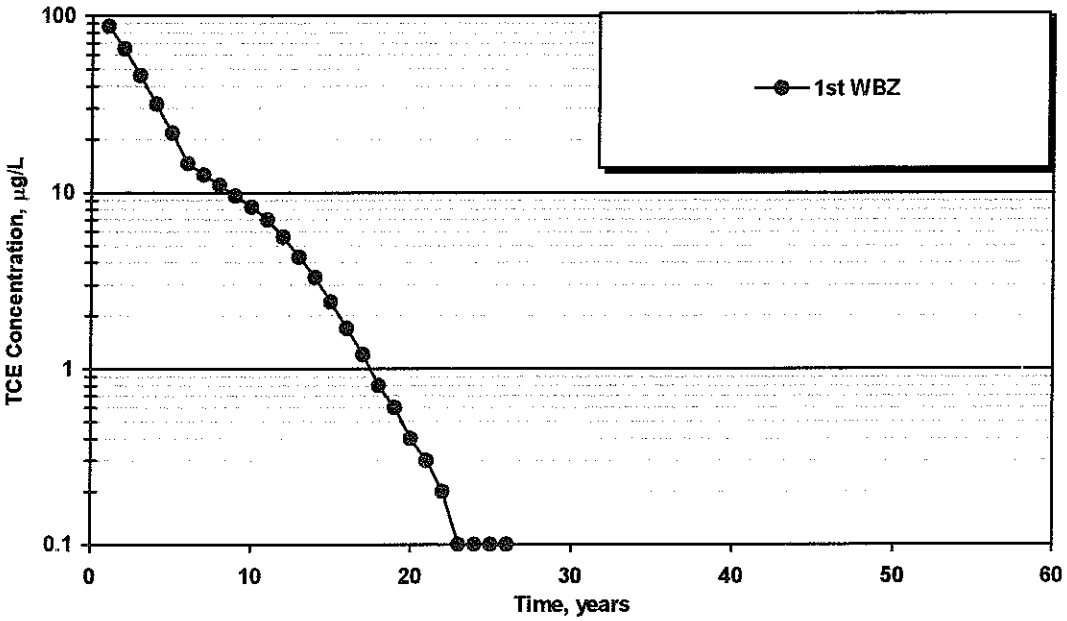


Figure 5-49
Predicted Maximum TCE Concentrations Under Alternative 7

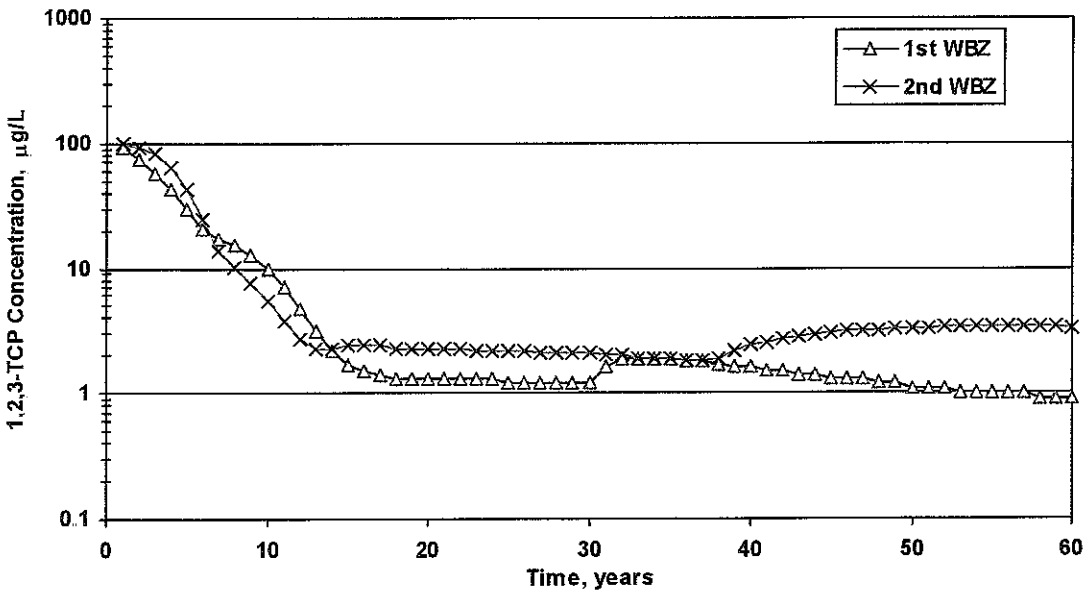


Figure 5-50
Predicted Maximum 1,2,3-TCP Concentrations Under Alternative 7

The extracted groundwater under this alternative would be treated using GAC, which involves a transfer of dissolved contaminants to a solid phase (i.e., carbon). The spent GAC would most likely be regenerated in a high-temperature furnace at a permitted off-site facility operated by the carbon supplier. The adsorbed VOCs would be destroyed during the carbon regeneration process.

An additional benefit of Alternative 7 is that thermal treatment of approximately 1,750 cubic yards of soil would reduce the potential for TCE in contaminated soil to leach to groundwater. Contaminated soil would be treated on-site with a TDU and would then be used for backfill. The desorbed VOCs in the TDU vapor stream would be destroyed prior to discharge to the atmosphere.

It is technically infeasible to remove all contamination from the VOC plumes given the prevalence of fine-grained materials, the propensity of organic contaminants to partition between the adsorbed and dissolved phases, and other factors that limit contaminant recovery. Therefore, while Alternative 7 should effectively remove a significant portion of the mobile contamination in the first two WBZs, the extent to which the residual, immobile VOCs would continue to affect the aquifer over the long term remains unknown. Modeling-based predictions indicate that VOC concentrations within the plume areas would remain slightly above site remediation goals after 30 years.

5.10.2.4 IMPLEMENTABILITY

Implementability of Alternative 7 would be nearly identical to that of Alternative 3, which is discussed in Section 5.4.2.4. The additional components under Alternative 7, including soil excavation and treatment using a TDU on-site, have been demonstrated to be feasible for the soil types found at Former MCAS Tustin, based on the long-term operation of a TDU for petroleum hydrocarbons at sites within Former MCAS Tustin. The technical components of a TDU are well established and have been widely used at other sites with TCE and related VOC contamination in soil. The equipment to be used is proven and reliable. Availability of a mobile TDU may be affected due to scheduling limitations by the vendors who supply mobile units in the region.

Treated water from the treatment system would be discharged to a city of Tustin storm drain eventually emptying into Peters Canyon Channel. The discharge of water to the channel would comply with substantive ARARs for surface water discharges.

The DON has reviewed the need to obtain an NPDES permit for the eventual discharge of treated water into Peters Canyon Channel and has determined that such a permit would not be necessary. A discussion of this determination is presented in Section 5.4.1.3.

5.10.2.5 COST

Table 5-20 summarizes the cost estimate developed for Alternative 7. The net present cost for hydraulic containment with hot spot soil and groundwater removal would be approximately $4.3 million. Major cost elements include excavation and treatment of

Table 5-20
Summary of Cost Estimate[a] for Alternative 7

Description	Capital Cost	O&M Costs		Total Costs[b]
		Annual Average	5th Year	
Engineering study/design/monitoring plan (3,200 hours @ $85.00/hour)	$272,000			$272,000
Removal of Source Materials				
Excavate, treat and backfill	$53,000			$53,000
Low-temperature thermal desorption system	$318,000			$318,000
Install five extraction wells (two wells in each WBZ, one in plume hot spot)	$302,000			$302,000
Wells O&M (average 30 years)		$20,333		$610,000
Piping	$154,000			$154,000
Carbon adsorption treatment system	$16,000			$16,000
GAC unit O&M (average 30 years)		$17,033		$511,000
Monitoring and Reporting				
Install two monitoring wells	$26,000			$26,000
Electrical distribution	$47,000			$47,000
Performance monitoring (average 30 years) (includes sample collection, analysis, water levels)		$76,300		$2,289,000
Annual monitoring report[c]		$10,000		$240,000
5-year review			$26,000	$156,000
Total				**$4,994,000**
Contingency (20%)				$999,000
Escalation (Base 01 January 2001)				$3,029,000
Total Cost				**$9,022,000**
Net Present Value of Alternative 7 (2002 $'s)				**$4,266,000**

Notes:
[a] see Appendix D for cost estimate details; sums may not agree due to rounding
[b] total costs reflect groundwater extraction for 6 years; monitoring activities (annual and 5-year) continue for assumed 30-year project duration
[c] cost not incurred every 5th year
[d] contingency and other indirect costs not incurred on studies, plans, and reports

Acronyms/Abbreviations:
GAC – granular activated carbon
O&M – operation and maintenance
WBZ – water-bearing zone

soil with a TDU, installation of extraction wells, and construction of the conveyance piping and treatment system. Long-term monitoring of groundwater quality, sampling of the treatment plant influent and effluent, and completion of detailed 5-year reviews are the largest components of O&M costs. For the purpose of this estimate, it was assumed that operation of the extraction and treatment systems and performance monitoring would be conducted for 30 years.

Backup and supporting details for the Alternative 7 cost estimate are provided in Appendix D. It is important to note that this estimate is intended solely for comparative purposes in this FS Report. It should not be used for budgetary or planning purposes.

5.10.2.6 COMPLIANCE WITH ARARs

The following discussion summarizes the expected performance of Alternative 7 with respect to chemical-, location-, and action-specific ARARs. A full discussion of ARARs is included in Appendix A.

Chemical-Specific ARARs

The trend lines presented in Figures 5-49 and 5-50 indicate that Alternative 7 would eventually comply with the chemical-specific ARARs identified in Appendix A (Section A2) and summarized in Section 2.4. Substantial VOC concentration reductions (and therefore risk reductions) are expected during the initial 15 years of hydraulic containment. Within 15 years under Alternative 7, maximum predicted concentrations of TCE would fall below 2.8 μg/L, the concentration corresponding to a 1.0×10^{-4} cancer risk level for drinking water exposure according to U.S. EPA Region 9 PRGs for tap water (U.S. EPA 2002), and would also fall below the site remediation goal of 5 μg/L (Figure 5-49). However, predicted maximum 1,2,3-TCP concentrations would remain slightly above the site remediation goal of 0.6 μg/L at the end of the 30-year operating period assumed in this FS Report, and may still exceed this goal after more than 60 years under Alternative 7.

Chemical-specific requirements that would eventually be met through implementation of Alternative 7 include the following:

- **Federal:** SDWA MCL (40 C.F.R. § 141.61[a]) for TCE; RCRA groundwater protection standards in Cal. Code Regs. tit. 22, § 66264.94(a)(1), (a)(3), (c), (d), and (e); CWA of 1977 (40 C.F.R. § 131.36 and 131.38); and RCRA requirements for waste generation (Cal. Code Regs. tit. 22, §§ 66262.11, 66261.100[a][1], 66261.21, 66261.22[a][1], 66261.23, and 66261.24[a][1])
- **State:** Substantive portions of the beneficial uses and water quality objectives in the WQCP for the Santa Ana River Basin (RWQCB 1995) as delineated in Table A2-2 in Appendix A; and DTSC requirements for waste generation (Cal. Code Regs. tit. 22, § 66261.3[a][2][C], 66261.3[a][s][F], 66261.101[a][1], 66261.101[a][2], 66261.22[a][3], 66261.22[a][4], and 66261.24[a][2]–[8])

The persistence of VOC contamination within the plume areas would prevent beneficial use of groundwater on approximately 44 acres of the Former MCAS Tustin property. No such restrictions on beneficial use would occur in presently uncontaminated areas on adjacent off-site properties or for any portion of the deeper Irvine Pressure Subbasin (regional aquifer) underlying the station.

Location-Specific ARARs

The primary activities under Alternative 7 that might trigger location-specific requirements are those related to the excavation of contaminated soils, installation and operation of extraction and monitoring wells, and the groundwater conveyance/treatment/discharge system. Given the minimal groundwater extraction rates expected and the limited size of the treatment plant and related appurtenances, the "footprint" associated with Alternative 7 is expected to be relatively small. Approximately 3,000 feet of trenching (less than 4 feet deep) would be required to install the groundwater conveyance and discharge piping if a central treatment plant is selected. Otherwise, no major construction, earthwork, or drainage manipulation activities of the type most likely to complicate compliance with location-based ARARs would occur under Alternative 7.

Construction activities for Alternative 7 would be designed and implemented to meet all location-based requirements, which are identified in Appendix A (Section A3) to include the following:

- **Federal:** Archaeological and Historical Preservation Act (16 U.S.C. § 469–469c-1); see Table A3-1 in Appendix A for specific implementing provisions of the requirement

Action-Specific ARARs

The major components of Alternative 7 that trigger action-specific ARARs are the generation of solid waste (excavated soil from specific source areas, soil cuttings from well installations, trench spoils, and spent GAC), extraction and treatment of contaminated groundwater containing TCE and 1,2,3-TCP, and discharge of treated groundwater to a nearby storm drain. As identified in Appendix A (Section A4.4), the action-specific requirements for hydraulic containment and hot spot soil and groundwater removal include the following:

- **Federal:** RCRA requirements for waste generators (Cal. Code Regs. tit. 22, §§ 66262.10[a], 66262.11, 66264.13[a] and [b], and 66262.34); groundwater monitoring (Cal. Code Regs. tit. 22, § 66264.91[a] and [c], 66264.97, 66264.98, and 66264.100[a] and [b]); secondary containment for piping (Cal. Code Regs. tit. 22, § 66264.193 [a], [b], [c], and [f]); CAA requirements regarding use of equipment for controlling air pollution (SCAQMD Rule 212), the emissions of halogenated VOCs (SCAQMD Rule 1303), and the emissions of carcinogenic air contaminants (SCAQMD Rule 1401); RCRA requirements for thermal treatment of hazardous waste (Cal. Code Regs. tit. 22, § 66265.370–383 with the exception of § 66265.382); and Criteria for Classification of Solid Waste

Disposal Facilities and Practices regulations with regards to solid waste disposal (40 C.F.R. § 257.3-4 and Appendix I) as specified in Table A4-1

- **State:** SWRCB and California RWQCB requirements for actions affecting water quality in the Santa Ana region (Basin Plan [RWQCB 1995] and Cal. Water Code div. 7, §§ 13241, 13243, 13263[a], 13269, and 13360); antidegradation provisions of SWRCB Resolution No. 68-16 (SWRCB 1968); California Civil Code requirements for land-use controls (Cal. Civ. Code § 1471); and California Health and Safety Code requirements for institutional controls (Cal. Health & Safety Code §§ 25202.5, 25222.1, and 25233[c]) and substantive provisions of SCAQMD Rules 212, 1303, 401(b)(1)(A), 403, 404, 405, and 1401

All activities under Alternative 7 that produce solid waste (excavated soil, soil cuttings, trench spoils, and spent GAC) would be implemented in a manner compliant with federal and state action-specific ARARs at Cal. Code Regs. tit. 22, § 66262. These residuals would be characterized with respect to criteria for the identification of RCRA and non-RCRA hazardous waste. If soil cuttings or excavated contaminated soil were classified as hazardous waste (an unlikely outcome, given available data in the RI [BNI 1997a]), then the LDRs of Cal. Code Regs. tit. 22, § 66268 would also be potential ARARs for treatment of the waste if it is proposed for on-site disposal. Because Alternative 7 involves on-site thermal treatment, it is subject to RCRA requirements for thermal treatment of hazardous waste, as specified in Cal. Code Regs. tit. 22, § 66265.370–383, with the exception of § 66265.382. Implementing Alternative 7 in compliance with these requirements would not be expected to present significant complications from a technical or administrative viewpoint.

Another action-specific consideration for Alternative 7 regards classification of the extracted groundwater under RCRA. As noted in Appendix A (Section A1.4.1), none of the groundwater samples collected from the first and second WBZs during the RI had TCE concentrations greater than the 500 µg/L, the limit established for designation as a RCRA characteristic hazardous waste. Based on the modeling described in Appendix B, the maximum TCE concentrations in the extracted groundwater for Alternative 7 would be less than the 500 µg/L RCRA threshold (Figure 5-49). More accurate estimates of expected TCE concentrations in the extracted groundwater would be obtained during remedial design and start-up of the groundwater treatment system. If groundwater from the wells were classified as hazardous waste, then the requirements of Cal. Code Regs. tit. 22, § 66264 would be potential ARARs for portions of the extraction and treatment systems. Included in these requirements would be technical standards such as double-containment of the extracted groundwater conveyance pipelines. The design of the groundwater treatment plants would also have to be modified slightly to include secondary containment. TCE concentrations below the RCRA limits would not trigger any hazardous waste management ARARs. RCRA hazardous waste criteria have not been set for 1,2,3-TCP.

Alternative 7 would also comply with Basin Plan requirements to maintain beneficial uses and meet water quality objectives for groundwater in the Irvine Pressure Subbasin

(regional aquifer) by limiting further migration of contaminated groundwater and *ex situ* treatment. During the first 6 years of groundwater extraction, significant progress would be made toward attaining these goals in the shallow aquifer system underlying Former MCAS Tustin, which is also required by the Basin Plan. However, based on groundwater modeling results, achieving these requirements throughout all the areas affected by the VOC plumes would require longer than the 30-year period assumed in this FS Report.

Performance goals for treatment of the extracted groundwater would be the same as for Alternatives 6 and 6A, reducing all site-related VOC contaminant to levels acceptable for discharge to a city of Tustin storm drain. The NPDES general permit discharge limits would be used as TBC guidance for conducting on-site discharge of treated groundwater in compliance with the beneficial uses and WQOs for the surface water provided in the Basin Plan. The DON and RWQCB have "agreed to disagree" concerning the applicability of the permit exclusion of CERCLA Section 121(e). Consistent with this agree-to-disagree compromise, the DON maintains that surface water discharge related to OU-1A remedial action is exempt from such permit requirements, but the DON agrees to comply with the substantive requirements of the permit as a means of ensuring compliance with the substantive provisions of the WQCP and other state ARARs as provided by Section 121(d) of CERCLA. Performance monitoring requirements would be submitted for regulatory agency review in the Operation and Maintenance Plan.

The additional activities of Alternative 7 due to on-site thermal treatment fall under the ARARs already specified for Alternative 6. The substantive portions of the SCAQMD rules identified as action-specific ARARs for this alternative would control the potential atmospheric emissions of VOC-containing soil vapor that may be desorbed by the TDU and fugitive dust emissions that may be generated during soil excavation and on-site treatment. Use of an incinerator or GAC to treat the TDU vapors would satisfy the SCAQMD requirement to install best available control technology on sources potentially emitting toxic air pollutants, a category which includes some of the OU-1A COCs. Dust control measures common to excavation site management would assure fugitive dust is either not generated or minimized to meet the SCAQMD dust control requirements.

5.10.2.7 OVERALL PROTECTION OF HUMAN HEALTH AND ENVIRONMENT

Alternative 7 would protect human health and the environment. Proven technology would be used to contain the plumes at and downgradient of IRP-13S. This alternative would eventually comply with all identified ARARs, prevent any further migration of contaminated groundwater in the shallow aquifer underlying Former MCAS Tustin, limit or prevent migration of the VOC plumes onto adjacent properties, and eliminate potential ecological impacts associated with future discharges of contaminated groundwater to Barranca Channel. Treatment of the extracted groundwater using GAC, a well-established process, would remove VOCs to concentrations acceptable for discharge to surface water. Implementation and enforcement of institutional controls should effectively prevent human exposure to VOC-affected shallow groundwater. The deed restrictions required by Alternative 7 would be limited to approximately 54.1 acres overlying the existing areas of OU-1A contamination. Over time, concentrations of TCE

and 1,2,3-TCP in shallow groundwater, along with the associated risks to potential residential receptors, would decline due to the removal of contaminant mass by the extraction wells. Performance monitoring and periodic reviews would verify plume containment and track the overall performance of the remedy.

The primary disadvantage of Alternative 7 is that it must be implemented and maintained for a significant length of time. Groundwater modeling completed for this FS Report indicates that the groundwater extraction and treatment system, would have to remain effective for well over 30 years while contaminant levels are reduced to proposed site cleanup goals listed in Table 2-5. A prolonged period of operation increases the chance that unforeseen problems, such as equipment breakdowns or a failure to enforce institutional controls, could reduce the overall protectiveness of Alternative 7.

Section 6
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The nine alternatives evaluated in Section 5 provide a wide range of options for remediation of VOC-contaminated groundwater at OU-1A. As discussed in Section 4.1, these alternatives were developed after consideration of the requirements of the NCP and U.S. EPA technical guidance (U.S. EPA 1988a), the statutory preferences listed in CERCLA Section 121(b), and the RAOs and site cleanup goals established in Section 2.

This section compares the relative performance of the remedial alternatives considered in this FS against the NCP evaluation criteria specified at 40 C.F.R. § 300.430(e)(9)(iii). These criteria are discussed in greater detail in Section 5.1. This comparative analysis is intended to distinguish the advantages and disadvantages of each alternative and identify key trade-offs that must be balanced by the DON during remedy selection. Table 6-1 summarizes the comparative analysis of the remedial alternatives evaluated for OU-1A.

