California Regional Water Quality Control Board
San Francisco Bay Region

Third Five-Year Review

TRW Microwave Site
825 Stewart Drive
Sunnyvale, Santa Clara County, California

September 2009

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List of Acronyms

AMD	Advanced Micro Devices, Inc.
ARAR	Applicable or Relevant and Appropriate Requirements
bgs	Below Ground Surface
BPHE	Baseline Public Health Evaluation
cis-1,2-DCE	cis-1,2-Dichloroethene
CDM	Camp Dresser & McKee, Inc.
DHC	Dehalococcodies
EAB	Enhanced Anaerobic Biodegradation
ESL	Environmental Screening Levels
FRAP	Final Remedial Action Plan
GWET	Groundwater extraction and treatment
HRC	Hydrogen Release Compound
MCL	Maximum Contaminant Level
ug/L	Micrograms per liter
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OU 1	Operable Unit 1
PCE	Tetrachloroethene
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
Regional Water Board	Regional Water Quality Control Board
SCR	Site Cleanup Requirements
SVET	Soil Vapor Extraction and Treatment
TCA	1,1,1-trichloroethane
TCE	Trichloroethene
TOC	Total Organic Carbon
TRW	TRW Microwave
USEPA	United States Environmental Protection Agency
VFA	Volatile Fatty Acids
VC	Vinyl chloride
VOC	Volatile Organic Compound

Executive Summary

The remedy for groundwater contamination at the former TRW Microwave (TRW) Superfund site (Site) in Sunnyvale, California, has included source removal, soil vapor extraction and treatment (SVET), groundwater extraction and treatment (GWET), enhanced anaerobic biodegradation (EAB), groundwater monitoring, and institutional controls. Investigations identified the former underground storage tank (UST) area as the only source for groundwater contamination at the Site. This is the third five-year review for the former TRW site and it covers remedial activities conducted between September 2004 and September 2009.

The source for groundwater contamination (i.e., UST) and surrounding soils was removed for off-site disposal between 1993 and 1996. Soil vapor extraction and treatment (SVET) was conducted between 1993 and 1996, and the SVET system was removed in 1998 after soi1 cleanup standards were met. Groundwater extraction was conducted across the entire site through October 2000, at which time groundwater extraction was suspended within the former source area to allow implementation of the EAB pilot test. The groundwater extraction was suspended across the entire Site in April 2001 and has not been resumed since that time. Prior to suspension of extraction, groundwater concentrations had declined across the pollution plume but had reached asymptotic levels. Since initiation of EAB in October 2000, contaminant concentrations have been reduced significantly except in the former source area where contaminant concentrations remain elevated above cleanup standards in the former source area.

The remedy at the TRW Microwave (TRW) Superfund site in Sunnyvale, California is currently protective of human health and the environment. Current information indicates that the remedy may not be able to restore the groundwater to its beneficial use as a potential drinking water source. Enhanced Anaerobic Biodegradation process is currently being tested at the Site. In the short-term, the institutional controls are preventing exposure to, and the ingestion of, contaminated groundwater. Additionally, while there is currently no exposure risk from vapor intrusion because the current building is unoccupied, the necessity of a restrictive covenant for vapor intrusion will be determined after a vapor intrusion assessment is completed which considers changes in the building's current or future use, and/or redevelopment of the building or Site. The ROD and final SCR need to be amended.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name (from WasteLAN): TRW Microwave		
EPA ID (from WasteLAN): CAD009159088		
Region: 9	State: CA	City/County: Sunnyvale/Santa Clara

SITE STATUS	
NPL status: Final	
Remediation Status: The ROD groundwater extraction remedy is shut off; EAB Testing is underway.	
Multiple OUs? No	Construction completion date: 1988
Has site been put into reuse? The site has been vacant since 2001.	

REVIEW STATUS	
Lead agency: State of California	
Author Name: Max Shahbazian	
Author title: Engineering Geologist	Author affiliation: CA Regional Water Quality Control Board (Lead Agency)
Review period: March 2009 to September 2009	
Date(s) of site inspection: 3/24/2009	
Type of Review: (in bold) _Post-Sara _Pre-Sara _NPL-Removal only _Non-NPL Remedial Action Site x **NPL State/Tribe-lead** _Regional Discretion	
Review number: (in bold) _1 (first) _2 (second) **3 (third)** Other (specify)	
Triggering action: (in bold) _Actual RA Onsite Construction at OU#__ _Actual RA Start at OU#__ _Construction Completion x **Previous Five-Year Review Report** _Other (specify)	
Triggering action date (from WasteLAN)**:** 9/30/2004	
Due Date: 9/30/2009	

Issues:

The following issues were identified during the review:

1) Operation of selected remedy ceased approximately 9 years ago. Enhanced Anaerobic Biodegradation is being evaluated.
2) The existing restrictive covenant was recorded prior to the passage of California Civil Code section 1471, which establishes the framework for environmental covenants in California.

Recommendations and Follow-up Actions:

The following are recommendations and follow-up actions for the above-mentioned issues:

1. Continue groundwater monitoring to assess the potential success of the EAB pilot testing. Evaluate alternatives to achieve Remedial Action Objectives in the groundwater. The ROD and final SCR need to be amended.
2. The legal owners of the former TRW Microwave property should record a new restrictive covenant that is consistent with current California law.

Protectiveness Statement:

The remedy at the TRW Microwave (TRW) Superfund site (Site) in Sunnyvale, California is currently protective of human health and the environment. Current information indicates that the remedy may not be able to restore the groundwater to its beneficial use as a potential drinking water source. Enhanced Anaerobic Biodegradation process is currently being tested at the Site. In the short-term, the institutional controls are preventing exposure to, and the ingestion of, contaminated groundwater. Additionally, while there currently is no exposure risk from vapor intrusion because the current building is unoccupied, the necessity of a restrictive covenant for vapor intrusion will be determined after a vapor intrusion assessment is completed which considers changes in the building's current or future use, and/or redevelopment of the building or Site. There is no exposure risk from vapor intrusion because the current building is unoccupied. The ROD and final SCR need to be amended.

I. Introduction

The purpose of the five-year review is to determine whether the remedy at a site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in Five-Year Review reports. In addition, Five-Year Review reports identify issues found during the review, if any, and identify recommendations to address them.

The Agency is preparing this Five-Year Review report pursuant to CERCLA §121 and the National Contingency Plan (NCP). CERCLA §121 states:

If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

The Agency interpreted this requirement further in the NCP; 40 CFR §300.430(f)(4)(ii) states:

If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

The California Regional Water Quality Control Board, San Francisco Bay Region, conducted the five-year review of the remedy implemented at the TRW 825 Stewart Drive Superfund Site (Site) in Sunnyvale, Santa Clara County, California. This is the third five-year review for the Site. The triggering action for this policy review is the completion of the second five-year review on September 30, 2004. The five-year review is required due to the fact that hazardous substances, pollutants, or contaminants remain at the Site above levels that allow for unlimited use and unrestricted exposure.

II. Site Chronology

Activity	Date
Aertech Industries began microwave and semiconductor assembly and testing.	1968
TRW acquired the property from Aertech Industries; no change in operations.	1974
Soil and groundwater contamination discovered at the site.	1983
Regional Water Board issued Cleanup and Abatement Order.	Jun 1984
TRW removed underground solvent storage tanks and acid waste sumps and associated piping, and excavated contaminated soils.	1984
TRW began groundwater extraction and treatment. NPDES permit issued for discharge of treated effluent.	1985
FEI Microwave acquired property from TRW and continues operations.	1987
Regional Water Board adopted Site Cleanup Requirements order.	Jan 1988
Site formally added to the National Priorities List (NPL).	Feb 1990
Baseline Public Health Evaluation completed for site.	1990
Regional Water Board and USEPA approved Final RI/FS Report and Remedial Action Plan (RAP) for TRW and adjacent AMD and Philips sites.	Jun 1991
Regional Water Board adopted Order No. 91-103, the Final Site Cleanup Requirements Order for the former TRW site.	Jun 1991
USEPA issued Record of Decision (ROD) for TRW and adjacent AMD and Philips sites.	Sep 1991
Industrial operations ceased at Site.	1993
RWQCB and EPA complete First Five Year Review	Sep 1999
TRW suspended groundwater extraction in the former source area only, and initiated Enhanced Anaerobic Biodegradation project in B 1-zone aquifer in former source area.	Oct 2000
TRW suspended groundwater treatment throughout the Site.	Apr 2001
Enhanced Anaerobic Bioremediation expanded to A-zone.	Jun 2001
Northrop Grumman purchased TRW and the Site.	Dec 2002
TRW sampled indoor air for VOCs and evaluated vapor intrusion	Oct 2003

