



**Final Report** #2  
**Development of Risk-Based Cleanup Standards**  
**Harbert Transportation Site**  
**19984 Meekland Avenue**  
**Hayward, California**

February 4, 1998

SHD 1879

*Prepared For :*

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AGI Project No. 15,833.001

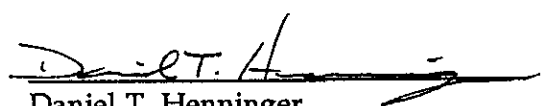
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A Report Prepared For :

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**FINAL REPORT  
DEVELOPMENT OF RISK-BASED CLEANUP STANDARDS  
HARBERT TRANSPORTATION SITE  
19984 MEEKLAND AVENUE  
HAYWARD, CALIFORNIA**

February 4, 1998

  
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**GLOSSARY**

ACFCWCD	Alameda County Flood Control and Water Conservation District
ACHCS	Alameda County Health Care Services
AGI	AGI Technologies
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BETX	benzene, ethylbenzene, toluene, and total xylenes
bgs	below ground surface
CDI	Chronic Daily Intake
COC	chemicals of concern
CPF	carcinogenic potency factor
CRWQCB	California Regional Water Quality Control Board
CSWQCB	California State Water Quality Control Board
DTSC	Department of Toxic Substances Control
EBMUD	East Bay Municipal Utility District
EPA	United States Environmental Protection Agency
g/min	gallon per minute
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HQ	hazard quotient
IRIS	Integrated Risk Information System
IUBK	Integrated/Uptake Biokinetic
LDI	Lifetime Daily Intake
LUFT	Leaking Underground Fuel Tank
MDEP	Massachusetts Department of Environmental Protection
µg/dL	micrograms per deciliter
µg/ft <sup>2</sup> /hr	micrograms per square foot per hour
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL/g	milliliters per gram
MMWD	Moreland Mutual Water District
MSL	Mean Sea Level
OLM	Organic Leachate Model
PCE	tetrachloroethylene
RBSL	risk-based screening level
RfD	chronic reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
TCE	trichloroethylene
TNRCC	Texas Natural Resource Conservation Commission
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons quantified as diesel
TPH-G	total petroleum hydrocarbons quantified as gasoline



## GLOSSARY

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UST	underground storage tanks
VF	volatilization factor
VOC	volatile organic compounds
1,2-DCA	1,2-dichloroethane

## EXECUTIVE SUMMARY

In August 1989, three gasoline underground storage tanks (USTs) and one underground waste oil tank were removed from the Harbert Transportation site located at 19984 Meekland Avenue in Alameda County near Hayward, California. Subsequent investigations indicated the presence of petroleum hydrocarbon and volatile organic compounds (VOCs) in soil and groundwater at the site. This report presents AGI Technologies' (AGI) development of site-specific risk-based soil and groundwater cleanup standards for the site.

Cleanup standards were developed for the Harbert Transportation site using existing toxicological data of specific chemicals found at the site to determine the risk posed by these chemicals to human health and environmental resources. Based on the exposure assessment and calculated risks, soil and potential groundwater cleanup standards were established for the site. The basic assumptions used in the risk assessment include:

- Onsite commercial use is the scenario used.
- Surface infiltration and the proximity to underground storage tanks, sewer systems, and drainage systems precludes shallow zone water from being used as drinking water.
- Domestic water needs are sufficiently met by three water districts in the area.

Total petroleum hydrocarbons (TPH) detected in subsurface soil samples were characterized as gasoline (TPH-G) and diesel (TPH-D). Benzene, ethylbenzene, toluene, and total xylenes (BETX), 1,2-dichloroethane (1,2-DCA), TPH-G, and TPH-D were consistently detected in wells near the former USTs. These same compounds were also consistently detected in three on-site downgradient wells at concentrations of one-half to an order of magnitude lower than in the source area wells.

Potential receptors were evaluated by screening chemical concentrations found at the site against promulgated standards and risk-based concentrations protective of human health. Chemicals whose maximum detected concentrations exceeded one or more screening criteria were termed chemicals of concern (COC).

Based on AGI's evaluation, toluene is the only COC in surface soil (0 to 5.5 feet below ground surface). BETX, 1,2-DCA, TPH-G, and TPH-D are considered COCs in subsurface soil (5.5 to approximately 27 feet below ground surface). BETX, 1,2-DCA, TPH-G, TPH-D, and lead are considered COCs in groundwater.

Potential cleanup levels for the COCs in each medium were compiled from risk-based concentrations calculated according to the various exposure pathways and regulatory levels.

In surface soils (0 to 5.5 feet below ground surface), no cleanup concentration was determined because the maximum concentration of toluene detected in all samples was below the published risk-based concentration selected as the cleanup level. In subsurface soils, a cleanup concentration of 0.118 milligrams per kilogram (mg/kg) was determined for benzene. No subsurface soil cleanup concentration was determined for ethylbenzene, toluene, xylenes, and 1,2-DCA given that the

maximum concentrations detected were below the published risk-based concentration selected as the cleanup level. A subsurface soil cleanup concentration of 1,000 mg/kg was selected for TPH-G and TPH-D using an interim regulatory approach for determining soil cleanup levels.

In groundwater, a cleanup concentration of 3.82 milligrams per liter (mg/L) for benzene was determined. No cleanup concentrations were determined for ethylbenzene, toluene, xylenes, and 1,2-DCA since the maximum concentrations detected for these constituents were below the published risk-based concentration selected as the cleanup level.

## 1.0 INTRODUCTION

This report presents AGI Technologies' (AGI) development of site-specific risk-based soil and groundwater cleanup standards for the former Harbert Transportation site located at 19984 Meekland Avenue in Alameda County near Hayward, California. This report is presented on behalf of Harbert Transportation, formerly of Hayward, California.

### 1.1 REGULATORY FRAMEWORK

Regulatory oversight for the Harbert Transportation site is provided by Alameda County Health Care Services (ACHCS). The technical basis for establishing cleanup standards using risk-based procedures is provided in the following documents:

- United States Environmental Protection Agency (EPA), *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals* (EPA, 1991a).
- EPA, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final*, (EPA, 1989a).
- EPA, *Soil Screening Level Guidance*, (EPA, 1994c).
- American Society for Testing and Materials (ASTM), *Emergency Standard Guide for Risk-Based Correction Action Applied at Petroleum Release Sites* (ASTM ES 38-94, 1994).
- California Regional Water Quality Control Board (CRWQCB), *LUFT Field Manual*, (CSWRCB 1989).
- CRWQCB, *Screening Levels for Petroleum-Impacted Sites* (CRWQCB, 1994).

### 1.2 TECHNICAL BASIS

The technical basis for development of risk-based cleanup standards includes work performed by AGI and others for Harbert Transportation. A formal Remedial Investigation (RI) has not been performed for the site, but several environmental assessments and site characterizations have been conducted. These are summarized in the following reports:

- Applied GeoSystems, *Subsurface Environmental Investigation* (July 1986).
- CTTS Inc., *Phase II Report for Durham Transportation* (November 1990).
- CTTS Inc., *Well Abandonment and Groundwater Water Monitoring Well Installations* (January 1990).
- CTTS Inc., *Report for Additional Well Installation* (April 1991).

- CTTS Inc., Work Plan for the Delineation, Containment and Remediation of Soil and Groundwater Contamination (November 1992).
- AGI Technologies Quarterly Groundwater Monitoring Report (September 1994 and February 1995).

While data gaps remain for full implementation of remedial action, data collected to date is, in our opinion, adequate to generally characterize the primary contaminants and their distribution, and to identify and evaluate the most likely remedial actions.

### 1.3 RATIONALE

The risk-based approach presented in the following sections uses existing toxicological data of site-specific chemicals to determine the risk posed by these chemicals to human health and environmental resources. Based on the exposure assessment and calculated risks, soil and groundwater cleanup standards are established for the site. Basic assumptions used in the risk assessment are presented below:

- The site will be designated for commercial use. *new*
- Surface infiltration and the proximity to industrial contaminant sources, sewer systems, and drainage systems precludes shallow zone water from being used as drinking water. The only designated beneficial use of shallow groundwater in the vicinity is for industrial and irrigation applications.
- Domestic water needs are sufficiently met by three water districts in the area.

## 2.0 STUDY AREA DESCRIPTION

The site is located in an unincorporated area of Alameda County near the City of Hayward, at the northeast corner of Meekland Avenue and Blossom Way intersection, as shown on Figures 1 and 2. During the 1940s and 1950s, the subject site operated as a family-owned service station. Harbert Transportation purchased the site in the 1960s and operated it as a vehicle fueling and maintenance facility until 1986. In 1986, Durham Transportation of Austin, Texas purchased the property from Harbert Transportation and operated the site as a fueling and maintenance facility until 1989.

In August 1989, three gasoline underground storage tanks (USTs) with capacities of 4,000, 5,000, and 6,000 gallons and one 5,000-gallon waste oil UST were removed. The locations of these tanks are shown on Figure 3. Subsequent investigations have indicated petroleum hydrocarbon and volatile organic compounds (VOCs) are present in soil and groundwater at the site. Based on the results of site characterization activities, 10 groundwater monitoring wells were installed in 1989 and 1993 to monitor groundwater elevation and water quality. Groundwater monitoring, which began in 1989, is currently being conducted on a quarterly basis at the site. Historical analytical chemistry results from soil and groundwater samples are summarized in Tables 1 and 2, respectively.

The site is bounded by single-family homes to the north and east, Meekland Avenue to the west, and Blossom Way to the south (see Figure 2). An apartment complex is located west of the site across Meekland Avenue. Small businesses occupy three corners of the four-corner intersection formed by Meekland Avenue and Blossom Way. These businesses are located south, west, and southwest of the site and include a trading store, liquor store, and auto repair shop. Both the auto repair shop and liquor store locations were previously occupied by gas stations.

In March 1990, existing structures at the site were demolished and removed. Currently, the site is fenced on all sides and contains no structures. The ground surface is covered with concrete except where previous excavations were located to remove the USTs and associated piping.

Underground utilities at the site are likely to consist of water, sewer, and decommissioned electrical power lines. Underground piping associated with former USTs has been removed. Off-site underground utilities are likely to consist of water, sewer, storm, telephone, cable, and electrical lines.

### 2.1 REGIONAL AND LOCAL LAND USE

Regional land use in the area can be split into four categories:

- residential
- commercial
- industrial
- undeveloped open spaces

Land use in the area is a mixture of residential, commercial, and industrial sites, with the majority of residences located east of Interstate 880. Commercial development consists of transportation facilities, shopping complexes, and service industries. Major industrial areas are generally located near Interstate 880 and the Southern Pacific Railroad, which runs north to south adjacent to the interstate.

Land use surrounding the site is mixed residential and commercial and has been zoned as CN—a commercial neighborhood business district—since 1961. The area has been zoned to remain this way through the year 2000.

## 2.2 CLIMATE

The local area exhibits a Mediterranean climate, which features winter rains and summer dryness. Winter rains are from frontal storms generated in the northern Pacific Ocean. Most precipitation occurs during the months of November through March. Average annual rainfall for the City of Hayward is approximately 21 inches. The 100-year storm is capable of producing up to 5 inches of precipitation in a 24-hour period.

## 2.3 DOMESTIC WATER SUPPLY

Drinking water is supplied by East Bay Municipal Utility District (EBMUD), Hayward Water, and the Moreland Mutual Water District (MMWD). EBMUD water is imported from the Mokulume River system, with additional contributions from the EBMUD reservoir network located in the East Bay hills. Hayward Water is supplied by San Francisco Water Department, which imports water from Hetch Hetchy Reservoir. MMWD water is supplied by groundwater pumped from the Lower Zone Aquifer located near Chabot College in Hayward, approximately 5 miles southwest of the site.

## 2.4 SITE GEOLOGY

Soils in the area generally consist of a mixture of gravels, sands, and clays that were deposited on the San Leandro and San Lorenzo alluvial cones west of the Diablo Range. The soils are pliocene-pleistocene to late pleistocene in age and extend to depths ranging from 300 to 800 feet below ground surface (bgs). In general, the particle size and bed thickness of the alluvium decrease westward toward San Francisco Bay.

Three to four feet of fill overlies native soils at the site. The fill consists of clay, sand, and gravel, and extends from just below the asphalt surface to approximately 4 feet bgs. Underlying the fill are unconsolidated, fine-grained alluvial and floodplain deposits extending to 45 feet bgs, the maximum depth explored at the site. These deposits are derived from the Diablo Range located 2 miles east of the site and consist primarily of silty clays and clayey silts with interbedded lenses of silty sand and gravel 3 to 4 inches thick.

## 2.5 LOCAL HYDROGEOLOGY

Aquifers in the local area are divided into two zones, Upper and Lower. The Upper Zone is located from ground surface to approximately 400 feet bgs. The Lower Zone is located 400 to 800 feet bgs. The Upper Zone aquifer sequence contains four separate water-bearing deposits derived from the San Leandro and San Lorenzo Creeks. These deposits are known as the Shallow, Newark, Centerville, and Fremont Aquifers. The Newark, Centerville, and Fremont Aquifers consist of discontinuous beds of sand and gravel which extend westward under San Francisco Bay and are capped by confining layers of clay.

Shallow Aquifers typically occur at depths ranging from ground surface to 50 feet bgs. These aquifers have limited areal extent and generally occur under perched conditions, although some are confined by thin beds of clay. Groundwater recharge to these aquifers is by infiltration or rainfall, irrigation, and streamflow, with yields generally less than 35 gallons per minute (usually only sufficient for irrigation purposes).

Groundwater monitoring data collected from the site indicate groundwater elevations are highest in the spring and lowest in the fall. Since April 1991, groundwater elevations at the site have ranged from approximately 24 to 31 feet above Mean Sea Level (MSL). The highest groundwater elevations were encountered at the site in 1993. The lowest groundwater elevations were encountered in December 1991. Calculations using data collected from quarterly monitoring performed at the site have continually shown groundwater flow to be westward toward San Francisco Bay.