When selecting a final remedy under CERCLA, the NCP evaluation criteria are arranged in the following hierarchy per 40 C.F.R. § 300.430(f):

- threshold criteria
  - overall protection of human health and the environment
  - compliance with ARARs
- primary balancing criteria
  - long-term effectiveness and permanence
  - reduction of toxicity, mobility, or volume through treatment
  - short-term effectiveness
  - implementability
  - cost
- modifying criteria
  - state acceptance
  - community acceptance

CERCLA Section 121(d) and the NCP at 40 C.F.R. § 300.430(f)(1)(ii) require that final remedial actions must protect human health and the environment and comply with ARARs, unless justification to waive a specific ARAR is provided in the ROD. In other words, both threshold criteria must be satisfied for a remedial alternative to be eligible for selection, unless an ARAR waiver applies. The trade-offs among eligible alternatives will, therefore, generally be in the areas addressed by the five primary balancing criteria and the two modifying criteria.

The following subsections address the threshold and primary balancing criteria only. To facilitate the discussion, these seven criteria are evaluated and compared in the same order as in the detailed analysis of individual alternatives presented in Section 5.2 through Section 5.10. Alternatives 4 and 4A and Alternatives 6 and 6A are grouped together for the discussion since they are identical except for the disposal of excavated soil contaminated with VOCs. As noted in

Table 6-1
Summary of Comparative Analysis of OU-1A Remedial Alternatives

Criterion	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation	Alternative 3 Hydraulic Containment	Alternatives 4/4A Aggressive Groundwater Extraction	Alternative 5 Permeable Reaction Wall	Alternatives 6/6A Vacuum-Enhanced Extraction	Alternative 7 Hydraulic Containment With Hot Spot Removal
Short-term effectiveness	○	◑	◕	◔	◔	◔	●
Long-term effectiveness and permanence	○	○	◑	◕	◔	◑	●
Reduction of toxicity, mobility, or volume through treatment	○	○	◑	◕	◑	◕	◕
Implementability	●	●	◕	◑	○	◑	◕
Cost	●	●	◕	◑	○	◑	◕
Compliance with ARARs	Not applicable	Complies	Complies	Complies	Complies	Complies	Complies
Overall protection of human health and the environment	Not Protective	Not Protective	Protective	Protective	Protective	Protective	Protective

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
NCP – National Oil and Hazardous Substances Pollution Contingency Plan
OU – operable unit

Relative Performance in Satisfying NCP Criteria

○	◔	◑	◕	●
Low	Low to Moderate	Moderate	Moderate to High	High

Section 5.1.8 and Section 5.1.9, the two modifying criteria (state acceptance and community acceptance) are not addressed in this report. The DON's evaluation of these criteria will be documented in the ROD once formal comments have been received on this FS Report and the PP and a final remedy selection decision has been made.

6.1 SHORT-TERM EFFECTIVENESS

Considering all the factors listed in Section 5.1.5, Alternative 7, hydraulic containment with hot spot removal, would be the most effective option in the short term. It is, therefore, rated high (Table 6-1). Excavation and on-site treatment of soil, installation of groundwater monitoring and extraction wells and conveyance pipelines, and construction of a treatment plant would pose relatively minor risks to workers and the surrounding community. Construction-related impacts would be minimized through development and implementation of a rigorous safety and health plan, and through use of appropriate engineering controls during soil excavation and on-site treatment, and start-up of the remedial facilities. As under Alternative 3, the combination of institutional and engineering controls would effectively limit further migration of VOCs at OU-1A while significantly reducing potential human exposure to VOCs in shallow groundwater. Compared to Alternative 3, the additional risks posed by excavation and on-site treatment activities are balanced by a shorter overall remediation period and lower concentrations of VOCs in groundwater. Deed restrictions would be limited to approximately 40 acres. Although this option would not achieve complete aquifer restoration for many years, if ever, this disadvantage is balanced by the fact that hydraulic containment satisfies all other RAOs established for OU-1A and can be implemented in less than 1 year with minimal construction-related impacts. Alternative 7 is, therefore, rated high in terms of short-term effectiveness.

Alternative 3 (hydraulic containment), similar to Alternative 7, would also be an effective option in the short term and, with no soil excavation or treatment activities, would pose fewer risks to workers and the surrounding community than Alternative 7. The relatively minor risks posed to workers and the surrounding community by implementing Alternative 3 would be readily managed through engineering controls and standard safety and health protocols. Alternative 3 would limit further migration of VOCs in groundwater at OU-1A while significantly reducing potential human exposure to VOCs in shallow groundwater. Deed restrictions would be limited to approximately 40 acres. Although this option would not achieve complete aquifer restoration for many years, if ever, this disadvantage is balanced by the fact that hydraulic containment satisfies all other RAOs established for OU-1A and can be implemented in less than 1 year with minimal construction-related impacts. Alternative 3 is, therefore, rated next highest in terms of short-term effectiveness.

Alternative 2 (monitored natural attenuation) would also present very few risks during field implementation. All of these risks could be controlled through a site-specific safety and health plan. Deed restrictions and a long-term groundwater monitoring program could be implemented within a year following issuance of the ROD. Human exposure to

VOCs in shallow groundwater would be effectively controlled by this alternative. However, Alternative 2 would not prevent further downgradient migration of VOCs in groundwater at OU-1A and would not achieve remediation goals for over 100 years. Alternative 2 is considered to be less effective than Alternative 3 in the short term primarily because of the length of time required to mitigate the major threats associated with OU-1A and is, therefore, rated as moderate.

Alternatives 4 and 4A (aggressive groundwater extraction with off-site soil disposal and on-site soil treatment, respectively), Alternative 5 (permeable reaction wall), and Alternatives 6 and 6A (VEE with off-site soil disposal and VEE with on-site soil treatment, respectively) are all rated the same with respect to short-term effectiveness. These alternatives would combine institutional controls, groundwater extraction or *in situ* treatment, and long-term monitoring. The major components of these alternatives could be in place 9 months (Alternatives 4/4A and 6/6A) to 3 years (Alternative 5) after initial mobilization for field construction. Once implemented, these alternatives would prevent or significantly reduce further downgradient migration of the VOC plumes while controlling human exposure to VOCs in shallow groundwater. Assuming that restoration of the shallow aquifer underlying Former MCAS Tustin is technically feasible, the time required to attain site cleanup goals is estimated to range from 50 years to 60 years for Alternatives 4 and 4A, and several decades longer for Alternatives 5, 6, and 6A. In addition, each of these alternatives would involve relatively large-scale soil excavation projects, and Alternatives 4 and 6 would require many truck trips from the site to an off-site landfill. Construction-related impacts would be minimized through development of a rigorous safety and health plan, implementation of appropriate engineering controls during the soil excavations and on-site treatment (if conducted), and the use of a licensed commercial hauler for all off-site transportation of VOC-affected soils. Nevertheless, some risks to workers and the surrounding community would remain, and these risks would not be balanced by any significant reduction in the time required to achieve RAOs compared to hydraulic containment. Therefore, Alternatives 4/4A, 5, and 6/6A are considered to be less effective than Alternative 3 in the short term and are rated as moderate.

Alternative 1 (no action) is the least desirable alternative from the standpoint of short-term effectiveness and is rated low. Since this alternative does not entail any on-site remedial activities, there would be no construction-related risk to workers or to the surrounding community. However, the only protection afforded by Alternative 1 would be the existing well permit controls in Orange County (i.e., the OCHCA permit process for new water supply wells). There would be no groundwater monitoring or deed restrictions under Alternative 1. The VOC plumes would continue to expand in a downgradient direction, and further downward migration of 1,2,3-TCP to the third WBZ would still be possible. The time required to achieve RAOs would be determined by the natural processes controlling VOC fate and transport in the subsurface. Groundwater modeling results presented in the RI Report (BNI 1997b) suggest that contaminant concentrations in the first and second WBZs would exceed site cleanup goals for more than 100 years under Alternative 1.

6.2 LONG-TERM EFFECTIVENESS AND PERMANENCE

The expected performance of each of the remedial alternatives is compared by illustrating the maximum predicted concentrations of TCE and 1,2,3-TCP through time in the first and second WBZs based on groundwater modeling results (Figures 6-1 through 6-3). As discussed in Section 2.6, the shallow aquifer system underlying Former MCAS Tustin is heterogeneous, with potentially significant quantities of VOCs adsorbed to fine-grained, low-permeability clay layers. These VOCs, especially those adsorbed to the lower confining layer of the first WBZ, cannot easily be remediated and may serve as a continuing source of contamination to the more transmissive sand layers for many decades. It is difficult to accurately model the long-term effect that VOCs released from the clay layers could have on groundwater quality in the first and second WBZs. Thus, complete aquifer restoration by groundwater extraction or *in situ* treatment (included in all alternatives excluding Alternatives 1 and 2) may not be technically practicable within a reasonable period of time, despite model predictions indicating otherwise. This uncertainty should be factored into any evaluation of the relative long-term effectiveness and permanence of the nine remedial alternatives presented in this FS Report.

With this qualification, a review of Figures 6-1 through 6-3 indicates that Alternative 7 would provide the best overall long-term performance among the remedial options evaluated in this FS. While maximum TCE concentrations would initially decline faster for Alternatives 6 and 6A (VEE), the performance of Alternative 7 is generally expected to be similar to that of Alternatives 6 and 6A after approximately 20 years of remediation. Other advantages of Alternative 7 include the use of proven and reliable technologies to excavate contaminated soils and extract and treat VOC-affected groundwater. Alternative 7 would prevent significant migration of VOCs beyond existing plume boundaries by extracting a significant amount of contaminated groundwater from near-source, relatively elevated concentration portions of the plumes before VOCs are allowed to migrate to hydraulic containment wells located at the downgradient margins of the plumes. Alternative 7 would also prevent future discharges of contaminated groundwater to Barranca Channel. Deed restrictions would be limited to about 40 acres. Alternative 7 is, therefore, rated high for long-term effectiveness and permanence.

Alternatives 4 and 4A are the next best options in terms of long-term effectiveness and permanence as they include the use of proven and reliable technologies to excavate contaminated soils and extract and treat VOC-affected groundwater, prevent significant VOC migration beyond existing plume boundaries, and prevent future discharges of contaminated groundwater to Barranca Channel. Deed restrictions would be limited to about 40 acres. Although heterogeneities in the shallow aquifer system may ultimately preclude complete groundwater restoration, as noted above, Alternatives 4 and 4A would, at the very least, contain the OU-1A plumes through extraction and prevent human exposure to VOCs through institutional controls. Therefore, Alternatives 4 and 4A are rated moderate to high.

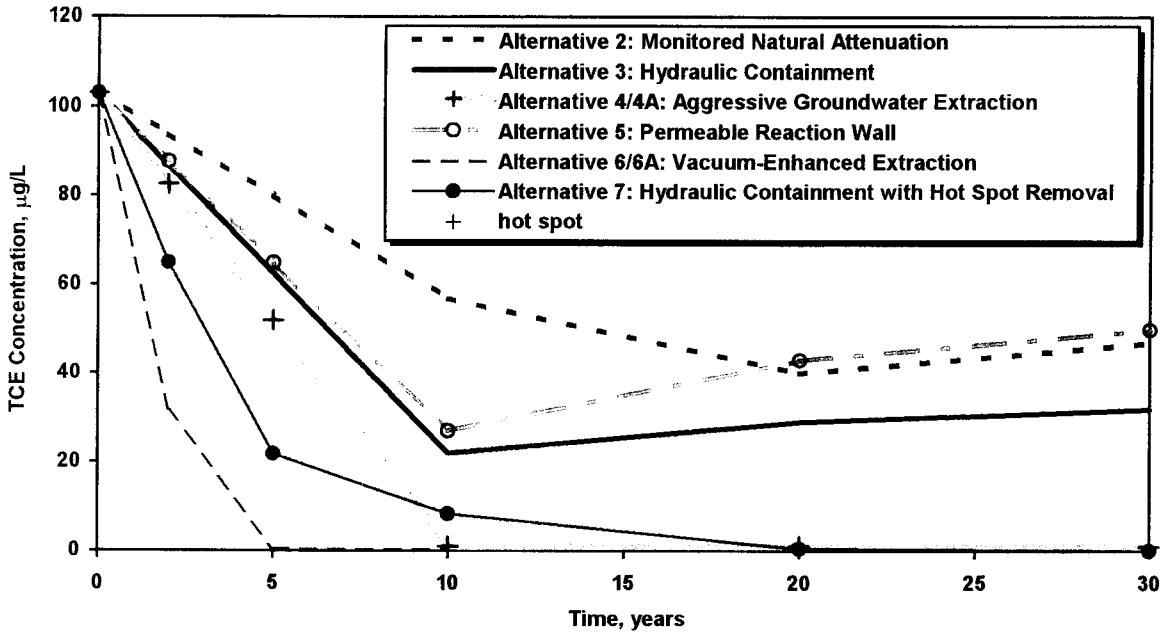


Figure 6-1
Maximum Predicted TCE Concentrations in the First WBZ

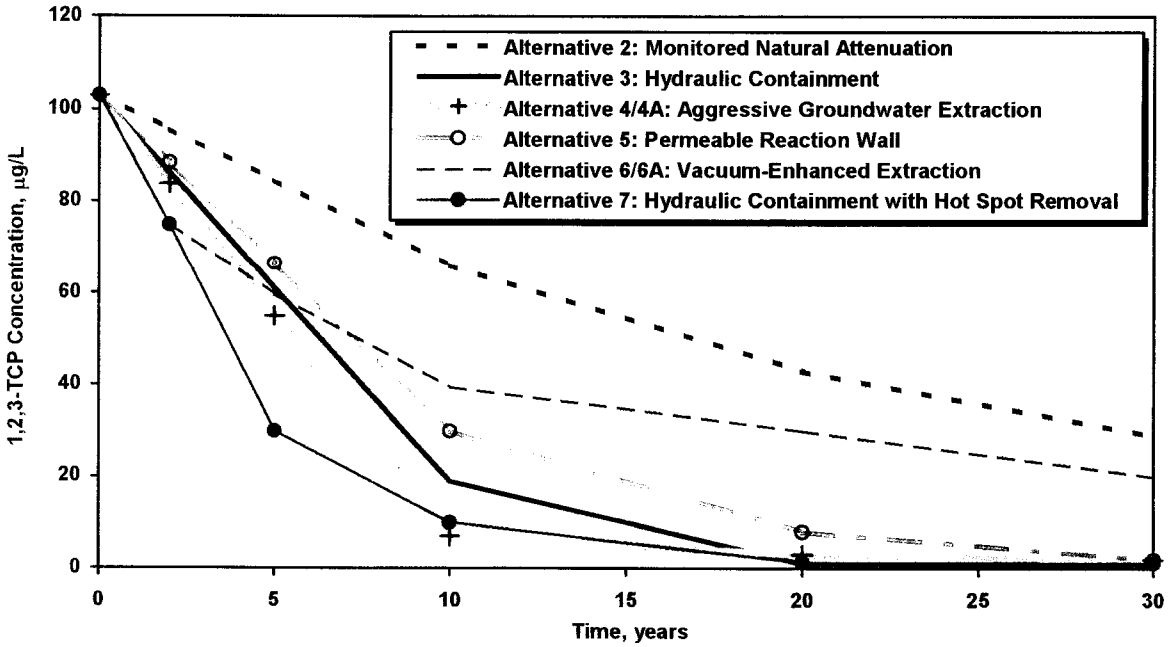


Figure 6-2
Maximum Predicted 1,2,3-TCP Concentrations in the First WBZ

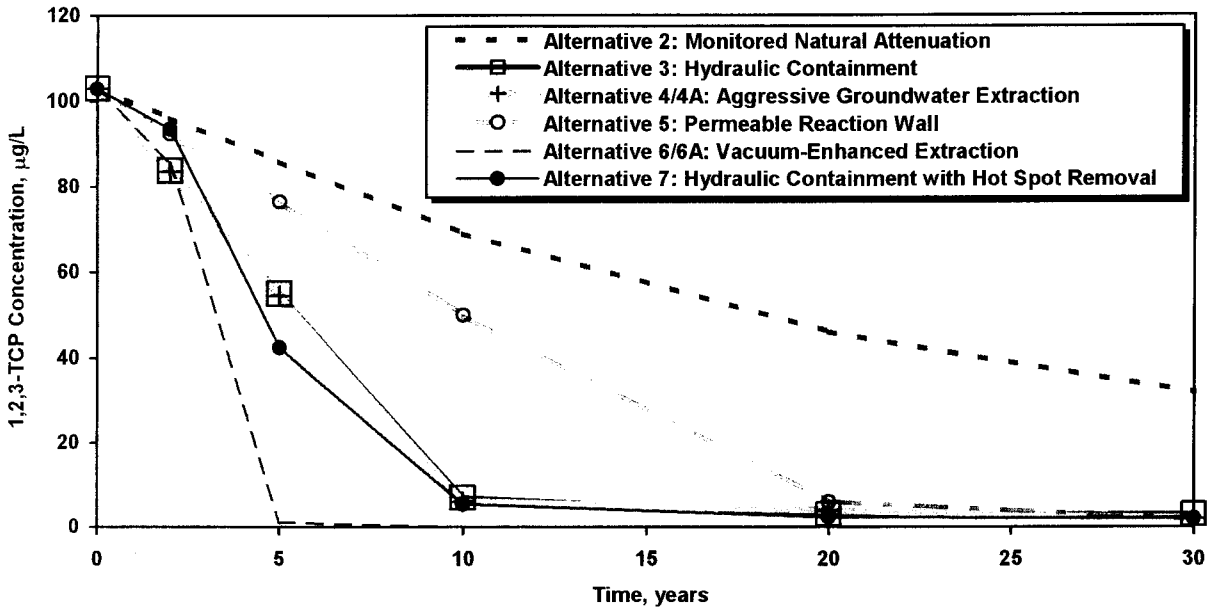


Figure 6-3
Maximum Predicted 1,2,3-TCP Concentrations in the Second WBZ

Although Alternatives 6 and 6A are predicted to achieve the most rapid and complete reduction in maximum TCE concentrations, as well as maximum 1,2,3-TCP concentrations in the second WBZ, these model-based results assume high groundwater extraction rates of 12 gpm per well in the first WBZ. Such extraction rates may not be sustained in practice, based on a recent VEE field test at nearby site IRP-3 (BNI 1999a). Furthermore, if VEE could significantly enhance groundwater extraction, the modeling presented in Appendix B suggests that 1,2,3-TCP would be drawn upward from the lower confining clay layer into the sand layer of the first WBZ. As a result, a significant amount of 1,2,3-TCP would remain in the first WBZ when VEE operations cease in about 15 years. For these reasons, Alternatives 6 and 6A are considered to be less technically effective over the long-term than Alternatives 4 and 4A. Otherwise, the advantages of VEE are similar to those for aggressive groundwater extraction. Alternatives 6 and 6A are rated moderate.

Alternative 3, hydraulic containment, is also rated less favorably than Alternatives 4 and 4A with respect to long-term effectiveness and permanence. The hydraulic containment option would use institutional controls and proven technology to achieve significant risk reduction over 30 years, contain the VOC plumes within their existing boundaries, prevent discharges of contaminated groundwater to Barranca Channel, and limit the downward migration of 1,2,3-TCP to the third WBZ. Deed restrictions on the Former MCAS Tustin property would be limited to about 40 acres. The major advantages of Alternative 3 include preventing both human exposure to VOCs in shallow groundwater (through institutional controls) and further migration of contaminated groundwater (through groundwater extraction at the downgradient plume margins). The major

disadvantage of Alternative 3 is that it would potentially require continuing O&M for the groundwater extraction and treatment system for many decades beyond the 30-year period considered in this FS. Alternative 3 is, therefore, rated moderate in terms of long-term effectiveness and permanence.

The long-term effectiveness and permanence of Alternative 5, permeable reaction wall, are considered to be less than those of Alternative 3. Since permeable reaction walls employ innovative technology (*in situ* reductive dehalogenation of VOCs using zero-valent iron), the performance of Alternative 5 over several decades is considered uncertain. Technical uncertainties are especially pronounced at Former MCAS Tustin because the hardness of the shallow aquifer would increase the potential for mineral precipitation on the reactive iron media. In addition, remediation of the VOC plumes in the second WBZ would require installing iron wall sections to depths of approximately 70 to 75 feet bgs, which is deeper than any full-scale applications reported in the literature to date. While Alternative 5 would capture most contamination in the first two WBZs (and could be designed to completely contain the OU-1A plumes within existing boundaries), it would not prevent the downward migration of 1,2,3-TCP to the third WBZ in a localized area at OU-1A. Institutional controls would prevent human exposure to VOCs in shallow groundwater. Groundwater modeling results, presented on Figures 6-1 through 6-3, indicate that the permeable reaction walls would significantly reduce maximum TCE and 1,2,3-TCP concentrations and, therefore, reduce risk as well. However, residual VOC concentrations after 30 years would generally be greater for Alternative 5 than for other alternatives considered in this FS (except for monitored natural attenuation and no action), primarily because Alternative 5 employs a passive process that would rely on natural groundwater flow to transport VOCs to the reactive iron. For these reasons, Alternative 5 is rated low to moderate.