Activity	Date
TRW installed and operated a temporary mechanical ventilation system within the Site building and collected indoor air samples in order to determine the effectiveness of ventilation on reducing concentrations of VOCs to acceptable levels.	Apr 2004
TRW submitted the Report of Findings – Installation and Operation of a Temporary Mechanical Ventilation System and Indoor Air Sampling report to the Water Board. In this report, Northrop Grumman concluded that the rate of vapor intrusion into the Site building appeared to be low enough to be mitigated solely with operation of a standard ventilation system.	May 2004
Regional Water Board approved the re-designation of Site well 36D as a Zone A well rather than a Zone B1 well. Northrop Grumman sold the Site to Pacific Landmark, LLC	Aug 2004
RWQCB and EPA complete Second Five Year Review	Sep 2004
TRW conducted another round of indoor air sampling without a mechanical ventilation system in operation.	Oct 2004
TRW submitted the Report of Findings – October 2004 Indoor Air Sampling report to the Water Board. In this report, Northrop Grumman concluded that mitigation of indoor VOC concentrations to below threshold levels could be achieved with operation of a standard ventilation system	Nov 2004
TRW submitted a preliminary draft RMP to the Regional Water Board. The RMP to be finalized after installation of permanent ventilation system and intended use of building is identified by property owner.	Apr 2005
TRW expanded the EAB pilot program to include groundwater immediately down-gradient of the former Site source area (around wells T-8A, T-8B, and T-10B).	Aug 2005
As part of the EAB expansion, TRW installed four additional Zone A wells, T-13A, T-14A, T-15A, and T-16A, and one additional Zone B1 well T-17B at the Site	Sep 2005
TRW submitted work plan for additional Zone A EAB remediation activities, which proposed to conduct four quarterly cheese whey injections in the expanded portion of Zone A aquifer down-gradient of the former Site source area (CDM, 2007).	Jun 2007
TRW installed seven injection wells (T-18A to T-24A) and one monitoring well (T-25A) as part of the down-gradient Zone A EAB treatment area.	Aug 2007
TRW completed the fourth quarterly cheese whey injection event into wells T-13A, T-14A, and T-18A through T-24A.	Jun 2008

III. Background

Physical Characteristics

The former TRW Microwave site (Site) is located south of Highway 101 in Sunnyvale at 825 Stewart Drive (see Appendix B - Site Location Map). The Site is located in a light industrial and commercial area dominated by the electronics industry that is known as the Silicon Valley, which is a portion of the larger Santa Clara Valley. Sunnyvale has a population of approximately 100,000, and is part of the San Francisco Bay Metropolitan Region, which has a total population of about six million. The surrounding area is also predominantly industrial. The closest residential areas are located approximately 1,100 feet north of the Site.

In 1995, the Site was purchased by Stewart Associates, who leased the property to Diablo Research Corporation, a contract research and development company. The on-site building has been vacant since January 2001. Between 2001 and 2003, the building's exterior was remodeled. As part of this remodeling, a portion of the building was demolished and a new structure, contiguous with the remaining portion of the existing building, was constructed. The Site remained unoccupied during this five-year review period (September 2004 through September 2009).

In December 2002, TRW merged with Northrop Grumman. In 2004, the Site property was purchased by Pacific Landmark, LLC. Since the Site was identified and listed on the NPL, TRW, and then Northrop Grumman, have retained responsibility for Site cleanup.

Site Operational History

Industrial operations began at the Site in 1968, when Aertech Industries began assembling and testing microwave and semiconductor components. In 1974, TRW acquired the Site from Aertech and continued similar operations. In 1987, Tech Facility 1, Inc. purchased the Site from TRW and leased the facility to FEl Microwave. FEl Microwave operated the facility until 1993. Operations were continuous with no significant process changes between 1968 and 1993.

During operations at the Site between 1968 and 1993, trichloroethene (TCE) and several other industrial solvents and hazardous compounds were used, and hazardous wastes were generated as a by-product of the operations. Waste solvent composed mainly of TCE was stored in an underground storage tank (UST) from 1970 through 1982. The tank was removed in early 1983. Figure 2-1 presents the location of the former UST area. An in-ground, three-stage, ammonia gas acid neutralization system (ANS) operated from 1968 to 1984, when it was disconnected and removed; it was replaced by an aboveground system with secondary containment. The aboveground ANS was disconnected and removed in 2001, during remodeling of the Site building.

This five-year review covers only remedial activities conducted at the former TRW site. Separate five-year reviews will be prepared and issued for the adjacent Advanced Micro Devices Superfund sites at 901-902 Thompson Place and 915 DeGuigne Drive (Appendix C - Site Vicinity Map).

Hydrogeology

The Site is located in the Santa Clara Valley, a structural basin bounded by the Santa Cruz Mountains to the south and west and San Francisco Bay to the north. The basin is filled with Quaternary-age alluvial sediments that were derived from the Santa Cruz Mountains and deposited along northward-trending ancestral streams en-route to San Francisco Bay. The depositional environment was characterized by meandering and braided stream systems that created sequences of coarse-grained sand and gravel units inter-bedded with fine-grained clay and silt.

The alluvial sediments in the Site area have regionally been divided into two broad hydrogeologic intervals or zones, referred to as the Upper Aquifer Zone and the Lower Aquifer Zone. These two zones are separated by extensive clay and silt aquitard that generally occurs at depths beginning at about 100 feet below ground surface (bgs). Numerous course-grained sand and gravel units have been identified in the Upper and Lower Aquifer Zones, and these water-yielding zones correlate throughout the area. The Upper Aquifer Zone consists of two water-yielding zones, designated as Zones A and B.

Zone A occurs within the interval from the water table to a depth of about 25 feet bgs. Zone B consists of five sub-zones (Zones B1 through B5), encountered at depths of approximately 30 feet bgs to 100 feet bgs. Drinking water aquifers occur below 150 feet bgs, beneath the regional aquitard.

On-site VOC impact has been shown to be present in Zones A, B1, and B2. Zones B3 and B4 have not been shown to contain VOCs beneath the Site, suggesting that the aquitard separating Zones B2 and B3 is continuous and sufficiently competent to prevent the vertical migration of VOCs.

The direction of regional groundwater movement for the three monitored zones in the Site vicinity (A, B1, and B2) has historically been to the north-northeast. However, groundwater extraction at offsite locations adjacent to the Site has substantially influenced the groundwater movement direction, particularly in Zones B1 and B2.

Vertical groundwater gradients are generally downward, as monitored in cluster wells screened in Zones A, B1, and B2, and are likely influenced by pumping at the adjacent sites, in particular, the site located at 815 Stewart Drive (see Figure 1-2).

History of Contamination

As a result of responses to a Water Board questionnaire that was submitted in 1983 after the removal of the on-site Site UST, TRW initiated an investigation of potential impacts to soil and groundwater at the Site. Between 1983 and 1986, several subsurface investigations were conducted in the vicinity of the former areas of the UST, the ANS, and associated piping. The investigations identified volatile organic compounds (VOCs) as the only chemicals of concern at the Site and the former UST area as the only source of VOC impact to Site groundwater.

Groundwater contamination from this Site, consisting primarily of trichloroethylene (TCE) and related chlorinated volatile organic compounds (VOCs), commingles with similar discharges from the adjacent Philips and AMD 901/902 Thompson Place sites. VOCs in groundwater are limited to water-bearing units in the upper 60 feet that are not used for public water supply.

The highest concentrations of contaminants exist in the A-zone and B1-zone. VOCs are also present in elevated concentrations in the B2-zone beneath the Site, but the composition of chemicals in this zone suggests migration from an off-site source.

The Advanced Micro Devices (AMD) site at 901-902 Thompson Place is located to the south of the TRW Site, and the Philips Semiconductors site at 811 East Arques Avenue site is located to the southwest of the TRW Site (Appendix C). An additional VOC release site, the AMD facility at 915 DeGuigne Drive, is located immediately north of the TRW Site. Along with the TRW Site, the two AMD sites are Superfund sites, whereas the Philips site is regulated under the RCRA program. A commingled VOC plume has migrated northward from the TRW, Philips, and AMD 901-902 Thompson Place sites. This commingled plume is referred to as "The Companies" Offsite Operable Unit. The commingled plume is approximately 4,000 feet long and extends beyond Highway 101.

Initial Response

Remedial action at the Site began in 1984 with the removal of the UST and associated contaminated soils. In total, TRW excavated and removed approximately 200 cubic yards of VOC-impacted soil. The excavation was approximately 19 feet by 16 feet in area, and extended to a depth of about 20 feet, terminating in a low permeability clay layer separating Zone A and Zone B1. TRW began groundwater extraction and treatment (GWET) in 1985.

Summary of Basis for Taking Action

The Site overlies the Santa Clara Valley groundwater basin. Groundwater from this basin provides up to 50% of the municipal drinking water for over 1.5 million residents of the Santa Clara Valley. The TRW Site was made a Superfund site primarily because of the potential threat to this valuable drinking water resource.

IV. Remedial Actions

Remedy Selection

A Baseline Public Health Evaluation (BPHE) was submitted in 1990. In 1991, USEPA and Regional Water Board approved the Remedial Investigation/Feasibility Study (RI/FS). These documents form the basis of the remedial action plan. The Regional Water Board adopted Final Site Cleanup Requirements (SCR) Order No. 91-103 in June 1991. The Final SCR Order contains the approved remedy for cleanup at the Site. A Record of Decision (ROD) was issued by USEPA in September 1991. The remedy selected in the ROD consisted of the following elements:

1) Groundwater extraction;
2) Treatment of extracted groundwater by air stripping; and
3) Discharge of treated water under an NPDES permit.

