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EXECUTIVE SUMMARY

This document is a risk assessment for Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California. The purpose of this risk assessment is to evaluate whether constituents in soils or groundwater at the site could pose a threat to human health or the environment under current conditions.

This report is based on the analytical results of groundwater samples collected by Leyton & Associates in March and May 1996, and the analytical results of soil samples collected by Kaprelian Engineering in November 1992 and Leyton & Associates in March 1996. Constituents of concern (COCs) in groundwater and soils at the site include benzene, toluene, ethylbenzene, and xylenes (BTEX).

Currently, the site is used as a commercial office building for Thompson & Thompson Fence Company. Benzene in soils is detected at depth. Groundwater in the vicinity of the site is not used as a water-supply source. Drinking water for the area is supplied by East Bay Municipal Utilities District (EBMUD).

There are no plans for improvements at the site. Therefore, it is very unlikely that groundwater would be used at the site. Total dissolved solids data were used to determine whether groundwater is usable at the site. Groundwater discharges into the San Francisco Bay, approximately 1/4 mile west of the site. Therefore, the nearest downgradient beneficial use of the groundwater would be the bay. Assuming groundwater from the site reaches the bay, the potential could exist for aquatic life to be exposed to COCs discharged with the groundwater. This potential exposure pathway also was evaluated in the risk assessment.

Maximum detected groundwater concentrations were all below available water-quality criteria for the protection of aquatic life, with the exception of the maximum detected concentration of xylenes. Natural attenuation processes such as dispersion and biodegradation were not considered in this assessment, and it is likely that these processes would act to reduce released concentrations below current on-site concentrations. Thus, assuming that contaminated groundwater were to discharge to the San Francisco Bay (1/4 mile downgradient of the site) impact to aquatic life would be unlikely.

The only potentially significant pathway for human exposure to the COCs is that of inhalation of vapors which may migrate from the groundwater into the office building. A summary of the calculated vapor inhalation risks is provided in Table 14. Calculated excess lifetime cancer risk (ELCR) is 3.5E-05. The ELCR falls within the U.S. Environmental Protection Agency's (USEPA's) target acceptable cancer risk range of 10^{-6} to 10^{-4} . The calculated hazard index (HI) is less than the USEPA greatest acceptable HI value of 1.0.

**RISK ASSESSMENT
THOMPSON & THOMPSON FENCE COMPANY
2584 GRANT AVENUE
SAN LORENZO, CALIFORNIA**

1.0 INTRODUCTION

Leyton & Associates (L&A) was retained to evaluate the potential threat to human health for gasoline constituents detected in soils and groundwater at the site occupied by Thompson & Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California. This risk evaluation was performed by evaluating the magnitude and likelihood of exposure to constituents released to soil and groundwater at the site. Previous investigations have been conducted on the property, and the majority of the contamination was removed in November 1992. This risk assessment evaluates potential exposures to residual levels of contamination on the property.

The current property owner has expressed an interest in refinancing the property and does not plan on making any improvements. Potential exposures to residual gasoline constituents in soil and groundwater were evaluated for on-site office workers. Groundwater in the vicinity of the site is not used as a water-supply source. Drinking water from the area is supplied by East Bay Municipal Utility District (EBMUD). Total dissolved solids data in groundwater is presented on Table 2. Groundwater discharges into the San Francisco Bay, approximately 1/4 mile west of the site. Therefore, the nearest downgradient beneficial use of the groundwater would be the bay, assuming groundwater from the site reaches the bay. The most recent groundwater data were compared to water-quality criteria for the protection of aquatic life to evaluate whether potentially discharging current concentrations of the on-site constituents would degrade San Francisco Bay or pose a threat to aquatic life in the bay.

The methodologies used in this risk assessment were designed to be consistent with guidelines established by the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region (RWQCB, 1990), the Alameda County Department of Environmental Health (1993), and the U.S. Environmental Protection Agency (USEPA) (1989a, 1991a) for risk assessments. The report is organized as follows:

- Section 2 - Site Characterization
Describes Thompson & Thompson Fence Company, provides a summary of the history of the site, and describes the geology, hydrology, and climatology of the site and surrounding area.
- Section 3 - Contaminant Characterization
Identifies and summarizes the occurrence of gasoline-constituents in soil and groundwater.

- Section 4 - Toxicity Assessment
Identifies and presents summaries of the pertinent toxicological properties of the chemicals detected at the site.
- Section 5 - Exposure Assessment
Discusses the physical and chemical properties influencing contaminant migration, potential exposure routes, and potential receptors exposed to chemicals detected in soil and groundwater.
- Section 6 - Risk Characterization
Summarizes the potential risk to human health and the environment from exposure to chemicals detected in soil and groundwater.
- Section 7 - Uncertainties in the Risk Assessment
Discusses the inherent uncertainties in the risk assessment process.
- Section 8 - Findings and Conclusions
Summarizes the results of the risk assessment.

2.0 SITE CHARACTERIZATION

This section describes the subject site and surrounding area; the geology, hydrogeology, and climatology at the site; and observations on-site, obtained from site investigations conducted to date.

2.1 SITE DESCRIPTION AND HISTORY

The subject site is located in the town of San Lorenzo, Alameda County, California. The site is on the south side of Grant Avenue, which runs east-west. Across from the subject site is the Oro Loma Sanitary District, and Mei Ling's Chinese restaurant. The sanitary district surrounds the subject site on the north, west and south boundaries. Adjacent and to the east of the site are additional commercial properties used for manufacturing. San Francisco Bay is to the west of the subject site.

One 1,000-gallon underground storage tank (UST) previously existed at the subject site, and contained leaded gasoline to be used by company trucks. The UST was emptied and removed from the site in November 1992. The UST removal and related activities were performed by Paradiso Construction of San Leandro, California. Soil samples were collected (by Kaprelian Engineering of Concord, California) from both ends of the former UST at approximately 8.5 feet below ground surface (bgs). Soil samples collected and analyzed during tank removal activities contained total

petroleum hydrocarbons as gasoline at concentrations of 960 and 2,000 parts per million (ppm). Benzene was detected in the soil samples at concentrations of 13 and 38 ppm. Analytic results for lead indicated that concentrations of 7.4 and 11 ppm were present. Groundwater was not encountered during tank removal activities.

There are no current plans for property improvement at the site.

2.2 SITE-SPECIFIC GEOLOGY

The site is on a broad alluvial plain extending from the Hayward Hills on the east to San Francisco Bay on the west. The site is underlain by silt and clay to a depth of approximately 15 feet bgs. A 10-foot-thick sand layer is underlain by clay in borings MW-1 and MW-3. Cross-sections presenting subsurface sediments are included as Figures 3 and 4.

2.3 SITE-SPECIFIC HYDROLOGY

2.3.1 Groundwater

Depth to groundwater at the site varies depending on the frequency and rate of precipitation. In May 1996, groundwater was encountered at approximately 4.50 feet bgs. The groundwater flow direction was westerly at that time (L&A, 1996).

2.3.2 Surface Water

The closest surface water is San Francisco Bay, located approximately 1/4 mile west of the site.

2.4 CLIMATOLOGY

The climate of San Lorenzo is mild with mean monthly temperatures ranging from 48 degrees Fahrenheit (°F) in January to 65 °F in September (National Oceanic and Atmospheric Administration [NOAA], 1974). Monthly average high temperatures range from 55°F in January to 75°F in September, while monthly average low temperatures range from 41°F to 56°F in January and August, respectively. The average annual precipitation for the area is 17.93 inches (NOAA, 1974). The mean wind speed is 3.6 meters per second (m/sec) from a westward direction (NOAA, 1974).

3.0 CHARACTERIZATION OF CONTAMINANT CONSTITUENTS

This section describes the data reduction and occurrence of the gasoline constituents in soil and groundwater at the subject site. Groundwater analytical data were collected by L&A in March and May, 1996. Soil analytical data were collected by Kaprelian Engineering in November 1992 and by L&A in March 1996.

Chemical concentration data for soil and groundwater are summarized in Tables 1 and 2. Table 3 lists the detection frequency of each constituent, the range of sample quantitation limits (SQLs), the range of detected values, the arithmetic mean concentration, and the 95 percent upper confidence limit (UCL) on the mean assuming a normal distribution. Compounds that were not detected in a specific medium were not included in the data summary tables. The mean and UCL calculations were based on the detected concentration(s) and one-half the reported SQL for the non-detects, unless half the SQL exceeded the maximum detected value. When this occurred, the maximum detected concentration was used instead of one-half the SQL.

3.1 SOIL

Table 1 summarizes the soil data from previous investigations. The soil was collected from the former UST area and soil borings for monitoring wells MW-1, MW-2 and MW-3. Sampling depths for monitoring well soil samples ranged from 5.5 to 16 feet bgs. The locations for the monitoring well locations are shown on Figure 2. A total of 14 samples were collected, of which 7 samples were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH) as gasoline; 5 samples were analyzed for BTEX with methyl-tert-butyl-ether (MTBE) distinction; and 2 samples were analyzed for total lead. The range of concentrations for total lead detected is below background ranges reported for soils in the western United States (U.S. Geological Survey [USGS], 1984).

The soil samples collected from the UST removal detected TPH as gasoline at concentrations of 960 parts per million (ppm) to 2,000 pp at a depth of approximately 8.5 feet bgs. Benzene was also detected at concentrations of 13 and 38 ppm in these samples.

The soil samples collected and analyzed during well installation activities indicate that benzene is present in the two down-gradient monitoring wells (MW-1 and MW-2) at concentrations of 0.041 and 0.050 ppm. These concentrations were detected in the 9.5 to 10.5 foot bgs interval.

3.2 GROUNDWATER

Groundwater samples summarized in Table 2 were collected from monitoring wells MW-1, MW-2 and MW-3 in March and May 1996. The monitoring well locations are shown on Figure 2.

These samples were analyzed for BTEX with MTBE distinction, TPH and total dissolved solids by EPA Methods 8020, 8015 and 160.1, respectively. A total of 6 samples were collected and analyzed. BTEX were detected in 4 of the 6 samples, TPH as gasoline was detected in 4 of the 6 samples. Depth to groundwater at the subject site was 4.5 feet bgs in March 1996.