Alternative 1, no action, and Alternative 2, monitored natural attenuation, are the least attractive options from the standpoint of long-term effectiveness and permanence and, therefore, are rated low. Neither alternative would meet RAOs established for the site. Existing permitting processes in Orange County would potentially prevent human exposure to VOCs in shallow groundwater; deed restrictions under Alternative 2 would provide for enforcement of institutional controls by the DON and DTSC. However, neither Alternative 1 nor Alternative 2 would employ active measures to prevent the off-station migration of VOC-affected groundwater and the eventual discharge of contaminants to Barranca Channel. The further vertical migration of 1,2,3-TCP to the third WBZ would also not be controlled. VOCs in the OU-1A plumes would likely exceed site remediation goals for more than 100 years.

6.3 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Based on computer modeling results, the residual masses of TCE and 1,2,3-TCP predicted to remain in the subsurface after the 30-year period considered in the FS are illustrated on Figures 6-4 and 6-5, respectively. These results indicate that Alternatives 6

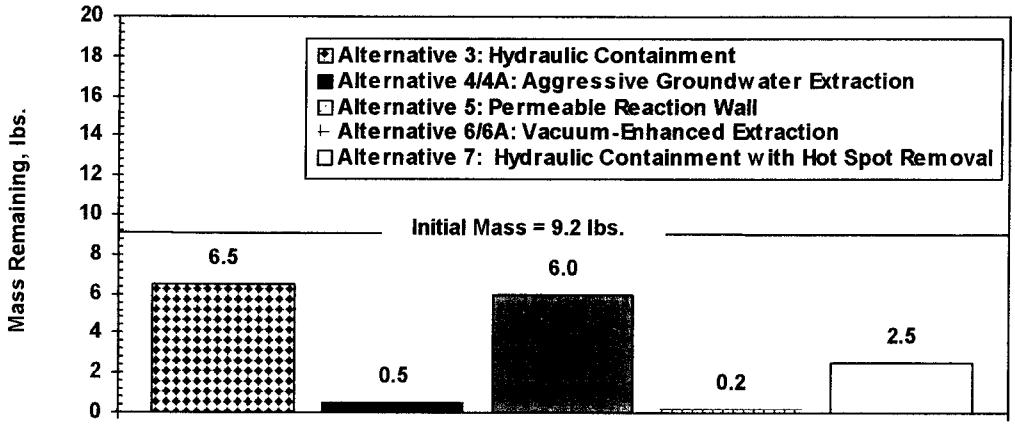


Figure 6-4
Residual TCE Mass After 30 Years

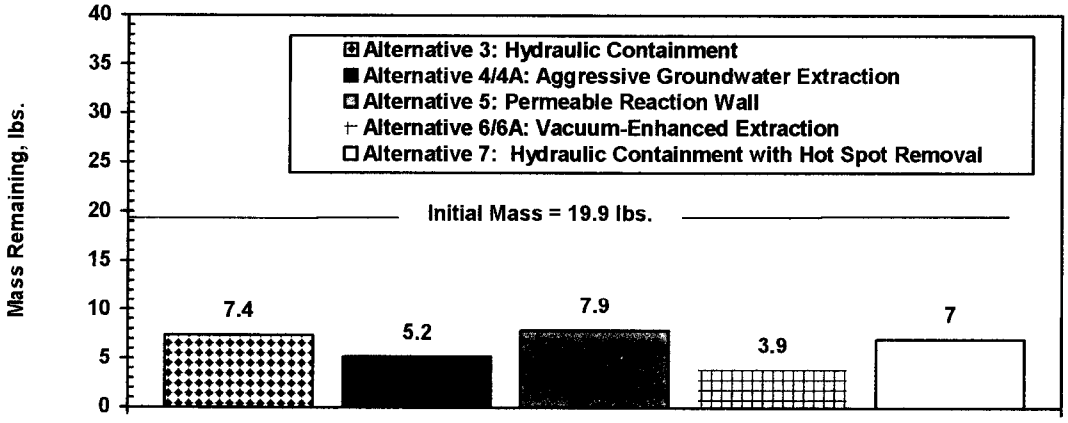


Figure 6-5
Residual 1,2,3-TCP Mass After 30 Years

and 6A (VEE) would achieve the greatest reductions in contaminant mass, reducing the overall mass of TCE and 1,2,3-TCP by more than 97 percent and 80 percent, respectively. Contaminant toxicity, mobility, and volume would be controlled under Alternatives 6 and 6A through a combination of groundwater extraction and excavation of VOC-affected soils from the source areas. Under Alternatives 6 and 6A, excavated soils with the highest concentrations of VOCs would be disposed in a permitted Class II landfill, or would be treated by thermal desorption and reused on-site, respectively. VOCs removed with the extracted groundwater would be adsorbed on GAC and destroyed during off-site regeneration of the spent carbon.

It is important to note that the contaminant mass removals predicted for Alternatives 6 and 6A (Figures 6-4 and 6-5) were based on the groundwater modeling assumption that VEE would achieve a sustained pumping rate of 12 gpm in each well in the first WBZ. As discussed in Appendix B, it is theoretically possible to extract groundwater at this rate at an applied vacuum of 0.3 to 0.4 atmosphere.

However, results from a VEE test conducted at IRP-3 suggest that achieving groundwater extraction rates of 12 gpm per well may not be possible in the field (BNI 1999a). Therefore, the groundwater modeling results presented on Figures 6-4 and 6-5 may overestimate the contaminant mass reductions actually achievable under Alternatives 6 and 6A.

Alternatives 4 and 4A (aggressive groundwater extraction) and Alternative 7 (hydraulic containment with hot spot removal) are rated slightly less effective than Alternatives 6 and 6A in reducing contaminant toxicity, mobility, or volume through treatment (Figures 6-4 and 6-5). However, mass removal under Alternatives 6 and 6A is probably overestimated based on VEE pilot test results from IRP-3. Therefore, Alternatives 4 and 4A, 6 and 6A, and 7 are rated equally as moderate to high for this criteria. Under Alternative 7, the mass of TCE and 1,2,3-TCP would be reduced by approximately 73 and 65 percent, respectively; however, by implementing Alternatives 4 and 4A, residual TCE and 1,2,3-TCP mass would be reduced by 95 and 74 percent, respectively. For Alternatives 4 and 4A, the excavated soils with the highest concentrations of VOCs would either be disposed in a permitted Class II landfill or treated by thermal desorption and reused on-site, respectively. VOCs in the extracted groundwater would be removed by GAC and thermally destroyed during spent carbon regeneration.

Based on the estimated cumulative mass removals shown on Figures 6-4 and 6-5, Alternative 3, hydraulic containment, and Alternative 5, permeable reaction wall, are rated similarly with respect to reduction of contaminant toxicity, mobility, or volume through treatment. Both alternatives would reduce the mass of TCE and 1,2,3-TCP by approximately 30 percent and 60 percent, respectively. Alternative 3 would control VOC mobility through hydraulic containment, whereby the toxicity and volume of contaminated groundwater would gradually be reduced through extraction at the downgradient plume margins. VOCs in the extracted groundwater under Alternative 3 would be adsorbed onto GAC and destroyed when the spent carbon is thermally regenerated at an off-site facility. Alternative 5 would reduce contaminant toxicity,

mobility, and volume through *in situ* reductive dehalogenation of VOCs as the VOC plumes pass through the reactive iron walls. Based on these factors, Alternatives 3 and 5 are rated moderate.

Alternative 1, no action, and Alternative 2, monitored natural attenuation, would result in no reduction in contaminant toxicity, mobility, or volume other than that attributable to natural processes. These alternatives are, therefore, rated low using this criterion. Groundwater modeling results presented in Appendix B indicate that maximum VOC concentrations in groundwater would be reduced by 60 to 75 percent over 30 years due to dilution, dispersion, and adsorption. However, there would be no decrease in the mass of TCE or 1,2,3-TCP since VOC biodegradation is assumed to be negligible under the prevailing aerobic conditions of the shallow aquifer at Former MCAS Tustin. The VOC plumes would continue to migrate into areas currently unaffected by VOCs, increasing the overall volume of contaminated groundwater.

6.4 IMPLEMENTABILITY

The best alternatives from an implementability perspective are Alternative 1, no action, and Alternative 2, monitored natural attenuation. These alternatives are rated high (Table 6-1). The absence of field construction or other remedial activities under Alternative 1 and the limited scope of groundwater monitoring under Alternative 2 make each of these alternatives readily implementable from a technical viewpoint. As discussed in Section 5.3.1.1, the deed restrictions required by monitored natural attenuation are not expected to prevent or unnecessarily complicate redevelopment of the Former MCAS Tustin property. Administratively, execution of the long-term groundwater monitoring program under Alternative 2 should present no unusual concerns.

The technical feasibility of Alternatives 3 and 7 is rated moderate to high, as both would employ reliable, widely available technologies. Each alternative would be implemented using conventional equipment and construction methods. The deed restrictions required by these alternatives would be limited to approximately 40 acres and would be compatible with redevelopment of the Former MCAS Tustin property. No difficulties are anticipated with regard to reliability or scheduling.

Alternatives 6 and 6A (VEE), and 4 and 4A are considered less implementable than Alternative 3 or 7. The benefits of using VEE to capture VOC-affected groundwater in the first WBZ are technically uncertain in at least two respects. First, results of a recent VEE field test conducted at IRP-3 suggest that groundwater extraction rates of 12 gpm per well may not be sustainable over the long term (BNI 1999a). Therefore, the model-based predictions of VEE performance presented in Appendix B may be overly optimistic. Furthermore, as noted in Sections 5.8.2.2 and 6.2, high rates of groundwater extraction from the sand layer of the first WBZ (if technically achievable using VEE) may induce upward vertical migration of 1,2,3-TCP from the lower clay layer at IRP-13S. This would significantly compromise the ability of VEE to achieve the site cleanup goal for 1,2,3-TCP (0.6 μg/L) in the first WBZ within a relatively short period of time. Alternatives 4 and 4A are considered less implementable than Alternatives 3 and 7 due to

the installation of 18 injection wells and a greater number of extraction wells than that required under Alternatives 3 and 7. While both VEE and groundwater injection are considered proven and reliable technologies, the greater level of effort and time required for installation of these technologies would reduce the technical implementability of Alternatives 4 and 4A and 6 and 6A. The necessary deed restrictions, covering approximately 40 acres, are considered compatible with redevelopment of the Former MCAS Tustin property. Alternatives 6 and 6A and 4 and 4A are rated moderate in terms of implementability.

Alternative 5 is the least implementable remedial option considered in this FS. Permeable reaction wall technology is considered innovative, and there are very few full-scale applications as large as what would be required at OU-1A. Conditions at the site, specifically the hardness of the shallow groundwater, raise concerns about possible chemical precipitation on the surface of the reactive iron that could adversely affect the long-term reliability of this technology. In addition, the constructability of permeable reaction walls to remediate the second WBZ is uncertain. There have been no published reports of relatively thick (5 to 6 feet) permeable reaction wall installations to the required depths of 70 to 75 feet bgs. The deed restrictions required by Alternative 5 would also constrain redevelopment on those parcels overlying the slurry walls and permeable reaction walls. Further reducing the administrative implementability of Alternative 5 is the fact that only one process vendor markets the technology. The number of construction contractors potentially capable of installing the deeper iron wall that would be required at OU-1A may also be limited. Alternative 5 is, therefore, rated low.

6.5 COST

The estimated costs for the remedial alternatives cover a wide range, as summarized on Table 6-2. In terms of net present value, the alternatives may be grouped into four relatively low-cost options (under $5 million), four moderate-cost options (under $10 million), and one high-cost option (approximately $19 million).

The least expensive among the relatively low-cost options are Alternative 1 (no action), which has no associated costs, and Alternative 2 (monitored natural attenuation), with a net present value of $0.8 million. Alternative 3 (hydraulic containment) and Alternative 7 (hydraulic containment with hot spot removal) are somewhat more expensive, with estimated net present values of $3.8 and $4.3 million, respectively.

Net present values for the moderate-cost options, Alternatives 4 and 4A (aggressive groundwater extraction) and Alternatives 6 and 6A (VEE), are estimated to range from $5.6 million to $8.5 million. As noted in Section 5.8.2.5, the estimated net present cost of Alternative 6 could increase by $0.5 million to approximately $6.1 million if additional VEE wells are required to contain the OU-1A plumes and obtain the desired groundwater extraction rates in the first WBZ. A similar increase would also apply to Alternative 6A. Given the accuracy of the cost-estimation procedures used in this FS (-30 percent to

Table 6-2
Summary of Cost Estimates for OU-1A Remedial Alternatives
(dollars in millions)

Alternative	Total Capital Cost	Total O&M Cost[a]	Total Cost	Net Present Value[b]
Alternative 1 no action	0	0	0	0
Alternative 2 monitored natural attenuation	0.7	0.0	2.0	0.8
Alternative 3 hydraulic containment	1.0	0.9	8.7	3.8
Alternative 4 aggressive groundwater extraction with off-site soil disposal	9.9	1.7	11.4	8.5
Alternative 4A aggressive groundwater extraction with on-site soil treatment	8.6	1.7	10.6	7.6
Alternative 5 permeable reaction wall	23.0	6.9	31.2	19.0
Alternative 6 vacuum-enhanced extraction with off-site soil disposal	9.3	0.8	9.0	6.4[c]
Alternative 6A vacuum-enhanced extraction with on-site soil treatment	8.1	0.8	8.1	5.6[c]
Alternative 7 hydraulic containment with hot spot removal	8.1	1.1	9.0	4.3

Notes:
[a] includes other indirect costs, escalation, and contingency during assumed 30-year project duration
[b] in 2002 dollars
[c] cost of Alternatives 6 and 6A may increase by up to $0.5 million if additional VEE wells are required; actual extraction rates in the first WBZ could be as low as 5 gpm per well, as obtained in a recent VEE field test (BNI 1999a), rather than the 12 gpm per well estimated by the model presented in Appendix B

Alternatives/Abbreviations:
gpm – gallons per minute
O&M – operation and maintenance
OU – operable unit
VEE – vacuum-enhanced extraction
WBZ – water-bearing zone

+50 percent), the $2.1 million to $2.0 million cost difference between Alternative 4 and Alternative 6, and Alternative 4A and Alternative 6A, is not significant. For purposes of this comparative analysis, the costs of aggressive groundwater extraction and VEE should be considered equivalent.

The most expensive remedial option considered in this FS is Alternative 5 (permeable reaction wall), at an estimated net present cost of $19.0 million. The high capital costs associated with this alternative are primarily due to installation of the reactive iron walls (particularly the deep and thick iron walls at IRP-13S), transportation and off-site disposal of contaminated soils removed during the initial construction, the assumed need to replace the reactive iron after 15 years, the licensing fee paid to the process vendor, the initial pilot study at Plume 12W, and installation of new monitoring wells. Section 5.7.2.5 and Appendix D provide additional details regarding the estimated costs for Alternative 5.

6.6 COMPLIANCE WITH ARARs

Alternative 3 (hydraulic containment), Alternatives 4 and 4A (aggressive groundwater extraction), Alternative 5 (permeable reaction wall), Alternatives 6 and 6A (VEE), and Alternative 7 (hydraulic containment with hot spot removal) would comply with all chemical-, location-, and action-specific ARARs for OU-1A identified in Appendix A.

Alternatives 4 and 4A, 6 and 6A, and 7 are intended to restore groundwater within OU-1A to the site cleanup goals established in Section 2.5, to the extent practicable. With one notable exception, Alternatives 4 and 4A and 6 and 6A are expected to achieve the site remediation goals throughout the first and second WBZs within about 50 years to 60 years. Alternatives 6 and 6A would require many additional decades to reduce 1,2,3-TCP in the first WBZ to the cleanup goal of 0.6 μg/L, for reasons noted in Sections 6.2 and 6.4. Alternative 7 essentially achieves the site remediation goals established for shallow groundwater at OU-1A (5 μg/L TCE) in approximately 15 years, although the modeled 1,2,3-TCP concentrations are predicted to slightly exceed the MCL.

As discussed above, it is important to qualify these model-based predictions of aquifer restoration time frames. Heterogeneities in the shallow aquifer system at the site, along with the presence of potentially significant contamination adsorbed to low permeability clays, represent significant technical concerns. These complications could make complete restoration of groundwater within the existing OU-1A plume boundaries impractical, even with source area excavation and aggressive groundwater extraction programs such as those proposed under Alternatives 4 and 4A, 6 and 6A, and 7. However, the potential impact of aquifer heterogeneity on groundwater restoration potential cannot be determined until these extraction systems have been installed and operated for a period of time, perhaps a year or more.

The hydraulic containment and permeable reaction wall alternatives are not intended as aquifer restoration alternatives. However, both Alternative 3 and Alternative 5 would also achieve potentially significant reductions in contaminant mass and concentrations

and would control VOC migration. Under both alternatives, site cleanup goals would eventually be attained within the existing boundaries of the VOC plumes, but only after many decades.

Alternative 2 (monitored natural attenuation) would eventually satisfy the chemical-specific ARARs identified for the shallow aquifer system, which are driven by RWQCB's classification of the underlying Irvine Pressure Subbasin (regional aquifer) as a potential source of drinking water supply. However, in the absence of an action remedy, the time to achieve these ARARs is expected to take longer than Alternatives 3 through 7. Monitored natural attenuation does not entail any active measures to prevent downgradient migration of the VOC plumes within the first and second WBZs, nor does it address the potential for further downward migration of 1,2,3-TCP into the third WBZ.

ARARs are not triggered by Alternative 1 (no action). Therefore, Alternative 1 cannot be evaluated with respect to ARARs compliance.

6.7 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

As shown in Table 6-1, Alternative 3 (hydraulic containment), Alternatives 4 and 4A (aggressive groundwater extraction), Alternatives 6 and 6A (VEE), and Alternative 7 are considered protective of human health and the environment. All six alternatives would satisfy the RAOs established in Section 2 by accomplishing the following:

- preventing human exposure to VOCs in shallow groundwater through institutional controls
- containing the VOC plumes within their existing boundaries
- preventing the off-base migration of contaminated groundwater and eliminating the potential for future VOC discharges to Barranca Channel
- controlling threats to water quality in the third WBZ and deeper regional aquifer by controlling the potential for further downward migration of 1,2,3-TCP from the second to the third WBZ
- substantially reducing TCE and 1,2,3-TCP mass and concentrations over 30 years, thereby reducing potential risk to human health and the environment
- complying with all identified ARARs and eventually achieving site remediation goals throughout the areas currently affected by the VOC plumes
- tracking and verifying the progress of groundwater remediation through a systematic program of long-term monitoring and periodic site reviews
- limiting the area covered by deed restrictions to 40 acres; in all cases, the required deed restrictions should be compatible with redevelopment of the Former MCAS Tustin property

In addition to these benefits, Alternatives 4 and 4A, 6 and 6A, and 7 would remove VOC-affected soils from the source areas at OU-1A.

Alternative 5 (permeable reaction wall) would provide many of the same advantages as those listed above for Alternatives 3, 4 and 4A, 6 and 6A, and 7 and is protective of human health and the environment. However, Alternative 5 is rated slightly less protective of overall human health and the environment for three reasons. First, the long-term performance of the technology is uncertain, since the hardness in shallow groundwater at Former MCAS Tustin would increase the potential for chemical precipitates to foul the reactive iron. Second, the deep iron wall installations required to remediate the plume in the second WBZ may be difficult to construct. Finally, because it is a passive process, Alternative 5 would not actively reverse the potential for further downward migration of 1,2,3-TCP into the third WBZ. For these reasons, Alternative 5 is rated moderate. Groundwater monitoring would be provided to track VOC contamination over time and evaluate possible threats to water quality in the deeper regional aquifer.

Alternative 2 (monitored natural attenuation) would be slightly more protective than Alternative 1 (no action), but would offer decidedly less protection to human health and the environment than would the other remedial alternatives. Alternative 2 would prevent human exposure to VOCs in shallow groundwater through institutional controls. However, monitored natural attenuation would not comply with all action-specific ARARs or prevent plume migration to off-station areas, resulting in the eventual discharge of VOCs to Barranca Channel. Alternative 2 would allow significant expansion of the VOC plumes on the Former MCAS Tustin property as well as the further downward migration of 1,2,3-TCP into the third WBZ. The continued migration of VOC-affected groundwater could have a negative effect on site redevelopment. The deficiencies identified for Alternative 2 would be mitigated somewhat by long-term monitoring and periodic reviews, which would track plume movement and provide a basis for additional remedial actions.

Alternative 1 would not protect human health and the environment as it would not reduce contaminant mass in the subsurface. It has the same deficiencies noted above for Alternative 2 without the benefits of either deed restrictions or long-term monitoring (to track plume migration and identify unanticipated risks). Although there is no current human exposure to VOCs in shallow groundwater at OU-1A, redevelopment of the property may change this situation over time. No action would not provide the engineering or strengthened institutional controls included with the other alternatives to mitigate future risks. Therefore, overall protection of human health and the environment is considered unacceptable under Alternative 1.