### 3.0 DEVELOPMENT OF SITE-SPECIFIC RISK-BASED CLEANUP STANDARDS

Cleanup standards were developed for the Harbert Transportation site using health risk as the primary focus. For each chemical, a concentration that does not threaten human health or the environment was estimated using conditions specific to the site. For individual cancer-causing chemicals (carcinogens), a concentration was estimated so that the target risk level (a person's chance of developing cancer during a lifetime of consistent exposure to a hazardous chemical) does not exceed ten-in-a-million ( $1 \times 10^{-5}$ ). For a commercial scenario, this level is sufficient to ensure that the cumulative risks are within the  $10^{-4}$  to  $10^{-6}$  range for all chemical/pathway combinations (EPA, 1994a). Levels for noncarcinogens must be below that which could cause an adverse health effect in humans, nominally set at a hazard quotient (HQ) of 1. The potential for additive effects of noncarcinogenic chemicals that have the same toxic end-point or mechanism of action was considered.

The following documents formed the basis for development of risk-based concentrations:

- ASTM's *Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1995)
- EPA's *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals* (EPA, 1991b)

Risks were calculated following the equations and guidance of EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final* (1989a) using standard default exposure parameters. The California Water Resources Control Board's *LUFT Field Manual* (CWRCB, 1989); and its interim approach during revision, *Screening Levels for Petroleum Impacted Sites* (CRWQCB, 1994); EPA's *Soil Screening Level Guidance* (EPA, 1994c); and other documents were consulted for readily available cleanup levels that matched conditions at the site.

### 3.1 SUMMARY OF ANALYTICAL DATA

Various investigations have taken place at the Harbert Transportation site over the last 6 years. Sampling and analytical methods as well as detection limits were generally consistent between investigations. Use of the historic data in conjunction with current data allows us to evaluate seasonal patterns as well as changes in concentration over time.

Tables 1 and 2 summarize historical soil and groundwater data for the Harbert Transportation site. These data are discussed below.

#### 3.1.1 Surface Soil

Samples from the 0 to 5.5 foot depth are considered representative of surface conditions. Toluene is the only compound positively detected in samples from 0 to 5.5 feet in depth. It was detected in each of the four samples taken from this depth range.

### 3.1.2 Subsurface Soil

Table 3 shows the frequency of detection for chemicals in subsurface soil. Benzene, ethylbenzene, toluene, and xylenes (BETX) were detected at a frequency greater than 50 percent in soil at depths between 5.5 and 45 feet (termed subsurface). The majority (two-thirds) of the detections for benzene, ethylbenzene, and xylenes were at depths of 20 feet or greater. Half of the detections for toluene were at depths of 20 feet or greater. 1,2-Dichloroethane (1,2-DCA) was detected in 23 percent of the subsurface samples analyzed for it, with 75 percent of those detections at a depth of 20 feet or greater. Trichloroethylene (TCE) was detected in one subsurface sample (34 total analyses), for a detection frequency of less than 3 percent. Tetrachloroethylene (PCE) was not detected in any of the 35 gasoline analyses of subsurface soil.

Total petroleum hydrocarbons (TPH) detected in subsurface soil samples was characterized as gasoline (TPH-G) and diesel (TPH-D). The laboratory reported that the diesel component resembled weathered gasoline as opposed to the heavier diesel components. Weathered gasoline is comprised mostly of hydrocarbons in the C7 to C12 range because the lighter hydrocarbons (C1 to C6 of gasoline) have evaporated. Weathered gasoline could be interpreted as diesel on a chromatogram because diesel fuel generally consists of hydrocarbons in the C10 to C20 range, which would overlap with the carbon range in weathered gasoline. There are no records of diesel storage on site; therefore, the laboratory's interpretation of the results appears valid. Weathered gasoline has significantly different properties than unweathered gasoline and is therefore considered separately when risk-based factors are calculated.

TPH-G was detected in 46 percent of the subsurface samples analyzed for this compound. Of those, 63 percent were at or below 20 feet in depth. TPH-D was detected in 26 percent of the subsurface samples analyzed, with 70 percent of the detections at or below 20 feet.

### 3.1.3 Groundwater

Table 4 presents the frequency of detections for each chemical in each well and the total for the site. BETX, 1,2-DCA, TPH-G, and TPH-D were consistently detected in wells in the source areas: MW1 and MW5 located near the former USTs, and MW7 located near the former waste oil tank. These same compounds were also consistently detected in the three on-site downgradient wells (MW3, MW6, and MW9) at concentrations of one-half to an order of magnitude lower than in the source area wells. Monitoring well MW11, located approximately 70 feet off site in a directly downgradient flow path, had concentrations of benzene, ethylbenzene, TPH-G and TPH-D at an order of magnitude lower than MW3, MW6, and MW9. Ethylbenzene and toluene were detected only once in MW11 and 1,2-DCA was not detected at all. Concentrations of BETX, 1,2-DCA, TPH-G, and TPH-D detected in monitoring well MW10, located approximately 90 feet off-site and slightly west of the presumed downgradient flow path.

Lead in groundwater was not consistently analyzed; however, it had a 75 percent frequency-of-detection (six detections out of eight total analyses) in those samples analyzed for lead.

Trichloroethylene was detected in one analysis (from MW-4) out of 86 from the wells on-site. PCE was detected in three on-site wells, including upgradient well MW8. MW8 and MW7 display a consistent pattern of PCE detections and concentration (see Table 2). PCE was detected once in MW9 out of 10 analyses.

### 3.2 CHEMICALS OF CONCERN

The general methodology for development of risk-based cleanup standards involved compiling site- and chemical-specific information and evaluating possible adverse effects associated with potential receptor exposure to contaminated media. Evaluation of potential receptors comprises "screening" chemical concentrations against promulgated standards and risk-based concentrations protective of human health. Chemicals whose maximum detected concentrations exceed one or more screening criteria are termed contaminants of concern (COC). Other contaminants are not considered further.

Toluene was the only COC detected in surface soils and, as such, is the only COC for surface soils. BETX, 1,2-DCA, TPH-G, and TPH-D are considered COCs in subsurface soil. TCE is not included as a COC because it has a low frequency of detection (3 percent). PCE is not included as a COC because it was not detected in any soil samples taken, regardless of location or depth.

BETX, 1,2-DCA, TPH-G, TPH-D, and lead are considered COCs in groundwater. TCE is not included as a COC because it has a low frequency of detection (1 percent). Given the groundwater hydrology and the absence of PCE in soil, it appears that PCE is present in upgradient groundwater and has migrated on site. Therefore, PCE is not considered a COC in groundwater for this site.

*? not a good enough reason!*

### 3.3 BENEFICIAL USE SUMMARY

The site is designated by the City of Hayward as industrial property and has a history of continuous industrial use. The site was first developed for industrial use during the 1940s. Prior to that time, the property was undeveloped. The surrounding area consists of mixed industrial and limited residential use. According to the City of Hayward Planning Department, the land use and zoning are unlikely to change in the future.

EBMUD and Moreland Water provide all residents and businesses with potable water. The newest domestic groundwater supply well is located approximately 5 miles from the site. Alameda County Flood Control and Water Conservation District (ACFCWCD) indicated that there are three irrigation wells within a 5-mile radius of the site. ACFCWCD has stated that the shallow zone aquifer (approximately 27 to 50 feet bgs) should not be used for potable supply.

Groundwater is not used as a source of drinking water. The highest beneficial use is irrigation.

### 3.4 RECEPTOR SURVEY AND POTENTIAL EXPOSURE ROUTES

Future use of this site is likely to be commercial and future receptors likely to be adult workers. Potential exposure routes for COCs in surface soil, subsurface soil, and groundwater were considered for adult workers (Table 5). Interactions between these media such as COC migration from subsurface soil to groundwater through leaching is also considered.

Toluene is the only COC in surface soil. Workers are likely exposed through ingestion of soil and inhalation of emissions. Dermal absorption is not considered a complete pathway for toluene because of its volatility. Volatiles in soil are more likely to dissipate into the atmosphere than be absorbed through the skin (EPA, 1992a).

Workers are not expected to have direct exposure to subsurface soil. The only potential exposure route is through inhalation of volatilized COCs (BETX and 1,2-DCA). These compounds could volatilize from subsurface soil to ambient air or to soil gas which then can accumulate inside buildings. BETX and lead are commonly detected in ambient air. Sources of the COCs range from industrial use and auto exhaust to dry cleaning and household cleaning products. The national indoor background concentration range for volatiles is presented in Table 6 (ASTM, 1994).

Worker exposure to groundwater would be from inhalation of volatilized COCs which have accumulated inside a building. As with subsurface soil, the potential exists for vertical migration of volatile COCs in groundwater. Lead, however, is not a volatile COC, does not have a route of exposure to the adult worker, and is not further considered.

### 3.5 RISK-BASED CONCENTRATIONS

A risk-based concentration is the concentration of an individual chemical, using reasonable maximum exposure (RME) conditions, that would result in a:

- $1 \times 10^{-5}$  excess lifetime cancer risk if the chemical is classified as a carcinogen.
- Hazard quotient of 1 for a chemical that results in a noncarcinogenic effect.

Risk-based concentrations were calculated only for those chemicals that exceed the "target risk" for a specific exposure pathway using the average detected concentration of the chemical in the media under consideration and equations presented in EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part 3), Interim Final* (EPA, 1989a).

Risk-based concentrations were adjusted for noncarcinogens to account for exposures to multiple chemicals. Adjustments are necessary to ensure that total noncarcinogenic risk presented by site exposures following cleanup will not exceed a hazard index of 1.0 for noncarcinogenic substances producing the same toxic response.

#### 3.5.1 Compilation of Toxicity Information

The toxicity factors of chemicals detected in soil and groundwater were compiled from EPA's Integrated Risk Information System (IRIS) (EPA, 1994a) and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1994b). Target organs and toxic end points are identified for each COC. Table 7 lists toxicity information, where available, for each COC.

The toxicity values presented in Table 7 for TPH-G and TPH-D are provisional and were derived by EPA (EPA, 1992b). These values were used as opposed to a "reference compound or surrogate" approach because of the need for component chemical group data (number of carbon atoms in each component group such as the alkanes, cycloalkanes, alkenes, and aromatics) to characterize toxicity using reference compounds (MDEP, 1994). Surrogate compound data are not available for this site.

Further, Heath, et al. (1993) recommends that surrogate selection be site-specific and states that the selection of surrogates can vary the outcome of the risk estimates by over 10 orders of magnitude. Therefore, in order to obtain a consistent estimate of risk, the toxicity values derived by EPA from whole product studies were used. MDEP (1994) reports that the use of EPA-derived provisional toxicity values compares favorably with the use of reference compounds; the risks generated with EPA's values were an order of magnitude more conservative than with the reference compound approach (MDEP, 1994). Risk from BETX and TPH-G were quantified separately.

### 3.5.2 Estimation of Risk and Development of Risk-Based Concentrations

Risk-based concentrations were developed using the exposure routes shown in Table 5. Risk-based concentrations are shown in Table 8.

**Surface Soil :** Exposure to COCs in surface soil is possible through ingestion of toluene (a noncarcinogen) in surface soil and inhalation of toluene emissions from surface soil. Risk from ingestion of toluene is estimated since a risk-based concentration was not available in the literature. Table A-1 (in Appendix A) provides a sample calculation for this pathway. The risk-based concentration for ingestion of surface soil was found to be 408,000 mg/kg, which is greater than the maximum concentration found onsite.

The risk-based concentration for inhalation of toluene emissions from surface soil required equations estimating volatilization of toluene from surface soil. These equations (Table A-2 in Appendix A) are used by EPA (1994c) to calculate a soil screening level for the inhalation pathway. These equations are only valid if the calculated chemical concentration in soil using a volatilization factor is less than the calculated chemical concentration at which the soil pore water is saturated. If the calculated soil concentration using the volatilization factor is greater than the soil saturation concentration, the soil screening level is set equal to the soil saturation concentration. Since this is the case for toluene, the soil screening level is set equal to the soil saturation concentration of 150 mg/kg. This concentration also exceeds the maximum concentration found onsite. An example of a screening level calculation for a carcinogenic contaminant is shown in Table A-3. This calculation uses default parameters for a commercial/industrial scenario and chemical specific data for benzene.

**Subsurface Soil :** Exposure to COCs in subsurface soil could only occur if volatile COCs (BETX and 1,2-DCA) are released from soil as soil-gas, migrate vertically through soil, enter a building through cracks in the foundation, accumulate inside the building, and are inhaled by workers. Concentrations of volatile COCs inside the home were estimated using the Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites (ASTM, 1995). Table A-4 shows ASTM-based volatilization factor formulas.

The ASTM methods were used to calculate volatilization factors (VF) for chemical transport from groundwater, through the vadose zone, and through foundation cracks into a basement. For transport of a carcinogenic or noncarcinogenic COC from subsurface soil to a basement:

$$RBSL_s = RBSL_{AIR} / VF_{SESP} \quad [1]$$

where  $RBSL_s$  is the risk-based screening level (RBSL) for the COC in soil,  $RBSL_{AIR}$  is the risk-based screening level for the COC in air, and  $VF_{SESP}$  is the volatilization factor for COC transport from subsurface vadose zone soil to an enclosed space (i.e., a basement). Equations shown here do not include unit conversion factors; however, these factors were used in calculations.  $RBSL_{AIR}$  was

calculated differently for carcinogens and noncarcinogens. For carcinogens, benzene and 1,2-dichloroethane,  $RBSL_{AIR}$  were based on  $1 \times 10^{-5}$  excess individual cancer risk and were calculated as follows:

$$RBSL_{AIR} (\text{cancer}) = 1 \times 10^{-5} / \text{CPF} / \text{LDI} \quad [2]$$

where CPF is the carcinogenic potency factor (Table 7) and LDI is the lifetime daily intake rate calculated to be  $0.007 \text{ m}^3/\text{kg}\cdot\text{day}$  (Table 5). The RBSL for 1,2-dichloroethane was calculated similarly.