The SCR and the ROD set groundwater cleanup standards at California proposed or adopted Maximum Contaminant Levels (MCLs), USEPA MCLs, California Action Levels, or levels based on a risk assessment. The Site groundwater cleanup standards are listed in Table 1 below:

Table 1 - Site Groundwater Cleanup Standards

Chemical	Cleanup Standard (ug/L)
1,2-dichlorobenzene (1,2-DCB)	600
1,1-dichloroethane (1,1-DCA)	5
1,1-dichloroethene (1,1-DCE)	6
cis-1,2-dichloroethene (cis-1,2-DCE)	6
trans-1,2-dichloroethene (trans-1,2-DCE)	10
Freon 113	1,200
tetrachloroethene (PCE)	5
1,1,1-trichloroethane (1,1,1-TCA)	200
trichloroethene (TCE)	5
vinyl chloride (VC)	0.5

Remedy Implementation

The GWET system and groundwater monitoring program were fully implemented at the time the final SCRs were adopted in 1991. A restrictive covenant was prepared for the property and recorded with the Santa Clara County Records Office on August 20, 1992. The restrictive covenant includes prohibitions on the use of groundwater from the shallow aquifer (i.e., A- and B-zone aquifers as described above) as a source of drinking water until cleanup standards are achieved. On August 6, 2009, a title search for the Site property was conducted. The search reflected that the restrictive covenant is still in place and in effect. Remedial activities conducted by TRW during this review period are summarized below.

Groundwater Extraction and Treatment

The GWET system operated at the Site from 1985 to April 2001 (See Appendix D - Site Plan Map). The system was shut down in the source area in October 2000 to allow an EAB treatability study The GWET system consisted of seven extraction wells completed at three cluster locations (T-2A, B and C; T-8A and B; and, T-9A and B) and the Eductor well. Although these eight wells are no longer used for groundwater extraction, they will all continue to be used for groundwater monitoring. Previously, extracted groundwater was treated through an air stripper to remove VOCs. Treated groundwater was discharged to the local storm drain under the Site's National Pollution Discharge Elimination System (NPDES) permit. VOC-enriched off-gas from the air stripper was discharged with treatment to the atmosphere under the Site's Bay Area Air Quality Management District (BAAQMD) permit.

Even though the GWET system was removing VOCs from Site groundwater, in 1998, TRW concluded that the system was reaching its technical limitations. Decreases in TCE concentrations were most dramatic during the first five years of system operation (1985 to 1990). During the 1990s, the TCE concentrations appeared to have reached near asymptotic levels, in particular those in the former Site source area (Eductor well and wells T-2A and T-2B). In 2000, the annual TCE mass removed was only 30 percent of that removed by the system in 1985.

A commingled off-site plume has migrated northward from the TRW, Philips, and AMD 901-902 sites. The Philips GWET system currently maintains capture of the off-site sources for VOCs present in Zone B2, and the on-site and off-site sources for VOCs present in Zone B1. The Regional Water Board oversees the Philips Site and the clean-up of the off-site plume under Order No. 91-104. Inasmuch, the Regional Water Board approved permanent suspension of TRW's on-property, Zone B2 extraction wells to avoid potential groundwater pumping interference problems with the operation of the Philips GWET system.

Soil Vapor Extraction and Treatment

In July 1993, TRW began SVE from the Eductor and wells T-2A and T-8A to enhance cleanup in the unsaturated zone in the vicinity of the former UST area. The SVE system was permitted to operate by the BAAQMD and consisted of a 5-horsepower (HP), 100 standard cubic feet per minute (scfm) vacuum blower, a knockout drum, and three 200-pound (lb) granular activated carbon (GAC) vessels. The system was later upgraded to a 15-HP blower and three 1,200-pound GAC vessels in September 1995. During late 1994 and early 1995, 13 additional SVE points, using a three-foot screened interval at the bottom, were installed to a depth of about 12 feet bgs and connected to the SVE system.

The SVET system operated full-time through November 1996. Rebound testing was conducted in September 1997 and July 1998, during which time VOC concentrations decreased to 5 parts per million or lower except for one extraction point in the former UST location. In August 1998, TRW demonstrated that the Regional Water Board's six criteria for SVE closure had been fulfilled and the site-specific soil cleanup criteria had been met, and received permission from the Regional Water Board to terminate soil remediation. SVET system removed approximately 140 pounds of TCE. The SVET system was removed in November 1998.

Enhanced Anaerobic Biodegradation in Former Source Area

EAB Implementation

In August 2000, following completion of the *Evaluation of Natural Attenuation and Chemical Oxidation Report* and approval from the Regional Water Board, TRW implemented the Zone B1 EAB application. Wells T-2B and T-8B were temporarily shut down in August 2000. In October 2000, TRW initiated the EAB application by injecting polylactate ester (an HRC) beneath the EAB application area into the Zone B1 aquifer.

Approximately 1,190 pounds of the slow-releasing HRC and 1,190 pounds of the fast-releasing HRC were injected into 29 locations at the Site. Both fast and slow releasing HRC products were injected into the aquifer to provide a rapid reduction in competing electron acceptors and to create a gradual-release of lactate to provide a sustained carbon source for continued dechlorination of VOCs. The 29 injection locations were advanced using a Geoprobe rig within the most chemically affected area at the Site. The injection locations were spaced on approximately 6 to 20-foot centers and covered a total injection area of approximately 4000 ft^2. As detailed in the *Work Plan – Enhanced Anaerobic Bioremediation Pilot Test Report*, wells T-7B, T-2B, and T-8B were monitored to assess the effectiveness of EAB for the Zone B1 aquifer.

Based on Zone A aquifer data at the time of preparation of the *Evaluation of Natural Attenuation and Chemical Oxidation Report,* TRW concluded that EAB would not be an effective remediation alternative for the Zone A aquifer. The intent of the Zone B1 EAB application was to only inject HRC product into the Zone B1 aquifer. However, due to the injection method, a small portion of the HRC product was also injected into the Zone A aquifer. In January 2001,

TRW investigated the effect of the HRC product within the Zone A aquifer by monitoring Zone A within the EAB application area.

Based on the monitoring data from the Zone A aquifer, TRW concluded that the limited amount of HRC product applied to the Zone A aquifer had changed conditions within the aquifer to support EAB. Therefore, the use of the HRC product for EAB appeared to be an effective remediation alternative for the treatment of VOCs in the Zone A aquifer. TRW recommended to the Water Board that implementation of the EAB application be expanded to include the Zone A aquifer, and that the Zone A wells within the EAB application area be shut down. On April 6, 2001, the Water Board approved the expansion of the EAB application to include Zone A and the temporary shutdown of pumping at the Eductor, T-2A, and T-8A wells during the application.

In June 2001, TRW injected approximately 3,300 pounds of slow-releasing HRC at 30 additional locations at the Site. The 30 locations were advanced using a Geoprobe rig into Zone A in the same area of the Site as in October 2000. The injection locations were spaced on approximately 6 to 20-foot centers between the locations advanced in October 2000.

TRW conducted pre-injection monitoring and continues to conduct post-injection monitoring events at T-7A, T-2A, T-8A, and the Eductor to assess the effectiveness of the EAB application. During each EAB monitoring event, groundwater was purged and groundwater parameters were measured using an overflow design and the appropriate field meters.

The field and analytical parameters included:

- fatty acids such as lactic acid, butyric acid, pyruvic acid, propionic acid, and acetic acid;
- general environmental parameters such as temperature, pH, conductivity, oxidation-reduction potential (ORP), alkalinity, turbidity, dissolved hydrogen, and total organic carbon (TOC);
- electron acceptors such as dissolved oxygen (DO), nitrate/nitrite, sulfate, and total iron (combination of ferric iron and ferrous iron);
- metabolic by-products such as ferrous iron, dissolved manganese, sulfide, chloride, methane, ethane, and ethane; and,
- VOCs such as chlorinated ethenes and chlorinated ethanes.

A detailed discussion of the relevance of the individual parameters was presented in the *Evaluation of Natural Attenuation and Chemical Oxidation Report*. A detailed discussion of the EAB process, and groundwater oxidizing and reducing conditions was presented in CDM's August 2000 work plan for the EAB program.

EAB Monitoring Events Results

In October 2000, the EAB program was initiated at the former Site source (T-2A, T-2B, and the Eductor wells). By April 2004, concentrations of PCE, TCE, cDCE, and VC were reported at non-detectable concentrations (less than 1.0 micrograms per liter [µg/L]) in Eductor well groundwater samples. However, as the EAB program continued from 2004 to 2007, TCE concentrations in groundwater samples from the Eductor well fluctuated; with groundwater sample TCE concentration fluctuations ranging from 4 µg/L in 2004 up to 4,800 µg/L in 2006. These VOC concentration fluctuations appear to have been caused by desorption of VOCs from the soil matrix into groundwater along with the breakdown of parent VOC compounds (PCE and TCE) into their respective daughter by-products (cDCE and VC). The decreasing chemical concentration degradation trends observed in the relative concentrations of parent and daughter compounds in collected groundwater samples indicated that the EAB process was still active more than two years after the last HRC injection.