Section 7
REFERENCES

AFCEE. *See* Air Force Center for Environmental Excellence.

Air Force Center for Environmental Excellence. 1996. Draft Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater. Revision 1. Prepared for Technology Transfer Division, Brooks Air Force Base. November.

Bechtel National, Inc. 1995. Navy CLEAN II MCAS Tustin, Draft Final Candidate Technologies Memorandum. Prepared for Southwest Division Naval Facilities Engineering Command. September.

———. 1996a. Draft Feasibility Study Report, Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. November.

———. 1996b. Draft Final Background Concentrations of Metals Issue Paper, Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. October.

———. 1997a. Draft Final Remedial Investigation Report for Operable Units 1 and 2, Marine Corps Air Facility Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. November.

———. 1997b. Draft Final RCRA Facility Assessment Report Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. April.

———. 1998a. Draft Technical Memorandum: TCE-in-Soil Confirmation Sampling, Pilot-Scale Extraction Test, Bench-Scale Column Test, and Model Sensitivity Analysis, Marine Corps Air Facility Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. March.

———. 1998b. Final 1997 Annual Groundwater Monitoring Report, Marine Corps Air Facility Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. August.

———. 1999a. Revised Draft Feasibility Study Report for Operable Unit 1, Marine Corps Air Facility Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. March.

———. 1999b. Draft Technical Memorandum: Pilot-Scale Vacuum-Enhanced Extraction Test, Marine Corps Air Facility Tustin, California. February.

———. 1999c. Final Technical Memorandum, Limited Deep HydroPunch Investigation at IRP-13S, Marine Corps Air Facility, Tustin, California. April.

———. 1999d. 1998 Annual Groundwater Monitoring Report, Marine Corps Air Facility, Tustin, California. June.

———. 2000a. Draft Final Feasibility Study Report for Operable Unit 1, Marine Corps Air Facility Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. February.

———. 2000b. Final 1999 Annual Groundwater Monitoring Report, Marine Corps Air Facility Tustin, California. November.

———. 2001a. Draft 2000 Annual Groundwater Monitoring Report, Marine Corps Air Facility Tustin, California. June.

———. 2001b. Draft Final Feasibility Study Report for Operable Unit 1B, Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. October.

———. 2002a. Final Feasibility Study Report for Operable Unit 1B, Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. January.

———. 2002b. Draft 2001 Annual Groundwater Monitoring Report, Marine Corps Air Station Tustin, California. Prepared for Southwest Division Naval Facilities Engineering Command. August.

BNI. *See* Bechtel National, Inc.

Brown and Caldwell. *See* Brown and Caldwell Consulting Engineers.

Brown and Caldwell Consulting Engineers. 1985. Initial Assessment Study of Marine Corps Air Station Tustin, California. NEESA 13-075. Prepared for Naval Energy and Environmental Support Activity. September.

California Department of Water Resources. 1991. California Well Standards. Bulletin 74-90 (Supplement to Bulletin 74-81). June.

California Regional Water Quality Control Board Santa Ana Region. 1995. Water Quality Control Plan, Santa Ana River Basin (8).

———. 2001. Letter from John Broderick, Regional Water Quality Control Board Santa Ana Region, to Dean Gould, BRAC Environmental Coordinator, MCAS El Toro. Proposal to Discharge Treated Groundwater from Former Marine Corps Air Station El Toro, IRP 16, to Bee Canyon Wash. 26 January.

California State Water Resources Control Board. 1968. Statement of Policy With Respect to Maintaining High Quality of Waters in California. Resolution No. 68-16. 28 October.

DOE. *See* United States Department of Energy.

DON. *See* United States Department of the Navy.

DWR. *See* California Department of Water Resources.

EnviroMetal Technologies Incorporated. 1998a. Bench-Scale Test Report – Treatability Study of the EnviroMetal Process at the Marine Corps Air Facility Tustin, California. Prepared for Bechtel National, Inc. January.

———. 1998b. Construction Methods for Installation of *In-Situ* Permeable Reactive Barriers Using Granular Iron. Memorandum to file. March.

ETI. *See* EnviroMetal Technologies Incorporated.

Focht, R., J. Vogan, and S. O'Hannesin. 1996. Field of application of reactive "iron walls" for *in-situ* degradation of volatile organic compounds in groundwater. In *Remediation*. John Wiley & Sons, Inc. Summer.

Jacobs Engineering Group Inc. 1992. Marine Corps Air Station (MCAS) Tustin, California, Facility Assessment Revised Preliminary Review/Draft Visual Site Inspection Report. Prepared for Southwest Division Naval Facilities Engineering Command. March.

JEG. *See* Jacobs Engineering Group Inc.

OCHCA. *See* Orange County Health Care Agency.

O'Hannesin, S.F., and R.W. Gillham. 1998. Long-term performance of an *in situ* "iron wall" for remediation of VOCs. *Ground Water*. 36(1):164-170. January–February.

OHM. *See* OHM Remediation Services Corp.

OHM Remediation Services Corp. 2000. Draft No Further Action Report, Volume I, for Temporary Storage Units ST-18B, ST-19, ST-20A, ST-20B, ST-48, ST-49, ST-50, ST-81, ST-86, and ST-87. Marine Corps Air Facility, Tustin, California. 01 May.

———. 2001a. Final Memorandum, Remedial Activities for Site MWA-18 at Marine Corps Air Station Tustin, California. 10 January.

———. 2001b. Final No Further Action Report – Volume I. TS Units -35, -36, -51, -72A, -88, -89, -90, and -91. Marine Corps Air Facility Tustin, California. 06 March.

———. 2001c. Final Memorandum, Remedial Activities for Site ST-72B at Marine Corps Air Station Tustin, California. 22 June.

Pacific Treatment Environmental Services. 2002. Quarterly Groundwater Progress Monitoring Data Summary, Operable Unit OU-1 and UST Site 222, Summer 2002, Marine Corps Air Station Tustin, California. December.

PTES. *See* Pacific Treatment Environmental Services.

RWQCB. *See* California Regional Water Quality Control Board Santa Ana Region.

Sass, B.M., A.R. Gavaskar, N. Gupta, W.S. Yoon, J.E. Hicks, D. O'Dwyer, and C. Reeter. 1998. Evaluating the Moffett Field permeable barrier using groundwater modeling and geochemical modeling. In *Designing and Applying Treatment Technologies: Remediation of Chlorinated and Recalcitrant Compounds*. G.B. Wickramanayake and R.E. Hinchee, eds. Proceedings of the First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, 18–21 May 1998. Columbus, Ohio: Battelle Press.

Southwest Division Naval Facilities Engineering Command. 1998. Base Realignment and Closure Cleanup Plan (BCP), Marine Corps Air Facility, Tustin, California. March.

SWDIV. *See* Southwest Division Naval Facilities Engineering Command.

SWRCB. *See* California State Water Resources Control Board.

The Planning Center. 1996. Draft Marine Corps Air Station (MCAS) Tustin Specific Plan/Reuse Plan. July.

———. 1998. MCAS Tustin Specific Plan/Reuse Plan. Specific Plan/Reuse Plan ERRATA. September.

Tierra Madre Consultants. 1993. Report for a Biological Assessment, Marine Corps Air Station Tustin. 11 March.

United States Department of Energy. 1995. Innovative Technology Summary Report demonstrated at U.S. Department of Energy M Area Savannah River Site and 300-Area Hanford Site, Aiken, SC, and Richland, WA. Office of Environmental Management, Office of Technology Development. April.

United States Department of the Navy. 1999. Final Environmental Impact Statement/ Environmental Impact Report, Disposal, and Reuse of MCAS Tustin, California. In conjunction with the city of Tustin.

United States Environmental Protection Agency. 1987. Remedial Action Costing Procedures Manual. EPA/600/8-87/049. October.

———. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. OSWER Directive 9355.3-01. EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

———. 1988b. Guidance on Remedial Actions for Contaminated Ground-Water at Superfund Sites. EPA/540/G-88/033. December.

———. 1988c. CERCLA Compliance with Other Laws Manual: Draft Guidance. EPA/540/G-89-006. Office of Emergency and Remedial Response. August.

———. 1989a. Evaluation of Groundwater Extraction Remedies: Volume 1 Summary Report. EPA 540/2-89/054. September.

———. 1989b. Considerations in Ground-Water Remediation at Superfund Sites. OSWER Directive 9355.4-03. October.

———. 1990. Basics of Pump-and-Treat Ground-Water Remediation Technology. EPA/600/8-90/003. March.

———. 1991. Estimating Potential for Occurrence of DNAPL at Superfund Sites. OSWER Publication 9355.4-07FS. December.

———. 1992. Methodologies for Evaluating *In-situ* Bioremediation of Chlorinated Solvents. EPA/600/R-92/042. March.

———. 1993a. Presumptive Remedies: Policy and Procedures. EPA 540-F-93-047. OSWER Directive 9355.0-47FS. September.

———. 1993b. Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils. EPA 540-F-93-048. OSWER Directive 9355.0-48FS. September.

———. 1993c. Guidance for Evaluating the Technical Impracticability of Ground Water Restoration. OSWER Directive 9234.2-25. Interim Final. September.

———. 1994a. Contaminants and Remedial Options at Solvent-Contaminated Sites. EPA 600/R-94/203. November.

———. 1994b. Remediation Technologies Screening Matrix and Reference Guide. EPA 542/B-94/013. NTIS PB95-104782. October.

———. 1994c. Methods for Monitoring Pump-and-Treat Performance. EPA 600/R-94/123. June.

———. 1995. Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground Water Restoration at Superfund Sites. OSWER Directive 9200.4-14. January.

———. 1996a. User's Guide to the VOCs in Soils Presumptive Remedy. EPA 540/F-96/008. OSWER Directive 9355.0-63FS. July.

———. 1996b. Presumptive Response Strategy and *Ex-Situ* Treatment Technologies for Contaminated Ground Water at CERCLA Sites. EPA 540-R-96-023. OSWER 9283.1-12. Final Guidance. October.

———. 1997a. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. OSWER Directive 9200.4-17. Interim Final. December.

———. 1997b. Presumptive Remedy: Supplemental Bulletin Multi-Phase Extraction (MPE) Technology for VOCs in Soil and Groundwater. EPA 540-F-97-004. OSWER Directive 9355.0-68FS. April.

———. 2000. Drinking Water Standards and Health Advisory. U.S. EPA Region 9, Drinking Water Branch. February.

———. 2002. Region 9 Preliminary Remediation Goals (PRGs) 2002. U.S. EPA Region 9. 01 October.

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

Vogan, J.L., B.J. Butler, M.S. Odziemkowski, G. Friday, and R.W. Gillham. 1998. Inorganic and biological evaluation of cores from permeable iron reactive barriers. In *Designing and Applying Treatment Technologies: Remediation of Chlorinated and Recalcitrant Compounds*. G.B. Wickramanayake and R.E. Hinchee, eds. Proceedings of the First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, 18–21 May 1998. Columbus, Ohio: Battelle Press.

Warner, S.D., C.L. Yamane, N.T. Bice, F.S. Szerdy, J. Vogan, D.W. Major, and D.A. Hankins. 1998. Technical Update: The first commercial subsurface permeable reactive treatment zone composed of granular zero-valent iron. In *Designing and Applying Treatment Technologies: Remediation of Chlorinated and Recalcitrant Compounds*. G.B. Wickramanayake and R.E. Hinchee, eds. Proceedings of the First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, California, 18–21 May 1998. Columbus, Ohio: Battelle Press.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 1: General Comment -- Unfortunately it has taken the Navy years to finish preparation of this Final Feasibility Study (FS) Report for Operable Unit 1A. The City of Tustin provided comments on the Navy's previous Draft Final FS for OU-1 on March 9, 2000 and we have no record that the Navy formally responded to these comments. To assist us in reviewing and commenting on the current draft Final FS, the Navy should have provided a formal response to these and other previous BCT/RAB comments concurrent with the release of the subject document. Please provide responses to our March 9, 2000 comments as soon as possible. Prior to final approval of the subject document, please provide all commenters with a copy of responses to all comments received on this document.	**Response to Comment 1:** The Navy transmitted Response to Comments on the Draft Final Operable Unit (OU)-1 Feasibility Study (FS) to the BRAC Closure Team (BCT) on 11 October 2000. Another copy of the RTCs was sent to the city of Tustin under separate cover, as requested.
Comment 2: General Comment -- None of the alternatives evaluated within the subject FS document would implement remediation of the known contamination in less than 30 years. The absence of any short-term (15 years or less) solutions begs the question as to whether such alternatives exist or not. If they exist, the Navy should include the least costly one or more of these alternatives for comparison in this document. If the Navy has determined that a short-term solution of the contamination at OU-1A does not exist, then such a statement should be provided in the document, to explain why a short-term alternative has not been evaluated.	**Response to Comment 2:** A Conceptual Alternative was presented at the request of the RAB to evaluate closure of the OU-1 Sites (IRP-3, -12, and -13S) within approximately 10 years (i.e., short-term alternative). The following text was added to the end of Section 4.3, Alternatives Screening, to provide information on the results of the Conceptual Alternative: "A Conceptual Alternative for closure of OU-1 Sites (IRP-3, -12, and –13S) within 10 years was developed to evaluate a short-term alternative for cleanup and associated costs. Under this Conceptual Alternative, all contaminated soil and groundwater would be removed and closure would be reached within 10 years. The costs for this alternative were estimated at approximately $34 million: $29 million for excavation and dewatering; $5 million for groundwater extraction, but excluding additional costs for engineering design, oversight for the excavation, screening of the soil, monitoring for 10 years or more, and producing reports and other documentation. This Conceptual Alternative presents the magnitude of what would be involved in an expedited cleanup, without constraints on the total cost. At the beginning of the FS process, three NCP evaluation criteria, including implementability, effectiveness and cost, are applied to evaluate a wide range of technologies. An alternative can often be screened out right away based on one or more of these

COMMENTS FROM:	RESPONSES FROM:
D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	Navy
COMMENTS	**RESPONSES TO COMMENTS**
	criteria. If this alternative had been developed it would have been screened out early in the FS due to high cost and implementability issues. The technical infeasibility of achieving total aquifer restoration in the short-term using available technologies and given site-specific conditions at OU-1A is discussed further in Section 2.4.5, Cleanup to Background Levels." Also please see Responses to Comments 8, 11, 17, and 18.
Comment 3: Page ES-2, Development of the OU-1 Feasibility Study -- This section should be clarified to explain that the previous draft final FS pertained to OU-1, before the Navy's establishment of OU-1A and OU-1B. In addition, the first sentence is confusing in its reference to the previous document's evaluation of "eight" remedial alternatives, since the number of alternatives was originally six, with alternatives 4a and 6a also discussed. The current document evaluates seven alternatives. Please correct.	**Response to Comment 3:** The last paragraph presented on the previous page (Page ES-1) explains the splitting of OU-1 into OU-1A and OU-1B. To avoid additional confusion to the reader, the fifth sentence in the second paragraph on page ES-2 was revised to read: "Community and regulatory agency comments were again received and addressed, and an additional remedial alternative (Alternative 7) with potential to decrease remediation time was considered."
Comment 4: Page ES-2, Station Location – Please clarify that approximately 95 acres of former MCAS Tustin property lies within the City of Irvine.	**Response to Comment 4:** The text was revised as requested.
Comment 5: Page ES-3. Figure ES-1 – The figure incorrectly identifies the groundwater plume associated with UST 222 as part of the Area of Institutional Controls established for OU-1A. As you know, UST 222 is a RCRA site that is being remediated under a process separate from the CERCLA remedies suggested in the FS for OU-1A. Please revise to eliminate the UST 222 plume from this exhibit and any discussion within the text, other than reference and background.	**Response to Comment 5:** Figure ES-1 has been revised to remove the buffer zone for Institutional Controls from the MTBE plume and present the buffer zone around the perimeter of the OU-1A plume only. The buffer zone for OU-1A will overlap a portion of the MTBE plume since the two plumes are commingled. The UST 222 plume will remain on the figure since MTBE is addressed in Section 1.6.2 (Soil and Groundwater Investigations at IRP-13S) and in the risk assessment conducted for OU-1A. Also please see Response to Comments 20 and 21.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 6: Page ES-4, first paragraph – Please replace the word "closed" in the first sentence with the word "disposed". Also, all references to the Reuse Plan/Specific Plan (the Planning Center 1998) should be revised throughout the document to read "MCAS Tustin Specific Plan", as adopted by the Tustin City Council on February 3, 2003. In addition, the last sentence in this paragraph indicates that the remedial actions planned for use at the site "must be adequate to support residential redevelopment generally considered the most sensitive reuse option." Please note in the text that several locations in the vicinity of the groundwater plume are planned for a variety of educational uses, including two child care facilities located within the approved Learning Village.	**Response to Comment 6:** The first sentence on Page ES-5 was revised to read: "MCAS Tustin ceased active military operations in July 1999, and is being disposed of in accordance with the Base Closure and Realignment Act." The fourth sentence in the first paragraph on Page ES-5 was revised to read: "According to the MCAS Tustin Specific Plan, as adopted by the Tustin City Counsel on February 3, 2003, future land use at the station will include commercial and residential areas, schools and childcare facilities, parks, a golf course, and other recreational facilities (Figure ES-1)." Requirements for residential reuse of property at OU-1A are considered more protective than requirements for educational or childcare uses. This is due in part to the fact that contamination at OU-1A is in subsurface groundwater and not in surface soils (and therefore not available for ingestion by children), and that residential receptors are exposed to risks over a 30-year period while educational and childcare, or park user receptors are exposed over a much shorter period, and therefore the risk is less. These factors among others, account for the fact that residential reuse is considered more protective than educational or childcare uses. The last sentence in the first paragraph on Page ES-5 was therefore not revised. (Also, please see Response to Comments 13 and 16 below).
Comment 7: Page ES-9, Remedial Action Objectives – The last paragraph states: "cleanup of contaminated soils to health-based criteria is not a remedial action objective for this FS." The regulatory agencies should concur with this statement and the conclusion that reuse of the affected property can occur for the uses identified in the adopted Specific Plan, including educational use.	**Response to Comment 7:** The remedial investigation concluded that no adverse health affects would result from direct contact with contaminated soil at the site. However, treatment of soil was included in the remedial alternatives to improve the efficiency of the groundwater remediation and to reduce the overall time necessary to complete remediation.
Comment 8: Page ES-12, first paragraph -- The paragraph states that Alternative 7 "would not achieve complete aquifer restoration for many years, if ever…" The purpose of the remediation planned for MCAS Tustin must be remediation within a set period of time. Containment without	**Response to Comment 8:** The NCP specifically states that CERCLA cleanup actions are intended to be protective of human health and the environment. For a full description of how RAOs, were developed for the site (including restoration time frame), see Section 2, Remedial Action Objectives.