For noncarcinogens, toluene, ethylbenzene, and xylenes,  $RBSL_{AIR}$  were based on a hazard quotient of 1 and were calculated as follows:

$$RBSL_{AIR} (\text{noncancer}) = \text{RfD} / \text{CDI} \quad [3]$$

where RfD is the toxicological reference dose (Table 7) and CDI is the chronic daily intake rate calculated to be  $0.196 \text{ m}^3/\text{kg}\cdot\text{day}$  (Table 5).

The volatilization factor,  $VF_{SESP}$  in Equation [1] is defined (ASTM, 1995) as a function of the parameters in Table 9. The parameters in Table 9 are based on default parameters in the ASTM protocol, results of field investigations, or data from the literature. COC-specific parameters are listed in Table 10. The value for  $\rho_s$  (1.5) was based on typical clayey soil bulk densities (Brady, 1984).

Tables A-5 to A-9 show results of these calculations yielding risk-based concentrations in vadose zone soil. Table 11 shows the noncarcinogenic hazard quotients and excess lifetime cancer risks based on averaged soil concentrations of BETX and 1,2-DCA.

Risk-based concentrations for TPH-G and TPH-D could not be estimated because of the lack of physical/chemical parameters to describe these mixtures. Cleanup concentrations for these compounds were taken from the Regional Water Quality Board's *Screening Levels for Petroleum Impacted Sites* (CRWQCB, 1994), which provides an interim approach for determining soil cleanup levels. These interim cleanup levels, reported in Table 8, assume depth to groundwater is approximately 30 feet and that groundwater is not used as a source of drinking water.

**Groundwater:** Constituents in groundwater identified as volatile may also be released as soil-gas and migrate vertically through cracks in a foundation and accumulate inside a site building. Concentrations of volatile COCs inside a building were estimated using ASTM methods as for subsurface soil.

For transport of a carcinogenic or noncarcinogenic COC from groundwater, through subsurface soil, into a basement; the risk-based screening level for water is:

$$RBSL_w = RBSL_{AIR} / VF_{WESP} \quad [4]$$

where  $RBSL_w$  is the risk-based screening level for the COC in groundwater,  $RBSL_{AIR}$  is the risk-based screening level for the COC in air, and  $VF_{WESP}$  is the volatilization factor for COC transport from groundwater, through the vadose zone, to an enclosed space (i.e., a basement). The RBSLs for carcinogens and noncarcinogens were calculated as described above in Equations 2 and 3.

The volatilization factor,  $VF_{SESP}$  in Equation [1] is defined (ASTM, 1995) as a function of the parameters in Table 12. The parameters in Table 12 were determined as previously described for subsurface soil.

Tables A-4 through A-8 show results of the calculations yielding risk-based concentrations in groundwater. Table 13 shows the noncarcinogenic hazard quotients and excess lifetime cancer risks based on averaged groundwater concentrations of BETX and 1,2-DCA.

Risk-based concentrations for TPH-G and TPH-D could not be estimated due to the lack of physical/chemical parameters to describe these mixtures.

### 3.5.3 Compilation of Cleanup Levels

Potential cleanup levels for each medium are compiled in Table 14 from the risk-based concentrations calculated according to the various exposure pathways and the regulatory levels reported in Table 8. To be protective of public health, the most stringent risk-based concentration should be chosen as the proposed cleanup level.

The use of natural or area background when the most stringent calculated risk-based concentration is below background must be considered. For volatile emissions from subsurface soil or groundwater that accumulate inside a building, the concentration of benzene indoors that results in an excess lifetime cancer risk to workers inhaling the air for 8 hours/day, 250 days/year for 25 years is  $1.43 \mu\text{g}/\text{m}^3$ . Concentrations in subsurface soil and in groundwater were then estimated that would result in the release and accumulation of benzene to this level. However, this level is within the range of national indoor background concentrations for benzene (Table 6). If the benzene concentration at the high end of the range ( $21.5 \mu\text{g}/\text{m}^3$ ) is used to estimate a cleanup concentration, that concentration would be approximately 0.4 mg/kg in subsurface soil and 23 mg/L in groundwater.

Table 14 does not present cleanup levels for exposure routes where a risk-based concentration was not calculated because the maximum concentration does not present a risk greater than the target risk level or a literature derived cleanup level was not available.

## 3.6 COMPARISON OF CLEANUP LEVELS WITH SITE CONCENTRATIONS

This subsection compares cleanup levels with site concentration data to evaluate the need for further remediation.

### 3.6.1 Surface Soil

The concentrations of toluene in all samples taken from 0 to 5.5 feet are below the literature reported risk-based concentration selected as the cleanup level.

### 3.6.2 Subsurface Soil

The majority of concentrations of benzene detected in subsurface soil are below the selected cleanup level. Eleven samples (out of 29 detections and 62 total analyses) had concentrations exceeding the 0.118 mg/kg cleanup level. Samples B3 and MW3 collected on November 28, 1989 appear to be duplicated in Table 1; they are counted once and listed as B3 here. The sample locations, sample dates, and concentrations are as follows:

T1-W (8/89) at 12 mg/kg  
 T3-E (8/89) at 1.9 mg/kg  
 ABW-12-12(12/89) at 0.2 mg/kg  
 B1 (10/90) at 1.2 mg/kg  
 B3 (11/89) at .44 mg/kg  
 B3 (11/89) at .13 mg/kg  
 B3 (11/89) at .54 mg/kg

MW3 (11/89) at .44 mg/kg  
 MW3 (11/89) at 0.13 mg/kg  
 MW3 (11/89) at .54 mg/kg  
 MW5 (8/90) at 9.6 mg/kg  
 MW7 (10/90) at 0.31 mg/kg  
 MW9 (2/91) at .15 mg/kg  
 MW9 (2/91) at .18 mg/kg

Total petroleum hydrocarbons quantified as gasoline and as diesel were found to exceed the selected soil cleanup levels of 1,000 mg/kg in two samples. In sample F3, TPH-G was detected at 2,000 mg/kg and TPH-D was detected at 1,300 mg/kg. In sample F6, TPH-G was detected at 3,800 mg/kg and TPH-D was detected at 1,300 mg/kg.

### 3.6.3 Groundwater

Benzene concentrations detected in samples from three wells: MW1, MW3, and MW5 exceeded the selected cleanup level of 3.82 mg/L. Samples collected through October 1992 in MW1 and June 1993 in MW5 have benzene concentrations that exceed the cleanup level. However, benzene concentrations in MW3 appear to be decreasing as the only exceedances in this well were in April 1989 and July 1990.

TPH-G concentrations detected in samples from six wells (MW1, MW3, MW5, MW6, MS7, and MW10) exceeded the selected cleanup level of 12,500 µg/L. As for benzene detections, most samples from MW1 and MW5 exceed the cleanup level. In MW6, three samples exceeded cleanup levels from these collection dates: 10/90, 4/91, and 1/93. Samples from MW3, MW7, and MW10 have not exceeded cleanup levels since 11/89, 10/90, and 5/92, respectively. Only one sample, taken from MW1 in July 1992, exceeded the selected cleanup level of 15,000 µg/L for TPH-D.



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\_\_\_\_\_  
Patrick J. Evans, Ph.D.  
Associate Chemical Engineer



**Table 1**  
**Summary of Historical Soil Analytical Data**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Sample Number	Date Sampled	Depth (ft)	EPA Test Method									
			8015 Modified			8020				8010		
			TPH-G	TPH-D	TPH-MO	Benzene	thylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
B-1	06/30/86	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-2	06/30/86	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW1	06/30/86	20.0	240 <sup>d</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA
T1-E	08/11/89	13.0	2.208	NA	NA	ND	33	59	180	NA	NA	NA
T1-W	08/11/89	11.0	5.203	NA	NA	12	67	83	420	NA	NA	NA
T2-E	08/11/89	13.0	6.178	NA	NA	ND	56	68	360	NA	NA	NA
T2-W	08/11/89	13.0	0.0124	NA	NA	ND	ND	ND	ND	NA	NA	NA
T3-E	08/11/89	13.0	2.857	NA	NA	1.9	36 <sup>c</sup>	17	220 <sup>c</sup>	NA	NA	NA
T3-W	08/11/89	13.0	ND	NA	NA	ND	0.013	0.026	0.11	NA	NA	NA
T4	08/11/89	7.5	ND	ND	NA	ND	0.012	0.03	0.14	NA	NA	NA
B-3	11/28/89	20.5	ND	NA	NA	0.13	ND	0.022	ND	0.2	ND	ND
B-3	11/28/89	25.5	52	NA	NA	0.44	0.2	0.48	0.93	ND	ND	ND
B-3	11/28/89	30.5	23	NA	NA	0.54	0.21	0.188	0.4	ND	ND	ND
B-4	11/28/89	15.5	ND	NA	NA	0.02	0.013	0.019	ND	NA	NA	NA
B-4	11/28/89	20.5	ND	NA	NA	0.075	0.026	0.02	0.015	NA	NA	NA
B-4	11/28/89	35.5	ND	NA	NA	ND	ND	0.013	ND	NA	NA	NA
MW3	11/28/89	20.5	NA	NA	NA	0.13	ND	0.022	ND	0.2	ND	ND
MW3	11/28/89	25.5	52	NA	NA	0.44	0.2	0.48	0.93	NA	NA	NA
MW3	11/28/89	30.5	23	NA	NA	0.54	0.21	0.188	0.4	NA	NA	NA
MW4	11/28/89	15.5	NA	NA	NA	0.02	0.013	0.019	NA	NA	NA	NA
MW4	11/28/89	20.5	NA	NA	NA	0.075	0.026	0.02	0.015	NA	NA	NA
ABW-12-12	12/12/89	12.0	1.8	NA	NA	0.2	0.024	0.018	0.034	NA	NA	NA
Test Pit #10	06/20/90	7.5	NA	NA	NA	ND	ND	0.005	NA	NA	NA	NA
Test Pit #11	06/20/90	7.5	NA	NA	NA	ND	ND	0.034	NA	NA	NA	NA
Test Pit #7	06/20/90	9.0	NA	NA	16	ND	ND	NA	NA	NA	NA	NA
Test Pit #8	06/20/90	2.5	NA	NA	20	ND	ND	0.069	NA	NA	NA	NA
Test Pit #8	06/20/90	8.0	NA	NA	NA	ND	ND	0.017	NA	NA	NA	NA
Test Pit #9	06/20/90	7.0	NA	NA	NA	ND	ND	0.024	NA	NA	NA	NA

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 Hayward, California

Sample Number	Date Sampled	Depth (ft)	EPA Test Method									
			8015 Modified			8020				8010		
			TPH-G	TPH-D	TPH-MO	Benzene	thylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
MW6	08/30/90	20.5	ND	ND	ND	0.046	ND	ND	ND	ND	ND	ND
MW6	08/30/90	30.5	23	5.3	ND	0.07	0.06	0.096	0.059	ND	ND	0.0057
MW6	08/30/90	45.5	1.2	ND	ND	0.02	0.015	0.035	0.056	ND	ND	ND
MW5	08/31/90	5.5	ND	ND	ND	ND	ND	0.0039	ND	ND	ND	ND
MW5	08/31/90	10.5	ND	ND	ND	0.037	0.0035	0.016	0.019	ND	ND	0.0024
MW5	08/31/90	20.5	560	6.4	ND	9.6	7.4	22	45	ND	ND	0.061
MW5	08/31/90	45.5	ND	ND	ND	0.014	0.0073	0.021	0.034	ND	ND	ND
TP1	09/04/90	8.5	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
TP2	09/04/90	9.0	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
TP3	09/04/90	9.0	NA	ND	16	NA	NA	NA	NA	NA	NA	NA
TP4	09/04/90	2.5	ND	ND	20	ND	ND	0.069	ND	ND	ND	ND
TP4	09/04/90	8.0	ND	ND	ND	ND	ND	0.017	ND	ND	ND	ND
TP5	09/04/90	7.0	ND	ND	ND	ND	ND	0.024	ND	NA	NA	NA
TP6	09/04/90	7.5	ND	ND	ND	ND	ND	0.005	ND	ND	ND	ND
TP8	09/04/90	7.5	ND	ND	ND	ND	ND	0.034	NA	ND	ND	ND
B1	10/01/90	5.5	ND	ND	13 <sup>b</sup>	ND	ND	0.036	ND	ND	ND	ND
B1	10/01/90	15.5	ND	ND	ND	0.04	0.0058	0.034	0.025	ND	ND	0.014
B1	10/01/90	25.5	150	3.7	ND	1.2	2.1	2.4	8.4	ND	ND	0.041
MW7	10/01/90	15.5	ND	ND	ND	ND	ND	0.015	ND	ND	ND	ND
MW7	10/01/90	25.5	ND	ND	ND	0.043	0.0034	0.0044	0.01	ND	ND	ND
MW7	10/01/90	35.5	ND	ND	ND	ND	ND	0.027	0.0057	ND	ND	ND
MW7	10/01/90	45.5	1.1	ND	ND	0.0071	0.012	0.036	0.056	ND	ND	ND
MW7	10/01/90	Auger	120	23	ND	0.31	1.7	1.4	6.9	ND	ND	0.0059
MW8	02/13/91	25.0	NA	NA	NA	ND	ND	0.0033	ND	NA	NA	NA
MW8	02/13/91	35.0	NA	NA	NA	ND	ND	0.028	ND	NA	NA	NA
MW9	02/13/91	20.0	2.2	NA	NA	0.15	0.029	0.066	0.067	ND	ND	0.0079
MW9	02/13/91	30.0	39	6	NA	0.18	0.23	0.34	1	NA	ND	0.011
MW9	02/13/91	40.0				ND	ND	0.011	ND	NA	NA	NA

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**Summary of Historical Soil Analytical Data**  
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 Hayward, California