TPH as gasoline has been detected in the two down-gradient monitoring wells (MW-1 and MW-2) at concentrations ranging from 11,000 parts per billion (ppb) to 33,000 ppb. Benzene has also been detected in these same wells at concentrations ranging from 410 ppb to 2,200 ppb. Total dissolved solids were detected in the three samples analyzed at concentrations ranging from 1,800 ppm to 2,100 ppm.

3.3 SELECTION OF CONSTITUENTS OF CONCERN

Constituents of concern (COCs) were selected for the site according to USEPA guidance (1989a). All of the organic compounds analyzed were included as COCs since they were assumed to be related to activities at the site. Table 3 summarizes the list of COCs for each medium.

4.0 TOXICITY ASSESSMENT

Risk associated with exposure to chemical constituents is a function of toxicity and exposure. A distinction is made between non-carcinogenic and carcinogenic effects, and two general criteria are used to describe risk: the hazard quotient (HQ) (for non-carcinogenic effects), and excess lifetime cancer risk (ELCR) (for constituents which are thought to be potential human carcinogens). Toxicity values for non-carcinogenic and carcinogenic effects are determined from available databases: the Integrated Risk Information System (IRIS) (1993); Health Effects Assessment Summary Tables (HEAST) (USEPA, 1993), and California Air Pollution Officers Association (CAPCOA) Risk Assessment Guidelines (1992).

4.1 NON-CARCINOGENIC EFFECTS

For many non-carcinogenic effects, protective physiological mechanisms must be overcome before a toxic effect is manifested. Therefore, a finite dose (threshold), below which adverse effects will not occur, is believed to exist for non-carcinogens. A single compound might elicit several adverse effects depending on the magnitude of the dose, the exposure route, and the frequency and duration of exposure. For a given chemical, the dose that elicits no observable adverse effect levels (NOAELs) when evaluating the most sensitive response (the adverse effect which occurs at the lowest dose) in the most sensitive species is used to establish a reference dose (RfD). The RfD is an estimate of a daily exposure level that is unlikely to cause non-carcinogenic health effects. Thus, exposure levels must exceed a threshold dose to produce toxic effects. Chronic RfDs are used to

assess long-term exposures ranging from 7 years to a lifetime. Subchronic RfDs evaluate the potential for adverse health effects associated with exposure to chemicals during a period of a few days to 7 years. RfDs typically are derived by dividing the NOAELs by uncertainty factors usually ranging from 10 to 10,000 depending on the suitability and quality of the available database.

RfDs that are sanctioned by the USEPA are called verified reference doses (RfD_vs) for oral exposure or reference concentrations (RfCs) for inhalation exposure. In this risk assessment, RfCs have been converted to reference doses for inhalation exposure (RfD_is) by assuming a breathing rate of 20 cubic meters per day (m³/day) and a body weight of 70 kilograms (kg) (USEPA, 1993). Table 4 summarizes the RfDs used in this risk assessment. Target sites affected by each constituent are listed in the table for both inhalation and oral exposures. The confidence levels (low, medium, high) assess the degree of confidence in the extrapolation of available data. The uncertainty factor represents a specific area of uncertainty inherent in the extrapolation from the available data.

Toxicity values for dermal exposure are rarely available. As a result, the oral RfD is adjusted to an absorbed dose using the constituent-specific oral absorption efficiency, as recommended by USEPA (1989a), to derive an adjusted RfD to assess dermal exposure. In calculating a dermal RfD from an oral RfD, the oral RfD is multiplied by the oral absorption efficiency.

4.2 CARCINOGENIC EFFECTS

Constituents are classified as known, probable, or possible human carcinogens based on the USEPA weight-of-evidence scheme in which chemicals are systematically evaluated for their ability to cause cancer in humans or laboratory animals. The USEPA classification scheme (USEPA, 1989a) contains six classes based on the weight of available evidence, as follows:

- A known human carcinogen;
- B1 probable human carcinogen - limited evidence in humans
- B2 probable human carcinogen - sufficient evidence in animals and inadequate data in humans;
- C possible human carcinogen - limited evidence in animals
- D inadequate evidence to classify; and
- E evidence of non-carcinogenicity.

Constituents in Classes A, B1, B2, and C generally are included in risk assessments as potential human carcinogens; however, Class C carcinogens may be evaluated on a case-by-case basis (USEPA, 1989a).

Currently, the USEPA uses the linearized multistage model for extrapolating cancer risk from high doses associated with laboratory animal studies to low doses typically associated with environmental exposures. This model provides a 95 percent upperbound estimate of cancer incidence at a given dose. The slope of the extrapolated curve, called the cancer slope factor (CSF), is used to calculate the probability of cancer associated with the exposure dose. Other methods of extrapolation generally are used to develop the CSF using epidemiological data from occupational exposures to humans.

Benzene, a Class A (known human) carcinogen, was the only carcinogen detected at the site. The CSF for benzene was obtained from IRIS (1993) and is shown on Table 7. CSFs are derived from the assumption that any dose level has a probability of causing cancer. The cumulative dose regardless of the exposure period determines the risk; therefore, separate CSFs are not derived for subchronic and chronic exposure periods. CSFs are derived for oral and inhalation exposures. Dermal effects are also evaluated by calculating an adjusted CSF from the oral CSF. This is done by dividing the oral CSF by the oral absorption efficiency.

4.3 TOXICITY SUMMARY

A summary of the potential health effects of the COCs considered in this report is provided in Table 8. It is not implied that these health effects will occur as a result of exposure to the COCs at the site; rather, the listed adverse health effects are for informational purposes only. Some of the toxic effects listed in the table are associated with high levels of exposure that are not likely to occur at the site.

5.0 EXPOSURE ASSESSMENT

An exposure assessment was conducted as part of the health risk assessment to evaluate the potential exposure pathways that may exist at the site. An exposure pathway is defined by four elements: (1) a source and a mechanism of constituent release to the environment; (2) an environmental transport medium for the released constituent; (3) a point of potential contact with the contaminated medium (the exposure point); and (4) an exposure route at the exposure point. The purpose of the exposure assessment is to estimate how a population potentially may be exposed to constituents originating at a site. Typically this involves projecting concentrations along hypothetical pathways between sources and receptors. The projection usually is accomplished using site-specific data and, when necessary, mathematical modeling.

Migration of the COCs from the subject site is dependent on the physical and chemical properties of the constituents and the characteristics of the surrounding environment. This section

discusses the physical and chemical properties for the COCs and their influence on the potential for migration in soil and groundwater. This information then is used to outline the exposure scenarios used in this risk assessment to evaluate potential human health and environmental impacts from exposure to the COCs.

5.1 PHYSICAL AND CHEMICAL PROPERTIES INFLUENCING CONSTITUENT MIGRATION

The environmental fate and transport of constituents are dependent on the physical and chemical properties of the constituents, the environmental transformation processes affecting them, and the media through which the constituents are migrating. This section will describe the primary physical and chemical properties affecting fate and transport and the processes expected to control the fate and transport of the COCs. Key chemical and physical properties discussed in this section include water solubility, specific gravity, volatility, organic-carbon partition coefficient (K_{oc}), and half-lives. Physical and chemical properties of the COCs are summarized in Table 8.

The water solubility of a substance is a critical property affecting migration in soils, groundwater, and surface water. Solubility is expressed in terms of the number of milligrams of a constituent that can dissolve in one liter of water (mg/L) under standard conditions of 25 degrees Centigrade ($^{\circ}\text{C}$) and one atmosphere of pressure (atm). Solubilities range from less than 1 mg/L to totally miscible with most common organic chemicals falling between 1 mg/L and 1,000,000 mg/L (Lyman et al., 1990). The higher the value of the solubility, the greater the tendency of a constituent to dissolve in water; thus, a highly soluble constituent is generally more mobile in groundwater and more likely to leach in soil than a constituent with a lower solubility. Constituents with solubilities greater than 1,000 mg/L are considered highly soluble; constituents having solubilities less than 10 mg/L are considered slightly soluble (Ney, 1990).

The specific gravity is the ratio of the density of a chemical in its pure state to density of water. Non-aqueous phase liquids with a specific gravity greater than one are denser than water and will sink through the water table, whereas constituents that are completely dissolved in water will not form a separate phase regardless of the specific gravity.

Volatilization of a constituent from environmental media will depend on its vapor pressure, water solubility, and diffusion coefficient. Highly water soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Vapor pressure, a relative measure of the volatility of chemicals in their pure state, ranges from about 0.001 to 760 millimeters of mercury (mm Hg) for liquids, with solids ranging down to less than 10^{-10} mm Hg.

The Henry's Law Constant, combining vapor pressure with solubility and molecular weight, is used for estimating releases from water to air. The Henry's Law Constant is a partition coefficient used to predict the tendency of an organic constituent to volatilize or "partition" from the aqueous or water phase to the vapor phase and may be experimentally determined or calculated from vapor pressure and solubility. Organic compounds with Henry's Law Constants in the range of 10^{-3} atmospheres-cubic meter per mole ($\text{atm}\cdot\text{m}^3/\text{mol}$) and greater, and molecular weights equal to or less than 200 grams per mole (g/mol), can be expected to readily volatilize from water (i.e., VOCs); those with values ranging from 10^{-3} to 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mol}$ are associated with possibly significant, but not facile, volatilization, while compounds with values less than 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mol}$ will volatilize only slowly from water to a limited extent. All of the COCs are expected to volatilize from water.

The diffusion coefficient can be used as a means to predict the rate at which a compound moves through the environment. Molecular diffusion is determined by both molecular properties (e.g., size and weight) and by the presence of a concentration gradient, which means that molecules of a constituent will migrate from areas of higher concentration to areas of lower concentration.

The K_{ow} often is used to estimate the extent to which a constituent will partition from water into lipophilic parts organisms, for example, animal fat. Similarly, the K_{oc} reflects the propensity of a compound to adsorb to the organic matter found in the soil or sediments. The bioconcentration factor (BCF) is the ratio of the concentration of the constituent in fish tissue to its concentration in water. The volatile organic compound COCs for the subject site have low K_{ow} , K_{oc} , and BCF, indicating a tendency not to partition into media other than water.