COMMENTS FROM:	RESPONSES FROM:
D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	Navy
COMMENTS	**RESPONSES TO COMMENTS**
obtaining full remediation should not be considered a remedy by the Navy or the BCT. Please clarify whether any of the alternatives proposed in the FS will implement full remediation.	time frame), see Section 2, Remedial Action Objectives. Section 2.6, Restoration Time Frame, describes the U.S. EPA guidance for groundwater remediation time frames. The preamble to the NCP states that U.S. EPA will usually consider several different alternative restoration time periods and methodologies to achieve site remediation goals. The most appropriate option will be selected by balancing tradeoffs between the NCP criteria of long-term effectiveness; reduction of contaminant toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost (55 Federal Register 8732, 08 March 1990). A number of factors influence the choice of groundwater response actions and, thus, the restoration schedule. At IRP-13S, these factors include the current use and value of the aquifer, the ability to monitor and control VOC migration, and technical considerations associated with extracting contaminated groundwater. Each of these issues is examined in section 2.6 of the FS Report. Also please see Response to Comment 2, 11, 17, and 18.
Comment 9: Page ES-12, last paragraph – it is stated that the "no action" alternative is the Navy's least desirable alternative. It is the City understands that Base Closure Law requires the Navy to perform remediation at closed sites and that taking no action is not a legal alternative. In addition, page ES-27 states that the "No Action" alternative "would not protect human health and the environment". Please add clarifying language that Alternative 1 is not a viable alternative for these reasons.	**Response to Comment 9:** The following sentences were added to the last paragraph on page ES-12: "The NCP and CERCLA require consideration of a no action alternative as a basis for comparison with other remedial alternatives developed during the FS. The no action alternative is not considered a viable alternative at OU-1A because it would not be protective of human-health and/or the environment."
Comment 10: Page ES-17, Table ES-2 – Please clarify why the cost estimate for Alternative 5 ($19.0 million) has been dramatically reduced from what was stated in the February 2000 Final Draft FS ($35.4 million)?	**Response to Comment 10:** The draft final FS Report for OU-1 evaluated Installation Restoration Program (IRP) sites IRP-3 and IRP-12 (now considered OU-1B), and IRP-13S (now considered OU-1A) and the cost to implement the alternatives at all three sites. Therefore, cost estimates for all eight alternatives (including Alternative 5) presented in the draft final OU-1 FS Report include

COMMENTS FROM:	RESPONSES FROM:
D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	Navy
COMMENTS	**RESPONSES TO COMMENTS**
	costs for IRP-3, -12, and –13S, while the costs presented in the draft final FS Report for OU-1A present costs only for IRP-13S.
Comment 11: Page ES-23, Reduction of Toxicity – The Section summarizes by percentage the level of completion each alternative will attain if implemented for a 30-year timeframe. None of the alternatives are anticipated to attain a 100% remediation within this period of time. Please provide additional narrative that describes the anticipated period of time for the alternative remedies to complete full remediation of the contamination.	**Response to Comment 11:** Recognizing that uncertainty accompanies all groundwater remediation projects, groundwater modeling was used to develop restoration time frame estimates for the remedial alternatives evaluated in this FS. Such estimates should not be construed as absolute cleanup schedules for the OU-1A plumes. Rather, the estimated time frames presented in Section 5 were calculated for the purpose of developing cost estimates, conducting a detailed analysis of remedial alternatives, and comparing the relative performance of each alternative. The estimates of remediation time presented in the FS Report were not meant to be used to establish milestones or to satisfy regulatory or legal requirements. In addition, estimating restoration time frames may not be practical for alternatives involving containment, natural attenuation, or no action, especially if such time frames extend for many decades, beyond the point at which modeling remains a technically viable predictive tool. Also please see Response to Comments 2, 8, 17, and 18.
Comment 12: Page ES-27, first paragraph –Please correct the typographical error to provide the missing information that should have been continued from Page E-26.	**Response to Comment 12:** The typographical error in the last paragraph beginning on Page ES-26 was corrected.
Comment 13: Page 1-12, third paragraph – Please correct the typographical error regarding the date that most of MCAS Tustin was transferred to the City of Tustin (May 13, 2002). Also, at the end of the sentence, please replace the "various public agencies" with "the City of Tustin". In the fifth paragraph, the Section states that "remediation would have to be adequate to support residential redevelopment". Again, it should be noted that educational uses are proposed within the vicinity of the OU-1A site.	**Response to Comment 13:** The third paragraph on Page 1-12 was revised to read: "On 13 May 2002, the DON transferred the majority of Former MCAS Tustin property including the property surrounding IRP-13S under various conveyance documents to the city of Tustin. Additional property within the former housing areas at MCAS Tustin was sold through public sale in early 2003. Remaining property at the station that is under the control of the DON includes areas where environmental investigations are ongoing or cleanup has yet to be initiated." Please see Response to Comment 6 above.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM:	RESPONSES FROM:
D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 14: Page 1-13, Figure 1-4 – There is currently no land use described in the legend for the bulk of the former MCAS Tustin (shown in white). Please correct.	**Response to Comment 14:** The figure was revised to include land-use descriptions for the central area shown in white.
Comment 15: Page 1-23, Figure 1-8 – The outline description of the former MCAS Tustin should be revised to include former military housing areas located in Irvine.	**Response to Comment 15:** The purpose of Figure 1-8 as indicated in the first sentence of the last paragraph on Page 1-18, is to show the approximate relative position of Former MCAS Tustin relative to the Irvine Groundwater Subbasin. No revisions to Figure 1-8 are necessary.
Comment 16: Page 1-69, Summary of Baseline Risk Assessment (and subsequent subsections) – the Section states that a residential risk assessment is being used for the site affected by OU-1A. It should be noted that educational and park uses are also proposed within the vicinity of the site and that remediation will support the Reuse Plan for MCAS Tustin.	**Response to Comment 16:** Please see Response to Comment 6 above.
Comment 17: Page 2-19, Section 2.6.4 – the Section states: "an accelerated restoration may not be practical given the technical limitations on contaminant removal from the shallow aquifer". As noted in comment 2 above, an "accelerated restoration" alternative is not evaluated in the current FS document. Consequently, the statement in this section must be substantiated through the provision of such an analysis.	**Response to Comment 17:** Please see Response to Comment 2 above.
Comment 18: Page 5-7, Table 5-1 (and throughout the document) – The cost estimates provided for each alternative are based on operation of the remedy for a period of 30 years. As noted in comment 11 above, the FS document does not identify the length of time each alternative would need to operate to attain 100% remediation of OU-1A. As an example, an alternative method costing $1 million over 30 years would cost $100 million if the remedy required 3,000 years to complete. Ultimately, the final cost to the	**Response to Comment 18:** Please see Response to Comments 2 and 11 above.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
U.S. taxpayer might be less if the Navy selected a remedy with a higher short term cost with a shorter term of completion. It is again requested that the Navy provide additional narrative that describes the anticipated period of time for the alternative remedies to complete full restoration of the OU-1A contamination.	
Comment 19: Page 5-24, Institutional Controls (and throughout) – Please add at the end of the first bullet point the following: "without the review and approval by the DON and other regulatory agencies".	**Response to Comment 19:** Text was revised as requested.
Comment 20: Page 5-25, Figure 5-3A (and throughout) – The exhibit depicts the limits of the proposed Institutional Controls that includes the MTBE plume and a buffer around that plume. As noted in comment 5 above, the remedies discussed in the FS should not involve the MTBE plume, which is currently being remediated by the Navy through the RCRA program. Please revise the Figure to eliminate the MTBE plume from inclusion in the Area of Institutional Control for OU-1A.	**Response to Comment 20:** Please see Response to Comments 5 and 21.
Comment 21: Page 5-27, first paragraph (and throughout) – The Section states that deed restrictions "would not hinder the development" of the former MCAS Tustin. The City believes this to be untrue. The establishment of deed restrictions will create a stigma that will negatively affect marketing of the property for as long as the deed restrictions exist. In addition, currently unknown requirements to treat treated groundwater prior to disposal into the local storm drain system could significantly impede redevelopment of the property. Please revise the document to clarify the extent that deed restrictions will hinder the future development of MCAS Tustin.	**Response to Comment 21:** Institutional controls in the form of deed restrictions will not hinder redevelopment of the property because they will only restrict subsurface activities at the site including extraction and reuse of shallow contaminated groundwater. Although these restrictions are already in-place through other local regulations, the Navy intends to add an additional layer of protection which would require Navy and regulator review and authorization prior to anyone receiving approval to extract shallow groundwater at the site. After the final remedy is selected, the institutional controls will be fully delineated in the Record of Decision. Also please see Response to Comments 5 and 20.
Comment 22: Page 5-36, second paragraph (and throughout) – The Section states that coordination with State and local agencies is needed to implement and enforce deed restrictions required for this alternative. Please note, the	**Response to Comment 22:** Comment noted.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: D. Ogdon (City of Tustin) Comments dated 31 March 2003 Received on 31 March 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
City of Tustin has not accepted any role or responsibility for performing implementation activities associated with any of the alternative remediation methods identified in this FS.	
Comment 23: Page 5-41, Description (and throughout) – Remedial alternatives 3, 6 and 7 involve implementation of a pump and treat system with the resulting treated groundwater being discharged to a local storm drain system. Alternative 4 involves implementation of a pump and treat system with treated groundwater re-injected into the local aquifer rather than being discharged to the local storm drain system. Due to environmental constraints associated with the upper Newport Bay and to comply with NPDES requirements, the City does not believe that the Navy would be allowed to discharge treated groundwater to the local storm drain system. Consequently the Navy must revise the remedial design alternatives 3, 6 and 7 to utilize a re-injection method rather than a discharge method. Failure to incorporate a re-injection method at this point in time will fail to disclose significant cost and feasibility elements of the design that are important for Navy decision makers and the community to understand prior to selecting a preferred remedy. Please provide.	**Response to Comment 23: :** The Navy will evaluate options for disposal of extracted and treated groundwater including reinjection, infiltration as percolation ponds, and as "purple water" for irrigation purposes during the Remedial Design phase of this project. This evaluation will take into consideration technical total maximum daily load (TMDL) discharge limits to surface water for selenium and other chemicals and other factors such as potential use of treated groundwater compatible with reuse in the area.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 27: Page 1-69, Paragraph 1, line 9, "BNI 1997c" is not referenced in the reference section.	**Response to Specific Comment 27:** The reference was updated in the text.
Specific Comment 28: Page 1-70, Paragraph 2, line 3, "OHM 1999 and OHM 2001a, b" are not referenced in the reference section.	**Response to Specific Comment 28:** The references were updated in the text and in Section 7, References.
Specific Comment 29: Page 2-10, section 2.4.3 California Drinking water Standards, Paragraph 2, line 1 DHS has established Action Levels for 1,2,3-TCP. Please discuss how this action level could incorporate for cleanup goal.	**Response to Specific Comment 29:** Please see Responses to Comments regarding DHS action levels for 1,2,3-TCP for J. Broderick (RWQCB) and J. Christopher (DTSC).
Specific Comment 30: Page 2-12, Paragraph 1, line 4, "US EPA 1988c" is not referenced in the reference section.	**Response to Specific Comment 30:** The reference was updated in the text..
Specific Comment 31: Page 2-12, Paragraph 3, line 7. Please delete "and current".	**Response to Specific Comment 31:** The text was revised as requested.
Specific Comment 32: Page 2-16, Paragraph 2, line 14, "Cal/EPA 1999" is not referenced in the reference section.	**Response to Specific Comment 32:** The reference was updated in the text and in Section 7, References.
Specific Comment 33: Page 2-16, Paragraph 3, line 4, "US EPA 2002" is not referenced in the reference section.	**Response to Specific Comment 33:** The reference was updated in Section 7, References.
Specific Comment 34: Page 3-37, Section 3.3.2.8, Bullet 3; Reword "Treated Groundwater will be discharged to City of Tustin storm drain which eventually discharges to Peters Canyon Channel."	**Response to Specific Comment 34:** Text on Page 3-37, Section 3.3.2.8, Bullet 3 was revised to, "surface water discharge that eventually discharges to Peters Canyon Channel."
Specific Comment 35: Page 3-37, Section 3.3.2.8, Paragraph 4, lines 2-3, "Possible discharge… storm drains". Please replace with "Treated Groundwater will be discharged to City of Tustin storm drain which eventually discharges to Peters Canyon Chann."	**Response to Specific Comment 35:** The text on Page 3-37, Section 3.3.2.8, Paragraph 4, lines 3 was replaced with, "Treated groundwater will be discharged to the city of Tustin's storm drain which will eventually discharge to Peters Canyon Channel."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 36: Page 3-42, Paragraph 1, line 1, Please add "S" after "13."	**Response to Specific Comment 36:** The text was revised as requested.
Specific Comment 37: Page 4-17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, line 4, and treated groundwater will be discharged to "Peters Canyon Channel". However, page 5-184 section 5.10,1,9 Groundwater Disposal, paragraph 1, line 2, mentions treated groundwater will be discharged to "Barranca Channel" Please clarify the discrepancy.	**Response to Specific Comment 37:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No. 2. The text on Pg. 5-184, Section 5.10.1.9, paragraph 1, line 1 will be revised to state: "Treated water from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."
Specific Comment 38: Page 4-18, Figure 4-4: Please Change "IRP 12" to "IRP 13S".	**Response to Specific Comment 38:** The figure was revised as requested.
Specific Comment 39: Page 5-14 Section 5.1.8 State Acceptance, paragraph 1, line 5, reference "BNI 2001a" cited in the reference section is not the correct one.	**Response to Specific Comment 39:** The reference was updated in Section 7, References.
Specific Comment 40: Page 5-25, Figure 5-3A- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 40:** Please see Response to General Comment 1 above.
Specific Comment 41: Page 5-25, Figure 5-3A- Legend Symbol for extent of groundwater contamination from UST 222 does not match the one shown on figure. Please make it consistent	**Response to Specific Comment 41:** The same symbol was used in the legend and on the figure; however, the figure was revised to be more readable
Specific Comment 42: Page 5-33, Figure 5-7- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 42:** Please see Response to General Comment 1 above.
Specific Comment 43: Page 5-43, Figure 5-8- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 43:** Please see Response to General Comment 1 above.
Specific Comment 44: Page 4-47, Section 5.4.1.3 Groundwater Disposal, Paragraph 1, line1-2, Treated water from treatment system would be discharged to an on-site culvert that eventually empties Barranca Channel, however, Page 4-	**Response to Specific Comment 44:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No.2. The text on Pg. 5-47, Section 5.4.1.3, paragraph 1, line 1 will be revised to state, "Treated water

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, line 4, treated groundwater will be discharged to "Peters Canyon Channel" Please clarify the discrepancy.	from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."
Specific Comment 45: Page 5-49, Paragraph 3, line 2, "RWQCB 2001" is not referenced in the reference section.	**Response to Specific Comment 45:** The reference was updated in Section 7, References.
Specific Comment 46: Page 5-54, Paragraph 1, line 7, "BNI 1998e" is not referenced in the reference section.	**Response to Specific Comment 46:** The reference was updated in the text and in Section 7, References.
Specific Comment 47: Page 5-67, Figure 5-16- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 47:** Please see Response to General Comment 1 above.
Comment 48: Page 5-113, Figure 5-27- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 48:** Please see Response to General Comment 1 above.
Specific Comment 49: Page 5-139, Figure 5-35- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 49:** Please see Response to General Comment 1 above.
Specific Comment 50: Page 5-147, Section 5.8.1.8 Groundwater Disposal: line 1-2, "Treated water… Barranca Channel" Page 4-17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, and line 4, treated groundwater will be discharged to "Peters Canyon Channel" Please clarify the discrepancy.	**Response to Specific Comment 50:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No. 2. The text on Pg. 5-147, Section 5.8.1.8, paragraph 1, line 1 will be revised to state, "Treated water from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."
Specific Comment 51: Page 5-153, Paragraph 3, line 6, "BNI 1998e" is not referenced in the reference section.	**Response to Specific Comment 51:** The reference was updated in the text and in Section 7, References.
Specific Comment 52: Page 5-157, paragraph 4, lines 1-2, "Treated water… Barranca Channel". Page 4-17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, line 4, treated groundwater will be discharged to "Peters Canyon Channel" Please clarify the discrepancy.	**Response to Specific Comment 52:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No. 2. The text on Pg. 5-157, Section 5.8.2.4, paragraph 5, line 1 will be revised to state, "Treated water from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 53: Page 5-165, Paragraph 1, line 3, "BNI 1998e" is not referenced in the reference section.	**Response to Specific Comment 53:** The reference was updated in the text and in Section 7, References.
Specific Comment 54: Page 5-173, Section 5.10 Alternative 7 – Hydraulic Containment with Hot Spot Removal- paragraph 1, lines 6-7, "Treated groundwater… Barranca Channel". Page 4-17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, line 4, treated groundwater will be discharged to "Peters Canyon Channel" Please clarify the discrepancy.	**Response to Specific Comment 54:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No.2. The text on Pg. 5-173, Section 5.10, paragraph 1, 3rd sentence will be revised to state, "Treated water from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."
Specific Comment 55: Page 5-175, Figure 5-41- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 55:** Please see Response to General Comment 1 above.
Specific Comment 56: Page 5-179, paragraph 1, line 3, please change "if" to "as".	**Response to Specific Comment 56:** The text was revised as requested.
Specific Comment 57: Page 5-180, The section 5.10.1.4 and Figure 5-44 discusses the backfilling scenario for alternative 7. A geotextile liner is proposed to be placed above the clean fill and the water table. The soil with no or low concentrations of VOCs is proposed for the rest of the backfilling. The integrity of the geotextile liner for long periods of time will be difficult to predict. Please evaluate the backfill option with the clean import fill for the entire excavation without using a geotextile liner and non- detect/low VOCs soil.	**Response to Specific Comment 57:** The evaluation of excavation and backfill of hot spot soils at OU-1A was conducted to be consistent with OU-1B. Based on groundwater modeling conducted for OU-1A, even if the geotextile liner were breached at some point in the future, residual contamination in treated soils with VOCs at non-detect or low concentrations would not act as a continuing source of contamination to groundwater at concentrations exceeding MCLs. No change to the text is necessary.
Specific Comment 58: Page 5-184, Section 5.10.1.9 Groundwater disposal- paragraph 1, lines 1-2, "Treated groundwater…. Barranca Channel". Page 4-17, Section 4.2.7 Hydraulic Containment with Hot Spot Removal, Paragraph 1, line 4, "treated groundwater will be discharged to Peters Canyon Channel" Please clarify the discrepancy.	**Response to Specific Comment 58:** The text on Page 4-17, Section 4.2.7 is correct and consistent with General Response No.2. The text on Pg. 5-184, Section 5.10.1.9, paragraph 1, line 1 will be revised to state, "Treated water from the treatment system would be discharged to the city of Tustin's storm drain, ultimately discharging into Peters Canyon Channel."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 59: Page 5-184, Section 5.10.1.9 Groundwater disposal: The treated groundwater to be discharged in to the Barranca Channel may further lower the depleting groundwater. The reason for rejecting the re-injecting groundwater option is described as groundwater mounding for the Alternative 7. It is not clear why the re-injection was considered for other alternatives such as Alternate 4 and 4A DTSC suggests reevaluating the advantages and disadvantages for the re-/percolation/irrigation options of discharging treated groundwater. The following analyses may be needed to evaluate these options: groundwater mounding in the aquifer at various distances from the infiltration well for the re-injection option groundwater mounding in the aquifer at various inflow rates for the re-injection option system analyses for percolation ponds and spray irrigation systems	**Response to Specific Comment 59**: The text in Section 5 for all appropriate remedial alternatives was revised to indicate that all disposal options for treated groundwater including reinjection, as "purple" irrigation water, or using percolation ponding will be evaluated during the Remedial Design phase of this project. This evaluation will take into consideration TMDL discharge limits for selenium and other chemicals as appropriate. Reinjection of treated groundwater was considered as a component of Alternatives 4/4A to conceptually evaluate the efficiency of this technique in improving the remediation (by flushing) and/or capture of 1,2,3-TCP in the first and second WBZs. The Remedial Design is the appropriate phase to evaluate such factors as potential for mounding associated with reinjection and other potential uses consistent with the reuse at the base. It is important to note that the disposal of treated groundwater may consist of one or more of the disposal options to be evaluated during the Remedial Design.
Specific Comment 60: Page 5-185, Figure 5-45 Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 60:** Please see Response to General Comment 1 above.
Specific Comment 61: Page 5-187, Figure 5-46 Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 61:** Please see Response to General Comment 1 above.
Specific Comment 62: Page 6-1, Under References: To make it easy for this comment number the references as 1, 2…74. The following references are not referenced in the text: 9, 10, 14, 16, 17, 18, 28, 29, 30, 31, 32, 34, 35, 37, 39, 40, 41, 42, 47, 49, 51, 53, 61, 65, 68, 71, and 72.	**Response to Specific Comment 62:** Section 7, References and the text were revised as indicated in Response to Comments above.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT AND PROPOSED PLAN FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 1: Overall: The risk assessment and proposed plan can become acceptable upon adequate responses to our Specific Comments below. Most importantly, we require that the Navy include MTBE in its estimates of cancer risk using "Federal" criteria and 1,2,3-TCP in its estimate using "State" criteria. Notwithstanding this, we agree that cancer risks will be reduced approximately 92% by implementing the Navy's favored alternative, source removal and above-ground treatment of groundwater. The draft proposed plan can become acceptable with correction of the cancer risk estimates.	**Response to General Comment 1:** The Navy acknowledges California Department of Toxic Substances Control (DTSC's) comments on cancer risk using federal and state criteria as noted in Responses to Specific Comments below.
Comment 2: Estimates of Cancer Risk: We agree with the Navy that cancer risks for residents under current conditions exceed the "generally acceptable" range of 1 E-6 to 1 E-4, whenever the 1,2,3-TCP-contaminated groundwater is assumed to be available for domestic use. For future conditions, we agree that cancer risks will be lower, due to a combination of remediation of 1,2,3-TCP and institutional controls prohibiting domestic use of groundwater. We do not agree that the Navy's estimates are accurate. We find the Navy's method of "dual tracking" for carcinogens produces a confusing set of estimates for OU-1A. By dual tracking we mean presenting two sets of cancer risk estimates for each exposure setting, one using USEPA cancer potency factors and the other using Cal/EPA factors. The method used here produces underestimates of cancer risk in all cases. "Federal" estimates are too low because MTBE is not treated as a carcinogen. "State" estimates are too low because 1,2,3-TCP is not included. The Navy should provide a complete picture of potential cancer risks for risk managers, both for remedial decisions and for future users of the property. We believe the best estimate would be one which incorporates the USEPA cancer slope factor for 1,2,3-TCP into the "State" estimates. All changes in estimates of risk must be reflected in the Final Feasibility Study Report and in the Proposed Plan for OU-1A.	**Response to General Comment 2:** Federal estimates: The current cancer risk at the PAH Apron Study Area and the Auto Hobby Shop Area for the resident with beneficial groundwater use is quantified in excess of 10^{-3}. The current cancer risk for the resident with non-beneficial groundwater use is quantified in excess of 10^{-5}. 1,2,3-TCP is the principal risk driver at all three areas. The federal slope factor for MTBE was included in the federal risk estimates to evaluate any changes due to MTBE. Inclusion of MTBE does not alter the federal cancer risk estimates as presented below: PAH Apron Study Area: Without MTBE 4.7×10^{-3} With MTBE 4.7×10^{-3} Auto Hobby Shop Area Without MTBE 4.7×10^{-3} With MTBE 4.7×10^{-3} Resident beneficial groundwater use scenario Without MTBE 6.8×10^{-2}