Since 2007, the concentration of TCE in Educator well samples continued to increase in concentration with the most recent, October 2008, groundwater samples containing TCE at a concentration of 100,000 ug/L . TCE concentrations in groundwater data collected from monitoring well T-2A located approximately ten feet down-gradient from the Eductor have also fluctuated between 2004 and 2007, although these fluctuations are tempered at T-2A because of the differences in expected buffering capacities at each well location: soil at well T-2A and gravel backfill at the Eductor well. Recent TCE concentrations in groundwater samples collected from well T-2A, are less than its MCL cleanup standard of 5 µg/L. PCE concentrations were also below its cleanup standard (or below the detection limit) for over two years. .

In Zone B1, the reductions were more significant. The cDCE concentration in groundwater samples collected from well T-2B decreased from a pre-injection concentration of 1,700 µg/L to 3.3 µg/L. In July 2003, SCRs were met and maintained for all VOCs except VC. While VC concentrations still exceeded its SCR of 0.5 µg/L, VC was not anticipated to persist given the low concentrations of the parent VOCs, its decreasing concentration trend, and its ongoing degradation, as evidenced by elevated concentrations of ethane and ethane.

Outside the treatment area, response to the EAB program was more pronounced in Zone B1, which is consistent with the better transmissivity observed in the deeper aquifers. In Zone B1, the TCE and cDCE concentrations down-gradient from monitoring well T-8B had decreased by more than 40 percent from pre-injection concentrations, but these declines were accompanied by higher VC concentrations. TCE concentrations dcresed while cDCE concentrations increased to all-time highs in groundwater samples collected from well T-4B. In both wells, these trends appear to be directly associated with EAB activity in the treatment area.

In down-gradient Zone A monitoring wells, the observed trends since the initiation of the EAB program in 2000 were less dramatic and not clearly attributable to EAB activity in the treatment area. In groundwater samples collected from well T-8A, TCE and cDCE concentrations declined by 10 to 25 percent. TCE and cDCE concentrations declined by 40 to 45 percent from well T-9A, which is located further down-gradient. The observed trends in Zone A aquifer down-gradient from the treatment area, especially those at T-9A, probably had more to do with the suspension of pumping rather than EAB. However, the limited response down-gradient of the Zone A EAB treatment area (well T-8A) confirmed the low transmissivity and groundwater

movement rates and suggested that the EAB program, if limited to the former Site source area, would probably not be appropriate for achieving cleanup standards across the Site in a reasonable time period.

Enhanced Anaerobic Biodegradation in Down-gradient Area

The EAB program was expanded in August 2005 and September 2007 to include groundwater immediately down-gradient of the former Site source area. This section presents an explanation of the EAB applications utilized down-gradient of the former Site source area: HRC injections and cheese whey injections. This section also presents a discussion of the other EAB program results, which include natural attenuation parameters such as geochemical parameters, electron acceptors, metabolic by-products, HRC and cheese whey breakdown products, indicators like VFAs and TOC, and dechlorinating microbes.

HRC Injections

In August 2005, after approval from the Water Board, the EAB program was expanded to include a portion of the down-gradient Site plume in Zone A and Zone B1. The expanded EAB treatment area included the area immediately to the north of the existing treatment area (the former Site source area), and encompassed wells T-8A, T-8B, and T-10B. These wells had the highest concentrations of PCE and TCE, the main parent chlorinated VOC, within the Site plume. The objective of the expanded EAB program was to further accelerate the attenuation of VOCs across the Site by treating additional mass within the main portion of the Site plume.

The scope of the expanded EAB program was detailed in *Addendum to Work Plan for Enhanced Anaerobic Bioremediation Pilot Test*, dated July 20, 2005. In summary, approximately 4,480 lbs of the slow-releasing HRC was injected into 56 Zone A locations and 1,920 lbs of the slow-releasing HRC were injected into 24 Zone B1 locations.

The July 20, 2005, work plan called for converting eight of the HRC injection locations into pre-packed wells. However, due to the extended period of time required for the injected HRC to move into the aquifers, the wells were installed at locations between HRC injection locations in September 2005 (Northrop Grumman, 2006). Four Zone A wells (T-13A, T-14A, T-15A, and T-16A) were installed within the expanded EAB treatment area and one Zone B1 well, T-17B, was installed down-gradient of the expanded EAB treatment area. The locations of these wells are presented in Appendix D.

The four Zone A wells within the expanded EAB treatment area served as bioaugmentation injection wells. The objective of the bioaugmentation was to decrease the lag time for increasing the natural population of dechlorinating microbes in the expanded EAB treatment area to sufficient size to support complete reductive dechlorination. In accordance with the July 20, 2005, work plan groundwater taken from the Eductor well was injected into four wells (T-13A, T-14A, T-15A, and T-16A). The Zone B1 expanded EAB treatment area was not bioaugmented.

In September 2005, groundwater sampling of the Eductor well yielded a dechlorinating microbial population of approximately 50,000 cells of Dehalococcodies (DHC) type microbes per milliliter of groundwater (cells DHC/mL). In November 2005, approximately 22 gallons of groundwater from the Eductor well was extracted and injected into each of these four Zone A wells. These four wells and wellT-9A have been utilized to monitor the effectiveness of the EAB program in increasing the attenuation rate of VOCs across Zone A.

The one Zone B1 well installed down-gradient of the expanded EAB treatment area, T-17B, serves as a down-gradient boundary well to complement previously existing boundary well T-4B. These two wells, along with wells within the treatment area, T-2B, T-8B, and T-10B, have been utilized to monitor the effectiveness of the EAB program in increasing the attenuation rate of VOCs across Zone B1.

Cheese Whey Injections

Following the August 2005 expansion of the EAB program to include groundwater immediately down-gradient of the former Site source area, the EAB performance monitoring indicated partial biodegradation of chlorinated VOCs in Zone A, but there also appeared to be competition for hydrogen electron donors from electron acceptors, such as sulfate. The elevated sulfate concentrations (250 mg/L) were proving to be an impediment to the complete dechlorination of TCE to ethene and attaining the necessary methanogenic biogeochemical conditions. To enhance and achieve the biogeochemical conditions conducive for complete degradation of TCE in Zone A down-gradient from the former source area, electron donor addition, in the form of cheese whey, was proposed to the Regional Water Board.

In 2007, TRW installed seven injection wells (T-18A through T-24A) and one monitoring well T-25A in the area of existing Zone A wells T-13A and T-14A (see Figure 2-1 for well locations). The injection wells were installed at 10-foot centers to satisfy the 5-foot design radius of influence for cheese whey injection. The four quarterly cheese whey injection events were conducted in September and December 2007, and March and June 2008. During the September 2007 event, approximately 1,000 gallon of 2 percent cheese whey solution was injected into each of the nine injection wells (T-13A, T-14A, and T-18A through T-24A). During the December 2007 and March and June 2008 events, approximately 1,000 gallon of 1.5 percent cheese whey solution was injected into each of the nine injection wells.

In early November 2007, approximately 1.5 months following the first cheese whey injection event, a one-time, three-day, bioaugmentation injection event was conducted at the nine injection wells. Approximately 120 gallons of Eductor well water was introduced into each injection well (except well T-24A which received 66 gallons) to introduce indigenous DHC-type microbes. At these wells, except T-24A, the approximate 120 gallons of Eductor well water was injected under minimal pressure and pushed into the formation within a few hours. Due to apparent lithologic conditions or potential clogged screen intervals from previous cheese whey injection, only 66 gallons of water could be injected into well T-24A over the three days.

In addition to Zone A wells T-13A and T-14A, new wells T-19A, T-23A, and T-25A were included in the EAB performance monitoring program for this area. EAB performance

monitoring was conducted simultaneously with October 2007 and October 2008 annual monitoring event.

Following the 2007/2008 cheese whey injections, sulfate concentrations from up to 250 mg/L decreased to as low as 3.3 mg/L (for T-19A in July 2008) and methane concentrations increased up to 16,000 µg/L (for T-9A in April 2008). With the change in biogeochemical conditions in the expanded EAB treatment area, complete dechlorination of TCE to ethene was observed. Ethene concentrations increased in the injection wells and immediately down-gradient monitoring wells T-25A and T-8A.

TOC concentrations in cheese whey injection wells increased from non-detect (<5 mg/L) to 3,500 mg/L for injection well T-19A (October 2007), 110 mg/L for monitoring well T-25A (January 2008), and 51 mg/L for monitoring well T-8A (July 2008). In addition, VFAs were detected for monitoring well T-25A and T-8A (July 2008), confirming sufficient down-gradient influence/migration from the injection wells. In October 2008, VFAs were detected for injection wells T-13A and T-19A, but not for any of the wells down-gradient to the injection area, indicating a depletion of the remaining cheese whey material in the vicinity of these wells. The mass of remaining cheese whey material or the remaining duration for enhanced dechlorination from this mass is unknown.