Sample Number	Date Sampled	Depth (ft)	EPA Test Method									
			8015 Modified			8020				8010		
			TPH-G	TPH-D	TPH-MO	Benzene	ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
MW10	01/21/92	21.0	ND	ND	NA	0.0044	0.0036	0.014	0.018	ND	ND	ND
MW10	01/21/92	26.0	52	11 <sup>b</sup>	NA	ND	0.33	ND	1.5	ND	ND	ND
MW10	01/21/92	31.0	ND	ND	NA	ND	ND	0.0025	0.0034	ND	ND	ND
MW11	01/24/92	21.0	ND	ND	NA	0.0043	ND	0.008	ND	ND	ND	ND
MW11	01/24/92	30.0	ND	ND	NA	ND	0.0039	0.0041	ND	ND	ND	ND
MW11	01/24/92	35.0	ND	ND	NA	ND	ND	0.0045	ND	ND	ND	ND
MW-12-20-4	12/14/92	20.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
F-1	02/05/93	8.0	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
F-3 <sup>e</sup>	02/05/93	8.0	2,000	1,300 <sup>a</sup>	ND	ND	2.5	1.6	120	ND	ND	ND
F-6	02/05/93	12.0	3,800	1,300 <sup>a</sup>	ND	ND	ND	ND	20	NA	NA	NA
F-8	02/05/93	12.0	1.1	110 <sup>a</sup>	67	ND	ND	ND	ND	NA	NA	NA
MW-12-30-6		30.0	29	11 <sup>a</sup>	ND	0.078	0.1	ND	0.16	ND	ND	ND
MW-12-40-8		40.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Average <sup>f</sup>			138.5	73.4	8.8	0.46	3.35	4.15	25.2	0.013	0.001	0.005
Detection Limit			1.0	1.0	10	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002

Notes:

- a) The positive result for petroleum hydrocarbons quantified as Diesel appears to be due to the presence of lighter hydrocarbons rather than diesel.
- b) The positive result for the motor oil analysis on this sample appears to be a lighter hydrocarbon than diesel.
- c) Xylenes and ethylbenzene are over range.
- d) Reported as total hydrocarbons by EPA Method 8020.
- e) Lead = 52 mg/kg.
- f) Average of concentrations, ND equal to 1/2 detection limit.

NA - Not analyzed.

ND - Not detected at indicated detection limit.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.

TPH-D - Total petroleum hydrocarbons quantified as diesel.

TPH-MO - Total petroleum hydrocarbons quantified as motor oil.

TCE - Trichloroethylene.

PCE - Tetrachloroethylene.

1,2-DCA - 1,2-Dichloroethane.

1,1-DCA - 1,1-Dichloroethane.

**Table 2**  
**Summary of Historical Groundwater Analytical Data**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Well	Date Sampled	EPA Test Methods										Other µg/L
		8015 Modified			8020				8010			
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	
µg/L			µg/L				µg/L			µg/L		
MW1	07/86	42,000	NA	NA	5,500	NA	4,900	6,100	NA	NA	NA	
	03/90	27,000	NA	NA	2,700	491	840	800	ND	ND	ND	
	07/90	27,000	11,000	ND	4,000	ND	1,500	4,400	ND	ND	62	
	10/90	43,000	8,500	ND	3,400	1,200	2,700	5,300	0.4	ND	26	
	01/91	22,000	2,700	ND	3,000	990	1,800	2,800	ND	ND	27	
	04/91	42,000	3,100 <sup>a</sup>	NA	5,100	1,200	3,700	3,200	ND	ND	120	
	07/91	46,000	4,300 <sup>a</sup>	NA	6,500	830	2,900	3,700	ND	ND	64	
	10/91	27,000	4,300 <sup>a</sup>	NA	4,400	1,100	1,400	3,200	ND	ND	25	
	01/92	27,000	14,000 <sup>a</sup>	NA	3,300	1,200	1,600	3,800	ND	ND	24	
	04/92	33,000	11,000 <sup>a</sup>	NA	8,900	1,200	3,500	3,700	ND	ND	120	
	07/92	41,000	19,000 <sup>a</sup>	NA	5,600	1,300	2,600	4,000	ND	ND	49	
10/92	33,000	3,500 <sup>a</sup>	NA	4,400	1,200	2,100	4,000	ND	ND	61		
MW3	11/89	29,000	NA	NA	4,600	680	1,100	1,100	ND	ND	36	Lead 40
	11/89	NA	NA	NA	NA	NA	NA	NA	ND	ND	36	Lead 40
	03/90	12,000	NA	NA	2,300	59	300	490	ND	ND	ND	
	07/90	7,300	990	ND	5,200	ND	440	480	ND	ND	67	
	10/90	6,200	970	ND	75	7.5	150	250	ND	ND	48	
	10/90	NA	NA	NA	NA	NA	NA	NA	ND	ND	22	Lead 3
	01/91	4,600	680	ND	2,200	220	110	89	ND	ND	40	
	04/91	8,300	640 <sup>a</sup>	NA	2,800	370	490	760	ND	ND	43	
	07/91	6,600	890 <sup>a</sup>	NA	2,000	250	230	380	ND	ND	29	
	10/91	6,300	1,700 <sup>a</sup>	NA	2,000	410	330	550	ND	ND	27	
	01/92	4,000	790 <sup>a</sup>	NA	1,200	250	60	200	ND	ND	22	
	04/92	7,400	1,800 <sup>a</sup>	NA	730	370	180	640	ND	ND	19	
	07/92	3,000	2,400 <sup>a</sup>	NA	190	ND	2.8	410	ND	ND	30	
	10/92	5,000	970 <sup>a</sup>	NA	1,300	320	45	340	ND	ND	26	
01/93	2,300	680 <sup>a</sup>	NA (2)	630	180	31	330	ND	ND	13		
06/93	5,000	1,100 <sup>a</sup>	ND	730	240	43	380	ND	ND	13		



**Table 2**  
**Summary of Historical Groundwater Analytical Data**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Well	Date Sampled	EPA Test Methods										Other µg/L
		8015 Modified			8020				8010			
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	
µg/L			µg/L				µg/L			µg/L		
MW4	11/89	ND	NA	NA	33	1.3	1	5.2	NA	NA	NA	Lead 12
	03/90	ND	NA	NA	7.4	2	2	1.1	ND	ND	ND	
	07/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	
	10/90	ND	ND	ND	ND	ND	ND	ND	0.7	ND	0.5	
	01/91	80	ND	ND	9.2	2.4	1.7	0.7	ND	ND	ND	
	04/91	1,400	130 <sup>a</sup>	NA	2,200	72	ND	17	ND	ND	ND	
	07/91	130	ND	NA	14	3.3	9.7	ND	ND	ND	0.81	
	10/91	ND	ND	NA	5.3	1	ND	0.8	ND	ND	ND	
	01/92	ND	ND	NA	6.8	1.3	ND	ND	ND	ND	ND	
	04/92	780	130 <sup>a</sup>	NA	ND	51	ND	4.8	ND	ND	1.6	
	07/92	ND	ND	NA	ND	ND	ND	ND	ND	ND	1.3	
	10/92	100	ND	NA	9.5	ND	ND	2.6	ND	ND	ND	
	01/93	960	240 <sup>a</sup>	NA	200	41	4.6	9.4	ND	ND	1	
06/93	650	140 <sup>a</sup>	ND	150	21	ND	ND	ND	ND	3.7		
MW5	10/90	9,600	1,900	ND	1,200	70	160	520	ND	ND	22	Lead 3
	01/91	10,000	1,200	ND	1,600	720	200	510	ND	ND	33	
	04/91	18,000	860 <sup>a</sup>	NA	2,500	550	580	500	ND	ND	61	
	07/91	15,000	2,200 <sup>a</sup>	NA	4,800	610	1,100	760	ND	ND	62	
	10/91	14,000	3,300 <sup>a</sup>	NA	5,000	530	820	800	ND	ND	49	
	01/92	12,000	1,900 <sup>a</sup>	NA	4,300	390	380	590	ND	ND	56	
	04/92	23,000	6,400 <sup>a</sup>	NA	8,600	ND	2,600	1,900	ND	ND	125	
	07/92	27,000	5,900 <sup>a</sup>	NA	6,000	ND	1,500	1,600	ND	ND	93	
	10/92	13,000	2,100 <sup>a</sup>	NA	4,600	140	470	550	ND	ND	59	
	01/93	18,000	1,900 <sup>a</sup>	NA	5,800	560	1,900	1,600	ND	ND	110	
	01/93	19,000	2,100 <sup>a</sup>	NA	4,600	370	1,600	1,400	ND	ND	120	
	06/93	22,000	2,900 <sup>a</sup>	ND	8,300	740	2,500	1,900	ND	ND	110	
06/93	23,000	2,300 <sup>a</sup>	ND	9,600	730	3,000	1,900	ND	ND	110		

**Table 2**  
**Summary of Historical Groundwater Analytical Data**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Well	Date Sampled	EPA Test Methods										Other µg/L
		8015 Modified			8020				8010			
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	
µg/L			µg/L				µg/L			µg/L		
MW6	10/90	27,000	4,700	ND	2,700	450	2,900	3,300	ND	ND	40	Lead 9
	01/91	7,200	1,600	ND	1,400	ND	200	830	ND	ND	23	
	04/91	17,000	800 <sup>a</sup>	NA	2,800	610	1,200	1,800	ND	ND	53	
	07/91	11,000	1,400 <sup>a</sup>	NA	1,200	ND	380	750	ND	ND	29	
	10/91	4,800	1,600 <sup>a</sup>	NA	380	69	340	730	ND	ND	22	
	01/92	6,100	1,200 <sup>a</sup>	NA	460	180	200	590	ND	ND	26	
	04/92	7,200	1,800 <sup>a</sup>	NA	340	350	460	920	ND	ND	30	
	07/92	8,600	1,700 <sup>a</sup>	NA	1,300	380	280	1,100	ND	ND	35	
	10/92	1,600	110 <sup>a</sup>	NA	230	70	20	88	ND	ND	24	
	01/93	13,000	2,100 <sup>a</sup>	NA	2,500	370	540	2,400	ND	ND	36	
	06/93	7,400	1,900 <sup>a</sup>	ND	1,500	480	120	1,400	ND	ND	29	
MW7	10/90	14,000	2,700	ND	390	ND	18	1,200	ND	1.3	14	Lead 11
	01/91	4,500	1,400	ND	320	42	48	350	ND	ND	10	
	04/91	2,400	NA	NA	320	77	62	130	ND	0.6	11	
	07/91	2,000	910 <sup>a</sup>	NA	470	ND	24	88	ND	ND	9.7	
	10/91	ND	370 <sup>a</sup>	NA	ND	ND	ND	ND	ND	0.68	4.5	
	01/92	1,100	290 <sup>a</sup>	NA	230	45	7	88	ND	3.5	6.4	
	04/92	1,700	520 <sup>a</sup>	NA	310	78	28	170	ND	0.5	3.2	
	07/92	1,900	590 <sup>a</sup>	NA	410	78	21	170	ND	2.1	8.7	
	07/92 (dup)	1,200	700 <sup>a</sup>	NA	21	1	2.6	90	ND	2	8.2	
	10/92	1,800	320 <sup>a</sup>	NA	410	31	11	75	ND	1	7.4	
	01/93	2,100	660 <sup>a</sup>	NA	390	100	21	270	ND	0.6	3.7	
06/93	4,400	1,100 <sup>a</sup>	ND	830	330	49	620	ND	ND	8.6		

**Table 2**  
**Summary of Historical Groundwater Analytical Data**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Well	Date Sampled	EPA Test Methods										Other µg/L
		8015 Modified			8020				8010			
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	
µg/L			µg/L				µg/L			µg/L		
MW8	02/91	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND
	04/91	ND	ND	NA	ND	ND	ND	ND	ND	ND	0.5	ND
	07/91	ND	ND	NA	ND	ND	2	ND	ND	ND	1.2	ND
	10/91	ND	ND	NA	ND	ND	0.6	ND	ND	ND	0.4	ND
	01/92	ND	ND	NA	ND	ND	ND	ND	ND	ND	0.68	ND
	04/92	ND	ND	NA	ND	ND	ND	ND	ND	ND	0.8	ND
	07/92	ND	ND	NA	ND	ND	3.3	ND	ND	ND	1.6	ND
	10/92	ND	ND	NA	ND	ND	ND	ND	ND	ND	1.4	ND
	01/93	ND	ND	NA	ND	ND	ND	ND	ND	ND	0.8	ND
	06/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4	ND
MW9	02/91	6,000	1,600	NA	180	19	170	200	ND	ND	13	
	04/91	4,200	410 <sup>a</sup>	NA	520	130	410	580	ND	ND	26	
	07/91	1,900	180 <sup>a</sup>	NA	190	12	52	77	ND	6.5	12	
	10/91	880	300 <sup>a</sup>	NA	160	31	44	83	ND	ND	10	
	01/92	380	120 <sup>a</sup>	NA	14	7.6	2.2	14	ND	ND	9.6	
	04/92	2,900	700 <sup>a</sup>	NA	510	80	260	260	ND	ND	11	
	07/92	4,400	1,300 <sup>a</sup>	NA	860	210	340	640	ND	ND	22	
	10/92	200	290 <sup>a</sup>	NA	6.8	1.4	2.1	7.8	ND	ND	12	
	01/93	8,500	740 <sup>a</sup>	NA	2,400	390	620	1,500	ND	ND	29	
	06/93	8,200	1,300 <sup>a</sup>	ND	2,400	360	480	1,500	ND	ND	29	
MW10	01/92	13,000	3,700 <sup>a</sup>	NA	130	580	110	3,000	ND	ND	33	
	05/92	15,000	5,000 <sup>a</sup>	NA	180	ND	18	2,700	ND	ND	20	
	05/92 (dup)	13,000	7,500 <sup>a</sup>	NA	240	490	65	2,500	ND	ND	22	
	07/92	8,100	4,400 <sup>a</sup>	NA	74	360	ND	1,100	ND	ND	29	
	10/92	3,200	1,500 <sup>a</sup>	NA	ND	ND	ND	320	ND	ND	25	
	01/93	7,500	2,200 <sup>a</sup>	NA	130	170	20	710	ND	ND	18	
	06/93	8,000	2,100 <sup>a</sup>	ND	69	7.9	ND	490	ND	ND	16	