The potential for a constituent to sorb to soil particles will affect migration through soil and aquifer materials. When a constituent enters the soil/sediment environment, some of it will bind with particles through the process of sorption and some will dissolve in the water contained in the spaces between soil particles (pore water). The term "sorption" includes adsorption (constituent bound to the outside of soil particles) and absorption (constituent distributed throughout the particle matrix). Sorption to soil reduces volatilization, leaching, and biodegradation. A chemical that is absorbed is less mobile because it is not easily released from the particle. Conversely, a chemical that is adsorbed is released more easily and therefore may be mobile.

Adsorption potential typically is expressed in terms of a partition coefficient, K_{oc} or K_d . A partition coefficient is the ratio of the concentration of adsorbed constituent to the concentration of aqueous phase constituent and is expressed in units of milliliters per gram (mL/g). The K_{oc} may be determined empirically or may be estimated using constituent-specific and soil-specific parameters. The parameters most often used to calculate K_d for organic constituents are the K_{oc} which measures the selective affinity for soil organic carbon versus water, and the fraction of organic carbon (f_{oc}) in soil. In the absence of site-specific data, the K_d is expressed as the product of K_{oc} and f_{oc} (USEPA, 1989b). Higher values of K_{oc} (greater than 10,000 mL/g) indicate a greater potential for the

constituent to adsorb to organic carbon in soil and aquifer materials. Constituents with low K_{oc} values (less than 1,000 mL/g) do not adsorb strongly to soil and aquifer materials (Ney, 1990). Values of K_{oc} are shown in Table 9, and the values typically are based on several different types of studies or element-specific parameters. All of the constituents were detected at the subject site. These constituents do not tend to adsorb readily to soil or aquifer materials, and thus are characterized by high mobility in the environment.

The ability to volatilize from an environmental medium is an important property affecting the mobility and persistence of organic constituents. Vapor pressure, K_{oc} and water solubility govern the extent to which a chemical will volatilize into the air under ambient environmental conditions. Solubility and vapor pressure generally decrease with increasing molecular weight, and K_{oc} increases with increasing molecular weight. A constituent with a higher vapor pressure, lower K_{oc} , and/or high water solubility volatilizes more slowly than a constituent with a higher vapor pressure, lower K_{oc} , and/or lower water solubility (Ney, 1990).

Biodegradation is the biological process by which microorganisms break down organic chemicals. Environmental factors such as moisture, pH, temperature, and available nutrients will affect the rate of biodegradation. Constituents with high water solubility, low K_{oc} , and low K_{ow} values will likely biodegrade (Ney, 1990). Most of the COCs at the subject site have these properties.

Persistence is the "lasting power" of constituents and is commonly expressed in terms of half-lives ($T_{1/2}$) for specific environmental media. The half-life of a constituent is the period of time required for one-half of the mass of a compound to be transformed into other constituents from the time of its introduction to the environment. Half-lives of the detected constituents are presented in Table 9 in ranges because the rate of degradation varies according to environmental conditions and concentration. Half-lives may be used to characterize the relative persistence of a constituent in various environmental media.

5.2 MECHANISMS OF MIGRATION

There are several mechanisms by which constituents may migrate through environmental media at the subject site. Subsurface soils containing residual levels of constituents can act as the source of constituents to deeper soil, groundwater, and air. Migration into the air can occur via volatilization or fugitive dust emissions, and migration into groundwater can occur by percolation of infiltrating rain water. The mechanisms of migration are discussed in this section from a conceptual standpoint together with a discussion of constituent persistence and transformations that may occur in the source or transport medium.

5.2.1 Migration into Air

There are two processes controlling migration of constituents into air. Organic constituents may volatilize and migrate into the air. Constituents adsorbed to surface soil may migrate into the air through the generation of dust either through wind erosion in unpaved areas or mechanical means. Constituents released into the atmosphere are subject to transport and dispersion by prevailing winds. However, the potential for fugitive dust generation at the subject site is considered low because the residual contamination is found at depth.

Volatilization is the mass transfer of an organic compound from a specific medium (i.e., soil) to the air. The ability for this transfer or migration to occur will depend on the other competing processes which should hinder this migration. For example, if a constituent is adsorbed strongly to soil particles or dissolved in water, it will be less likely to volatilize into the air. Environmental factors that affect volatilization include temperature, soil porosity, soil water content, soil organic carbon content, and depth of contamination (Jury et al, 1983).

Generally, organic constituents with high vapor pressures (greater than 10 mm Hg) or high Henry's Law Constants (greater than 10^{-3} atm-m³/mol) and molecular weights less than 200 g/mol are expected to volatilize readily from soil and water. All of the COCs have these properties.

Constituents with relatively low organic carbon partition coefficients (K_{oc} values less than 1,000) and moderate to high water solubility (greater than 1 mg/L) are more likely to be associated with the water or vapor phases than to remain in soil and are therefore unlikely to be present in emitted dust. The BTEX mixture falls into this category; therefore these constituents are not expected to be emitted in dust.

5.2.2 Migration in Soil

Solubility in water, area rainfall characteristics, the tendency to bind to soil and organic carbon, type of soil (particle size distribution, clay content, organic material content, porosity, and permeability), and the depth to groundwater are significant factors in determining the potential for COCs to migrate from soil to groundwater. The more soluble constituents, such as BTEX, may migrate through soil to the groundwater with infiltrating precipitation. Typically, organic constituents with high water solubilities and low K_{oc} s are particularly susceptible to leaching. The more volatile constituents may migrate into air, as discussed in the previous section. The nature of the site soils significantly affects transport within the soil. Clays and minerals exhibit adsorptive behavior, while organic matter is capable of both adsorption and absorption. Coarse sands are very poor at sorbing chemicals. Because sorption is an equilibrium process, some of the sorbed constituents may "desorb" from the particles into the dissolved phase and be released into the soil moisture and be transported with infiltrating precipitation. These dissolved constituents then may

become sorbed again to aquifer materials, followed by dispersion by groundwater transport. The more mobile constituents at the subject site are expected to be BTEX.

5.2.3 Migration in Groundwater

Transport of constituents in groundwater is expected to be a primary mechanism of transport of the COCs at the site. Groundwater transport of organic compounds is controlled by many of the same processes discussed in the previous section. Solubility and sorption are the most important constituent properties affecting leaching and groundwater transport. The moderate to high solubility values and K_{oc} values of the COCs detected in groundwater at the site indicate that these constituents tend to move with the groundwater and not adsorb to aquifer materials. Constituents migrate in the subsurface primarily in the dissolved aqueous phase.

5.2.4 Biodegradation and Biotransformation Processes

Biological and chemical processes occurring in soil can be important in determining the ultimate fate of the constituents in soils and groundwater at the site. The extent and rates of these reactions are difficult to predict for each individual site. Microorganisms naturally occurring in soils are able to use several organics as a food source, degrading the components ultimately to carbon dioxide and water (Kostecki and Calabrese, 1989).

In most cases, an organic contaminant is not broken down completely to carbon dioxide and water by a bacterium, but is metabolized to an intermediate, which in turn is degraded further. The metabolites isolated depend primarily on the time at which the reaction is stopped. In general, these intermediates are more water soluble than the parent compound and are therefore more mobile.

BTEX may be degraded aerobically (i.e., in the presence of oxygen) in soils (Kostecki and Calabrese, 1989). In surficial soils, biodegradation can be relatively rapid, provided adequate amounts of oxygen, moisture, and nutrients (e.g., nitrogen, phosphorus) are available. Aerobic metabolism of constituents under these conditions may result in the total depletion of oxygen. When this happens, the microorganisms may begin utilizing inorganic ions, such as nitrate or sulfate, and continue aerobic respiration, or other types of microorganisms may become active in metabolizing the constituents (USEPA, 1989b).

It is likely that biodegradation and biotransformation processes are occurring with the COCs in soil and groundwater at the site. However, these processes are difficult to model on a site-specific basis, which creates uncertainty in predicting potential future concentrations based on these processes. Therefore, it is assumed in the risk assessment that the current concentrations remain constant, as though no biodegradation or biotransformation were to occur. This is a very

conservative assumption and is expected to result in calculated risks greater than any actual risks associated with future exposures at the site.

5.3 EXPOSURE PATHWAYS

The COCs for the environmental media at the site were selected as discussed in Section 3.0. Whether a constituent is actually of concern to human health depends on the likelihood of exposure, i.e., whether an exposure pathway exists. This section addresses the potential for exposure to the COCs detected in soil and groundwater.

The potential for exposure is analyzed from one perspective, the current land-use. Currently, the site is fenced, and largely covered with road gravels and is used as an office and equipment maintenance area by a fencing company. The soil COCs are detected at depths ranging from 9.5 to 10.5 feet. There currently is no groundwater use at the site or in the surrounding area. As a result, the only exposure is via vapors from inhalation of volatile constituents, emanating from soil and groundwater.

Drinking water for the area is supplied by the EBMUD. The groundwater in the site vicinity is not used as a source for drinking water. There are no water supply wells in the vicinity of the site. Based on this information, direct exposure to groundwater at the site is very unlikely under current future conditions. Volatile constituents in groundwater could migrate from groundwater into soil gas to the ambient indoor and outdoor air. If this migration pathway occurred, individuals outside at the site or in the building or downgradient of the site could become exposed to constituents through the inhalation route. Outdoor exposure is expected to be negligible relative to potential indoor exposure because of the action of outdoor wind currents to quickly disperse released vapors. Exposure of hypothetical on-site receptors likely would be greater than off-site receptors based on the expected decrease in concentrations as the plume migrates from the former source.

This risk assessment considered inhalation exposure as the most likely exposure pathway due to the depth of the COCs as well as the soil type. Groundwater is encountered at the site at approximately 4.5 feet bgs, varying with seasonal rainfall. This level is above the 9.5 to 10.5 foot bgs soil interval where the COCs are encountered. As a result, exposure due to dermal contact or soil inhalation is unlikely.

Additionally, the subsurface clay content generally prohibits the volatilization of COCs due to the adsorptive properties of clays.