An increase in ferrous iron (non-detect [<1 mg/L] to 0.42 mg/L), methane (750 to 3,700 µg/L), and ethene (0.26 to 7.4 µg/L) concentrations and a decrease in sulfate (260 to 150 mg/L), concentration in groundwater samples collected from well T-8A (October 2007) support the observed decrease in TCE concentration is due to dechlorination. The VOC and biogeochemical parameter trends for monitoring wells T-8A and T-25A support successful implementation of the enhanced EAB treatment zone around the cheese whey injection wells.

Although a minor decrease in population counts of DHC-type microbes for Eductor was observed in April 2007 (4.4E+05 cells/mL) in comparison to October 2006, the observed count indicates that robust numbers of DHC-type microbes still exist in the former Site source area. The DHC-type microbe concentration trends over time for Eductor and selected Zone A wells within the expanded EAB treatment area are presented in Figure 4-5 of the TRW's May 2009 Five-Year Status and Effectiveness Evaluation Report. The increase in DHC-type microbe population count detected from Zone A well T-13A (cheese whey injection well) in October 2008 may be a result of enhanced conditions from cheese whey injection events in 2007 and 2008.

System Operation and Maintenance

GWET has been suspended since 2001, but groundwater monitoring has continued on an annual basis across the Site and on a quarterly basis within the EAB treatment area since that time. Northrop Grumman submits groundwater-monitoring reports to the Regional Water Board annually. The SVE system was shut down in October 2000. The main costs associated with Site cleanup are sampling, analytical laboratory fees, site investigations, EAB treatment, consulting fees and reporting. These costs are summarized below in Table 2.

Table 2 - GWET System Operation and EAB Treatment Costs

From	To	Total Cost
Sept 1996	April 2001	$300,000
May 2001	May 2004	$301,000
June 2004	Dec 2008	$612,000

V. Progress Since Last Five-Year Review

The 2nd Five-Year Review, completed in September 2004, concluded that:

> *Remedial actions conducted at the Site until 2000 under the Final Site Cleanup Requirements Order functioned as designed and achieved positive results by maintaining hydraulic control of the plume and reducing VOC concentrations in groundwater throughout the plume. Since 2000, the EAB program has accelerated the pace of groundwater remediation. Groundwater cleanup goals (MCLs) have been achieved for TCE and related VOCs in the former Site source area. Continued monitoring is necessary for several more years to assess whether this success can be maintained without further treatment. It appears possible that cleanup goals can be achieved for the remainder of the TRW plume within five years. The remedy is currently protective of human health and the environment in terms of limiting ingestion of contaminated water through institutional controls prohibiting the use of shallow groundwater.*
>
> *The vapor intrusion threat at the Site has been assessed, and has been mitigated to some extent by reduction of groundwater VOC concentrations beneath the building. The results of indoor air sampling indicate that while vapor intrusion pathways exist, proper ventilation of the building can maintain indoor-air concentrations of TCE at levels that do not cause unacceptable, long-term human health risks. The remedy is currently protective of human health and the environment.*

The issues identified and actions taken since the last five-year review are summarized below in Table 3.

Table 3 - Actions Taken Since the Last Five-Year Review

Issues from Previous Review	Recommendation and Follow-Up Actions	Actions Taken and Outcome
Enhanced anaerobic bioremediation (EAB) appears more capable of achieving site cleanup goals than groundwater extraction and treatment	Discharger should evaluate the feasibility of expanding EAB into the area where VOC concentrations still exceed site cleanup goals	Expanded the EAB into the area down-gradient of the former Site source area and continued groundwater monitoring. Results indicate that EAB has better potential towards achieving site cleanup standards than GWET
Migration of groundwater contaminants onto the subject property from up-gradient sources threatens the long-term success of site remediation	Adjacent AMD and Philips sites must maintain plume control to prevent offsite migration of VOCs onto the former TRW site	Up-gradient VOC release site (Philips 815 Stewart Drive) operated a GWET system and maintained plume control in Zone B1 and B2
Resuming groundwater extraction at the site has the potential to induce migration of contaminants onto the Site from offsite sources	Northrop Grumman should consider implementing *in situ* bioremediation as the final remedy for the site. The ROD will need to be amended if there is a permanent change in remedy from GWET to EAB	Continued suspension of GWET and expanded the EAB into the area down-gradient of the former Site source area. VOC concentration trends are stable to decreasing across the site in Zone A. Initiated process with USEPA and Regional Water Board to implement *in-situ* bioremediation as the final remedy for the Site
Vapor intrusion from the groundwater plume into the overlying building has been documented	Northrop Grumman will perform an additional round of indoor air sampling in October 2004	Conducted indoor air (IA) sampling to evaluate the vapor intrusion pathway. Results indicate IA concentrations do not exceed acceptable risk levels as long as the building is adequately ventilated.

No potentially toxic or mobile transformation products have been identified during recent monitoring that were not already present at the time of the ROD and, therefore, did not have cleanup standards specified in the Site Cleanup Requirements.

VI. Five-Year review Process

Community Notification

The Regional Water Board published a public notice in the local newspaper regarding this third five-year review of cleanup actions undertaken at the Site. A copy of the public notice was published on August 26, 2009, in the Sunnyvale Sun.

Document Review

This five-year review consisted of a review of relevant documents including TRW's May 20, 2009, Five-Year Status and Effectiveness Evaluation Report and annual groundwater monitoring reports. There have been no changes in the established Maximum Contaminant Levels (MCLs) since the Final Site Cleanup Requirements were issued in June 1991.

Data Review

Groundwater Data

Groundwater monitoring data collected from 2004 to 2008 were reviewed to evaluate progress in remediation of the groundwater pollutant plume. The GWET system during its operation from 1985 to April 2001 was successful in controlling migration of the plume, in removing VOC mass from saturated soil, and reducing concentrations of VOCs in groundwater. There is no evidence that groundwater contamination has migrated vertically since groundwater extraction began.

Remedial efforts have reduced VOC concentrations in former Site source area and across the plume; however, VOC concentrations in groundwater remain above cleanup objectives due to the complexity of Site hydrogeology, former Site source area, migration of VOCs onto the property from the up-gradient AMD site, and the technical limitations of the remedial methods. The current (October 2008) maximum TCE concentrations in Zone A, Zone B1 and Zone B2 wells are 100,000 ug/L (in Eductor well located in the former site source area), 2,300 ug/L and 1,900 ug/L, respectively. With the exception of the former site source area, concentrations on the TRW site are generally lower than concentrations found at up-gradient AMD and Philips sites.

The highest concentrations of contaminants exist in the A-zone and B1-zone. VOCs are also present in moderate concentrations in the B2-zone beneath the site. The commingled groundwater VOC plumes from the Philips and AMD sites in the A- and B1-zones extend northward 4,000 feet to Highway 101.

Groundwater monitoring data collected between May 2004 and December 2008 support the following conclusions:

- The highest VOC concentrations in groundwater are in the former Site source, which is restricted to a relatively small and localized area (approximately 40 feet by 100 feet);
- Based on the 2008 Annual Groundwater Monitoring report prepared by Philips, impact to the Site from off-site sources continues to be apparent in Zones A, B1, and B2;
- Groundwater quality across the Site continues to improve following complete suspension of groundwater extraction in April 2001 and the implementation of the EAB program in the former Site source area (October 2000 and June 2001) and down-gradient areas from of the former Site source area (August 2005). The exception being the former Site source area where VOC concentration increases appear to be caused by desorption of VOCs from the soil matrix into groundwater along with the breakdown of parent VOC compounds (PCE and TCE) into their respective daughter by-products (cDCE and VC);
- Suspension of groundwater extraction at the Eductor and wells T-2A, T-2B, T-8A, and T-8B should be continued so as not to hinder the increased rate of VOC biodegradation occurring within the former Site source area;
- Suspension of groundwater extraction at wells T-9A, T-9B, and T-2C should be continued as it has halted pumping-induced migration of the Philips 815 Stewart Drive site plume toward the Site;
- Suspension of groundwater extraction has not increased VOC concentrations in groundwater down-gradient of the Site; and,
- Down-gradient of the EAB treatment area, the influence of EAB has been more pronounced in Zone B1, consistent with greater transmissivity in the deeper aquifers.

TCE and cis-1,2-DCE concentrations detected in groundwater from 2004 to 2008 are listed in Appendix D.

Mass Removal Data

At the time of its suspension in April 2001, the GWET system had removed a total of approximately 28 million, 44 million, and 43 million gallons of groundwater from Zones A, B1, and B2, respectively (total of approximately 115 million gallons of groundwater). The GWET system removed approximately 260, 1,480, and 1,310 pounds of VOCs (expressed as pounds of TCE-equivalent, the main VOC of concern) from Zones A, B1, and B2, respectively (total of approximately 3,050 pounds of VOCs).

Approximately 90% of the TCE mass (2,726 pounds) was removed from two wells, well T-2C and well T-9B. In 2000, the annual TCE mass removed was only 30 percent of that removed by the system in 1985. Between July 1993 and July 1996, the SVE system removed approximately 120 pounds of VOCs (expressed as pounds of TCE-equivalent, the main VOC of concern).