**Table 2**  
**Summary of Historical Groundwater Analytical Data**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Well	Date Sampled	EPA Test Methods										
		8015 Modified			8020				8010			Other
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	
µg/L			µg/L				µg/L			µg/L		
MW11	01/92	8,200	3,200 <sup>a</sup>	NA	23	250	ND	1,100	ND	ND	ND	
	04/92	160	1,200 <sup>a</sup>	NA	ND	ND	ND	ND	ND	ND	ND	
	07/92	2,100	710 <sup>a</sup>	NA	39	100	2.3	53	ND	ND	ND	
	10/92	660	220 <sup>a</sup>	NA	2.9	19	ND	3.8	ND	ND	ND	
	10/92	770	230 <sup>a</sup>	NA	3.2	26	ND	5.7	ND	ND	ND	
	01/93	780	370 <sup>a</sup>	NA	10	2.1	ND	39	ND	ND	ND	
	06/93	2,500	160 <sup>a</sup>	ND	27	99	ND	34	ND	ND	ND	
MW12	12/92	2,800	1,700 <sup>a</sup>	NA	14	ND	ND	ND	ND	ND	ND	
	06/93	1,100	750 <sup>a</sup>	ND	19	21	ND	57	ND	ND	ND	
B1	01/93	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	
	06/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
F3	02/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Well Abandoned	12/89	1,800	NA	NA	200	24	18	34	ND	ND	0.15	Lead 2,100
Average <sup>b</sup>		8,865	1,883	250	1,562	235	517	871	0.21	0.41	24.8	
Laboratory Detection Limit		50	50	500	0.5	0.5	0.5	0.5	0.4	0.4	0.4	

Notes:

a) The detection for petroleum hydrocarbons as diesel appears to be due to the presence of lighter hydrocarbons rather than diesel.

b) Average of sampled data, ND equals 1/2 detection limit.

µg/L - Micrograms per liter is approximately equivalent to parts per billion, depending on density of water.

NA - Not analyzed.

ND - Not detected.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.

TPH-D - Total petroleum hydrocarbons quantified as diesel.

TPH-MO - Total petroleum hydrocarbons quantified as motor oil.

TCE - Trichloroethylene.

PCE - Tetrachloroethylene.

1,2-DCA - 1,2-Dichloroethane.

**Table 3**  
**Frequency of Detections for Subsurface Soil (below 5.5 feet)**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Constituent	Total Number of Analyses	Number of Positive Detections	Overall Detection Frequency (%)	Positive Detections Below 20 feet	Detection Frequency Below 20 feet (%)
TPH-G	52	24	46	15	63
TPH-D	38	10	26	7	70
TPH-MO	32	6	19	3	50
Benzene	58	29	50	22	76
Ethylbenzene	58	32	55	20	63
Toluene	58	49	84	28	57
Xylenes	58	33	57	22	67
TCE	35	2	6	ND	0
PCE	35	0	0	ND	0
1,2-DCA	35	8	23	6	75

Note:

ND - Not detected.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.

TPH-D - Total petroleum hydrocarbons quantified as diesel.

TPH-MO - Total petroleum hydrocarbons quantified as motor oil.

**Table 4**  
**Frequency of Detections for Groundwater**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Constituent	Upgradient Wells						Source Area Wells								
	MW-3			MW-4			MW-1			MW-5			MW-7		
	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD
TPH-G	10	0	0%	14	7	50%	12	12	100%	11	11	100%	11	10	91%
TPH-D	10	0	0%	12	4	33%	10	10	100%	11	11	100%	10	10	100%
TPH-MO	1	0	0%	4	0	0%	3	0	0%	3	0	0%	3	0	0%
Benzene	10	0	0%	14	10	71%	12	12	100%	11	11	100%	11	10	91%
Ethylbenzene	10	0	0%	14	10	71%	11	10	91%	11	9	82%	11	8	73%
Toluene	10	3	30%	14	5	36%	12	12	100%	11	11	100%	11	10	91%
Xylenes	10	0	0%	14	8	57%	12	12	100%	11	11	100%	11	10	91%
TCE	10	0	0%	13	1	8%	11	1	9%	11	0	0%	11	0	0%
PCE	10	9	90%	13	0	0%	11	0	0%	11	0	0%	11	8	73%
1,2-DCA	10	0	0%	13	8	62%	11	10	91%	11	11	100%	11	11	100%
Lead				1	1	100%	2	1	50%	1	1	100%	1	1	100%

Constituent	Downgradient On-Site Wells									Downgradient Off-Site Wells								
	MW-3			MW-6			MW-9			MW-10			MW-11			MW-12		
	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD
TPH-G	14	14	100%	11	11	100%	10	10	100%	7	7	100%	7	7	100%	2	2	100%
TPH-D	12	12	100%	11	11	100%	10	10	100%	7	7	100%	7	7	100%	2	2	100%
TPH-MO	4	0	0%	3	0	0%	1	0	0%	1	0	0%	1	0	0%	1	0	0%
Benzene	14	14	100%	11	11	100%	10	10	100%	7	6	86%	7	6	86%	2	2	100%
Ethylbenzene	14	12	86%	11	9	82%	10	10	100%	7	5	71%	7	6	86%	2	1	50%
Toluene	14	14	100%	11	11	100%	10	10	100%	7	4	57%	7	1	14%	2	0	0%
Xylenes	14	14	100%	11	11	100%	10	10	100%	7	7	100%	7	6	86%	2	1	50%
TCE	16	0	0%	11	0	0%	10	0	0%	7	0	0%	7	0	0%	2	0	0%
PCE	16	0	0%	11	0	0%	10	1	10%	7	0	0%	7	0	0%	2	0	0%
1,2-DCA	16	15	94%	11	11	100%	10	10	100%	7	7	100%	7	0	0%	2	0	0%
Lead	2	1	0.5	1	1	100%												

Constituent	All Samples Taken		
	Total Analyses	Total Detections	FOD
TPH-G	123	91	74%
TPH-D	114	84	74%
TPH-MO	29	0	0%
Benzene	123	92	75%
Ethylbenzene	122	80	66%
Toluene	123	81	66%
Xylenes	123	90	73%
TCE	125	2	2%
PCE	125	18	14%
1,2-DCA	125	83	66%
Lead			

Note:

FOD - Frequency of detection.

**Table 5**  
**Exposure Parameters**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Exposure Scenario	Exposure Route	Receptor	Body Weight <sup>a</sup> (kg)	Intake Rate	Exposure Frequency (days/yr)	Exposure Duration (years)	Exposure Time	Averaging Time for Carcinogens <sup>a</sup> (Days)	Averaging Time for Noncarcinogens <sup>a</sup> (Days)	Lifetime Daily Intake	Chronic Daily Intake
Potential Adult	Surface soil ingestion	Adult	70	50 mg/day <sup>a</sup>	250	25	N/A	25,550	9,125	0.175	0.489
	Indoor inhalation	Adult	70	20 m <sup>3</sup> /day <sup>a</sup>	250	25	N/A	25,550	9,125	6.99E-02	0.196
Commercial Worker	Inhalation while irrigating	Adult	70	0.8 m <sup>3</sup> /hr <sup>b</sup>	50	25	487 hr/yr <sup>c</sup>	25,550	9,125	5.59E-04	1.57E-03

Notes:

- a) Source: EPA, 1989a.
  - b) Source: EPA, 1991b.
  - c) Site-specific parameters.
- N/A - Not applicable.

**Table 6**  
**National Indoor Background Concentrations**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Constituent	Concentration Range ( $\mu\text{g}/\text{m}^3$ )		
Benzene	3.25E-01	to	2.15E+01
Ethylbenzene	2.2E+00	to	9.7E+00
Toluene	9.6E-01	to	2.91E+02
Xylenes	4.85E+00	to	4.76E+01

Note:

$\mu\text{g}/\text{m}^3$  - Micrograms per cubic meter.

Source: ASTM, 1995.



**Table 7**  
**Toxicity Values and Critical Effects for Chemicals of Concern**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Constituent	Cancer Slope Factors				Weight of Evidence	Type of Cancer
	Oral (mg/kg-d) <sup>-1</sup>	Ref	Inhalation (mg/kg-d) <sup>-1</sup>	Ref		
Benzene	0.1	CA	0.1	CA	A	Leukemia
Ethylbenzene						
Toluene						
Xylenes						
1,2-DCA	0.07	CA	0.07	CA	B2	Tumor induction
TPH-G	0.0017	E	0.0017	E	C	Liver tumors
TPH-D						

Constituent	Oral RfD (mg/kg-d)	Ref	Inhalation RfD (mg/kg-d)	Ref	Uncert./ Modifying Factor	Confidence in RfD	Critical Effect
Benzene							
Ethylbenzene	0.1	I	0.29	I	1000/1:300/1	Low:Low	Liver& kidney toxicity:Developmental toxicity
Toluene	0.2	I	0.11	I	1000/1:300/1	Med:Med	Liver & kidney weight changes:Neurological effects
Xylenes	2	I	2	C	100/1	Med	Hyperactivity, decreased body weight
1,2-DCA							
TPH-G	0.2	E			1000	Low	Weight loss
TPH-D	0.008	E			10000	Low	Liver changes

Notes:

CA - California EPA, 1994  
 I - EPA, 1994b.  
 E - EPA, 1992b.  
 C - DTSC, 1994.  
 mg/kg-d - Milligrams per kilograms of body weight per day.  
 RfD - Reference dose.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.  
 TPH-D - Total petroleum hydrocarbons quantified as diesel.

**Table 8**  
**Summary of Risk-Based Concentrations and Suggested Regulatory Concentrations**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Constituent	Surface Soil (mg/kg)		Subsurface Soil (mg/kg)			Groundwater (µg/L)
	Ingestion	Inhalation	Indoor Inhalation	Regulatory	Leaching Potential	Indoor Inhalation
Benzene	NA	NA	0.118		1,100	3,820
Ethylbenzene	NA	NA	> max.		NC	> max.
Toluene	> max.	150	> max.		NC	> max.
Xylenes	NA	NA	> max.		NC	> max.
1,2-DCA	NA	NA	> max.		NC	> max.
TPH-G	NA	NA	NA	1,000	NC	NA
TPH-D	NA	NA	NA	10,000	NC	NA
Lead	NA	NA	NA		NC	NA

Notes:

> max. - The risk-based concentration is greater than the maximum detected concentration in the medium.  
mg/kg - Milligrams per kilogram.

µg/L - Micrograms per liter.

NA - Pathway not applicable.

NC - Not calculated.

**Table 9**  
**Parameters and Values Used to Calculate  $VF_{SESP}$** 

 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Definition	Value
H	Henry's law constant	See Table 10
$\rho_s$	Soil bulk density	1.5 g/cm <sup>3</sup>
$\theta_{\Omega}$	Volumetric water content in vadose zone	0.12 cm <sup>3</sup> -water/cm <sup>3</sup> -soil
$K_s$	Soil-water sorption coefficient ( $F_{OC} \times K_{OC}$ )	
$F_{OC}$	Fraction of organic carbon in soil (g-carbon/g-soil)	
$K_{OC}$	Carbon-water sorption coefficient	See Table 10
$\theta_{AS}$	Volumetric air content in vadose zone soil	0.26 cm <sup>3</sup> -air/cm <sup>3</sup> -soil
$D_s^{EFF}$	Effective diffusion coefficient in soil based on vapor-phase concentrations. Function of $D^{AIR}$ , $D^{WATER}$ , $\theta_{AS}$ , $\theta_T$ , and $\theta_{WS}$	
$D^{AIR}$	Diffusivity of the COC in air	See Table 10
$D^{WATER}$	Diffusivity of the COC in water	See Table 10
$\theta_T$	Total soil porosity	0.38 cm <sup>3</sup> /cm <sup>3</sup> -soil
$L_{GW}$	Depth to groundwater	910 cm or 30 ft
$L_s$	Depth to subsurface soil sources	610 cm or 20 ft
ER	Enclosed space air exchange rate	0.00023 s <sup>-1</sup>
$L_B$	Enclosed-space volume infiltration area ratio	300 cm
$D_{CRACK}^{EFF}$	Effective diffusion coefficient through foundation cracks. Function of $D^{AIR}$ , $D^{WATER}$ , $\theta_{ACRACK}$ , $\theta_T$ , and $\theta_{WCRACK}$	
$L_{CRACK}$	Enclosed-space foundation or wall thickness	15 cm
$\eta$	Areal fraction of cracks in foundations/walls	0.01 cm <sup>2</sup> -crack/cm <sup>2</sup> -total area

**Table 10**  
**Physical and Chemical Parameters for COCs**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Constituent	CAS #	MW g/mole	Henry's Law Constant [H] <sup>a</sup>		[Koc] <sup>b</sup> mL/g	Diffusivity in Air <sup>b</sup> cm <sup>2</sup> /s	Solubility <sup>c</sup> mg/L	Diffusion Coefficient in Water cm <sup>2</sup> /s
			atm-m <sup>3</sup> /mole	dimensionless				
Benzene	71-43-2	78	5.59E-03	0.23	83	0.093	1,750	1.1 x 10 <sup>-5</sup> <sup>d</sup>
Ethylbenzene	100-41-4	106	6.43E-03	0.26	1,100	0.067	152	8.5 x 10 <sup>-6</sup> <sup>d</sup>
Toluene	108-88-3	95	6.37E-03	0.26	300	0.078	535	9.4 x 10 <sup>-6</sup> <sup>d</sup>
Xylene	1330-20-7	106	7.04E-03	0.037	240	0.072	198	8.5 x 10 <sup>-6</sup> <sup>d</sup>
1,2-DCA	107-06-2	98.96	9.10E-04		65	0.09451	8,520	9.15 x 10 <sup>-6</sup> <sup>e</sup>
TPH-G								
TPH-D								

Notes:

- a) Source: TNRCC, 1994. The dimensionless numbers were calculated by dividing H (atm-m<sup>3</sup>/mole) by [R x T], where R is the ideal gas constant and T is the absolute temperature.
  - b) Source: Heath, et al., 1993.
  - c) Source: ATSM, 1994.
  - d) Source: ASTM, 1995.
  - e) Source: Calculated by the Hayduk and Laudie method described in Lyman, 1990.
- atm-m<sup>3</sup>/mole - Atmosphere-cubic meter per mole.  
 cm<sup>2</sup>/s - Square centimeters per second.  
 g/mole - Grams per mole.  
 mg/L - Milligrams per liter.  
 mL/g - Milliliters per gram.  
 TPH-G - Total petroleum hydrocarbons quantified as gasoline.  
 TPH-D - Total petroleum hydrocarbons quantified as diesel.