5.4 EXPOSURE DOSE CALCULATIONS

Average daily exposure doses were calculated for each receptor and exposure pathway using standard exposure assumptions (USEPA, 1989a, 1991a), site data, and professional judgement. Exposure point concentrations were selected as the lower value of either the maximum concentration or the UCL for each COC in each medium. A basic assumption underlying all exposure calculations was that the exposure point concentrations would remain constant throughout the exposure period. Natural attenuation processes in soil and groundwater were not considered. Therefore, using current maximum or UCL concentrations for the COCs as representative exposure point concentrations over the entire exposure period will result in overestimates of exposure.

Current risk-assessment guidance requires that the averaging time used to calculate average daily exposure doses depends on the toxic effect (cancer or non-cancer). For cancer effects, the total cumulative dose was averaged over a lifetime (70 years) whereas the total cumulative dose was averaged over the exposure period for non-cancer effects. The approach for carcinogens is based on the assumption that any dose may induce a response (non-threshold), and a given dose has the same probability of inducing a response regardless of the exposure period. In other words, a higher dose received over a short exposure period is equivalent to a lower dose received over a lifetime, as long as the total dose is the same.

The primary receptors identified in Section 5.4 are the current site workers. Specific assumptions and exposure dose calculations are presented in the following sections. Table 10 provides a summary of the exposure assumptions used in the risk assessment and described below.

5.4.1 Current Site Workers

The current building covers most of the site. Exposure to office workers and equipment maintenance personnel is evaluated. On-site workers could be exposed via inhalation to vapors migrating from contaminated groundwater into the office building. For the office worker, the principal exposure would be time spent at work in the office. The following assumptions were used to assess site worker inhalation exposure based on vapor intrusion from groundwater:

- (1) body weight of 70 kg (USEPA, 1991a)
- (2) exposure frequency of 250 days/year (USEPA, 1991a)
- (3) exposure duration of 25 years (USEPA, 1991a);
- (4) breathing rate of 20 m³/day for the 8-hour workday (USEPA, 1991a);

Table 11a lists the primary (basic) parameter values used to calculate the volatilization factor for volatile organic compounds (VOCs). The first three parameter values listed are for one particular compound, benzene; the values for the other aromatic compounds (toluene, ethylbenzene, and xylenes) are similar and are not listed. The remainder of the parameter values in Table 11a apply to any VOC. Site-specific values have been entered for h_{cap} , h_v , and L_s .

Table 11b lists the diffusion coefficients calculated for benzene; for other VOCs, one simply substitutes their respective values of D_{air} and D_w .

Below, we present an example calculation for benzene vapor intrusion.

- 1.) Calculate volatilization factor (VF)

$$VF = \frac{H_o [(D_s)(L_s^{-1})/(X_A)(L_B)] \times 10^3}{1 + [(D_s)(L_s^{-1})/(X_A)(L_B)] + f[(D_s)(L_s^{-1})/(D_F)(L_F^{-1})]}$$

adapted from ASTM Publication ES 38-94.

Substituting values listed in Tables 11a and 11b, we find:

$$VF = 9.4 \times 10^{-3} \text{ L/m}^3$$

- 2.) Calculate risk-based screening level for benzene in groundwater (RSBL_w) using an excess lifetime cancer risk (ELCR) of 1.0E-04.

$$RSBL_w = \frac{10^{-3}}{VF} RSBL_{air}$$

with RSBL_{air} = 49.3 ug/m³ for commercial/industrial buildings.

$$RSBL_w = \frac{49.3 \text{ ug/m}^3}{9.4\text{E-}03 \text{ L/m}^3} 10^{-3} \text{ mg/ug}$$

$$RSBL_w = 5.2 \text{ mg/L} \quad (\text{for ELCR} = 1.0\text{E-}04)$$

5200 ppb - 10⁻⁴
520 ppb - 10⁻⁵
18 = 1800 ppb →

The site has only 1.8 mg/L (UCL) of benzene in groundwater, which is approximately one-third of the RSBL_w. The implied ELCR is (1.8/5.2) x 1.0 E-04 = 3.5 E-05, which lies within the range of acceptability, 10⁻⁶ to 10⁻⁴.

The inhalation exposure dose (ExDi) can be calculated from the CSFI and ELCR as 1.2 E-03 mg/kg/day.

Table 12 summarizes the cancer risk for benzene and the non-cancer effects (hazard quotients, HQs) for all four aromatic compounds (benzene, ethylbenzene, toluene, xylenes).

5.5 ENVIRONMENTAL RECEPTORS

Exposure of environmental receptors to site-related constituents is not likely to occur because the subject site does not support a complex ecosystem. The area surrounding the site is developed. The Oro Loma Sanitary District surrounds the subject site on the north, west and south. The eastern boundary is occupied by commercial office spaces. The few areas with vegetative cover sufficient to provide a habitat for these receptors is located off-site on the Oro Loma Sanitation District property. As a result, terrestrial wildlife are not likely to find the subject site a suitable habitat, and hence will not become exposed to the constituents present in soils surrounding the site. The permeability and porosity of the clays beneath the site prohibit extensive downgradient migration of the COCs. The nearest downgradient surface water is the San Francisco Bay. It is unlikely that constituents present in groundwater would reach the bay. However, to evaluate whether or not currently detected concentrations of the groundwater COCs could pose a threat to aquatic life, the maximum detected groundwater concentrations were compared with ambient water-quality criteria, as seen in Table 13. The currently detected groundwater concentrations for benzene range from 410 ppb to 2,200 ppb. The soil concentrations for benzene range from <0.005 ppm to 38 ppm.

*Gradient has
not yet been
established.
Downgradient
concentrations?*

6.0 RISK CHARACTERIZATION

This section discusses the potential risks to human health associated with the subject site. Risks to environmental receptors are not evaluated since the site does not represent a suitable habitat for terrestrial wildlife. Risks to human health are evaluated for the exposure scenario identified in Section 5.0. The calculated exposure doses are combined with toxicity values identified in Section 4.0 to identify any potential threat to human health.

6.1 GENERAL CONCEPTS

Risks to human health can be evaluated quantitatively by combining exposure and hazard data. Two types of quantitative estimates are used to evaluate risk to human health: the excess lifetime cancer risk (ELCR) and the hazard quotient (HQ) or hazard index (HI) (for non-cancer risk).

The ELCR is an estimate of the increased risk of cancer which results from lifetime exposure, at specified average daily dosages, to constituents detected in media at the site. Estimated doses, or intakes, for each constituent are averaged over the expected lifetime of 70 years. It is assumed that a large dose received over a short period is equal to a smaller dose received over a longer period, as long as the total doses are equivalent. The ELCR, equal to the product of the exposure dose and the CSF, is estimated for each known, probable, or possible carcinogenic COC in each medium. The risk values provided in this report are an indication of the increased risk, above that applying to the general population, which may result from the exposure scenarios

described in the Exposure Characterization section (Section 5.0). The risk estimate is considered to be an upperbound estimate; therefore, it is likely that the true risk is less than the predicted risk. Current regulatory methodology assumes that excess lifetime cancer risks can be summed across routes of exposure and COCs to derive a "Total Site Risk" (USEPA, 1989a). USEPA guidance states that if the calculated ELCR is below the range of 1 in 10,000 (10^{-4}) to 1 in 1,000,000 (10^{-6}), in which the USEPA evaluates the potential acceptability of site-related exposure on a site-by-site basis, then the risk is acceptable (USEPA, 1991b).

Exposure doses are averaged only over the expected exposure period to evaluate non-carcinogenic effects. The HQ is the ratio of the estimated exposure dose and the RfD. An HQ greater than 1 indicates that the estimated exposure exceeds the RfD. This ratio does not provide the probability of an adverse effect as does the ELCR. Although an HQ greater than 1 indicates that the estimated exposure dose for that constituent exceeds acceptable levels for protection against non-carcinogenic effects, it does not necessarily imply that adverse health effects will occur. The sum of the HQs is the HI. Current regulatory methodology (USEPA, 1989a) advises summing HIs across exposure routes for all media at the site to derive a "Total Site Hazard Index." If the HI exceeds 1, COCs may be grouped according to critical toxic effects, and HIs may be calculated separately for each effect. The calculated HIs for each evaluated exposure scenario are summarized in Table 14.

7.0 UNCERTAINTIES IN THE RISK ASSESSMENT

The risk estimates presented here are conservative estimates of the risks associated with exposure to constituents detected in media at the subject site. Uncertainty is inherent in the risk assessment process, and these uncertainties are identified in this section. Each of the three basic building blocks for risk assessment (monitoring data, exposure scenarios, and toxicity values) contribute uncertainties. Environmental sampling itself introduces uncertainty, largely because of the potential for uneven distribution of constituents in the environment.

This risk assessment is based on the assumption that the available monitoring data adequately describe the occurrence of constituents in media at the site. Environmental sampling itself introduces uncertainty. This source of uncertainty can be reduced through a well designed sampling plan, use of appropriate sampling techniques, and implementation of laboratory data validation and quality assurance/quality control (QA/QC). The data used in this report meet QA/QC requirements and are appropriate for risk assessment.

Exposure scenarios and constituent transport models also contribute uncertainty to the risk assessment. Exposure doses for groundwater, soil, and air were calculated based on the assumption that the current conditions would remain stable throughout the exposure period. This simplifies reality because natural attenuation processes are expected to reduce constituent concentrations over

time. Exposure scenarios were developed based on site-specific information, USEPA exposure guidance documents, and professional judgment. Although uncertainty is inherent in the exposure assessment, the exposure assumptions were chosen to err on the side of conservatism.

The toxicity values and other toxicologic (health effects) information used in this report are associated with significant uncertainty. Many toxicity values are developed using results of studies in which laboratory animals are exposed to high doses. Although species differences in absorption, distribution, metabolism, excretion, and target organ sensitivity are well documented, available data are not sufficient to allow compensation for these differences. Most laboratory studies strictly control as many factors as possible, yet the human population is genetically diverse and affected by a variety of diets, occupations, pharmaceuticals, and other factors. When human epidemiologic data are available, a different set of uncertainties is present. For instance, exposure is seldom well characterized in epidemiologic studies.

