

RESPONSE PLAN  
FORMER SOUTHLAND STEEL PROPERTY

APPENDIX B  
RISK DOCUMENTS

1. CONCEPTUAL SITE MODEL
2. APPENDIX B OF SITE CHARACTERIZATION –  
HUMAN HEALTH RISK ASSESSMENT
3. SOIL VAPOR RISK-BASED SCREENING  
LEVELS

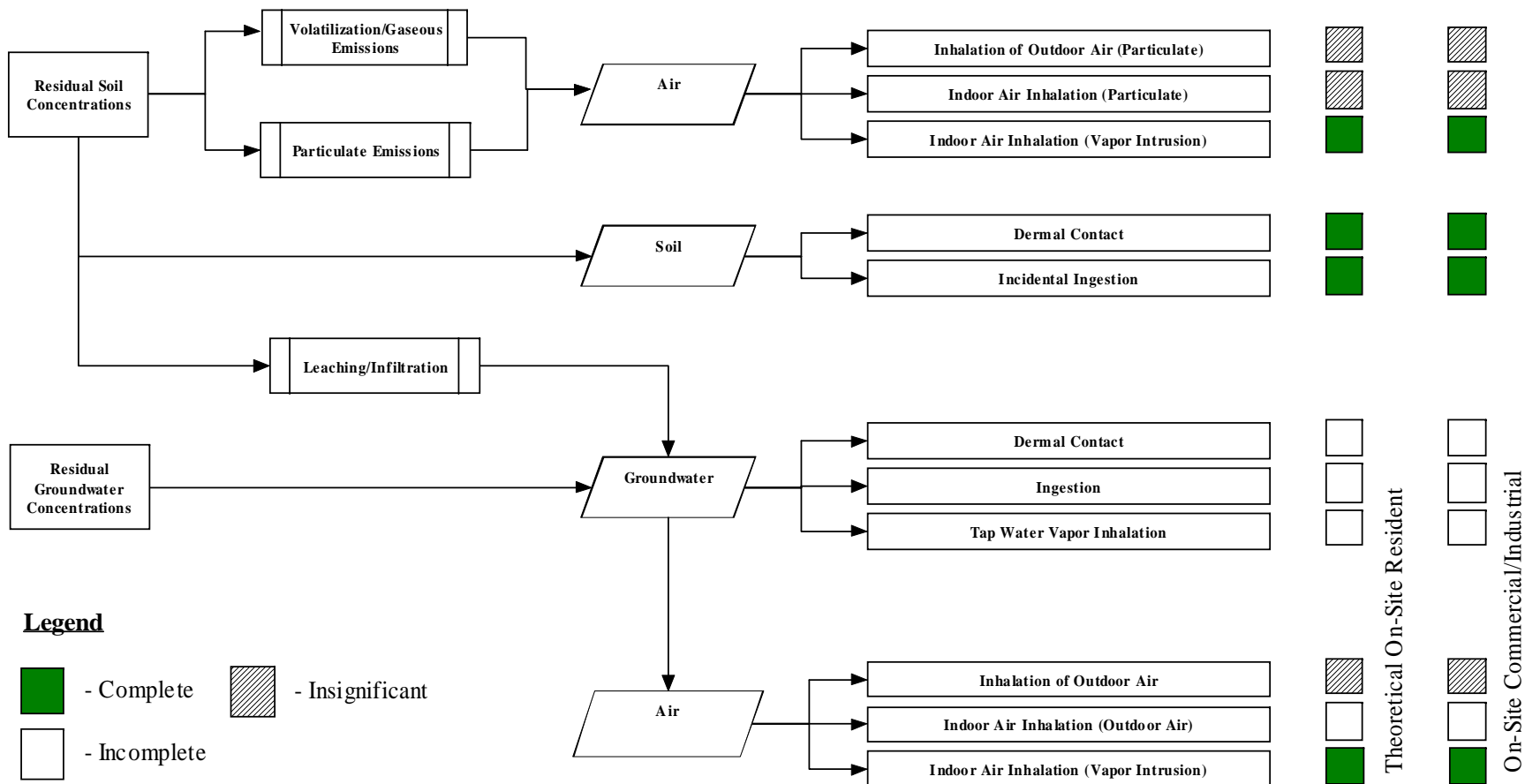
**COPC Source**

**Release Mechanism**

**Transport Medium**

**Pathway**

**Receptor**



# HUMAN HEALTH SCREENING EVALUATION

*SITE CHARACTERIZATION REPORT*

•REVISED FINAL•

**Southland Steel Property  
Alameda Street  
The City of Huntington Park  
California**

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- B JOHNSON & ETTINGER AIR MODELING SPREADSHEETS
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  - COMMERCIAL INDUSTRIAL USER