**Table 11**  
**Risk through Inhalation of Indoor Volatiles Released from Subsurface Soil**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Volatile Constituent	Average Soil Concentration	Modeled Indoor Air Concentration Max.	Chronic Daily Chemical Intake RME	Lifetime Daily Chemical Intake RME	Inhalation RfD <sup>a</sup>	Noncarcinogenic HQ	Inhalation Slope Factor <sup>a</sup>	Excess Lifetime Cancer Risk	
	mg/kg	mg/m <sup>3</sup>	mg/kg-day	mg/kg-day	mg/kg-day		kg-day/mg		
Benzene	0.46	0.01	1.1E-03	4.0E-04			0.1	4.0E-05	
Ethylbenzene	3.35	0.01	2.7E-03	9.7E-04	0.29	9.3E-03			
Toluene	4.15	0.07	1.4E-02	4.8E-03	0.11	1.2E-01			
Xylene	25.2	0.53	1.0E-01	3.7E-02	2	5.2E-02			
1,2-DCA	0.005	0.0001	1.1E-05	4.0E-06			0.07	2.8E-07	
<b>HI =</b>						<b>1.8E-01</b>		<b>Total Risk =</b>	<b>4E-05</b>

Media Intake Factor	
CDI RME	1.96E-01 m <sup>3</sup> /kg-day
LDI RME	6.99E-02 m <sup>3</sup> /kg-day

Notes:

a) See Table 6 for toxicity values.

HI - Hazard index.

HQ - Hazard quotient

kg-day/mg - Kilogram day per milligram.

mg/m<sup>3</sup> - Milligrams per cubic meters of body weight per day.

m<sup>3</sup>/kg-day - Cubic meters per kilogram day.

mg/kg-day - Milligrams per kilogram of body weight per day.

RfD - Reference dose.

RME - Reasonable maximum exposure.

**Table 12**  
**Parameters and Values Used to Calculate  $VF_{WESP}$**   
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Definition	Value
H	Henry's law constant	See Table 10
$\theta_{WS}$	Volumetric water content in vadose zone	0.12 cm <sup>3</sup> -water/cm <sup>3</sup> -soil
$\theta_{AS}$	Volumetric air content in vadose zone soil	0.26 cm <sup>3</sup> -air/cm <sup>3</sup> -soil
$D_S^{EFF}$	Effective diffusion coefficient in soil based on vapor-phase concentrations. Function of $D^{AIR}$ , $D^{WATER}$ , $\theta_{AS}$ , $\theta_T$ , and $\theta_{WS}$	
$D^{AIR}$	Diffusivity of the COC in air	See Table 10
$D^{WATER}$	Diffusivity of the COC in water	See Table 10
$\theta_T$	Total soil porosity	0.38 cm <sup>3</sup> /cm <sup>3</sup> -soil
$L_{GW}$	Depth to groundwater	910 cm or 30 ft
ER	Enclosed space air exchange rate	0.00023 s <sup>-1</sup>
$L_B$	Enclosed-space volume.infiltration area ration	300 cm
$D_{CRACK}^{EFF}$	Effective diffusion coefficient through foundation cracks. Function of $D^{AIR}$ , $D^{WATER}$ , $\theta_{ACRACK}$ , $\theta_T$ , and $\theta_{WCRACK}$	
$L_{CRACK}$	Enclosed-space foundation or wall thicknes	15 cm
$\eta$	Areal fraction of cracks in foundations/walls	0.01 cm <sup>2</sup> -crack/cm <sup>2</sup> -total area

**Table 13**  
**Risk through Inhalation of Indoor Volatiles Released from Groundwater**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Volatile Constituent	Average Groundwater Concentration	Modeled Indoor Air Concentration	Chronic Daily Chemical Intake RME	Lifetime Daily Chemical Intake RME	Inhalation RfD	Noncarcinogenic HQ	Inhalation Slope Factor	Excess Lifetime Cancer Risk
	µg/L	mg/m <sup>3</sup>	mg/kg-d	mg/kg-d	mg/kg-d		kg-day/mg	
Benzene	1,562	5.9E-04	1.1E-04	4.1E-05			0.1	4.1E-06
Ethylbenzene	235	1.7E-04	3.4E-05	1.2E-05	0.29	1.18E-04		
Toluene	517	4.4E-04	8.6E-05	3.1E-05	0.11	7.78E-04		
Xylene	871	7.2E-04	1.4E-04	5.0E-05	2	7.07E-05		
1,2-DCA	25	9.9E-06	1.9E-06	6.9E-07			0.07	4.9E-08
<b>HI =</b>						<b>9.7E-04</b>	<b>Total Risk =</b>	<b>4.1E-06</b>

Media Intake Factor		
CDI RME	1.96E-01	m <sup>3</sup> /kg-day
LDI RME	6.99E-02	m <sup>3</sup> /kg-day

Notes:

HI - Hazard index.

HQ - Hazard quotient.

kg-day/mg - Kilogram day per milligram.

mg/m<sup>3</sup> - Milligrams per cubic meter.

mg/kg-d - Milligrams per kilogram of body weight per day.

m<sup>3</sup>/kg-day - Cubic meters per kilogram day.

µg/L - Micrograms per liter.

RfD - Reference dose.

RME - Reasonable maximum exposure.

**Table 14**  
**Potential Risk-Based Cleanup Levels**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Constituent	Surface Soil	Subsurface Soil	Groundwater	Comments
	mg/kg	mg/kg	µg/L	
Benzene	150	0.118	3,820	<p>The most stringent concentration was not selected for groundwater because derivation using the dermal exposure pathway is too uncertain.</p> <p>The cleanup level selected for soil is that for TPH-G since the product identified as TPH-D is actually weathered gasoline.</p> <p>The most stringent concentration was not selected for groundwater because derivation using the dermal exposure pathway is too uncertain.</p>
Ethylbenzene		NC	NC	
Toluene		NC	NC	
Xylenes		NC	NC	
1,2-Dichloroethane		NC	NC	
TPH-G		1,000	12,500	
TPH-D		1,000	15,000	
Lead		N/A	N/A	

Notes:

mg/kg - Milligrams per kilogram.

µg/L - Micrograms per liter.

N/A - No concentration was available.

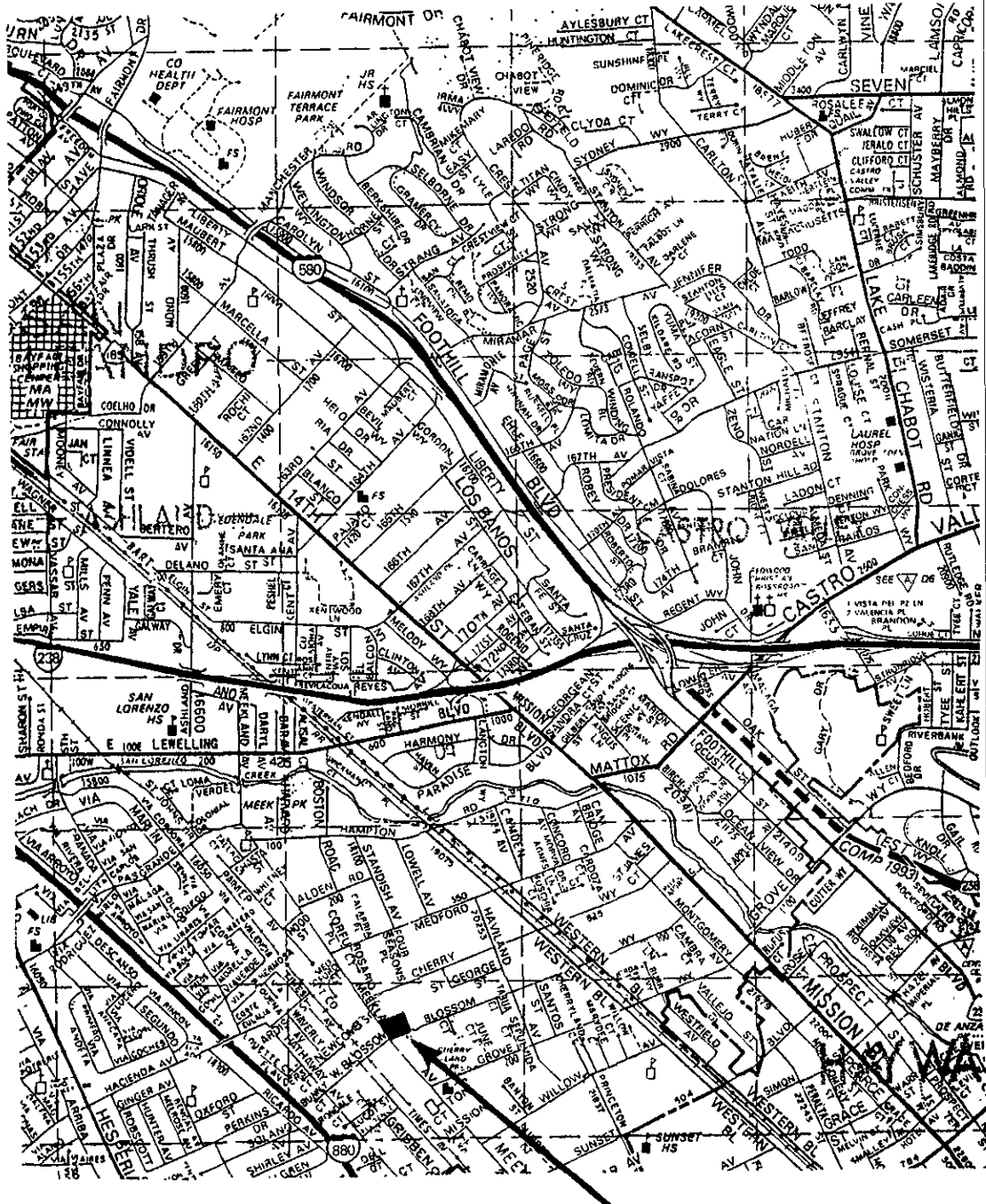
NC - No concentration selected. Maximum concentration detected was below risk-based concentration.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.

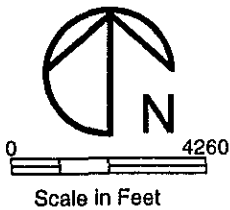
TPH-D - Total petroleum hydrocarbons quantified as diesel.







Site



**AGI**  
TECHNOLOGIES

**Vicinity Map**  
Harbert Transportation/Meekland Avenue  
Hayward, California

FIGURE

**1**

PROJECT NO.  
15,833.001

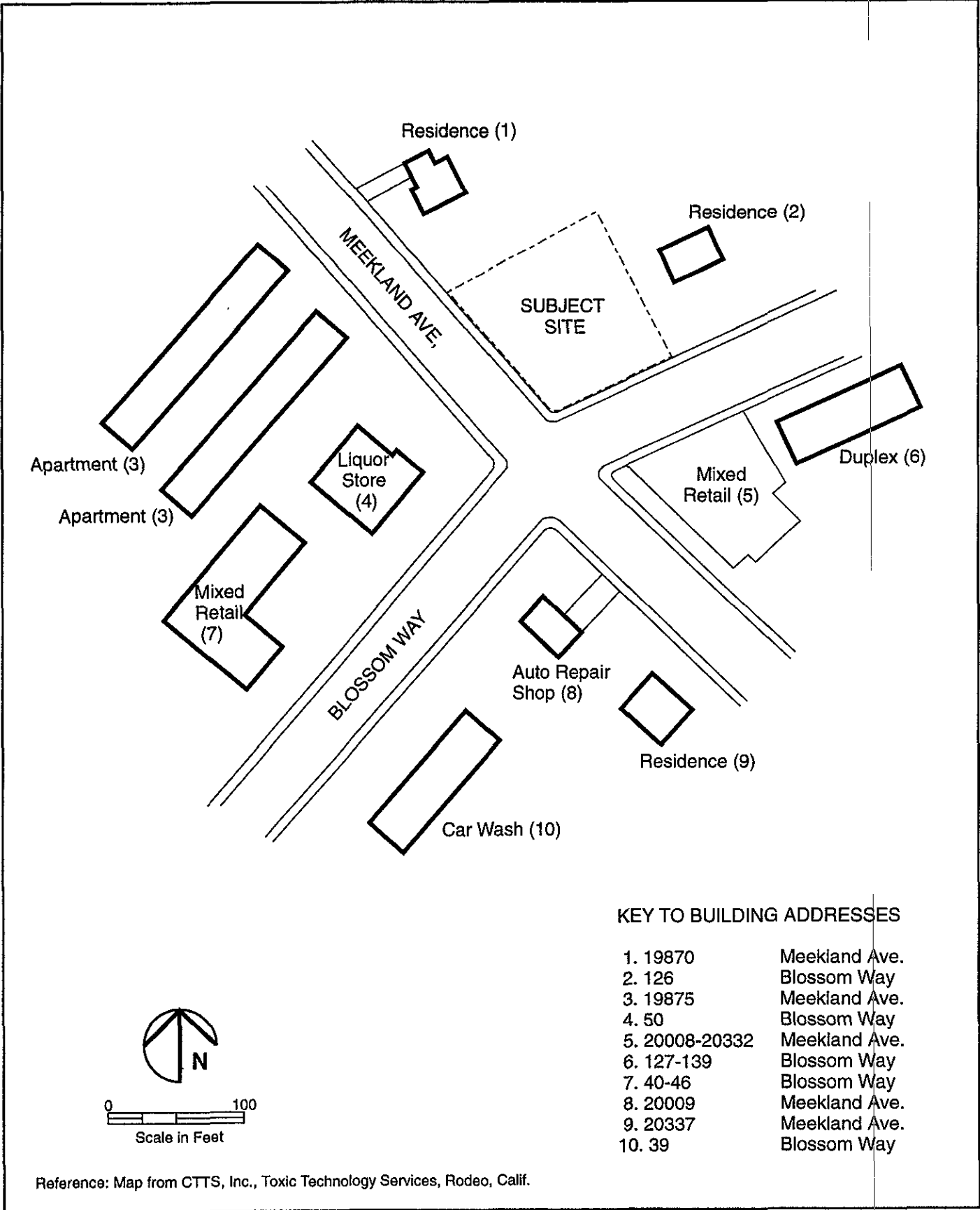
DRAWN  
DFF

DATE  
15 Aug 94

APPROVED

REVISED  
DFF

DATE  
7 Jul 95



Reference: Map from CTTS, Inc., Toxic Technology Services, Rodeo, Calif.