Recent research on the mechanisms of carcinogenesis suggests that use of the linearized multistage model may overestimate the cancer risks associated with exposure to low doses of chemicals. At high doses many chemicals cause large-scale cell death which stimulates replacement by division. Dividing cells are more subject to mutations than quiescent (nondividing) cells; thus, there is an increased potential for tumor formation. It is possible that administration of these same chemicals at lower doses would not increase cell division and thus would not increase mutations. This would suggest that the current methodology may overestimate cancer risk.

There also is uncertainty associated with the toxicity of mixtures. For the most part, data about the toxicity of chemical mixtures are unavailable. Rather, toxicity studies generally are performed using a single chemical. Chemicals present in a mixture can interact chemically to yield a new chemical or one can interfere with the absorption, distribution, metabolism, or excretion of another. Chemicals also may act by the same mechanism at the same target organ or can act completely independently. The risk assessment assumes that toxicity is additive; the ELCRs and HQs were summed across chemicals. This assumes that the mixture of constituents present at the site has neither synergistic nor antagonistic interactions.

This risk assessment was designed to evaluate the potential threat to human health based on current on-site worker scenario.

8.0 FINDINGS AND CONCLUSIONS

This health risk assessment was prepared to evaluate whether soils or groundwater at Thompson and Thompson Fence Company site could pose a threat to human health or the environment under current conditions. The fence company is currently fenced; and there currently are no significant exposure pathways at the site. This risk assessment was designed to evaluate whether the presence of residual constituents in soil and groundwater at the site poses a threat to human health and the environment.

COCs were identified based on the available data. These constituents include for soil and/or groundwater: benzene, ethylbenzene, toluene, and xylenes.

Two exposure scenarios were developed in this health risk assessment based on a review of current conditions. Current exposures included: (1) on-site worker exposure to soil and groundwater through incidental ingestion, dermal contact, and outdoor inhalation of vapors or dust and; (2) exposure of office workers to vapors migrating into the office building on-site.

The results of the risk assessment can be summarized as follows:

- The ELCR was $3.5 \text{ E-}05$ and the HI was $1.2 \text{ E-}01$ for an on-site worker in the office. These risks fall within the regulatory benchmarks of a target cancer risk between 10^{-4} to 10^{-6} and an HI not to exceed 1.
- Exposure of environmental receptors to site-related constituents is not likely to occur because the fence company does not support a complex ecosystem. The area surrounding the site is developed. There are no on-site areas with vegetative cover sufficient to provide a habitat for animal receptors. As a result, terrestrial wildlife are not likely to find the site to be a suitable habitat, and hence will not become exposed to the constituents present in soils at the site.
- The nearest downgradient surface water is San Francisco Bay. It is extremely unlikely that constituents present in groundwater would reach the bay. To evaluate whether or not currently detected concentrations of the groundwater COCs could pose a threat to aquatic life, the maximum detected groundwater concentrations were compared with ambient water-quality criteria. The currently detected groundwater concentrations were all less than the available criteria, with the exception of the maximum xylenes concentration. Natural attenuation processes such as dispersion and biodegradation will act to reduce concentrations, so that if the plume were to reach the bay, aquatic life would not be impacted.

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APPENDIX

SAN LEANDRO



Figure 1. Site Location Map - Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

SCALE: 1" = 20'
X = Groundwater Monitoring Well
Approximate Groundwater flow direction

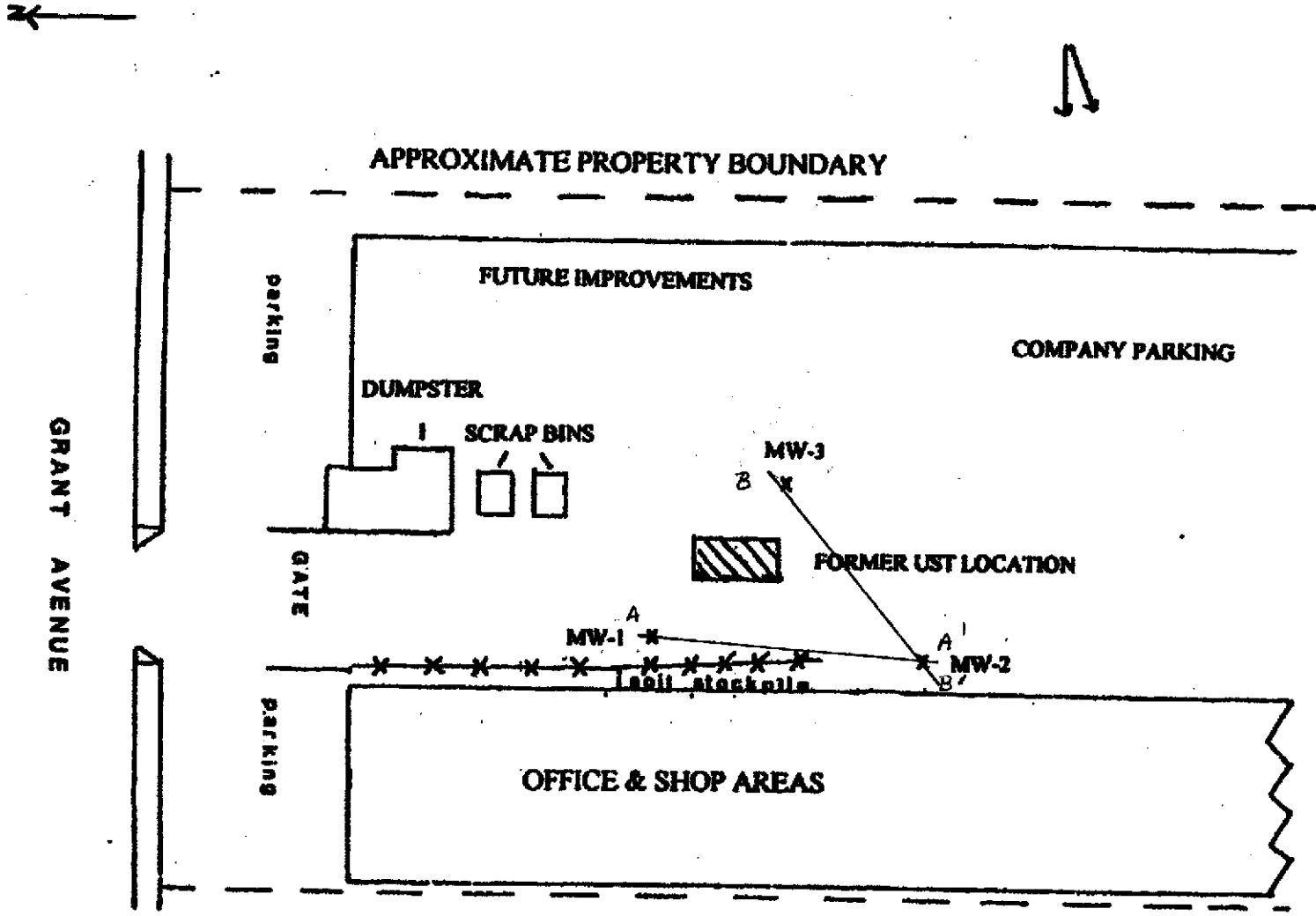


FIGURE 2. SITE BASE MAP AND GROUNDWATER MONITORING WELL LOCATION
MAP - THOMPSON & THOMPSON FENCE COMPANY, 2584 GRANT AVENUE, SAN LORENZO,
CALIFORNIA

<---- N

Horizontal Scale
1" = 10'

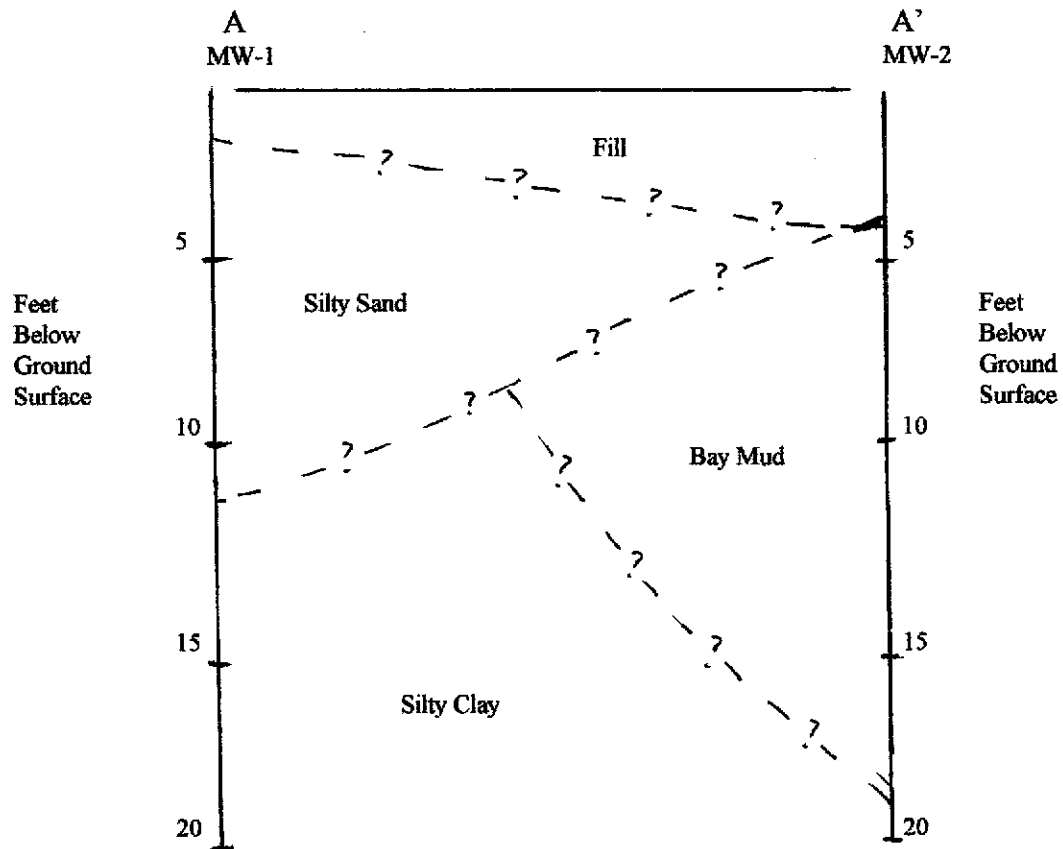


Figure 3. A - A' Cross-Section Profile, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