Since its initiation in 2000, EAB is estimated to have degraded approximately 1,550 pounds of TCE to ethene.

Vapor Intrusion

Indoor air samples were collected at the TRW Site in October 2003, April 2004 and October 2004 in the unoccupied, unventilated building at the Site. PCE, TCE and vinyl chloride were detected at fairly consistent levels over the three sampling periods with the maximum detected concentrations were 0.73 ug/m^3, 5.2 ug/m^3, and 0.15 ug/m^3, respectively. The maximum concentrations were compared to the RWQCB's Indoor Air ESLs for industrial exposure based on California toxicity values of 0.69 ug/m^3, 2.0 ug/m^3 and 0.052 ug/m^3 for PCE, TCE, and vinyl chloride, respectively. The summary report (CDM, *Report of Finding – October 2004 Indoor Air Sampling*, Nov. 2004) concluded that currently there was no risk associated with these levels because the building was unoccupied; however, a second round of sampling should be completed under normal building operations (i.e., with the ventilation system running), if the building becomes occupied.

In 2009, EPA adopted a harmonized set of screening levels that had previously been developed by several Regions and published "*Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites*." EPA's commercial, indoor air RSLs are higher (2.1 ug/$m^{3,}$ 6.1 ug/m^3 and 2.8 ug/m^3 for PCE, TCE, and vinyl chloride respectively. Based on EPA's current RSLs, the remedy is protective with respect to vapor intrusion. A summary table is listed below:

Contaminant	Maximum Concentration Indoor Air (ug/m3)	RWQCB 2003 ESL for Indoor Air (ug/m3)	EPA 2009 ESL for Indoor Air (ug/m3)
PCE	0.73	0.69	2.1
TCE	5.2	2.0	6.1
Vinyl Chloride	0.15	0.052	2.8

Site Inspection

Regional Water Board and US EPA staff conducted a site inspection on March 24, 2009. Groundwater extraction was discontinued in October 2000; however, the GWET system is still in place. The Site has been vacant since January 2001. The institutional controls that are in place include prohibitions on the use of groundwater until cleanup levels are achieved. No activities were observed that would have violated the institutional controls. VOC contamination is largely confined to groundwater; however, vapor intrusion from the groundwater plume into the overlying buildings has not been fully assessed.

VII. Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

No, the remedy selected in the Record of Decision is no longer in operation at the Site. The current groundwater-monitoring program is sufficient to track the plume and detect any migration beyond the current plume boundaries, as well as track the effectiveness of remedial actions. The remedy selected in the Final Remedial Action Plan (GWET, SVE and institutional controls) was implemented as planned and has achieved some success by removing VOC mass from soil and groundwater, maintaining plume control, and reducing VOC concentrations in groundwater. Contamination remains confined to the shallow groundwater bearing zones. VOC concentrations are declining over time but remain above cleanup levels with the exception of the Site source area. The GWET system was shut down in 2001 due to stable VOC concentrations and implementation of EAB. TRW concluded that it is not cost-effective to continue operation of the GWET. TRW continues with groundwater monitoring. The offsite Philips GWET system is maintaining plume control in Zone B1 of the Site. VOCs in Zone B2 beneath the Site are primarily due to migration from the up-gradient Philips site which is being controlled by the Philips GWET system.

The institutional controls in place include prohibitions on the use of groundwater until cleanup levels are achieved. No activities were observed that would have violated the institutional controls. The existing restrictive covenant was recorded prior to the passage of California Civil Code section 1471, which established the framework for environmental covenants in California. Therefore a new environmental restriction covenant should be recorded consistent with state law.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy selection still valid?

Changes in Site Conditions

There have been no changes to the physical conditions of the Site that would affect the protectiveness of the remedy. The Site has been vacant since January 2001. The Site building exterior was remodeled between 2001 and 2003. During this time a second story was added onto the western half of the building. The use of the area adjacent to the Site remains commercial, light industrial, and office space. There is some residential development more than 1,100 feet north of the Site. Institutional controls prohibit the use of groundwater, and groundwater is not currently used at the Site.

Changes in Cleanup Levels

There have been no changes to Applicable, Relevant, and Appropriate Requirements (ARARs) for the Site and no new standards that would affect the protectiveness of the remedy. TCE, PCE and cis-1, 2-DCE are the primary chemicals whose concentrations still routinely exceed the cleanup standards. Groundwater cleanup standards for these chemicals have not changed since the ROD was issued.

Changes in Toxicity

There have been a number of changes to the toxicity values for specific constituents of concern since the Baseline Public Health Evaluations (BPHE) was completed in 1991.

The majority of the chemical contaminants currently have toxicity values that are higher than in 1990 and, therefore; the original risk assessment for those are more conservative than originally calculated. Three other chemical contaminants, PCE, TCE, and Vinyl Chloride have had their toxicity values lowered since the 1991 BPHA. The Record of Decision chose the California MCL of 5 ug/l as the TCE cleanup level. Based on the new toxicity numbers, this would result in a 3×10^{-6} risk, which is still within EPA's risk range. The same is true for PCE and Vinyl Chloride. The recalculated risk for these chemicals considering its new toxicity value would result in a 4.5×10^{-5} risk and 3.1×10^{-5} risk, which is within EPA's risk range. Although there have been changes to the toxicity values, these changes do not increase the Site risk to unacceptable levels.

Changes in Exposure Assumptions

The exposure assumptions used to develop the Baseline Public Health Evaluations (BPHE) in 1991 were for potential future exposure if untreated groundwater were to be used for drinking water and if residential uses were to occur on the Site. The BPHE discuses the potential for vapor intrusion; but determined that since no residences exist over the plume then that pathway did not exist.

The 2004 five-year-review (FYR) recommended that the potential for vapor intrusion be assessed in light of our current understanding of the pathway. TRW monitored the vapor intrusion pathway from the groundwater plume into the overlying building in October 2003, in April 2004, and in October 2004. TRW concluded that mitigation of VOC vapor concentrations to levels below Regional Water Board indoor air ESLs can be achieved solely with installation and operation of a standard ventilation system. As of 2009, the Site building remains without a ventilation system and continues to be unoccupied. At the request of RWQCB, TRW will conduct another round of soil gas and indoor air sampling after the installation of a ventilation system and prior to occupancy of the Site building.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

There is no other information that calls into question the protectiveness of the remedy.

Technical Assessment Summary

The remedy has not been operated for nine years. There are indications that the remedy may not achieve restoration of groundwater to its beneficial use as a potential drinking water supply source in a reasonable timeframe. A pilot EAB program has been implemented. There have no been changes in the physical condition or land use at the Site that would effect the protectiveness of the remedy. There is no other information that calls into question the protectiveness of the remedy.

VIII. Issues

The following issues were identified during the review:

1. Operation of selected remedy ceased approximately 9 years ago. Enhanced Anaerobic Biodegradation is being evaluated.
2. The existing restrictive covenant was recorded prior to the passage of California Civil Code section 1471, which establishes the framework for environmental covenants in California.

IX. Recommendations and Follow-up Actions

The following are recommendations and follow-up actions for the above-mentioned issues:

1. Continue groundwater monitoring to assess the potential success of the EAB pilot testing. Evaluate alternatives to achieve Remedial Action Objectives in the groundwater. The ROD and final SCR need to be amended.
2. The legal owners of the former TRW Microwave property should record a new restrictive covenant that is consistent with current California law.

X. Protectiveness Statement

The remedy at the TRW Microwave (TRW) Superfund site (Site) in Sunnyvale, California is currently protective of human health and the environment. Current information indicates that the remedy may not be able to restore the groundwater to its beneficial use as a potential drinking

water source. Enhanced Anaerobic Biodegradation process is currently being tested at the Site. In the short-term, the institutional controls are preventing exposure to, and the ingestion of, contaminated groundwater. Additionally, while there is currently no exposure risk from vapor intrusion because the current building is unoccupied, the necessity of a restrictive covenant for vapor intrusion will be determined after a future vapor intrusion assessment is completed which considers changes in the building's current or future use, and/or redevelopment of the building or Site. The ROD and final SCR need to be amended.

XI. Next Review

The next five-year review for the Site is required by September 30, 2014. In order to synchronize the five-year reporting schedule between Regional Water Board and USEPA, TRW should submit its next Five-Year Summary Report to the Regional Water Board by December 31, 2013.