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
	With MTBE 7.4×10^{-2} Resident nonbeneficial groundwater use scenario Without MTBE 1.7×10^{-5} With MTBE 1.8×10^{-5} Section 1.8 will include a discussion on the federal slope factor for MTBE indicating that with the addition of MTBE, the federal risk estimates are not significantly different from previously calculated risk estimates. A new section will be included in Appendix F presenting text and tables on the evaluation conducted with the federal slope factor. State estimates: The methodology in the draft final FS used all the cancer slope factors published by the State of California Office of Environmental Health Hazard Assessment. The federal slope factor for 1,2,3 TCP will be added to the state risk estimate for the Source Area, PAH Apron Study Area, and Auto Hobby Shop Area presented in the draft final FS to compare the federal risk estimates with the equivalent state risk estimate. The federal and equivalent state risk numbers will be discussed in Section 1.8 and Appendix F of the FS Report. Tables in Section 1.8 and Appendix F will be revised to present the federal and revised state risk estimates.
Comment 3: Risk Reduction: The Navy estimates that 30 years of above-ground treatment of groundwater will reduce concentrations of 1,2,3-TCP by approximately 92%. A 92% reduction of cancer risk for the residential setting with domestic use of groundwater will leave an estimated cancer risk in excess of 1 E-4. It seems likely that institutional controls on use of this groundwater will be required for many years to come in order to protect human health.	**Response to General Comment 3:** The future estimate is intended to determine the reduction in risk from this pump-and-treat technology to technically achievable concentrations. At completion of pump-and-treat remediation (e.g., when remediation goals are achieved, pump-and-treat is no longer effective, or when the plume is stable without active remediation), risk managers will determine the need for continuing institutional controls.
Comment 4: Presentation on Compact Disk: We have some suggestions for ease of review of electronic documents. First, dividing the risk assessment into multiple Acrobat files is extremely cumbersome. A single file is much easier to	**Response to General Comment 4:** The FS for OU-1A was prepared similar to the FS for OU-1B. The vast majority of end users of these documents do not require the level of detail be incorporated into Appendix F as requested by

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
manipulate. Second, we strongly urge the Navy to insert hot links into the text for each reference to a table, figure, or literature citation. This would enable immediate access to the data on which the text is based. Third, hot links for entries in the Table of Contents would help the reviewer navigate throughout the document. If electronic reports amount to bare Adobe files, we prefer a hard copy.	DTSC. The discussion of risk presented in Section 1.8, Summary of Baseline Risk Assessment, is sufficient for understanding of the purpose and methods of the risk assessment. The additional effort to provide the recommended hot links to Appendix F would be beneficial to a limited number of users (i.e. risk managers). In addition, hard copy prints can be made as needed from the compact disc (CD) provided in the document. The Navy will provide a hard copy of Appendix F to DTSC for their use as a reference. The remainder of the documents to be distributed will provide the risk assessment appendix on CD.
SPECIFIC COMMENTS	**RESPONSES TO SPECIFIC COMMENTS**
Comment 1: Remedial Action Objectives (RAO) for TCE, Fig. 2-1, p. 2-15: Figure 2-1 appears to indicate that 30 years of above-ground treatment of groundwater will reduce concentrations of TCE to about 10 µg/L. However, the RAO for TCE in groundwater is set at 5 µg/L, the Maximum Contaminant Level (MCL) enforceable under the Safe Drinking Water Act. We find no discussion of what the Navy plans to do if and when the RAO for TCE is not met.	**Response to Specific Comment 1:** Figure 2-1 is a conceptual illustration of the decline in concentrations of VOCs as a function of time for plume restoration under groundwater extraction. The figure illustrates the initial rapid decline in concentrations during the first several years followed by a shallower decline to an asymptotic value. Actual predicted maximum concentrations of trichloroethylene (TCE) modeled for the remedial alternatives under consideration are presented in several figures in Section 5, Detailed Analysis of Remedial Alternatives (Please see Figures 5-4, -14, -20, -25, -33, -39, and -49). After the final remedy is implemented at OU-1A and during the operational period, it will be subject to 5-year reviews, which will be conducted to evaluate the effectiveness of the remedy in achieving remedial action objectives (RAOs) and remediation goals established for the site. Based on results of these 5-year reviews, the remedy may be modified to incorporate newer more advanced remediation technologies, or in the event that remediation is progressing more rapidly than anticipated, active remediation may be terminated or scaled-down sooner than currently anticipated.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT AND PROPOSED PLAN FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 2: RAO for 1,2,3-TCP, Sec. 2.5.2, pp. 2-16: The Navy proposes an RAO of 0.6 µg/L for 1,2,3-TCP in groundwater. Table 2-5 does not present a basis for this value. Text on page 2-16 presents the USEPA Region 9 Preliminary Remediation Goal for 1,2,3-TCP of 0.0056 µg/L, then applies a factor of 100 to reach the proposed RAO of 0.6 µg/L. The factor of 100 is derived by analogy from regulatory actions for 1,2-dibromo-3-chloropropane, another substance for which the concentration associated with a cancer risk of 1 E-6 is far below detection limits in water. After discussions with DTSC's Hazardous Materials Laboratory, we believe a reasonable level might be the practical quantitation limit for 1,2,3-TCP in water, which is 0.5 µg/L. HERD estimates that domestic use of groundwater with 1,2,3-TCP at 0.5 µg/L could be associated with cancer risk levels as high as 1 E-4. Risk managers should be aware of this level of risk presented by 1,2,3-TCP even at the detection limit as they consider future uses of groundwater at OU-1A. Therefore, we recommend against any value for the RAO higher than the practical quantitation limit of 0.5 µg/L.	**Response to Specific Comment 2:** The Navy agrees with DTSC's, Hazardous Materials Laboratory's (HML's) recommendation of 0.5 micrograms per liter (µg/L) as the remediation goal for 1,2,3-TCP in groundwater. The recommended 0.5 µg/L value for the remediation goal for 1,2,3-TCP is appropriate as it is the practical laboratory quantitation limit for this chemical in groundwater and is also the approximate technically feasible limit of pump-and-treat technology for 1,2,3-TCP in groundwater at OU-1A. As remediation proceeds towards achieving this concentration and the pump-and-treat technology is no longer effective, risk managers will determine the need for continuing institutional controls to prevent extraction of and domestic use of shallow groundwater at the site. The Navy anticipates that in the future there may be a maximum contaminant limit (MCL) promulgated for 1,2,3-TCP in groundwater, and/or changes in the cancer slope factors that risk managers will consider in their evaluation of the remedy installed at OU-1A in fulfilling the need to protect human health and the environment. The Navy proposes 0.5 µg/L as the remediation goal for 1,2,3-TCP based on the information presented above.
Comment 3: Assessment of MTBE, p. FI-1: Why is MTBE assessed at the PAH Apron Area and the Hobby Shop but not in the Source Area? Plume maps indicate that MTBE is found throughout much of OU-1A.	**Response to Specific Comment 3:** MTBE was not included in the three Source Area scenarios (current and future conditions with beneficial use and current conditions with non-beneficial groundwater use) per the agreed-upon procedures presented at the 6 August 2002 meeting between DTSC and the Navy, prior to beginning the risk assessment. Reported detections of MTBE in groundwater within the Source Area have been determined to be insignificant (i.e., contribution of 10^{-9}) and would not impact the risk estimates calculated using federal or state slope factors. MTBE was however, included in other risk assessment scenarios (the PAH Apron Study Area, the Auto Hobby Shop Area, the Construction/Utility Worker, and the Beneficial and Non-beneficial groundwater use scenarios) with results briefly discussed in

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
	Section 1.8 of the text and fully presented in the appendices. It is anticipated that risk managers will use results from these additional scenarios to address questions regarding institutional controls/construction provisions and to address site-specific groundwater contamination. A new section will be added to Appendix F to evaluate the contribution of MTBE without the consideration of 1,2,3-TCP. Additionally, a discussion on the contribution of MTBE in the Source Area will be included in Section 1.8 and Appendix F. Tables will be included to compare risk results for MTBE under several scenarios previously evaluated as part of the draft final FS Report. Dr. Christopher requested at the June 19, 2003 BCT meeting that the Navy conduct an evaluation showing the corresponding risks for various concentrations of MTBE. To address this request, the Navy proposes to add a discussion in the 2002 MTBE Performance Evaluation Report presenting risk reduction versus MTBE concentration. The evaluation report is the more appropriate document for this discussion since the report addresses the effectiveness of the MTBE treatment system under the PCAP.
Comment 4: Properties of Volatile Organic Chemicals, Sec. FI2.3.2, p. FI-24, Table FI-9: No source is shown for the values in Table FI-9, although they appear to be the same as those in the VLOOKUP tables from the Johnson & Ettinger spreadsheets published by USEPA. Please name the source of the values.	**Response to Specific Comment 4:** The source of the values will be added as follows: 1. Unless otherwise noted the values are derived from the VLOOKUP table from the Johnson & Ettinger. 2. For MTBE and for 1,2,3-TCP, Henry's and solubility constants were derived from the physical constants table published by Region 9 in the PRG table (PRG 2002).

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT AND PROPOSED PLAN FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 5: Risk Drivers, Tab. FI-12 & Figs. FI-3 & FI-5, pp. FI-36 ff.: In estimating risks using USEPA toxicity criteria, the Navy presents 1,2,3-TCP as the only risk driver. While it is true that this volatile chemical in groundwater is responsible for the great majority of the estimated cancer risks in all exposure settings, other detected carcinogens from Figures FI-37 and FI-39 present estimated risks on the same order as those estimated using Cal/EPA criteria. On the other hand, showing risk drivers for "State Toxicity Criteria" and omitting 1,2,3-TCP is simply incomplete. Cal/EPA may not have published toxicity criteria for 1,2,3-TCP, but the USEPA has and the Navy should use it whenever this carcinogen is encountered. Omitting 1,2,3-TCP from the "State" estimate of cancer risk is misleading, because it omits the great bulk of the risk, both current and future. These presentations artificially divide risk into bureaucratic categories which have no meaning. The foremost goal is to present estimates of risk to aid risk managers in making sound decisions on remedial alternatives. Omitting risk drivers or dividing them according to an artificial rule only serves to cloud the primary issue – protection of human health.	**Response to Specific Comment 5:** Please see Response to General Comment 2.
Comment 6: Toxicity Criteria, Sec. FII3, p. FII-10: The Navy has included consideration of the cancer potency factors published by the Office of Environmental Health Hazard Assessment (OEHHA) of Ca//EPA. However, they have not included OEHHA's criteria for non-carcinogenic effects. A list of chronic Reference Exposure Levels (RELs) may be downloaded from http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html. Alternatively, the Navy could contact HERD to receive copies of spreadsheets for the Johnson & Ettinger Models with all OEHHA values embedded in the VLOOKUP tables. Recently, OEHHA advised us that cadmium should be treated as a carcinogen only when inhaled. Cadmium is not volatile, so it cannot be inhaled in domestic use of water, nor can it infiltrate into buildings from groundwater. Cadmium presents no carcinogenic risk when it is present in groundwater or surface water. Cadmium should be considered carcinogenic at OU-1A only when it is present	**Response to Specific Comment 6:** It is not within the Navy's current policy to include OEHHA's criteria for non-carcinogenic effects in the Human Health Risk Assessment. DTSC and Navy personnel are currently discussing policy issues related to preparation of future risk assessments. No evaluation of non-carcinogenic effects using OEHHA's criteria will be included in this FS Report. The Navy will contact HERD in order to review the significant differences between U.S. EPA and OEHHA's Johnson & Ettinger Models. In future assessments, the Navy will treat cadmium as a carcinogen under the inhalation of dust pathway only. Please see Response to General Comment 2 addressing the federal slope factor for MTBE in the final FS Report.

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
in inhaled dust. The Navy may adjust its estimates of cancer risk downward accordingly. USEPA Region 9 now publishes a Preliminary Remediation Goal which treats MTBE as a carcinogen (http://www.epa.gov/region09/waste/sfund/prg/files/02table.pdf). Therefore, the Navy should add MTBE to its list of "Federal" carcinogens and assess it as such. This will lead to a significant increase in the Navy's estimates of cancer risk for "Federal" carcinogens	
Comment 7: Estimating Upper Confidence Limits (UCL) on the Mean, Sec. FII1.1.1, p. FII-3: Please note that the Land method for estimating the UCL on the mean for lognormal data becomes unstable as right-skew increases (Singh *et al.*, 1997) or if a dataset contains just one or two outliers (USEPA, 2002). Recent guidance from USEPA (2002) recommends several re-sampling techniques for these circumstances, including bootstrap, jackknife, several others. These re-sampling methods become especially useful when a data cannot be identified as being either normally or lognormally distributed, which is the case for most of the data shown in Appendix FIII.	**Response to Specific Comment 7:** The Navy concurs with DTSC's comment. However, it should be noted that the Upper Confidence Limit (UCL) generated by the Land method is similarly considered to be overly conservative in comparison to bootstrap and jacknife methods (Singh *et al.*, 1997). Hence, there is high confidence that the actual risk is not underestimated.
Comment 8: Fraction of Soil Ingested, Sec. FII2, p. FII-6: With the hypothetical receptors described for this risk assessment, we do not approve of the use of a "fraction of soil from the site" as a portion of total soil ingested per day. Please eliminate the factor "FI" from the equation at the bottom of page FII-6.	**Response to Specific Comment 8:** All of the soil ingested per day originated from the site. Hence, "FI" equaled 1.
Comment 9: *m,p*-Xylene in Source Area, Table FIII-4 (and elsewhere), p. FIII-37: This table states that concentrations of *m,p*-xylene in soil are normally distributed. However, this chemical was detected just once in 28 analyses, which does not present enough information to identify the underlying distribution. Please change the entry in the "Distribution" column to "Nonparametric" or "Not Evaluated". The correct exposure point concentration (EPC) for this chemical should be the value of single detection. Make the same	**Response to Specific Comment 9:** The distribution entries for soil m,p-xylene in the source area and naphthalene in groundwater will be changed to read "Nonparametric." The distribution of 1,3-dichloropropane is identified as being lognormal. According to Section 5.3.2 of RAGs, elevated detection limits are to be excluded from the quantitative risk assessment. Hence, 1,3-dichloropropane

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
(EPC) for this chemical should be the value of single detection. Make the same correction for naphthalene in Table FIII-9, where the frequency of detection was 2 of 62. In a similar vein, the distribution of 1,3-dichloropropane is identified as being lognormal, although it was detected in just was detected in 5 of 57 samples of groundwater analyzed across OU-1A (Table FIII-9). This is almost certainly an artifact of the statistical test; the EPC should probably be the maximum concentration detected (C_{MAX}). Without more sophisticated regression techniques, such as those of Helsel (1988, 1990), the only information that can be adduced here is a distribution of detection limits. We recommend that the Navy re-examine the software algorithm which produced these results, giving greater weight to low frequency of detection and low total numbers of detections.	samples with elevated detection limits were excluded from the analysis. The Navy will review the protocol used in the generation of exposure point concentrations (EPCs).
Comment 10: Appendix FIV: Many histograms and probability plots are shown for chemicals detected in just one sample or at a very low frequency of detection. These are of little value. The Navy need not remove them from this report; however, in the future, the Navy should build into the algorithm which produces these plots some sort of filter to avoid cluttering the document with unusable information. As mentioned above, we suggest screening for some minimum number of detections and a minimum frequency of detection. This will avoid calculating confidence intervals on distributions of detection limits. In his memorandum dated 4 April 2003, Dr. Brian Davis of HERD commented on a similar presentation for the "Draft Removal Site Evaluation Report, IR Site 10, Original Rick King Restaurant Site, Naval Station San Diego". All of Dr. Davis's comments are equally applicable to the current document	**Response to Specific Comment 10:** Exposure point concentrations (EPCs) represent the contact of an individual with a chemical of potential concern (COPC). Exposure is assumed to occur over time, the exposure duration assumed in the risk assessment was 30 years for an adult resident, 25 years for an industrial worker and 1 year for a construction worker. Additionally, contact is supposed to occur over the entire exposure area. Hence, it is unreasonable to assume that an individual will be exposed to a single result over the exposure duration used in the risk assessment. Since this risk assessment follows the Reasonable Maximum Exposure (RME) approach, all valid sample results are used in the estimation of the EPC. The histograms and probability plots provided represent a summary of the numerical values collected at the site, sample results for detects and sample quantitation limits for nondetects. This information is used in the estimation of the EPC therefore it is deemed significant to the report. The Navy will review the protocol used in the generation of EPCs.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT AND PROPOSED PLAN FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 11: Site-Specific Values for Johnson & Ettinger Modeling, Sec. FV2.2.1, p. FV-3: The Navy should state in the main text that most of the site-specific values models were actually measurements made at MCAS El Toro. Currently, this information is presented in footnotes to Tables FV-1.	**Response to Specific Comment 11:** Section FV2.1.1.1.2 states that "Site-specific values include parameters that were measured directly onsite, or laboratory data from samples collected onsite, or values published by BEI in reports from similar sites."
Comment 12: Cancer Risk Estimates in Draft Proposed Plan, Table 2, p. 8: The cancer risk estimates in this table should be corrected, after the Navy has re-calculated risk estimates to include MTBE for the "Federal" estimate" and 1,2,3-TCP for the "State" estimate.	**Response to Specific Comment 12:** Please see Response to General Comment 2 above.
Conclusions and Recommendations 1. **Estimates of Cancer Risk:** The baseline risk assessment underestimates cancer risk using either USEPA (omission of MTBE) or Cal/EPA cancer potency factors (omission of 1,2,3-TCP, the main risk driver). These estimates should be corrected in both the Draft Final Feasibility Study and the draft Proposed Plan for OU-1A. 2. **Risk Summary:** Under current conditions, Cancer risks and non-cancer hazards are unacceptably high for residents with domestic use of the groundwater. The main driver for both cancer and non-carcinogenic toxic effects is 1,2,3-TCP. Under future conditions without institutional controls, we do not believe cancer risk levels will fall below 1 E-4. Under future residential conditions with institutional controls on domestic of groundwater, cancer risks will decrease, possibly to values within the risk management range of 1 E-6 to 1 E-4. Risks for commercial/industrial workers and constructions workers are apparently within the risk management range, although we do not know the exact estimates without including MTBE along with the "Federal" carcinogens. Non-cancer hazards remain elevated slightly above the benchmark value of 1.0 in all future scenarios.	**Responses to Conclusions and Recommendations:** 1. See Response to General Comment 2 above. 2. Current federal cancer risk for construction workers are within the risk management range as shown below: Without MTBE 3.0×10^{-6} With MTBE 3.0×10^{-6}