← N

Horizontal Scale
1" = 10'

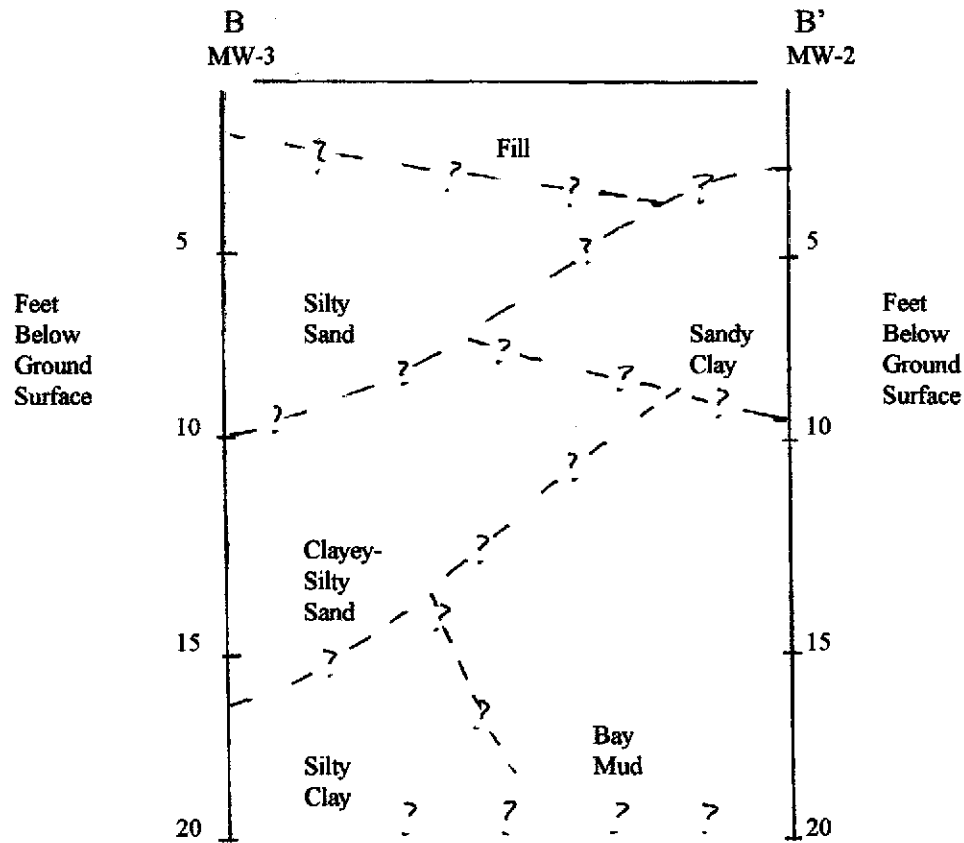


Figure 4. B - B' Cross-Section Profile, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

← N

NOT TO SCALE

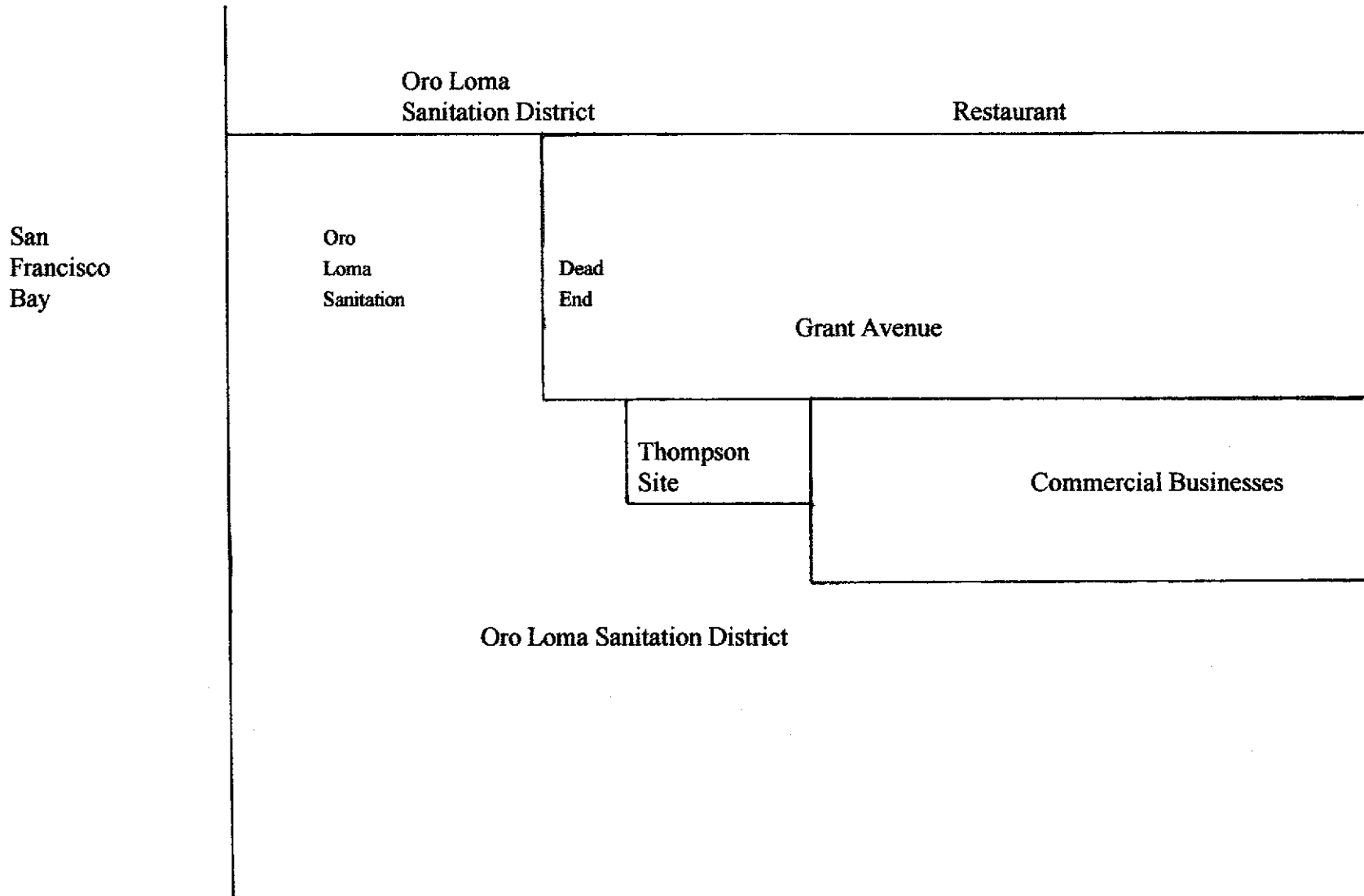


Figure 5. Surrounding Land Use - Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

Table 1. Analytic Results for Soil - Thompson & Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Date | Sample ID | Depth (ft) | Analytic Method | TPPH(G) | B | T | E | X | MTBE | Pb |
|---------|-----------|---------------|-----------------|---------------|--------|--------|--------|------|--------|-----|
| | | | | -----ppm----- | | | | | | |
| 11/6/92 | A1 | 8.5 | 8015/8020 | 960 | 13 | 38 | 15 | 79 | --- | 7.4 |
| 11/6/92 | A2 | 8.5 | 8015/8020 | 2,000 | 38 | 120 | 36 | 190 | --- | 11 |
| 3/7/96 | TW-1 | 9.5-10 | 8015/8020 | <0.005 | 0.041 | <0.005 | <0.005 | <0.2 | <0.050 | --- |
| | | 15.5-16 | 8015/8020 | <0.005 | <0.005 | <0.005 | <0.005 | <0.2 | <0.050 | --- |
| 3/7/96 | TW-2 | 10-10.5 | 8015/8020 | <0.005 | 0.050 | <0.005 | <0.005 | <0.2 | <0.050 | --- |
| 3/7/96 | TW-3 | 5.5-6 | 8015/8020 | <0.005 | <0.005 | <0.005 | <0.005 | <0.2 | <0.050 | --- |
| | | 10-10.5 | 8015/8020 | <0.005 | <0.005 | <0.005 | <0.005 | <0.2 | <0.050 | --- |

EXPLANATION:

TPPH(G) = Total Petroleum Hydrocarbons as Gasoline
 B = Benzene
 T = Toluene
 E = Ethylbenzene
 X = Xylenes
 MTBE = Methyl-Tert-Butyl-Ether
 Pb = Total Lead
 ft = feet below ground surface
 ppm = parts per million
 --- = Not Analyzed/Not Applicable

ANALYTIC METHODS:

8015 = EPA Method 8015/5030 for TPPH(G)
 8020 = EPA Method 8020 for BTEX with MTBE

ANALYTIC LABORATORY:

Analyses prior to 1993 were performed by Sequoia Analytical Laboratories of Concord, California.

Analyses after 1993 were performed by American Environmental Network of Pleasant Hill, California.