Table 4 - Issues, Recommendations and Milestone Dates

Issue	Recommendation and Follow-up Action	Responsible Party	Oversight Agency	Date	Affects Protectiveness (Yes/No)
Operation of selected remedy ceased approximately nine years ago. Enhanced Anaerobic Biodegradation is being evaluated	Research and assess cleanup technologies that can be implemented at the Site to achieve cleanup standards. Amend the ROD	TRW	Regional Water Board	2011	Short term: No Long term: Yes
The existing restrictive covenant was recorded prior to the passage of California Civil Code section 1471, which establishes the framework for environmental covenants in California	The legal owner of the former TRW Microwave property should record a new restrictive covenant that is consistent with current California law	TRW	Regional Water Board	2011	Short term: No Long term: Yes

APPENDIX A

TCE and cis-1,2-DCE Concentrations in Groundwater 2004-2008

Well Number/ Dates Sampled	***TCE (µg/L)***	***cis-1,2-DCE (µg/L)***
Site Cleanup Requirement	*5*	*6*
Zone A Wells		
T-2A		
Oct-08	2.4	83
Oct-07	<5.0	650
Oct-06	<5.0	580
Oct-05	<5.0	45
Oct-04	<5.0	200
T-3A		
Oct-08	140	8.0
Oct-07	210	15
Oct-06	230	49
Oct-05	180	48
Oct-04	130	41
T-6A		
Oct-07	22	17
Oct-06	24	22
Oct-05	21	28
Oct-04	14	30
T-7A		
Oct-08	370	79
Oct-07	370	80
Oct-06	330	85
Oct-05	340	130
Oct-04	370	110
T-8A		
Oct-08	84	28
Oct-07	59	71
Oct-06	57	34
Oct-05	200	130
Oct-04	130	39
T-9A		
Oct-08	50	98
Oct-07	120	130
Oct-06	100	100
Oct-05	56	170
Oct-04	110	74
T-13A		
Oct-08	38	<25

Well Number/ Dates Sampled	***TCE (µg/L)***	***cis-1,2-DCE (µg/L)***
Site Cleanup Requirement	*5*	*6*
Oct-07	48	260
Oct-06	210	99
Nov-05	200	98
T-14A		
Oct-08	<20	45
Oct-07	54	200
Oct-06	200	57
Nov-05	130	59
T-15A		
Oct-08	140	53
Oct-07	160	75
Oct-06	140	66
Nov-05	8.2	160
T-16A		
Oct-08	63	77
Oct-07	79	160
Oct-06	80	100
Nov-05	24	160
T-19A		
Oct-08	<50	<50
Oct-07	53	140
T-23A		
Oct-08	16	12
Oct-07	130	120
T-25A		
Oct-08	42	38
Oct-07	66	160
36S		
Sep-08+	98	13
Oct-07+	70	15
Oct-06+	98	20
Oct-05+	91	22
Oct-04+	91	34
36D		
Sep-08+	27	5.8
Oct-07+	17	6.1
Oct-06+	92	42
Oct-05+	4.6	1.5
Oct-04+	85	46
37S		
Sep-08+	81	3.6
Oct-07+	81	2.4

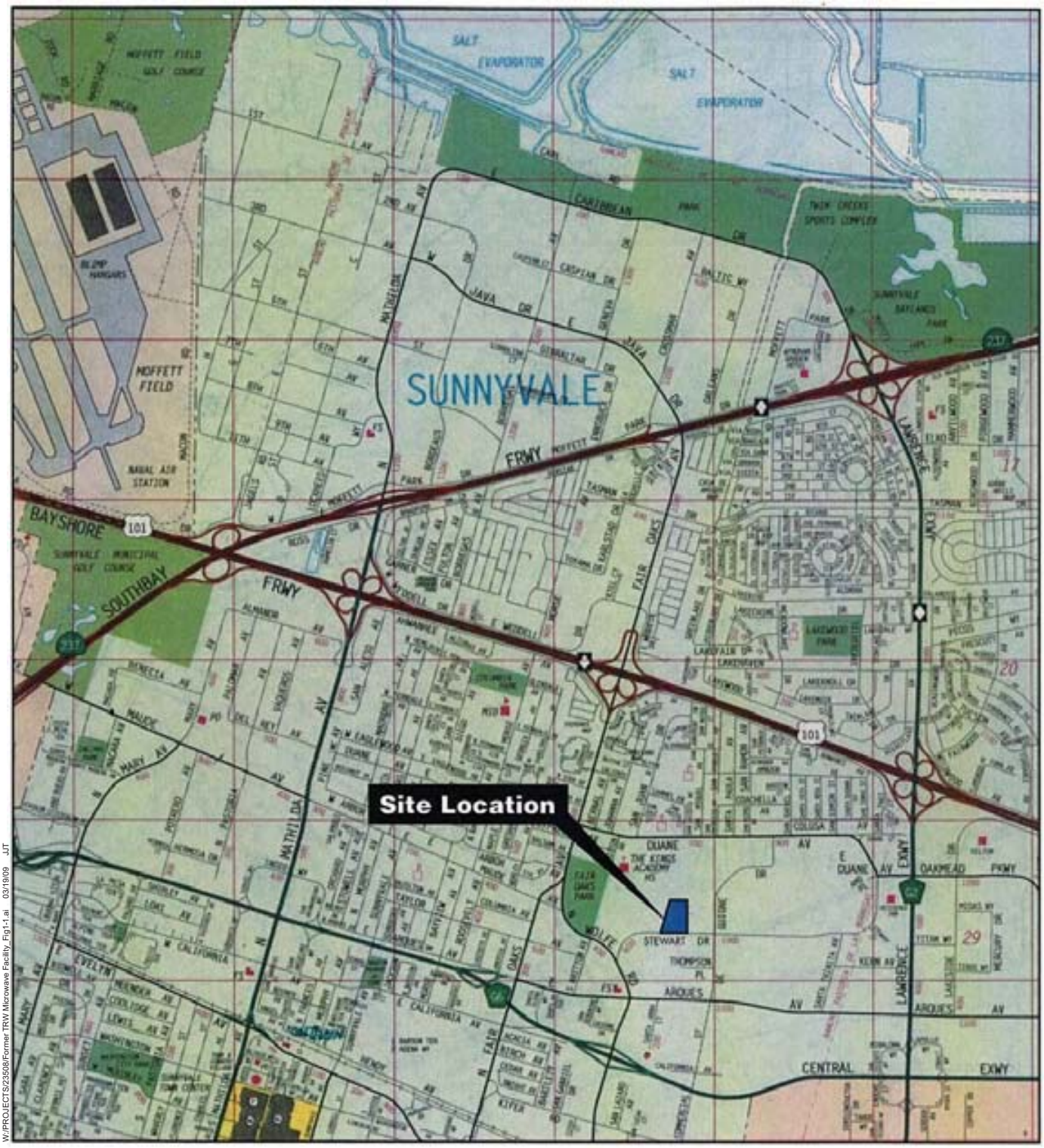
Well Number/ Dates Sampled	***TCE (µg/L)***	***cis-1,2-DCE (µg/L)***
Site Cleanup Requirement	*5*	*6*
Oct-05+	91	5.2
Oct-04+	11	3.3
38S		
Oct-08	50	82
Oct-07	85	50
Oct-06	130	33
Oct-05	140	68
Oct-04	190	190
EDUCTOR		
Oct-08	100,000	23,000
Apr-08	28,000	15,000
Oct-07	3,500	8,300
Oct-06	<100	25,000
Jan-06	4,800	2,300
Oct-05	<250	3,600
Jul-05	2,200	27,000
Apr-05	490	19,000
Jan-05	<0.5	4,700
Oct-04	<5.0	<5.0
Apr-04	<1.0	<1.0
Jan-04	<10	<10
Zone B1 Wells		
T-2B		
Oct-08	<2	88
Oct-07	<5.0	11
Oct-06	<5.0	<5.0
Oct-05	<5.0	6.2
Oct-04	<5.0	<5.0
T-4B		
Oct-08	5.3	500
Oct-07	7.9	550
Oct-06	<5.0	580
Oct-05	9.2	550
Oct-04	6.6	350
T-5B		
Oct-08	2,300	39
Oct-07	2,300	46
Oct-06	270	5.9
Oct-05	420	12
Oct-04	720	21
T-7B		
Oct-08	180	9.4

Well Number/ Dates Sampled	***TCE (µg/L)***	***cis-1,2-DCE (µg/L)***
Site Cleanup Requirement	*5*	*6*
Oct-07	190	16
Oct-06	80	10
Oct-05	95	13
Oct-04	140	14
T-8B		
Oct-08	36.0	150
Oct-07	7.5	220
Oct-06	6.3	220
Oct-05	7.7	190
Oct-04	33	72
T-9B		
Oct-08	280	110
Oct-07	470	190
Oct-06	4.6	31
Oct-05	16	630
Oct-04	470	300
T-10B		
Oct-08	45	48
Oct-07	86	62
Oct-06	120	130
Oct-05	180	79
Oct-04	170	57
T-17B		
Oct-08	400	62
Oct-07	610	79
Oct-06	240	280
Zone B2 Wells		
T-2C		
Oct-08	130	33
Oct-07	1,200	43
Oct-06	190	28
Oct-05	260	38
Oct-04	280	37
T-9C		
Oct-08	43	17
Oct-07	88	36
Oct-06	0.88	0.54
Oct-05	1.7	1.4
Oct-04	6.1	2.9
T-10C		
Oct-08	1,900	68
Oct-07	4,500	100

Well Number/ Dates Sampled	***TCE (µg/L)***	***cis-1,2-DCE (µg/L)***
Site Cleanup Requirement	*5*	*6*
Oct-06	340	14
Oct-05	710	28
Oct-04	270	10
T-11C		
Oct-08	18	1
Oct-07	290	20
Oct-06	330	22
Oct-05	28	1.6
Oct-04	27	1.2
T-12C		
Oct-08	170	65
Oct-07	210	19
Oct-06	210	37
Oct-05	180	39
Oct-04	240	50
36DD		
Sep-08+	1.6	24
Oct-07+	1.5	22
Oct-06+	0.8	22
Oct-05+	<0.5	73
Oct-04+	0.5	31