COMMENTS FROM: J. Christopher (DTSC) Comments dated 25 April 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
3. **Risk Reduction:** We accept the Navy's estimate of a 92% reduction in cancer risk with source removal and above-ground treatment of groundwater.	3. Comment acknowledged.
4. **Histograms, Probability Plots, and Exposure Point Concentrations:** We recommend that the Navy overhaul its software which generates these presentations. The current report presents many values which are either incorrect or of little utility. The particular errors we found do not affect the conclusions drawn in this report. Therefore, we recommend that Navy correct this problem for future submissions.	4. Please see Response to Specific Comment 10 above.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
General Comment 1: On all figures in the legend please change "Government Property line" to "Former MCAS Tustin Boundary".	**Response to General Comment 1:** Revising the legends on all figures in the feasibility study as requested would not add to the reader's understanding of the issues presented, and would involve substantial additional costs. The legend on this figure in future documents (i.e., OU-1A ROD) will be revised as requested.
General Comment 2: Treated groundwater will be ultimately discharged to Peters Canyon Channel and Barranca Channel. Both were used in the text. Please clarify.	**Response to General Comment 2:** The text throughout the document will be revised to specify that treated groundwater will be ultimately discharged to Peters Canyon Channel.
General Comment 3: Suggest considering other discharge points for the treated water such as for irrigation, groundwater recharge using percolation ponds, or to supply a wetlands.	**Response to General Comment 3:** The text in Section 3 will be revised to discuss the reevaluation of various options for disposal of the treated groundwater to be conducted in the Remedial Design. The text in Section 5 for Alternatives 3, 4, 4a, 6, 6a, and 7 will be revised to include a statement that disposal options will be reevaluated in the Remedial Design. The evaluation conducted in Section 3 is limited to evaluating the disposal options based on effectiveness, implementability, and cost. The evaluation in the Remedial Design will evaluate additional factors such as hydrogeology, regulatory/public input, and other available uses for the treated water such as irrigation, groundwater recharge using percolation ponds, and for wetlands.
General Comment 4: References cited in the text do not show in the reference section and vice versa.	**Response to General Comment 4:** The text was revised to include all references cited as indicated in the Response to Specific Comments below.
SPECIFIC COMMENTS	**RESPONSE TO COMMENTS**
Specific Comment 1: Page ES-2, paragraph 1, lines 6-7, "These Comments… Record of Decision" These comments should also to be addressed in the Final OU 1A F.S.	**Response to Specific Comment 1:** The last sentence on Page ES-2, paragraph 1 will be revised to state: "These comments have been addressed in this document and will be incorporated into the Proposed Plan as well as in a Record of Decision."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 2: Page ES-2, Under Development of the OU 1A Feasibility Study- Paragraph 1, lines 11-13, "Community and… Considered" This sentence was confusing. Please reword the sentence.	**Response to Specific Comment 2:** The referenced sentence: "Community and regulatory agency comments were again received and addressed, and a ninth remedial alternative with potential to decrease remediation time was considered." was revised to: "Community and regulatory agency comments were again received and addressed, and an additional remedial alternative (Alternative 7) with potential to decrease remediation time was considered."
Specific Comment 3: Page ES-3, Figure ES-1- Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 3:** Please see Response to General Comment 1 above.
Specific Comment 4: Page ES-3, Figure ES-1- Legend Symbol for extent of groundwater Contamination from UST 222 does not match the one shown on figure. Please make it consistent.	**Response to Specific Comment 4:** The same symbol was used in the legend and on the figure; however, the figure was revised to be more readable.
Specific Comment 5: Page ES-6, Paragraph 2, line 5, "BNI 1998e" is not referenced in the reference section.	**Response to Specific Comment 5:** The reference was updated in the text and in Section 7, References.
Specific Comment 6: Page ES-6, Paragraph 4, lines 2-3, "Peters Canyon… (Figure ES-1). Please label Peters Canyon Channel, Barranca Channel, and the Santa Ana-Santa Fe Channel on Figure ES-1.	**Response to Specific Comment 6:** Peters Canyon Channel, Barranca Channel and the Santa Ana-Santa Fe Channel are labeled on Figure ES-1; however, the figure was revised to make the labels more readable.
Specific Comment 7: Page ES-8, Paragraph 1, line 2, "BNI 1998e and BNI 2002c" is not referenced in the reference section.	**Response to Specific Comment 7:** The reference was updated in the text and in Section 7, References.
Specific Comment 8: Page ES-8, Risk Assessment Summary: Please explain why only human health risk assessment was conducted for one of the remedial alternatives hydraulic containment with hot spot removal. What about other alternatives?	**Response to Specific Comment 8:** After 30 years, the risk driver is 1,2,3-TCP and estimated to be approximately 1 μg/L. The concentration was used to estimate the residual risk for 1,2,3-TCP at this endpoint under Alternative 7. The other alternatives were evaluated and compared with respect to the relative costs and time to reach this endpoint. Text will be added to Page ES-9 to state, "Future risk is based on 1,2,3-TCP concentrations of 1 μg/L after remediation. The risk for the remedial alternatives can be evaluated based on the time to reach this endpoint in relation to the other alternatives."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 9: Page 1-7, Figure 1-2: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 9:** Please see Response to General Comment 1 above.
Specific Comment 10: Page 1-9, Figure 1-3: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 10:** Please see Response to General Comment 1 above.
Specific Comment 11: Page 1-12, Paragraph 3, lines 3-4- "additional property… public sale" If this sale is complete reword the sentence.	**Response to Specific Comment 11:** The referenced sentence was revised to read: "Additional property within the former housing areas at MCAS Tustin was sold through public sale in early 2003."
Specific Comment 12: Page 1-15, Figure 1-5: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 12:** Please see Response to General Comment 1 above.
Specific Comment 13: Please verify this figure 1-5 with FOST 4 figure 2 for consistency and make appropriate changes.	**Response to Specific Comment 13:** Figure 1-5 was verified and revised as requested.
Specific Comment 14: Page 1-17, under section 1.4.2 Surface Water Hydrology: Paragraph 3, line 4, "San Joaquin Channel" however figure 1-4 on page 1-13 refers to as "San Joaquin Ditch". Please clarify the discrepancy.	**Response to Specific Comment 14:** Ditch and channel are used in the text in Section 1.4.2, Surface Water Hydrology, and on Figure 1-4, Current Land Use at Former MCAS Tustin, respectively, as synonyms.
Specific Comment 15: Page 1-33, Figure 1-12: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 15:** Please see Response to General Comment 1 above.
Specific Comment 16: Page 1-35, Figure 1-13: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 16:** Please see Response to General Comment 1 above.
Specific Comment 17: Page 1-37, Paragraph 2, lines 4-6, "In the first and second…water supply." Please provide concentration numbers compared with drinking water criteria	**Response to Specific Comment 17:** The second sentence in the second paragraph on Page 1-37 was revised to read: "Background concentrations of sulfate, selenium, and nitrate in the first and second WBZs exceed DHS and U.S. EPA criteria for drinking water supply by approximately 10 times, 10 times, and 2 times, respectively."
Specific Comment 18: Page 1-39, Figure 1-14: Legend: Please change "Government Property Line" to "Former MCAS Tustin Boundary".	**Response to Specific Comment 18:** Please see Response to General Comment 1 above.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: A. Peddadda (DTSC) Comments dated 28 March 2003 Received on 10 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Specific Comment 19: Page 1-44, Paragraph 1, line 3, "OHM 2001a" is not referenced in the reference section.	**Response to Specific Comment 19:** The reference was updated in Section 7, References.
Specific Comment 20: Page 1-44, Paragraph 2, line 6, "OHM 2001b" is not referenced in the reference section.	**Response to Specific Comment 20:** The reference was updated in Section 7, References.
Specific Comment 21: Page 1-44, Paragraph 3, line 11, "OHM 2001c" is not referenced in the reference section.	**Response to Specific Comment 21:** The reference was updated in Section 7, References.
Specific Comment 22: Page 1-53, Figure 1-19- please add the date when the monitoring was conducted to this figure.	**Response to Specific Comment 22:** The title of Figure 1-19 was revised to read: "IRP-13S and UST Site 222, 2001 Groundwater Monitoring Results for the First WBZ."
Specific Comment 23: Page 1-55, Figure 1-20- please add the date when the monitoring was conducted to this figure.	**Response to Specific Comment 23:** The title of Figure 1-20 was revised to read: "IRP-13S and UST Site 222, 2001 Groundwater Monitoring Results for the Second WBZ."
Specific Comment 24: Page 1-57, Figure 1-21- please add the date when the monitoring was conducted to this figure.	**Response to Specific Comment 24:** The title of Figure 1-19 was revised to read: "IRP-13S and UST Site 222, 2001 Groundwater Monitoring Results for the Third WBZ."
Specific Comment 25: Page 1-59, Paragraph 3, line 2, "Pacific Treatment 2002" is not referenced in the reference section.	**Response to Specific Comment 25:** The reference was revised in Section 7, References.
Specific Comment 26: Page 1-60, under section 1.7.1 Subsurface VOC contamination - Paragraph 1 Line2, "VOCs are typically reported at very low concentrations in vadose zone in soils at the site". Please provide the values.	**Response to Specific Comment 26:** Concentrations of VOCs in soils are presented in the previous Section 1.6.2, Soil and Groundwater Investigations at IRP-13S on Figure 1-16, Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, ST-72 Source Area and Figure 1-17, Distribution of TCE and 1,2,3-TCP in Soil at IRP-13S, MWA-18 Source Area. The following text was added after the 2nd sentence in the 1st Paragraph of Section 1.7.1: "Results from previous soil sampling for VOCs in the vadose zone are presented in Section 1.6.2."

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Norby (RAB) Comments dated 28 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
EXECUTIVE SUMMARY COMMENTS	**RESPONSES TO EXECUTIVE SUMMARY COMMENTS**
Executive Summary Comment 1: ES-1 and globally: Capitalize City of Tustin even when used without Tustin, City here refers to a specific city	**Response to Executive Summary Comment 1:** According to the U.S. Government Printing Office Style Manual "city" is not capitalized when used as in "city of Tustin." See page 40 in Section 4, Guide to Capitalization, for further explanation.
Executive Summary Comment 2: Fig. ES-1: • Comes in order prior to its reference in the text. • Reuse parcel boundaries are not shown as keyed • In the Note, the plumes should be referenced to their respective legend indicators • The parcel numbers are unreadable through the plume screens	**Response to Executive Summary Comment 2:** • Figure ES-1 is first referenced on Page ES-1, prior to being presented on Page ES-3. • The figure was revised to include parcel reuse boundaries. • The same symbols were used in the legend and on the figure for the extent of groundwater contamination at IRP-13S and UST Site 222, however, the figure was revised to make it more readable. • The figure was revised to make the parcel numbers more readable.
Executive Summary Comment 3: Pg ES-2, Para 2: Eight alternatives from OU-1 are named. Then a new alternative (ninth) was evaluated. Is the Alt 7 of this report the same as that ninth alternative, it is not clear?	**Response to Executive Summary Comment 3:** Alternative 7 was the ninth alternative considered in the OU-1A FS. The fifth sentence in the second paragraph on Page ES-2 was revised to read: "Community and regulatory agency comments were again received and addressed, and a ninth remedial alternative (Alternative 7) with potential to decrease remediation time was considered."
Executive Summary Comment 4: Pg ES-5, line 8: Add the abbreviation (SP/RP) after Reuse Plan for later use.	**Response to Executive Summary Comment 4:** The acronyms for specific plan (SP) and reuse plan (RP) were added to the text as requested.
FEASIBILITY STUDY COMMENTS	**RESPONSES TO FEASIBILITY STUDY COMMENTS**
Feasibility Study Comment 1: Fig 1-3 & 1-5: The railroad bounding the north side of Edinger Avenue is not shown	**Response to Feasibility Study Comment 1:** The railroad bounding the north side of Edinger Avenue is shown on the two figures; however, it is difficult to reproduce high-resolution figures in a document of this type. The resolution of the figures and the reader's ability to distinguish the railroad on the north side of Edinger Avenue does not diminish the overall quality of the document.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Norby (RAB) Comments dated 28 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
Comment 2: Fig. 1-4: Areas of pink are identified as "vacant" residential area. (The term vacant refers to land without structures.) The appropriate term might be "unoccupied" as residences were to be sold undemolished. Also, the colors for buildings and drainage are difficult to distinguish	**Response to Feasibility Study Comment 2:** The figure was revised as requested.
Comment 3: Fig. 1-5: Key: Should distinguish between Parcel Numbers and facility numbers. Does not explain CO, FOSL	**Response to Feasibility Study Comment 3:** Parcel numbers 40 and 41 identify circulation and drainage facilities, respectively.
Comment 4: Pg. 1-17 1.4.1: Topography-First Paragraph states slopes gently in southwest direction, while second paragraph 75 ft MSL at northwest corner to 45 ft MSL in southeast. Does it slope in southwesterly or southeasterly direction?	**Response to Feasibility Study Comment 4:** The first paragraph in Section 1.4.1, Topography, indicates that the coastal plain slopes gently toward the Pacific Ocean in a southwesterly direction. The second paragraph in the referenced section indicates that the local topography at Former MCAS Tustin (within the larger coastal plain setting) is essentially flat with local topographic highs found in the northwestern portion and lows found in the southeast portion of the station.
Comment 5: Fig. 1-6: Topo on this figure is barely distinguishable and locations are hardly readable.	**Response to Feasibility Study Comment 6:** It is difficult to reproduce high-resolution figures that would show all the topographic contours in a document of this type. However, the resolution of the figures presented in this document does not diminish the overall quality of the document.
Comment 7: Fig. 1-7: The symbol at the convergence of the Former Agricultural Area II drainage is not identified [at E-14000/C on the map].	**Response to Feasibility Study Comment 7:** The symbol at the convergence of the Former Agricultural Area II identifies the location of a culvert that is a part of the drainage trench and storm drain channel system.
Comment 8: Fig. 1-10: It would be clearer to use BGS (below ground surface) with or instead of MSL (mean sea level) for understanding. Additionally, pattern as well as color graphics should be used to better depict the underground materials. Some colors were not distinguishable.	**Response to Feasibility Study Comment 8:** The figure was revised to include feet below ground surface (bgs) values on the left axis.
Comment 9: Fig. 1-15: Add the boundary of IRP-13S	**Response to Feasibility Study Comment 9:** The boundaries of IRP-13S surround the two source areas MWA-18 and ST-72, as is indicated by the bold red lines on the body of the figure.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Norby (RAB) Comments dated 28 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
Comment 10: Pg 1-44, Para 3: Add Time Critical Removal Action before TCRA	**Response to Feasibility Study Comment 10:** The definition for the acronym "TCRA" was provided earlier in the text on Page 1-1.
Comment 11: Fig. 1-16, Notes: Notes describe "J" and "ND" but not "NJ"	[redacted] **to Feasibility Study Comment 11:** Figure 1-16 was revised to include an explanation of "NJ."
Comment 12: Pg. 1-59, Para 2: Which are the alternatives that are not compatible with the TCRA system?	**Response to Feasibility Study Comment 12:** The third sentence in the second paragraph on Page 1-59 was revised to read: " Several of the alternatives evaluated in this FS are not compatible with the TCRA system (i.e., Alternative 1, no action; Alternative 5, permeable reaction wall; and Alternative 2, monitored natural attenuation, do not require groundwater extraction as part of the remedy and would not require compatibility with TCRA system)."
Comment 13: Pg. 1-59,1.6.4: Line 4, change "onto" to "under" to correct mistaken impression of surface flows.	**Response to Feasibility Study Comment 13:** The text was revised as requested.
Comment 14: Pg. 1-70: It is not understood why both cancer and non-cancer risks wouldn't be greater for the child.	**Response to Feasibility Study Comment 14:** Cancer risks for the resident child are based on 7 years of occupancy at the site compared to 30 years for adults. In addition, the respiration for adults exceeds those of children. These two factors, among others, account for risks for adults being greater than for children.
Comment 15: Pg 2-1, Para 2: Introduce first use of (RAOs) as an acronym after "remedial action objectives"	**Response to Feasibility Study Comment 15:** The acronym for remedial action objective (RAO) is defined earlier in the Executive Summary on Page ES-12 and in the main text on Page 1-2.
Comment 16: Pg 2-1, Para 3: First RAO needs to say to clean up all contaminants from the water to their MCLs, not just limit migration, stabilize plume and reduce concentrations.	**Response to Feasibility Study Comment 16:** There is no currently promulgated maximum contaminant limit (MCL) for 1,2,3-trichloropropane (TCP). Therefore, the main objective of the remedy at OU-1A is reducing the risk to protect human health and the environment.
Comment 17: Pg 2-1, Para 4: While contaminated soils are of concern as source of VOCs to groundwater, explain why direct human contact is not a significant+ health risk?	**Response to Feasibility Study Comment 17:** The risk assessment conducted as a part of the remedial investigation at IRP-13S (included in OU-1 at the time) indicated that direct contact with soil would not pose significant health risks to humans.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Norby (RAB) Comments dated 28 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
Comment 18: Pg 2-1, 2.1- line 5: "primary source risk to human health at this site". Does this site refer to the Base, IRP-13S or OU1A?	**Response to Feasibility Study Comment 18:** The referenced sentence refers to IRP-13S as the site, which is also known as Operable Unit (OU)-1A.
Comment 19: Table 6-1: Re-examine Alternatives 4/4A and 6/6A after considering the questions raised in *TOSC Comments* by M. Fernandez, dated March 27, 2003.	**Response to Feasibility Study Comment 19:** Please see Response to TOSC Comments by M. Fernandez.
APPENDICES COMMENTS	**RESPONSE TO APPENDICES COMMENTS**
Appendices Comment 1: A1-4, last para-graph: It is not clear which IRP sites are included in OU-1A because it says IRP-13S, IRP-3, and IRP-2 are in OU-1A. Please correct.	**Response to Appendices Comment 1:** The fourth sentence in the last paragraph on Page A1-4 was revised to read: "IRP-13S was designated OU-1A, and IRP-3 and –12 were included in OU-1B."
Appendices Comment 2: A1-6, 7: State of California – capitalize State. Reasoning: it refers to a specific state, California. Also correct globally throughout volumes and appendices. Also, on Pg A1-7, each bullet should begin with a capital.	**Response to Appendices Comment 2:** According to the Chicago Manual of Style (14th Edition) page 250 Section 7.40, words such as "state" or "city" which designate political divisions, are capitalized when used as an accepted part of the proper name, and are not capitalized when not used as an accepted part of the proper name such as in California State and state of California, respectively.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Broderick (RWQCB) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
SPECIFIC COMMENTS	**RESPONSES TO SPECIFIC COMMENTS**
Comment 1: Section 2.5.2 Establishing Remediation Goals and Cleanup Levels (Page 2-16). For 1,2,3-trichloropropane, the State Drinking Water Action Level is 0.005 micrograms per liter (ug/l). Therefore, the appropriate cleanup goal for the affected water-bearing zones is 0.005 ug/l for waters that have been designated beneficial uses that include municipal supply.	**Response to Specific Comment 1**: State drinking water action levels are drinking water advisory levels. They are not promulgated law or regulation, and therefore not enforceable. Thus, the action level for 1,2,3-trichloropropane (TCP) is not a potential ARAR for OU-1A. When ARARs are not identified that would be fully protective (i.e., no promulgated clean-up goal), other federal or state policies, guidelines, or proposed rules capable of reducing the risks posed by a site may be considered. Such To Be Considered (TBC) standards, while not legally binding (since they have not been promulgated), may be used in conjunction with ARARs to achieve an acceptable level of risk. TBCs are evaluated along with ARARs as part of the risk assessment conducted for each CERCLA site to set protective cleanup levels and goals. Because TBCs are not potential ARARs, their identification is not mandatory (RCRA, Superfund & EPCRA Hotline Training Module, June 1998). As noted in paragraph 2, page 2-16 of Section 2.5.2 of the FS, a risk-based approach was selected as the primary basis for establishing a cleanup goal for 1,2,3-TCP. However, the Navy also included TBC standards for comparison in the evaluation process, including the state action level for 1,2,3-TCP. This will be clarified in the second and third paragraphs on Page 2-16 as indicated in bolded text below. "Federal and/or state MCLs have not been established for 1,2,3-TCP, the major risk driver in groundwater at OU-1A. For contaminants with no established MCL, a risk level of 10^{-6} is used as the point of departure for determining remediation goals. However, the development of a remediation goal should consider technical limitations such as detection limits for a chemical and other factors related to uncertainty (40 C.F.R. § 300.430[e][I][A][2] and [3]). The DON has developed a remedial goal for 1,2,3-TCP based on an evaluation of other contaminants with similar characteristics that have established MCLs. U.S. EPA Region 9 has established a tap water PRG for 1,2,3-TCP at 0.0056 μg/L based on a lifetime incremental cancer risk of 1×10^{-6}. **For comparison, the state of California has established an action level for 1,2,3-TCP at 0.005 μg/L.** One contaminant with a tap water PRG similar to 1,2,3-TCP is 1,2-dibromo-3-chloropropane

COMMENTS FROM: J. Broderick (RWQCB) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
SPECIFIC COMMENTS	**RESPONSES TO SPECIFIC COMMENTS**
	with a PRG of 0.0016 µg/L and a federal and state MCL of 0.2 µg/L (U.S. EPA 2002). The MCL for 1,2-dibromo-3-chloropropane was established by U.S. EPA based on Best Available Technology and has been set to "reduce the risk in cancer or other adverse health effects which have been observed in laboratory animals," but is not considered a health-based standard (Cal/EPA 1999)." "U.S EPA Region 9 recognizes that PRGs have been used in the past to establish "action levels" or cleanup levels by multiplying the cancer PRG concentrations by 10 or 100. The resulting risks for a chemical would represent the carcinogenic risk at 10-5 and 10-4, respectively (U.S. EPA 2002). An evaluation of the PRG and corresponding MCL for 1,2-dibromo-3-chloropropane shows that the MCL is essentially calculated by multiplying the tap water PRG by 100. For comparison, a similar **evaluation of the action level for 1,2,3-TCP multiplied by 100 would result in an MCL at 0.5 µg/L.** Similar conditions exist for 1,2,3-TCP and 1,2-dibromo-3-chloropropane, including limitations on Best Available Technology for possible cleanup levels (modeling indicates concentrations of 1,2,3-TCP can be reduced to approximately 1 µg/L with proposed technologies) and the practical detection limit for 1,2,3-TCP of 0.5 µg/L (detection limit used by the local water districts). Based on this evaluation, the DON is proposing a remediation goal for 1,2,3-TCP of 0.6 µg/L (tap water PRG multiplied by 100)."
Comment 2: Section 3.3.2.8 GROUNDWATER DISCHARGE (DISPOSAL) The technical total maximum daily load (TMDL) for selenium in the San Diego Creek – Newport Bay Watershed was promulgated by the U.S. Environmental Protection Agency on June 14, 2002. The Regional Board has not completed our implementation plan for selenium in this watershed. Surface water discharges within this watershed containing selenium (Se) in excess of the TMDL (chronic – 5 microgram per liter(ug/l) or acute – 20 ug/l) are in violation of the California Toxic Rule. Monitoring wells at this site are known to have Se concentrations in excess of 5 ug/l, up to 300 ug/l. It is most likely that surface water	**Response to Specific Comment 2:** The Navy will evaluate options for disposal of extracted and treated groundwater including reinjection, infiltration as percolation ponds, and as "purple water" for irrigation purposes during the Remedial Design phase of this project. This evaluation will take into consideration technical total maximum daily load (TMDL) discharge limits to surface water for selenium and other chemicals, as appropriate.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Broderick (RWQCB) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
SPECIFIC COMMENTS	**RESPONSES TO SPECIFIC COMMENTS**
discharge of treated groundwater will not be allowed without treatment for selenium. Additionally, percolation of treated groundwater will likely require a plan to manage the discharge in order to limit unacceptable Se accumulation in soil and wildlife exposure.	