Table 2. Analytic Results for Groundwater - Thompson & Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Date/ | Sample ID | DTW (ft) | TOC | GWE (msl) | Analytic Method | TPPH(G) | <-----ppb-----> | | | | | TDS <---ppm---> |
|---------|-----------|-------------------|-------|--------------|------------------------------|---------|-----------------|------|-------|-------|--------|--------------------|
| | | | | | | | B | T | E | X | MTBE | |
| 3/7/96 | TW-1 | 5.28 ¹ | | --- | 8015/8020/160.1 ² | 28,000 | 700 | 210 | 830 | 4,600 | <500 | 2,100 |
| 5/15/96 | MW-1 | 4.69 | 21.00 | 16.31 | 8015/8020 ² | 33,000 | 2,200 | 770 | 1,100 | 6,500 | <1,000 | --- |
| 3/7/96 | TW-2 | 2.75 ¹ | | --- | 8015/8020/160.1 ² | 13,000 | 410 | 840 | 440 | 1,700 | <500 | 1,800 |
| 5/15/96 | MW-2 | 4.25 | 20.14 | 15.89 | 8015/8020 ² | 11,000 | 420 | 530 | 390 | 1,000 | <1,000 | --- |
| 3/7/96 | TW-3 | 3.28 ¹ | | --- | 8015/8020/160.1 | <50 | <0.5 | <0.5 | <0.5 | <2 | <50 | 2,000 |
| 5/15/96 | MW-3 | 4.49 | 22.48 | 17.99 | 8015/8020 | <50 | <0.5 | <0.5 | <0.5 | <2 | <50 | --- |
| 3/7/96 | TB | --- | --- | --- | 8015/8020 | <50 | <0.5 | <0.5 | <0.5 | <2 | --- | --- |
| 5/15/96 | | | | | 8015/8020 | <50 | <0.5 | <0.5 | <0.5 | <2 | --- | --- |
| 3/7/96 | BB | --- | --- | --- | 8015/8020 | <50 | <0.5 | <0.5 | <0.5 | <2 | --- | --- |
| 5/15/96 | | | | | 8015/8020 | <50 | <0.5 | <0.5 | <0.5 | <2 | --- | --- |

Table 2. Analytic Results for Groundwater - Thompson & Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California
(continued)

EXPLANATION:

TPPH(G) = Total Petroleum Hydrocarbons as Gasoline
B = Benzene
T = Toluene
E = Ethylbenzene
X = Xylenes
MTBE = Methyl-Tert-Butyl-Ether
TDS = Total Dissolved Solids
ft = feet below ground surface
msl = referenced to mean sea level
ppb = parts per billion
ppm = parts per million
TB = Trip Blank
BB = Bailer Blank
TW = Temporary Well
MW = Monitoring Well
-- = not analyzed/not applicable

ANALYTIC METHODS:

8015 = EPA Method 8015/5030 for TPPH(G)
8020 = EPA Method 8020 for BTEX with MTBE
160.1 = EPA Method 160.1 for TDS

ANALYTIC LABORATORY:

All analyses performed by American Environmental Network of Pleasant Hill, California.

NOTES:

- ¹ DTW data collected for grab groundwater sampling purposes only. Groundwater in wells had not stabilized therefore water level data not used for elevation purposes.
- ² Laboratory reporting limits raised for gasoline/BTEX with MTBE distinction due to high levels of target compounds. Sample run at dilution.

Table 3. Occurrence Summary of Constituents Detected in Soil, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | <u>Frequency</u> | <u>Range of SQLs</u> | <u>Range of Detects</u> | Mean | UCL | <u>Background Concentration [a]</u> | |
|--------------|------------------|----------------------|-------------------------|--------|--------|-------------------------------------|------|
| | Detects/Total | Min - Max | Min - Max | | | Range | Mean |
| <u>Vocs</u> | | | | | | | |
| Benzene | 4 / 7 | 0.0050 - 0.0050 | 0.041 - 38 | 12.77 | 24.90 | NA | NA |
| Ethylbenzene | 2 / 7 | 0.0050 - 0.0050 | 15 - 36 | 25.50 | 49.73 | NA | NA |
| Toluene | 2 / 7 | 0.0050 - 0.0050 | 38 - 120 | 79 | 154.05 | NA | NA |
| Xylenes | 2 / 7 | 0.0020 - 0.0050 | 79 - 190 | 134.50 | 262.28 | NA | NA |

Concentrations are reported in milligrams per kilogram (mg/kg).
 These data represent soil samples collected over the entire site.

[a] Background concentrations from the western United States (USGS, 1984).
 Mean Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
 NA Not available.
 SQL Sample quantitation limit.
 UCL 95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 4. Occurrence Summary of Constituents Detected in Groundwater, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | Frequency Detects / Total | Range of SOLs Min - Max | Range of Detects Min - Max | Mean | UCL |
|--------------|------------------------------|----------------------------|-------------------------------|-------|------|
| <u>Vocs</u> | | | | | |
| Benzene | 4 / 6 | 0.00050 - 0.00050 | 0.41 - 2.20 | 0.932 | 1.82 |
| Ethylbenzene | 4 / 6 | 0.00050 - 0.00050 | 0.39 - 1.10 | 0.690 | 1.35 |
| Toluene | 4 / 6 | 0.00050 - 0.00050 | 0.21 - 0.84 | 0.588 | 1.15 |
| Xylenes | 4 / 6 | 0.00020 - 0.00050 | 1.00 - 6.50 | 3.45 | 6.73 |

Concentrations are reported in milligram per liter (mg/L).

Samples collected in March and May 1996 from monitor wells MW-1, MW-2 and MW-3.

| | |
|------|--|
| Mean | Arithmetic average of the total number of samples, using proxy concentrations for non-detects. |
| SQL | Sample quantitation limit |
| UCL | 95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution. |

Table 5. List of Constituents of Concern (COCs) by Data Groups, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | Soil | Groundwater |
|-------------|------|-------------|
| <u>Vocs</u> | | |
| Benzene | x | x |
| Ethybenzene | x | x |
| Toluene | x | x |
| Xylenes | x | x |

coc Constituent of concern.
 x Denotes a COC.

Table 6. Reference Doses, Target Sites, and Confidence Levels for Constituents of Concern, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | <u>RfDo (mg/kg/day)</u> | | <u>RfDi (mg/kg/day)</u> | | Oral | <u>Target Sites</u> | | Confidence Level/ Uncertainty Factor |
|--------------|-------------------------|---------|-------------------------|---------|---------------|---------------------|---------------------------------|---|
| | Subchronic | Chronic | Subchronic | Chronic | | Inhalation | | |
| <u>Vocs</u> | | | | | | | | |
| Benzene | NA | NA | NA | 2.0E-02 | NA | | CNS/PNS | NA |
| Ethylbenzene | 1.0E+00 | 1.0E-01 | 2.9E-01 | 2.9E-01 | liver, kidney | | developmental | low/1000 |
| Toluene | 2.0E+00 | 2.0E-01 | 5.7E-01 | 1.1E-01 | liver, kidney | | CNS | medium/1000 |
| Xylenes | 4.0E+00 | 2.0E+00 | NA | 8.6E-02 | hyperactivity | | reproductive system/respiratory | medium/100 |

References: IRIS, 1993; USEPA, 1993; CAPCOA, 1992.

CNS Central nervous system.
mg/kg/day Milligrams per kilogram per day.
NA Not available.
PNS Peripheral nervous system.
RfDi Inhalation reference dose.
RfDo Oral reference dose.

Table 7. Cancer Slope Factors, Tumor Sites, and USEPA Cancer Classifications for Constituents of Concern, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | CSF (kg-day/mg) | | Tumor site | | USEPA Classification |
|-------------|-----------------|------------|------------|------------|----------------------|
| | Oral | Inhalation | Oral | Inhalation | |
| Benzene | 2.9E-02 | 2.9E-02 | leukemia | leukemia | A |

Reference: IRIS, 1993.

CSF Cancer slope factor.
kg-day/mg kilograms-day per milligram.

Table 8. Toxicity Summaries for Constituents of Potential Concern, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California

| Constituent | Acute Toxicity Summary | Chronic Toxicity Summary | Cancer Potential | Other |
|--------------|--|--|---|---|
| Benzene | Critical Effects: Drowsiness, dizziness, headache, vertigo, moderately toxic by ingestion. | Critical Effects: Pancytopenia, hearing impairment, polyneuritis. Data Summary: Not available | Class A; human carcinogen. The cancer slope factor was derived from human data in which leukemia rates increased. | Developmental: No evidence suggesting any adverse effects even when the mother exhibits toxicity. Reproductive: Ovarian hypofunction. Mutagenicity: Chromosomal aberrations in human lymphocytes. |
| Ethylbenzene | Critical Effects: Throat irritation, chest constriction, eye irritation, dizziness, vertigo. | Critical Effects: Increases in kidney to body weight ratios were seen in rats. Data Summary: The oral RfD is based on a NOEL of 97 mg/kg/day in rats. The inhalation RfD is based on a NOEL of 100 ppm in rats. | Class D; inadequate evidence of carcinogenicity. | Developmental: Increases in the incidence of fetal anomalies were seen in rats, mice and rabbits. Reproductive: No data available Mutagenicity: Negative results were seen in various <i>Salmonella typhimurium</i> assays. |
| Toluene | Critical Effects: Narcosis, CNS dysfunction, eye and skin irritation. Comments: Toluene is abused for its narcotic effects. This usually occurs with sniffing toluene-based glue. | Critical Effects: Decreased blood leukocytes, renal tubular acidosis, ataxia, tremors, impaired speech, hearing, and vision. Data Summary: The oral RfD was derived from a 13-week rat gavage study. A NOAEL of 223 mg/kg/day was developed. Changes in liver and kidney weights were seen at a LOAEL of 446 mg/kg/day. | Class D; no evidence of carcinogenicity. | Developmental: CNS anomalies, Growth retardation. Mutagenicity: Results were negative or inconclusive for various tests. |

Table 8. Toxicity Summaries for Constituents of Potential Concern, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | Acute Toxicity Summary | Chronic Toxicity Summary | Cancer Potential | Other |
|-------------|---|---|--|---|
| | | The on RfD is based on human data in which a NOAEL of 88 ppm resulted in CNS toxicity. | | |
| Xylenes | Critical Effects: Dyspnea, nose, skin, and throat irritation, vomiting, CNS depression; moderately toxic. | Critical Effects: Increased hepatic weights in rats, renal toxicity, tremors, and labored breathing. Data Summary: The oral RfD was based on a chronic rat gavage study in which a NOAEL of 250 mg/kg/day was reported. At higher doses, hyperactivity occurred. | Class D; inadequate evidence of carcinogenicity. | Developmental: Fetal hemorrhages and decreased fetal weights in rats. Reproductive: No data available. Mutagenicity: Negative results were seen in various tests. |
| References: | ATSDR, 1992; ATSDR, 1991; ATSDR, 1989a; ATSDR, 1989b; ATSDR, 1999c; IRIS, 1993; USEPA, 1993. | | | |
| CNS | Central nervous system. | | | |
| LOAEL | Lowest observed adverse effect level. | | | |
| mg/kg/day | Milligram per kilogram per day. | | | |
| NOAEL | No observed adverse effect level. | | | |
| NOEL | No observed effect level. | | | |
| PPM | Parts per million. | | | |
| RfD | Reference dose. | | | |