Table Notes:
+ - Data provided by AMD
µg/L - Micrograms per liter

APPENDIX B – SITE LOCATION MAP



W:/PROJECTS/23508/Former TRW Microwave Facility_Fig1-1.ai 03/19/09 JJT

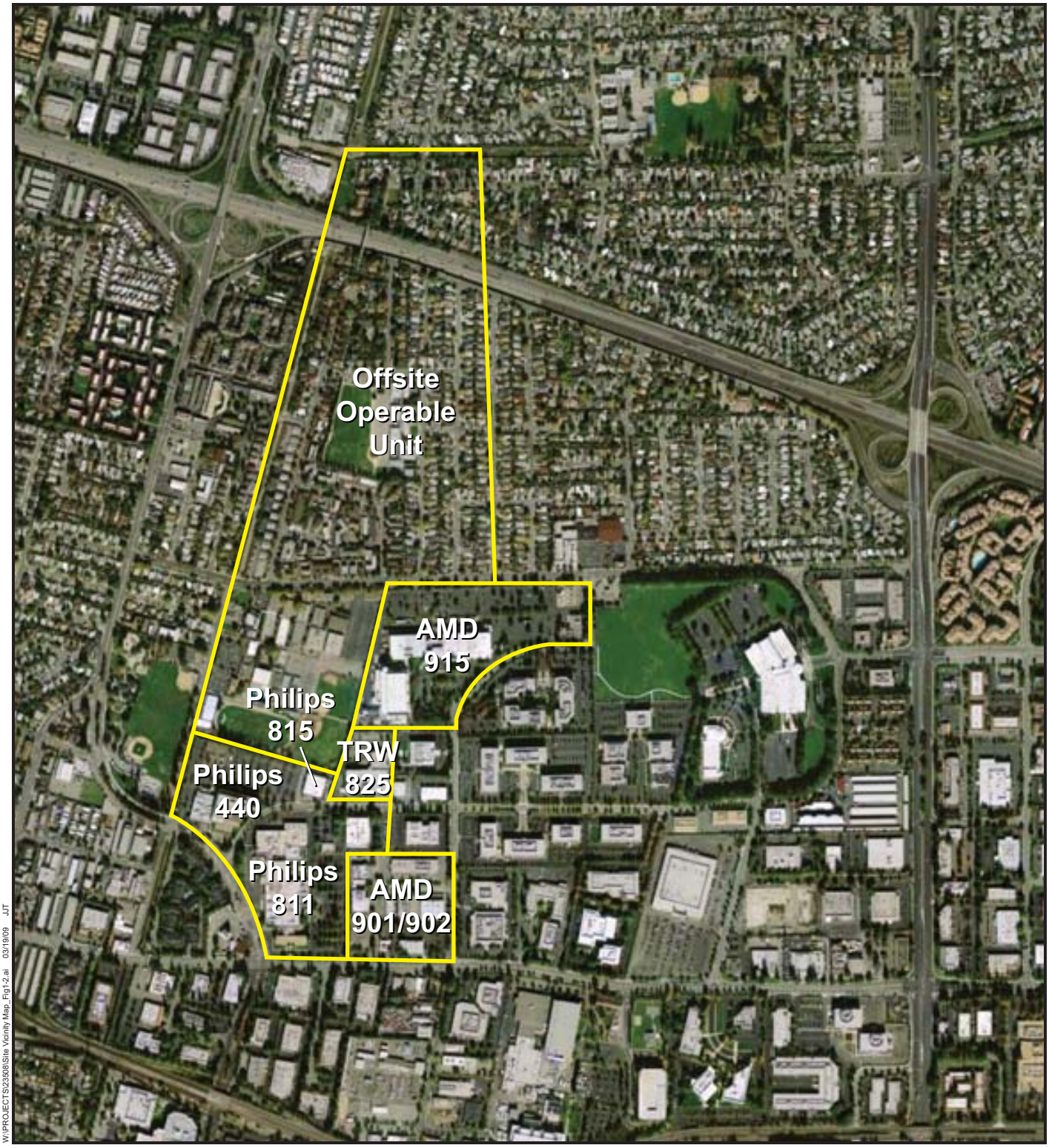
NORTH

0 1/2
MILE

Figure 1-1
Site Location Map
Former TRW Microwave Site
825 Stewart Drive
Sunnyvale, California

CDM

APPENDIX C – SITE VICINIITY MAP



NORTH

0 5,000
FEET

Figure 1-2
Site Vicinity Map
Former TRW Microwave Site
825 Stewart Drive
Sunnyvale, California

CDM

APPENDIX D – SITE PLAN

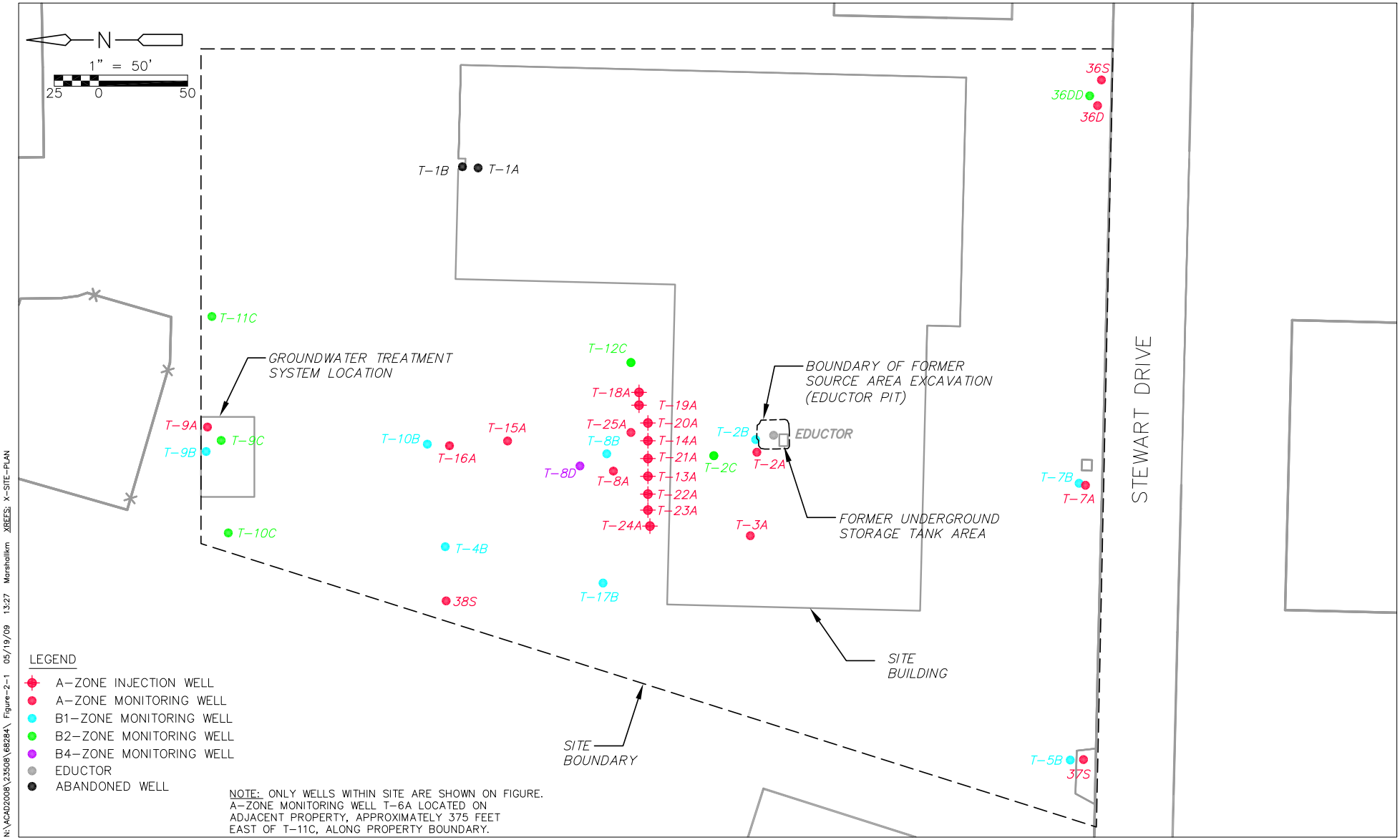


Figure 2-1
Site Plan

CDM

Former TRW Microwave Site
825 Stewart Drive, Sunnyvale, CA

APPENDIX E – SITE DOCUMENTS – STATE CLEARINGHOUSE LINK

http://geotracker.waterboards.ca.gov/profile_report.asp?global_id=SL721251223

The State Water Resources Control Board maintains the Geotracker website as a repository of environmental data for regulated facilities in California. You can use the following link(s) to find the covenant(s) that have been recorded for the Site property or properties. In addition, the environmental title search reports will shortly be available at the same link.