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Fernandez (TOSC) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Comment 1: Section 1, Pg. 1-76: Please explain the rationale for using Alternative as the basis of comparisons. How do the other alternatives compare?	**Response to Comment 1:** The risk assessment performed for Alternative 7 was used to evaluate the reduction in risk achieved after 30 years, at the end of remediation. The vast majority of the estimated cancer risk at the end of remediation is due to the presence of residual concentrations of 1,2,3-trichloropropane (TCP) in groundwater (at approximately 1.0 micrograms per liter [μg/L]). Residual concentrations of 1,2,3-TCP at 1.0 μg/L were assumed to be the endpoint for remediation for the other active remedial alternatives considered because it is the limit of remediation considered to be technically feasible to achieve. The remedial alternatives were evaluated with respect to their relative costs, effectiveness, and time to reach this relative endpoint concentration. This evaluation was summarized in Section 6, Comparative Analysis of Remedial Alternatives.
Comment 2: Section 2, Pg. 2-1: RAO#1 should be more specific and refer to achieving particular standards or cleanup goals. For example, groundwater will be treated to meet state or federal maximum contaminant levels for all contaminants of concern. What is meant by "stabilized" in this RAO? RAO #4: This RAO should refer to specific goals, i.e., prevent exposure to soil with contaminant concentrations above residential cleanup standards or prevent consumption of groundwater with contaminant concentrations exceeding MCLs.	**Response to Comment 2:** RAO#1: There is no Maximum contaminant level (MCL) promulgated for 1,2,3-trichloropropane (TCP), therefore the goal of the remedy at OU-1A is reduction in risk to protect human health and the environment. In the context of this remedial action objective (RAO), "stabilized" refers containing the volatile organic compounds (VOCs) in groundwater to within their current (or shrinking) plume boundaries. Once the plume is stabilized or is shrinking without active remediation, institutional controls and monitoring may be used to reduce risk and to protect human health and the environment. RAO#4: Remedial actions may include institutional controls, which would allow for transfer or reuse of the property, but are not necessarily considered as cleanup actions.
Comment 3: Section 3 Department of the Navy (DON) considered a reasonable range of technologies for evaluation Pg. 3-13: why is beneficial use of treated groundwater for irrigation, habitat maintenance, etc. not considered a representative technology?	**Response to Comment 3:** Comment acknowledged. Page 3-13: These options for disposal of treated groundwater weren't used in developing the alternatives however, these discharge methods will be evaluated as possible discharge methods during the Remedial Design phase of this project.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: M. Fernandez (TOSC) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Pg. 3-15: Why would the thermal desorption (TDU) unit be modified? What are the costs associated with these TDU modifications? Pg. 3-36: Why is the cost for GAC treatment in Alternative 3 ($172,000) so much greater than the cost for this treatment in Alternatives 4/4A, 6/6A, and 7 ($53,000)? Pg. 3-38: How will reinjection of treated groundwater affect vertical migration of contaminants? Has this been simulated using MODFLOW? Pg. 3-41: Dioxins may be generated by thermal treatment of chlorinated organic compounds. How will this be addressed in the event that on-site thermal treatment is selected for implementation?	Page 3-15: There was an option of using an existing low-temperature thermal desorption unit (TDU) at the site, which was configured for total petroleum hydrocarbons. Modifications including a to the TDU would have been necessary to treat chlorinated VOCs present in soil at OU-1A. Although modification costs were not quantified in detail, vendor information indicates it would be more cost effective to use a TDU built to treat chlorinated VOCs. Page 3-36: The higher costs for GAC treatment associated with Alternative 3 v. Alternatives 4/4A, 6/6A, and 7 are primarily due to the larger overall volume of groundwater extracted and treated under Alternative 3 compared with the volume treated under the latter alternatives. Pages 3-38 and 3-41: The potential vertical migration of contaminants affected by reinjection and the potential production of dioxins during thermal treatment of chlorinated compounds are based on site-specific conditions, and are issues that will be evaluated in Remedial Design phase of this project, if these are issues that are related to components of the selected remedy.
Comment 4: Section 4 DON assembled a reasonable range of remedial action alternatives for evaluation	**Response to Comment 4:** Comment acknowledged.
Comment 5: Section 5 Alternatives 3, 4/4A, 5, 6/6A, and 7: How will MTBE plume be affected by these treatment alternatives for OU1-A? Alternative 3: See question regarding page 3-36. Alternative 5: Please explain the basis for installing 38 new process monitoring wells. Why must the wells be located on 25 foot centers? Alternative 6: How will excavation of the contaminated clay layer affect	**Response to Comment 5:** Section 5: It is anticipated that MTBE will be addressed prior to implementation of the final remedy at OU-1A, and will therefore have no affect on the remedy. Alternative 3: Please see Response to Comment 3 above regarding Page 3-36. Alternative 5: Alternative 5 is a conceptual design based on literature on typical monitoring practices for reaction walls. As stated in the text, if Alternative 5 is selected, the exact number of wells and their locations will be determined in the Remedial Design phase using standard engineering practices. Alternative 6: If Alternative 6 is selected as the final remedy, the factors

COMMENTS FROM: M. Fernandez (TOSC) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
vertical migration of contaminants in groundwater? If the design pumping rate of 12 gpm is not possible, how will lower pumping rates affect contaminant removal efficiency? Will more wells be necessary at lower pumping rates? Please explain the need for institutional controls if treatment goals will be accomplished in approximately 8 years? Alternative 7: the soil excavation target level for TCE in this alternative is 400 ug/kg (page 5-174, Figure 5-42). Why does this differ from the 100 ug/kg goal in Alternatives 4/4A and 6/6A? How will the DON and RWQCB resolve the difference of opinion regarding permitting of surface discharges of treated groundwater?	presented in your comment will be evaluated and addressed prior to implementing the final remedy. The remedial design may include field testing to determine groundwater extraction rates. Institutional controls will be required to assure protection of human health and the environment until cleanup goals are met. Alternative 7: The excavation target level (400 ug/kg) for TCE in soil under Alternative 7 was to remove only hot spot soils that would act as a continuing source of contamination to groundwater at concentrations exceeding it's respective maximum contaminant level (MCL). The excavation target level for Alternatives 4/4A and 6/6A was selected to remove the bulk of contaminated soil at the site. During the remedial design phase of the project, the Navy will evaluate various appropriate alternatives for disposal of treated clean groundwater and will take into consideration technical total maximum daily load (TMDL) discharge limits to surface water for selenium and other chemicals, as appropriate.
Comment 6: Section 6 Pg. 6-6: Please explain the rationale for evaluating the short-term effectiveness of Alternatives 4/4A, and 6/6A as low to moderate, especially as compared to Alternative 7, hydraulic containment with hot spot removal. Why would aggressive groundwater extraction and vacuum enhanced treatment be less effective in the short-term than hot spot removal with hydraulic containment? Figures 6-1 through 6-3 indicate that these alternatives are roughly equivalent with respect to reducing contaminant concentrations both in the short-term and the long-term. Pg. 6-7: Given that the design pumping rate may not be achievable, why did DON not run simulations for Alternatives 6/6A at lower pumping rates with more wells? Pg. 6-11: The requirement for installing 18 injection wells and a greater number of extraction wells than in other alternatives does not affect the implementability of Alternatives 4/4A. The requirement for more wells at	**Response to Comment 6:** Page 6-6: Alternatives 4/4A and 6/6A would involve larger-scale excavations relative to the more limited hot spot excavations required under Alternative 7. The relatively limited excavation associated with Alternative 7 could be implemented relatively more rapidly than those associated with Alternatives 4/4A and 6/6A, and would not involve as much soil handling and treatment or off-site treatment and disposal. Page 6-7: Typical pumping rates and designs were used to compare the alternatives in the FS. Although they may be the same, it is not appropriate to assume that subsurface conditions (including sustainable pumping rates) at IRP-13S would be the same as those encountered during the vapor-enhanced extraction (VEE) field test at IRP-3. The feasibility study only qualitatively compared pumping rates for Alternatives 6/6A with the actual pumping rates encountered at IRP-3, and if Alternatives 6 or 6A were selected, the remedial design would have to consider potential for lower extraction rates.

COMMENTS FROM: M. Fernandez (TOSC) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
Tustin MCAS affects the cost and long-term reliability of this alternative, not its implementability.	Page 6-11: A greater level of effort and time is required for installation of wells under Alternatives 4/4A, and by comparison, other alternatives are easier to implement.
Comment 7: Appendix B What is the basis for the conclusion regarding downward migration into WBZ-3 and the decision not to propose treatment for this zone? What modeling or observations support this conclusion?	**Response to Comment 7:** The lateral distribution of 1,2,3-Trichloropropane (TCP) in the third water bearing zone (WBZ) and it's potential to migrate into the third WBZ was evaluated and reported in the April 1999 Final Technical Memorandum: Limited Deep Hydropunch Investigation at IRP-13S, Marine Corps Air Facility (MCAF), Tustin California (Technical Memorandum). The Technical Memorandum concluded that a localized lithologic discontinuity exists in a small area in the vicinity of third WBZ well IS72MW02D2 and that a prevalent upward vertical hydraulic gradient from the third to the second WBZ exists in this area. Quarterly groundwater monitoring data collected after the limited deep hydropunch investigation from monitoring wells installed in the third WBZ indicate that the extent of 1,2,3-TCP in the third WBZ is relatively stable. As of December 2001; 1,2,3-TCP was reported in 1 of 13 groundwater samples from downgradient monitoring well IS72MW9D2 at a concentration of 0.9 micrograms per liter. 1,2,3-TCP has not been reported in any groundwater samples from this well since spring 2000. In January 2002, a time-critical removal action (TCRA) was initiated to contain the TCP plumes in the first and second WBZs. It is anticipated that this system will act to control the downward migration of contaminants by reducing or reversing any downward vertical hydraulic gradient in the area of the 1,2,3-TCP plume in the third WBZ. The effectiveness of this TCRA system is being evaluated based on data collected during its operation. The need to further evaluate the distribution of 1,2,3-TCP in the third WBZ will be evaluated during the remedial design phase of this project. It should be noted that most active aquifer remediation technologies, including

COMMENTS FROM: M. Fernandez (TOSC) Comments dated 27 March 2003 Received on 08 April 2003	**RESPONSES FROM:** Navy
COMMENTS	**RESPONSES TO COMMENTS**
	groundwater extraction are not effective in remediating deep zone contamination because groundwater extraction from the deep (third WBZ) zone may induce further downward plume migration. If these systems are installed or operated incorrectly, they can have detrimental effects.

RESPONSE TO COMMENTS
DRAFT FINAL FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 1A
FORMER MARINE CORPS AIR STATION
TUSTIN, CALIFORNIA
JANUARY 2003

COMMENTS FROM: J. Ricks (US EPA) Comments dated 04 April 2003 Received on 06 May 2003	**RESPONSES FROM:** Navy
GENERAL COMMENTS	**RESPONSES TO GENERAL COMMENTS**
Comment 1: Overall, the Draft Final OU 1A FS is consistent with the FS process and methodology as outlined in the U.S. Environmental Protection Agency Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (OSWER 9355.3). The document is well organized and comprehensive in scope and approach. Therefore, EPA's specific comments will address clarifications and recommended substantive changes to the text to ensure that the reader ascertains an overall understanding of the purpose and objectives this separate and focused FS which addresses groundwater contamination at IRP-13 South (IRP-13S).	**Response to General Comment 1:** Comment acknowledged.
Comment 2: Please ensure that all reports, studies and other referenced citations discussed in the text are included in Section 7 "References." See specific comments discussed below.	**Response to General Comment 2:** Section 7, References, was revised to include all references cited in the text.
SPECIFIC COMMENTS	**RESPONSES TO SPECIFIC COMMENTS**
Comment 1: Pages 1-43 to 1-48. Section 1.6.2 "Soil and Groundwater Investigations at IRP-13S" In previously commenting on the 2001 Annual Groundwater Monitoring Report, the regulatory agencies expressed concern regarding the scope of monitoring and the evaluation of the extent of the 1,2,3-Trichloropropane (1,2,3-TCP) plume in the third WBZ. More specifically, the agencies recommended further hydrogeologic investigation in order to address an apparent data gap that was due to an absence of downgradient monitoring wells. The agencies asserted that this data was a critical independent variable for estimating the mass of the COCs and necessary for fully evaluating the remedial alternatives for IRP-13S. Thus, the agencies' request that the Navy discuss its assessment of the potential impact of this issue relative to modeling analysis used in the groundwater fate and transport evaluation and development of remedial alternatives.	**Response to Specific Comment 1:** The lateral distribution of 1,2,3-Trichloropropane (TCP) in the third water bearing zone (WBZ) was evaluated and reported in the April 1999 Final Technical Memorandum: Limited Deep Hydropunch Investigation at IRP-13S, Marine Corps Air Facility (MCAF), Tustin California (Technical Memorandum). The objectives of this investigation were to evaluate the lateral distribution of 1,2,3-TCP in the third WBZ to assess potential mechanisms for migration of 1,2,3-TCP into the third WBZ, and to provide information to be used in combination with other data provided in the Feasibility Study (FS) to support the selection of an effective alternative for groundwater remediation. Data presented and evaluated in the Technical Memorandum were collected in accordance with recommendations of the 1997 Annual Groundwater Monitoring Report (GWMR) for MCAF Tustin and additional planning documents included in it as appendices. All planning documents were developed in coordination with and with the concurrence of the Base

COMMENTS FROM:	RESPONSES FROM:
J. Ricks (US EPA) Comments dated 04 April 2003 Received on 06 May 2003	Navy
	Realignment and Closure (BRAC) Cleanup Team, which consisted of representatives from MCAS Tustin, California Department of Toxic Substances Control (DTSC), California Regional Water Quality Control Board, Santa Ana Region (RWQCB) and U.S. Environmental Protection Agency (U.S. EPA). The deep hydropunch investigation at IRP-13S included soil sampling and hydropunch groundwater sampling, installation of groundwater monitoring wells, and groundwater sampling. During the course of the investigation, it was determined that the groundwater flow direction in the third WBZ differed from the direction in the second WBZ by approximately 90 degrees (to the west). In addition, localized zones of thick layers of coarse-grained materials plus a seasonal reversal of vertical hydraulic gradients evident over several years of monitoring appeared to provide the mechanisms for limited migration of VOCs from the second to the third WBZ at the location of well IS72MW2D2. Quarterly groundwater monitoring data collected after the hydropunch investigation from monitoring wells installed in the third WBZ indicate that the extent of 1,2,3-TCP in the third WBZ is relatively stable. As of December 2001; 1,2,3-TCP was reported in 1 of 13 groundwater samples from downgradient monitoring well IS72MW9D2 at a concentration of 0.9 micrograms per liter. 1,2,3-TCP has not been reported in any groundwater samples from this well since spring 2000. In January 2002, a time-critical removal action (TCRA) was initiated to contain the TCP plumes in the first and second WBZs. It is anticipated that this system will act to control the downward migration of contaminants by reducing or reversing a normal downward vertical hydraulic gradient in the area of the 1,2,3-TCP plume in the third WBZ. The effectiveness of this TCRA system is being evaluated based on data collected during its operation. The need to further evaluate the distribution of 1,2,3-TCP in the third WBZ will be evaluated during the remedial design phase of this project.

COMMENTS FROM: J. Ricks (US EPA) Comments dated 04 April 2003 Received on 06 May 2003	**RESPONSES FROM:** Navy
	It should be noted that most active aquifer remediation technologies, including groundwater extraction are not effective in remediating deep zone contamination because groundwater extraction from the deep (third WBZ) zone may induce further downward plume migration. If these systems are installed or operated incorrectly, they can have detrimental effects.
Comment 2:.Pages 1-60. Section 1.7.1 "Subsurface VOC Contamination." The first two paragraphs of this section discuss contaminate levels for TCE and 1.2,3-TCP in qualitative terms. For example, VOCs described as being detected "at very low levels," or reported as Relatively elevated contaminant concentrations." EPA recommends including the actual values in the text whenever possible to further specific understanding of the discussed analyses.	**Response to Specific Comment 1:** The first two paragraphs were revised to include references to Figures 1-16 and 1-17, which present data regarding the distribution of TCE and 1,2,3-TCP in soil at IRP-13S source areas. This information was presented and described earlier in Section 1.6.2, Soil and Groundwater Investigations at IRP-13S.
Comment 3: Page 2-16. Section 2.5.2 "Establishing remediation Goals and Cleanup Levels,." third paragraph. In describing the action levels for establishing appropriate cleanup levels, the text should be revised to indicate that the action level for the State of California for 1,2,3-TCP is 0.005 micrograms per liter.	**Response to Specific Comment 3:** The second and third paragraphs on Page 2-16 were revised to include the action levels for 1,2,3-TCP as indicated in bolded text below. "Federal and/or state MCLs have not been established for 1,2,3-TCP, the major risk driver in groundwater at OU-1A. For contaminants with no established MCL, a risk level of 10^{-6} is used as the point of departure for determining remediation goals. However, the development of a remediation goal should consider technical limitations such as detection limits for a chemical and other factors related to uncertainty (40 C.F.R. § 300.430[e][I][A][2] and [3]). The DON has developed a remedial goal for 1,2,3-TCP based on an evaluation of other contaminants with similar characteristics that have established MCLs. U.S. EPA Region 9 has established a tap water PRG for 1,2,3-TCP at 0.0056 µg/L based on a lifetime incremental cancer risk of 1×10^{-6}. **For comparison, the state of California has established an action level for 1,2,3-TCP at 0.005 µg/L.** One contaminant with a tap water PRG similar to 1,2,3-TCP is 1,2-dibromo-3-chloropropane with a PRG of 0.0016 µg/L and a federal and state MCL of 0.2 µg/L (U.S. EPA 2002). The MCL for 1,2-dibromo-3-chloropropane was established by U.S. EPA based on Best Available Technology and has been set to "reduce the risk in cancer or other adverse health effects which have been observed in laboratory

COMMENTS FROM: J. Ricks (US EPA) Comments dated 04 April 2003 Received on 06 May 2003	RESPONSES FROM: Navy
	animals," but is not considered a health-based standard (Cal/EPA 1999)." "U.S EPA Region 9 recognizes that PRGs have been used in the past to establish "action levels" or cleanup levels by multiplying the cancer PRG concentrations by 10 or 100. The resulting risks for a chemical would represent the carcinogenic risk at 10-5 and 10-4, respectively (U.S. EPA 2002). An evaluation of the PRG and corresponding MCL for 1,2-dibromo-3-chloropropane shows that the MCL is essentially calculated by multiplying the tap water PRG by 100. For comparison, a similar **evaluation of the action level for 1,2,3-TCP multiplied by 100 would result in an MCL at 0.5 µg/L.** Similar conditions exist for 1,2,3-TCP and 1,2-dibromo-3-chloropropane, including limitations on Best Available Technology for possible cleanup levels (modeling indicates concentrations of 1,2,3-TCP can be reduced to approximately 1 µg/L with proposed technologies) and the practical detection limit for 1,2,3-TCP of 0.5 µg/L (detection limit used by the local water districts). Based on this evaluation, the DON is proposing a remediation goal for 1,2,3-TCP of 0.6 µg/L (tap water PRG multiplied by 100)."
Comment 4: Page 3-37. Section 3.3.2.8 "Groundwater Discharge (Disposal). EPA promulgated new Technical Total Maximum Daily Load (TMDL) limits for selenium in the San Diego Creek-Newport Bay Watershed (14 June 2002). The full reference for the EPA-established TMDLs for the San Diego Creek-Newport Bay Water shed may be found accessed at: http://www.epa.gov/region09/water/tmdl/nbay/summary0602.pdf. Authority for implementing the new TMDLs has been delegated to the State of California Regional Water Quality Control Board (RWQCB). Several monitoring wells at MCAS Tustin have detected selenium in concentrations in excess of TMDL (chronic-5 microgram perliter (ug/l) or acute –20 ug/l) for surface water discharges within the watershed. This may adversely impact any surface discharge of treated groundwater that does not provide for the treatment of selenium.	**Response to Specific Comment 4:** The text in Section 5 for all appropriate remedial alternatives was revised to indicate that all disposal options for treated groundwater including reinjection, as "purple" irrigation water, or using percolation ponding will be evaluated during the remedial design phase of this project. This evaluation will take into consideration Technical Total Maximum Daily Load (TMDL) discharge limits for selenium and other chemicals as appropriate.