Table 9. Physical and Chemical Properties of Organic Constituents of Concern, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California

| Constituent | Molecular Weight (g/mol) | Water Solubility (mg/L 25° C) | Specific Gravity | Vapor Pressure (mm Hg 25° C) | Henry's Law Constant (atm-m ³ /mol) (25° C) | Diffusivity (cm ² /sec) | Koc (mL/g) | Log Kow | Fish BCF (L/kg) | Groundwater | | Soil | |
|-----------------|--------------------------|-------------------------------|------------------|------------------------------|--|------------------------------------|-------------------|-------------|-----------------|-------------|------------|-----------|------------|
| | | | | | | | | | | T 1/2 low | T 1/2 high | T 1/2 low | T 1/2 high |
| <u>Vocs</u> | | | | | | | | | | | | | |
| Benzene | 78 | 1,780 | 0.88 | 9.5E+01 | 5.48E-03 | 0.09320 | 486 (49 - 100) | 1.56 - 2.15 | 5.2 | 10 - 720 | 5-16 | | |
| Ethylbenzene | 106 | 152 - 209 | 0.87 | 9.5E+00 | 8.68E-03 | 0.06667 | 95 - 260 | 3.05 - 3.15 | 37.5 | 6 - 228 | 3-10 | | |
| Toluene | 92 | 490 - 627 | 0.87 | 2.5E+01 | 6.74E-03 | 0.07829 | 115 - 150 | 2.11-2.80 | 10.7 | 7 - 28 | 4-22 | | |
| Xylenes (total) | 106 | 162 - 200 | 0.97 | 6.6E+00 | 6.30E-03 | 0.07164 | 128 - 1,590 | 2.77 - 3.20 | 132 | 14 - 360 | 7-28 | | |

References: Howard et al., 1991; Howard, 1990 and 1989; Lugg, 1968; Mackay and Shiu, 1991; Montgomery and Welkom, 1990; Research Triangle Institute (RTI 1987); Shen, 1982; USEPA, 1991c; and Verschuere, 1983.

atm-m³/mol Atmospheres-cubic meters per mole.
 BCF Bioconcentration factor.
 °C Degrees Celsius.
 Cm²/sec Square Centimeters per second.
 g/mol Grams per mole.
 Koc Organic carbon partition coefficient.
 Kow Octanol-water partition coefficient.

L/kg Liters per kilogram.
 mg/L Milligrams per liter.
 mL/g Milliliters per gram.
 mm Hg Millimeters of mercury.
 ND No data.
 T 1/2 Half-life.

Koc = Kow x 10⁴

Table 10. Exposure Parameters and Values, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Parameter | On-site Worker |
|---------------------------|----------------|
| APcarc (days/lifetime) | 25,550 |
| APnon (days/lifetime) | 9,125 |
| BR (m ³ /hour) | 20 |
| BW (kg) | 70 |
| ED (years) | 25 |
| EF (days/yr) | 250 |
| ET (hours/day) | 8 |

References: USEPA 1992; USEPA, 1991a; USEPA 1989a,c.

- APcarc Carcinogenic averaging period.
- APnon Non-carcinogenic averaging period.
- BR Breathing rate.
- BW Body weight
- cm² Square centimeters.
- ED Exposure duration.
- EF Exposure frequency.
- ET Exposure time.
- g/day Grw per day.
- kg Kilograms.
- m Meters.
- m³/hour Cubic meters per hour.
- mg Milligrams
- yr Year.

Table 11a. Primary Parameter Values Selected to Calculate the Volatilization Factor - Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| <u>Parameter</u> | <u>Value</u> | <u>Definition / (source)</u> |
|------------------|------------------------------|--|
| H_o | 0.224 | Air-water partition coefficient for benzene - dimensionless Henry's Law constant (ASTM, 1994). |
| D_{air} | 0.093 cm ² /sec | Diffusion coefficient in air for benzene (ASTM, 1994). |
| D_w | 1.1E-05 cm ² /sec | Diffusion coefficient in water for benzene (ASTM, 1994). |
| h_{cap} | 30 cm | Thickness of capillary zone (site data). |
| h_v | 100 cm | Thickness of vadose zone (site data). |
| L_s | 130 cm | $h_{cap} + h_v$ (site data). |
| L_B | 300 cm | Enclosed space volume divided by infiltration area, commercial building (ASTM, 1994). |
| L_F | 15 cm | Foundation thickness (ASTM, 1994). |
| X_A | 2.3E-04/sec | Air exchange rate, commercial building (ASTM, 1994). |
| f | 0.01 | Areal fraction of cracks in foundation (ASTM, 1994). |
| v_1 | 0.68 | Air-filled porosity in foundation cracks/total soil porosity (ASTM, 1994). |
| v_2 | 0.32 | Water-filled porosity in foundation cracks/total soil porosity (ASTM, 1994). |
| v_3 | 0.68 | Air-filled porosity in vadose zone/total soil porosity (ASTM, 1994). |
| v_4 | 0.32 | Water-filled porosity in vadose zone/total soil porosity (ASTM, 1994). |
| v_5 | 0.10 | Air-filled porosity in capillary zone/total soil porosity (ASTM, 1994). |
| v_6 | 0.90 | Water-filled porosity in capillary zone/total soil porosity (ASTM, 1994). |

Table 11b. Calculated Effective Diffusion Coefficients for Benzene* - Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| <u>Parameter</u> | <u>Value</u> | <u>Definition</u> |
|------------------|------------------------------|---|
| D_s | 3.4E-04 cm ² /sec | Effective diffusion coefficient between groundwater and soil surface: $D_s = (h_{cap} + h_v) (h_{cap}/D_{cap} + h_v/D_v)^{-1}$ |
| D_{cap} | 7.8E-05 cm ² /sec | Effective diffusion coefficient in capillary zone: $D_{cap} = [(D_{air})(V_5^p) + (D_w)(1/H_o)(V_6^p)]$ |
| D_v | 0.026 cm ² /sec | Effective diffusion coefficient in vadose zone: $D_v = [(D_{air})(V_3^p) + (D_w)(1/H_o)(V_4^p)]$ |
| D_F | 0.026 cm ² /sec | Effective diffusion coefficient in foundation: $D_F = [(D_{air})(V_1^p) + (D_w)(1/H_o)(V_2^p)]$ |
| p | 3.33 | exponent (ASTM, 1994). |

* For other Voc's, simply substitute their respective value of D_{air} and D_w .

Source: ASTM, 1994.

Table 12. Site Worker Inhalation Exposure Doses and Risks Based on Vapor Intrusion From Groundwater, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | Cgw (mg/L) | Ho (unitless) | ExDi (mg/kg/day) | Toxicity Value | Calculated Risk |
|----------------------------------|---|------------------|---------------------|---------------------|---|
| <u>CANCER RISK</u> | | | | | |
| VOCs | | | | CSFI (kg-day/mg) | ELCR |
| Benzene | 1.82 | 2.24E-01 | 1.2E-03 | 2.9E-02 | 3.5E-05 |
| | | | | Total ELCR | 3.5E-05 |
| <u>NON-CANCER EFFECTS</u> | | | | | |
| VOCS | | | | RfDi (mg/kg/day) | HQ |
| Benzene | 1.82 | 2.24E-01 | 1.2E-03 | 2.0E-02 | 6.0E-02 |
| Ethylbenzene | 1.35 | 3.55E-01 | 1.0E-03 | 2.9E-01 | 3.6E-03 |
| Toluene | 1.15 | 2.76E-01 | 7.0E-04 | 1.1E-01 | 6.4E-03 |
| Xylenes | 6.73 | 2.58E-01 | 4.3E-03 | 8.6E-02 | 5.0E-02 |
| | | | | HI | 1.2E-01 |
| HI | Hazard index (sum of the Hqs). | | | HQ | Hazard quotient (unitless). |
| Cgw | Constituent concentration in groundwater (mg/L). | | | Ho | Vapor/water partition coefficient (unitless). |
| CSFI | Cancer slope factor for inhalation exposure (kg-day/mg). | | | RfDi | Reference dose for inhalation exposure (mg/kg/day). |
| ELCR | Excess lifetime cancer risk (unitless). | | | | |
| ExDi | Inhalation exposure dose based on vapor intrusion from groundwater (mg/kg/day). | | | | |

Table 13. Range of Groundwater Concentrations and California Water-Quality Goals, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Constituent | Groundwater Concentration Range (mg/L) | California Water-Quality Goals [a] (mg/L) | |
|--------------|--|---|------------|
| | | Marine | Freshwater |
| VOCs | | | |
| Benzene | 0.0010 - 0.0490 | 0.70 [b] | 5.3 [c] |
| Ethylbenzene | 0.0080 - 0.34 | 0.43 | 32 [c] |
| Toluene | 0.0010 - 0.018 | 5.0 [b] | 17 [c] |
| Xylenes | 0.0010 - 0.25 | 0.040 [d] | 0.070 [d] |

a From 'A Compilation of Water Quality Goals', State of California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region September 1991.

b USEPA chronic lowest observed affect level (LOEL) (USEPA, 1991b).

c USEPA acute LOEL (USEPA, 1991b).

d Applied action level for aquatic life (AAL list, No.911-1, 7/INI).

Table 14. Summary of Calculated Risks, Thompson and Thompson Fence Company, 2584 Grant Avenue, San Lorenzo, California.

| Scenario | Calculated Risks | | Table Number |
|-------------------|------------------|---------|--------------|
| | ELCR | HI | |
| Site Worker | | | |
| Groundwater Vapor | 3.5E-05 | 1.2E-01 | Table 12 |
| Totals: | 3.5E-05 | 1.2E-01 | |

ELCR Excess lifetime cancer risk.
 HI Hazard index.