vicinity.cdr

PROJECT NO.  
15,833.001

DRAWN  
DFF

DATE  
7 Jul 95

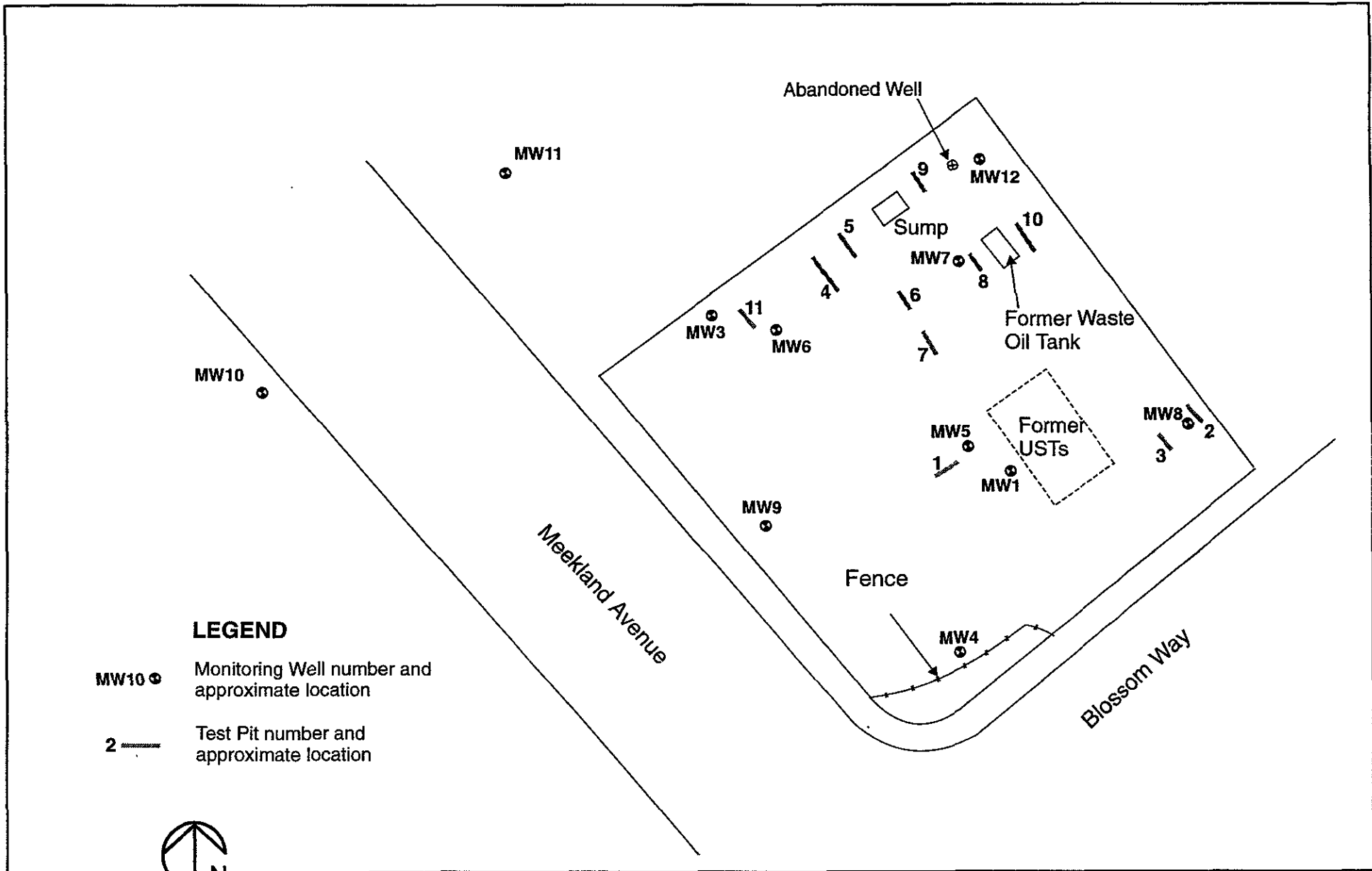
APPROVED  
*[Signature]*

REVISED  
DFF

DATE  
16 Aug 95

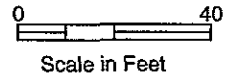
**Area Plan Map**  
Harbert Transportation/Meekland Avenue  
Hayward, California

FIGURE  
**2**



**LEGEND**

- MW10 ● Monitoring Well number and approximate location
- 2 — Test Pit number and approximate location



**AGI**  
TECHNOLOGIES

**Site Plan**

Harbert Transportation/Meekland Avenue  
Hayward, California

FIGURE

**3**

siteplan.cdr	PROJECT NO 15,833.001	DRAWN DFF	DATE 29 August 94	APPROVED <i>[Signature]</i>	REVISED DFF	DATE 16 Aug 95
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**APPENDIX A**  
**Example Calculations**

**APPENDIX A**

**TABLE A-1**  
Example Calculation:

Screening Level Equation for Ingestion of Noncarcinogenic Contaminants  
in Commercial Soil

$$\text{Screening Level (mg/kg)} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 365 \text{d/yr}}{1/\text{RfD}_o \times 10^{-6} \text{ kg/mg} \times \text{EF} \times \text{ED} \times \text{IR}_s}$$

where:

- THQ = Target hazard quotient (1 unitless)
- BW = Body weight (70 kg)
- AT = Averaging time (25 yrs)
- RfD<sub>o</sub> = Oral reference dose (toluene - 0.2 mg/kg-d)
- EF = Exposure frequency (250 d/yr)
- ED = Exposure duration (25 y)
- IR = Soil ingestion rate (50 mg/d)

\* For noncarcinogens, AT is equal to ED.

**TOLUENE EXAMPLE**

$$\text{Screening Level (mg/kg)} = \frac{1 \times 70 \text{ kg} \times 25 \text{ yrs} \times 356 \text{ d/yr}}{[1/0.2 \text{ (mg/kg-d)}] \times 10^{-6} \text{ kg/mg} \times 250 \text{ d/yr} \times 25 \text{ yr} \times 50 \text{ mg/d}}$$

Screening Level (mg/kg) = 408,000

APPENDIX A

TABLE A-2  
Example Calculation:

Screening Level Equation for Inhalation of Noncarcinogenic Contaminants  
in Commercial Soil

$$\text{Screening Level (mg/kg)} = \frac{\text{THQ} \times \text{BW} \times \text{AT} \times 356 \text{ d/yr}}{\text{EF} \times \text{ED} \times [\text{1/RfC} \times \text{IR}_a \times (\text{1/VF} + \text{1/PEF})]}$$

where:

- THQ = Target hazard quotient (1 unitless)
- BW = Body weight (70 kg)
- AT = Averaging time (25 yrs)
- R<sub>f</sub>C = Inhalation reference concentration (toluene - 0.11 mg/kg-d)
- EF = Exposure frequency (250 d/yr)
- ED = Exposure duration (25 y)
- PEF = Particulate emission factor (4.51 x 10<sup>9</sup> m<sup>3</sup>/kg)
- VF = Soil to air volatilization factor (m<sup>3</sup>/kg) 1.4 x 10<sup>4</sup> (Table 5 EPA 1994c)
- IR<sup>a</sup> = Work day inhalation rate (20 m<sup>3</sup>/day)

\* For noncarcinogens, AT is equal to ED.

TOLUENE EXAMPLE

Screening Level (mg/kg) = 7,900



**APPENDIX A**

**TABLE A-3**

Example Calculation:

Risk-Based Concentration Equation for Inhalation of Carcinogenic Contamination  
Commercial Soil

$$\text{ScreeningLevel (mg/kg)} = \frac{TR \times BW \times AT \times 365 \text{ d/yr}}{EF \times ED \times SF_i \times IR_a \times \left(\frac{1}{VF}\right)}$$

where:

- TR = Target risk (10<sup>-6</sup> unitless)
- BW = Body weight (70 kg)
- AT = Averaging time (70 yrs)
- EF = Exposure frequency (250 d/yr)
- ED = Exposure duration (20 d/yr)
- SF<sub>i</sub> = Inhalation cancer slope factor (0.029 (mg/kg-day)<sup>-1</sup>)
- IR = Inhalation rate (20 m<sup>3</sup>/day)
- VF = Volatilization factor (m<sup>3</sup>/kg) (Table 5, EPA 1994c)

**APPENDIX A**  
(Continued)  
**TABLE A-3**  
Example Calculation:

**Risk-Based Concentration Equation for Inhalation of Carcinogenic Contamination  
Commercial Soil**

Soil to Air Volatilization Factor

$$VF (m^3/kg) = (Q/C) \times \frac{(3.14 \times a \times T)^{1/2}}{2 \times D_{ei} \times P_a \times K_{sa}} \times 10^{-4} m^2/cm^2$$

$$a = \frac{D_{ei} \times P_a}{P_a + (v_d)(1-P_d)/K_{sa}}$$

where:

- Q/C = Inverse of the mean concentration at the center of a 0.5-acre square source (101.8 g/m<sup>2</sup>-s per kg/m<sup>3</sup>)
- T = Exposure interval (7.9 x 10<sup>8</sup> s)
- D<sub>ei</sub> = Effective diffusivity (D<sub>i</sub>(P<sub>a</sub><sup>3.33</sup>/P<sub>i</sub><sup>2</sup>cm<sup>2</sup>/s)
- P<sub>a</sub> = Air filled soil porosity (P<sub>i</sub>θβ unitless)
- P<sub>i</sub> = Total soil porosity (1 - (β/p<sub>s</sub>))
- θ = Soil moisture content (0.1 cm<sup>3</sup>-water/g-soil)
- β = Soil bulk density (1.5 g/cm<sup>3</sup>)
- p<sub>s</sub> = True soil density (2.65 g/cm<sup>3</sup>)
- K<sub>sa</sub> = Soil-air partition coefficient (chemical specific - H/K<sub>d</sub> x 41 g-soil/cm<sup>3</sup>-air)
- D<sub>i</sub> = Diffusivity in air (chemical specific cm<sup>2</sup>/s)
- H = Henry's law constant (chemical specific atm-m<sup>3</sup>/mol)
- K<sub>d</sub> = Soil-water partition coefficient (K<sub>oc</sub> x OC cm<sup>3</sup>/g)
- K<sub>oc</sub> = Organic carbon partition coefficient (chemical specific cm<sup>3</sup>/g)
- OC = Organic carbon content of soil (0.02 unitless)

**APPENDIX A**  
(Continued)  
**TABLE A-3**  
Example Calculation:

Risk-Based Concentration Equation for Inhalation of Carcinogenic Contamination  
Commercial Soil

*Risk-Based Concentration (mg/kg)* =

$$\frac{10^{-6} \times 70 \text{ kg} \times 70 \text{ yrs} \times 365 \text{ d/yr}}{250 \text{ d/yr} \times 25 \text{ yr} \times 0.029 \left(\frac{\text{mg}}{\text{kg-d}}\right)^{-1} \times 20 \text{ m}^3/\text{day} \times 1/8500 \text{ m}^3/\text{kg}}$$

Risk-Based Concentration (mg/kg) = 4.2

Particulate Emission Factor

$$PEF \text{ (m}^3/\text{kg)} = (Q/C) \times \frac{3,600 \text{ s/h}}{0.036 \times (1-G) \times (U_m/U_t)^3 \times F(x)}$$

where:

- Q/C = Inverse of the mean concentration at the center of an 0.5-acre square source (101.8 g/m<sup>2</sup>-s per kg/m<sup>3</sup>)
- 0.036 = Respirable fraction (unitless)
- G = Fraction of vegetative cover (0 unitless)
- U<sub>m</sub> = Mean annual wind speed (4.5 m/s)
- U<sub>t</sub> = Equivalent threshold value of wind speed at 10 m (12.8 m/s)
- F(x) = Function dependent on U<sub>m</sub>/U<sub>t</sub>, derived using Coward (EPA, 1985)

**APPENDIX A**  
(Continued)  
**TABLE A-3**  
Example Calculation:

**Risk-Based Concentration Equation for Inhalation of Carcinogenic Contamination  
Commercial Soil**

Soil Saturation Limit

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H' \times P_a)}{\beta}$$

where:

- $K_d$  = Soil-water partition coefficient ( $K_{oc} \times OC$  cm<sup>3</sup>/g)
- $K_{oc}$  = Organic carbon partition coefficient (chemical specific cm<sup>3</sup>/g)
- OC = Organic carbon content of soil (0.02 unitless)
- $C_w$  = Upper limit of free moisture in soil ( $S \times \theta$  mg/L-water)
- S = Solubility (chemical specific mg/L-water)
- $\theta_m$  = Soil moisture content (0.1 kg-water/kg-soil)
- $\beta$  = Soil bulk density (1.5 g/cm<sup>3</sup>)
- $P_a$  = Air-filled soil porosity ( $P_t - \theta \beta$  unitless)
- $P_w$  = Water-filled soil porosity ( $P_t - P_a$  unitless)
- $P_t$  = Total soil porosity ( $1 - (\beta/p_s)$ )
- $H'$  = Henry's law constant (chemical specific -  $H \times 41$  unitless)
- H = Henry's law constant (chemical specific atm-m<sup>3</sup>/mol)
- $\theta$  = Soil moisture content (0.1 L-water/kg-soil)
- P = True soil density (2.65 kg/L)

APPENDIX A

TABLE A-4  
ASTM Based Volatilization Factor Formulas

Groundwater → Enclosed space vapors

$$VF_{wesp} \left( \frac{\text{mg/m}^3\text{-air}}{\text{mg/L -H}_2\text{O}} \right) = \frac{H \left[ \frac{(D_{wat}/L_{GW})}{(ER)(L_B)} \right]}{1 + \left[ \frac{(D_{wat}/L_{GW})}{(ER)(L_B)} \right] + \left[ \frac{(D_{wat}/L_{GW})}{(D_{crack}/L_{crack})\eta} \right]} \times 10^3 \frac{\text{L}}{\text{m}^3}$$

Subsurface Soil → Enclosed space vapors

$$VF_{sesp} \left( \frac{\text{mg/m}^3\text{-air}}{\text{mg/kg -soil}} \right) = \frac{\left[ \frac{H\rho_s}{(\Theta_{ws} + k_s\rho_s + H\theta_{as})} \right] \left[ \frac{(D_s/L_s)}{(ER)(L_B)} \right]}{1 + \left[ \frac{(D_s/L_s)}{(ER)(L_B)} \right] + \left[ \frac{(D_s/L_s)}{(D_{crack}/L_{crack})\eta} \right]} \times 10^3 \frac{\text{cm}^3\text{-kg}}{\text{m}^3\text{-g}}$$

From: ASTM

**Table A-5**  
**Risk-Based Screening Level (RBSL) Calculation for Benzene**  
Harbert Transportation/Meekland Avenue  
Hayward, California

Parameter	Value	Parameter	Value
$D_{air}$ (cm <sup>2</sup> /s)	0.093 ✓	$D_s$ (cm <sup>2</sup> /s)	0.00725762
$D_{wat}$ (cm <sup>2</sup> /s)	1.10E-05 ✓	$D_{crack}$ (cm <sup>2</sup> /s)	0.00726663
ER (s <sup>-1</sup> )	0.00023 ✓	$D_{cap}$ (cm <sup>2</sup> /s)	2.131E-05
$f_{oc}$ (g-C/g-soil)	0.01 ✓	$D_{ws}$ (cm <sup>2</sup> /s)	0.00010531
H (L-H <sub>2</sub> O/L-air)	0.23 ✓	$VF_{wesp}$ ((mg/m <sup>3</sup> -air)/(mg/L-H <sub>2</sub> O))	0.00037499
$h_{cap}$ (cm)	50m / 182.88 ✓	$VF_{seep}$ ((mg/m <sup>3</sup> -air)/(mg/kg-soil))	0.01208291
$h_v$ (cm)	731.52 ✓		
$k_{oc}$ (g-H <sub>2</sub> O/g-C)	83 ✓	RBSL <sub>AIR</sub> (µg/m <sup>3</sup> -air)	1.43
$k_s$ (g-H <sub>2</sub> O/g-soil)	0.83 ✓	RBSL <sub>GW</sub> (mg/L-H <sub>2</sub> O)	3.816
$L_B$ (cm)	300 ✓	RBSL <sub>SOIL</sub> (mg/kg-soil)	0.118
$L_{crack}$ (cm)	15 ✓		
$L_{GW}$ (cm)	914.4 ✓		
$L_S$ (cm)	609.6 ✓		
$P_e$ (g/cm <sup>2</sup> -s)	6.90E-14		
$\eta$ (cm <sup>2</sup> -crack/cm <sup>2</sup> -total area)	0.01		
$\theta_{acap}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.038		
$\theta_{acrack}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -total area)	0.26		
$\theta_{as}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.26		
$\theta_T$ (cm <sup>3</sup> /cm <sup>3</sup> -soil)	0.38		
$\theta_{wcap}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.342		
$\theta_{wcrack}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -total volume)	0.12		
$\theta_{ws}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.12		
$\rho_s$ (g/cm <sup>3</sup> )	1.5		

*For what slope factor*

**Table A-6**  
**Risk-Based Screening Level (RBSL) Calculation for Ethylbenzene**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Value	Parameter	Value
$D_{air}$ (cm <sup>2</sup> /s)	0.067	$D_s$ (cm <sup>2</sup> /s)	0.00522859
$D_{wat}$ (cm <sup>2</sup> /s)	8.50E-06	$D_{crack}$ (cm <sup>2</sup> /s)	0.00523476
ER (s <sup>-1</sup> )	0.00023	$D_{cap}$ (cm <sup>2</sup> /s)	1.5009E-05
$f_{oc}$ (g-C/g-soil)	0.01	$D_{ws}$ (cm <sup>2</sup> /s)	7.4195E-05
H (L-H <sub>2</sub> O/L-air)	0.26	$VF_{wesp}$ ((mg/m <sup>3</sup> -air)/(mg/L-H <sub>2</sub> O))	0.0002988
$h_{cap}$ (cm)	182.88	$VF_{seep}$ ((mg/m <sup>3</sup> -air)/(mg/kg-soil))	0.00084015
$h_v$ (cm)	731.52	RBSL <sub>AIR</sub> (µg/m <sup>3</sup> -air)	1482
$k_{oc}$ (g-H <sub>2</sub> O/g-C)	1100	RBSL <sub>GW</sub> (mg/L-H <sub>2</sub> O)	4959
$k_s$ (g-H <sub>2</sub> O/g-soil)	11	RBSL <sub>SOIL</sub> (mg/kg-soil)	1764
$L_B$ (cm)	300		
$L_{crack}$ (cm)	15		
$L_{GW}$ (cm)	914.4		
$L_s$ (cm)	609.6		
$P_e$ (g/cm <sup>2</sup> -s)	6.90E-14		
$\eta$ (cm <sup>2</sup> -crack/cm <sup>2</sup> -total area)	0.01		
$\theta_{acap}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.038		
$\theta_{acrack}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -total area)	0.26		
$\theta_{as}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.26		
$\theta_T$ (cm <sup>3</sup> /cm <sup>3</sup> -soil)	0.38		
$\theta_{wcap}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.342		
$\theta_{wcrack}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -total volume)	0.12		
$\theta_{ws}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.12		
$\rho_s$ (g/cm <sup>3</sup> )	1.5		

**Table A-7**  
**Risk-Based Screening Level (RBSL) Calculation for Toluene**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Value	Parameter	Value
$D_{air}$ (cm <sup>2</sup> /s)	0.078	$D_s$ (cm <sup>2</sup> /s)	0.00608701
$D_{wat}$ (cm <sup>2</sup> /s)	9.40E-06	$D_{crack}$ (cm <sup>2</sup> /s)	0.00609382
ER (s <sup>-1</sup> )	0.00023	$D_{cap}$ (cm <sup>2</sup> /s)	1.7103E-05
$f_{oc}$ (g-C/g-soil)	0.01	$D_{ws}$ (cm <sup>2</sup> /s)	8.4565E-05
H (L-H <sub>2</sub> O/L-air)	0.26	$VF_{wesp}$ ((mg/m <sup>3</sup> -air)/(mg/L-H <sub>2</sub> O))	0.00034072
$h_{cap}$ (cm)	182.88	$VF_{sesp}$ ((mg/m <sup>3</sup> -air)/(mg/kg-soil))	0.00348174
$h_v$ (cm)	731.52	RBSL <sub>AIR</sub> (μg/m <sup>3</sup> -air)	562
$k_{oc}$ (g-H <sub>2</sub> O/g-C)	300	RBSL <sub>GW</sub> (mg/L-H <sub>2</sub> O)	1650
$k_s$ (g-H <sub>2</sub> O/g-soil)	3	RBSL <sub>SOIL</sub> (mg/kg-soil)	161.4
$L_B$ (cm)	300		
$L_{crack}$ (cm)	15		
$L_{GW}$ (cm)	914.4		
$L_S$ (cm)	609.6		
$P_e$ (g/cm <sup>2</sup> -s)	6.90E-14		
$\eta$ (cm <sup>2</sup> -crack/cm <sup>2</sup> -total area)	0.01		
$\theta_{acap}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.038		
$\theta_{acrack}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -total area)	0.26		
$\theta_{as}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.26		
$\theta_T$ (cm <sup>3</sup> /cm <sup>3</sup> -soil)	0.38		
$\theta_{wcap}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.342		
$\theta_{wcrack}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -total volume)	0.12		
$\theta_{ws}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.12		
$\rho_s$ (g/cm <sup>3</sup> )	1.5		



**Table A-8**  
**Risk-Based Screening Level (RBSL) Calculation for Xylenes**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Value	Parameter	Value
$D_{air}$ (cm <sup>2</sup> /s)	0.072	$D_s$ (cm <sup>2</sup> /s)	0.00561875
$D_{wat}$ (cm <sup>2</sup> /s)	8.50E-06	$D_{crack}$ (cm <sup>2</sup> /s)	0.00562428
ER (s <sup>-1</sup> )	0.00023	$D_{cap}$ (cm <sup>2</sup> /s)	1.4998E-05
$f_{oc}$ (g-C/g-soil)	0.01	$D_{ws}$ (cm <sup>2</sup> /s)	7.4196E-05
H (L-H <sub>2</sub> O/L-air)	0.29	$VF_{wesp}$ ((mg/m <sup>3</sup> -air)/(mg/L-H <sub>2</sub> O))	0.00033381
$h_{cap}$ (cm)	182.88	$VF_{seep}$ ((mg/m <sup>3</sup> -air)/(mg/kg-soil))	0.004427
$h_v$ (cm)	731.52	RBSL <sub>AIR</sub> (µg/m <sup>3</sup> -air)	10,220
$k_{oc}$ (g-H <sub>2</sub> O/g-C)	240	RBSL <sub>GW</sub> (mg/L-H <sub>2</sub> O)	30616
$k_s$ (g-H <sub>2</sub> O/g-soil)	2.4	RBSL <sub>SOIL</sub> (mg/kg-soil)	2309
$L_B$ (cm)	300		
$L_{crack}$ (cm)	15		
$L_{GW}$ (cm)	914.4		
$L_S$ (cm)	609.6		
$P_e$ (g/cm <sup>2</sup> -s)	6.90E-14		
$\eta$ (cm <sup>2</sup> -crack/cm <sup>2</sup> -total area)	0.01		
$\theta_{acap}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.038		
$\theta_{acrack}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -total area)	0.26		
$\theta_{as}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.26		
$\theta_r$ (cm <sup>3</sup> /cm <sup>3</sup> -soil)	0.38		
$\theta_{wcap}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.342		
$\theta_{wcrack}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -total volume)	0.12		
$\theta_{ws}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.12		
$\rho_s$ (g/cm <sup>3</sup> )	1.5		

**Table A-9**  
**Risk-Based Screening Level (RBSL) Calculation for 1,2-Dichloroethane**  
 Harbert Transportation/Meekland Avenue  
 Hayward, California

Parameter	Value	Parameter	Value
$D_{air}$ (cm <sup>2</sup> /s)	0.09451	$D_s$ (cm <sup>2</sup> /s)	0.00737662
$D_{wat}$ (cm <sup>2</sup> /s)	9.15E-06	$D_{crack}$ (cm <sup>2</sup> /s)	0.00742286
ER (s <sup>-1</sup> )	0.00023	$D_{cap}$ (cm <sup>2</sup> /s)	5.9899E-05
$f_{oc}$ (g-C/g-soil)	0.01	$D_{ws}$ (cm <sup>2</sup> /s)	0.00029007
H (L-H <sub>2</sub> O/L-air)	0.0373	$VF_{wesp}$ ((mg/m <sup>3</sup> -air)/(mg/L-H <sub>2</sub> O))	0.00016116
$h_{cap}$ (cm)	182.88	$VF_{seps}$ ((mg/m <sup>3</sup> -air)/(mg/kg-soil))	0.00257793
$h_v$ (cm)	731.52		
$k_{oc}$ (g-H <sub>2</sub> O/g-C)	65	RBSL <sub>AIR</sub> (µg/m <sup>3</sup> -air)	2.04
$k_s$ (g-H <sub>2</sub> O/g-soil)	0.65	RBSL <sub>GW</sub> (mg/L-H <sub>2</sub> O)	12.68
$L_B$ (cm)	300	RBSL <sub>SOIL</sub> (mg/kg-soil)	0.793
$L_{crack}$ (cm)	15		
$L_{GW}$ (cm)	914.4		
$L_S$ (cm)	609.6		
$P_a$ (g/cm <sup>2</sup> -s)	6.90E-14		
$\eta$ (cm <sup>2</sup> -crack/cm <sup>2</sup> -total area)	0.01		
$\theta_{acap}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.038		
$\theta_{acrack}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -total area)	0.26		
$\theta_{as}$ (cm <sup>3</sup> -air/cm <sup>3</sup> -soil)	0.26		
$\theta_T$ (cm <sup>3</sup> /cm <sup>3</sup> -soil)	0.38		
$\theta_{wcap}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.342		
$\theta_{wcrack}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -total volume)	0.12		
$\theta_{ws}$ (cm <sup>3</sup> -H <sub>2</sub> O/cm <sup>3</sup> -soil)	0.12		
$\rho_s$ (g/cm <sup>3</sup> )	1.5		