# HUMAN HEALTH SCREENING EVALUATION

•REVISED FINAL•

**Southland Steel Property  
Alameda Street  
City of Huntington Park, California**

## 1.0 INTRODUCTION

The purpose of the Human Health Screening Evaluation (HHSE) is to determine whether residual constituents in soils and soil-gas at the former Southland Steel Facility (the Site) located at 5959, 5969, 6011, 6161, and 6169 Alameda Street in the City of Huntington Park, California could adversely affect the health of future site users under regulatory default residential and/or future commercial industrial land use conditions. Consistent with standard risk assessment guidance, the HHSE methodology consists of six distinct steps, some of which may be performed independently of each other:

1. The first step in the HHSE is to assemble all readily available information related to operational history, hydrology, geology, waste characteristics, contaminant concentrations, remediation activities, topography, climate, and local meteorology.
2. In the second step, the chemicals of potential concern (COPCs) will be selected to ensure that the most significant potential for human exposure and risk is evaluated, as required by the regulatory agencies responsible for the development of human health assessment protocol in the State of California, the Department of Toxic Substances Control (DTSC) and the Office of Environmental Health Hazard Assessment (OEHHA).
3. Third, the conceptual exposure scenarios will be developed for the Site to describe the potential exposures and provide a basis for quantifying those exposures. Each exposure scenario will address the source of the COPCs, route or mechanism of exposure, exposure point quantification, and potentially exposed population(s), known as “receptors”.
4. The fourth step is to define for each identified COPC an understanding of its toxicity to humans as well as potential environmental effects. Toxicity information, which includes carcinogenic and noncarcinogenic effects, is assembled from regulatory agencies and scientific literature.
5. The fifth step is to characterize the potential risks. Risk characterization is the estimate of the potential health risk based on the selected COPCs (Step 2), the exposure scenarios and exposure point concentrations established in the

exposure assessment (Step 3), and chemical-specific toxicity information (Step 4).

6. The final step summarizes the basic assumptions and uncertainties of the HHSE.

The HHSE presented below follows these steps as established in the DTSC *Preliminary Endangerment Assessment Guidance Manual* (Cal/EPA, 1994; 1999) and other Cal/EPA risk assessment guidance.

## 2.0 INVESTIGATION HISTORY AND REMEDIAL ACTIVITIES

A comprehensive summary of site characterization efforts can be found in the body of this report. The findings of these investigations form the basis for the following HHSE. It is important to note, no remedial actions have been taken at the Site.

## 3.0 CHEMICALS OF POTENTIAL CONCERN

Results of the above investigations have shown the presence of several residual constituents in soils and soil-gas. The purpose of this section is to clearly document the methodologies utilized in the identification of COPCs for inclusion in the HHSE. The objectives of this screening process are to (1) ensure the analytes selected represent Site-related risks and (2) ensure that all localized hot spots, if any, are addressed.

### 3.1 CHEMICAL SELECTION CRITERIA

The selection of COPCs to be included in this evaluation was based on a review of the data collected during the previously outlined investigations. The data review process involved two steps: data evaluation and grouping of chemicals. Chemicals were divided into groups according to similar properties and according to guidelines presented in the *Preliminary Endangerment Assessment Guidance Manual* (Cal/EPA 1994, 1999). The criteria used to include chemicals as COPCs for further evaluation in the HHSE are as follows:

- Chemicals positively detected in at least one sample in a given medium, including chemicals with no qualifiers attached and chemicals with qualifiers attached that indicate known identities but unknown concentrations (e.g., J-flag)
- Inorganic chemicals (metals) detected at levels significantly elevated above naturally occurring levels of the same constituent if known or found above media-specific regulatory screening levels
- Chemicals only tentatively identified but that may be associated with the Site based on historical information
- Transformation products of chemicals demonstrated to be present
- Chemicals documented as having carcinogenic or non-carcinogenic toxicological effects on humans or laboratory test animals

The groups of chemicals described below were evaluated using the above criteria.

#### 3.1.1 TOTAL PETROLEUM HYDROCARBONS

Total petroleum hydrocarbon (TPH) sampling conducted at the Site showed a limited presence of heavy-end hydrocarbons in the vicinity of the former railroad line on the

property. These materials and associated concentrations were reviewed for inclusion as COPCs and subsequent quantification of potential exposures in the HHSE, however, DTSC has removed the interim guidance for the quantification of TPH exposures and risks. Therefore, the limited TPH materials found at the Site have not been included as COPCs in this HHSE.

### **3.1.2 VOLATILE ORGANIC COMPOUNDS**

Historical and recent Site investigation activities have included the collection of numerous soil matrix and soil-gas samples at various locations across the Site. Eleven volatile organic compounds (VOCs) were detected in soil matrix and soil-gas samples including: 1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, carbon tetrachloride, chloroform, dichlorodifluoromethane, naphthalene, tetrachloroethylene, toluene, trichloroethylene and xylenes. All of the VOC constituents detected in the soil matrix and soil-gas samples are not naturally occurring, and subsequently all are included as COPCs in this HHSE.

### **3.1.3 SEMI-VOLATILE ORGANIC COMPOUNDS**

Soil matrix sampling has shown the presence of semi-volatile organic compounds (SVOCs) at elevated concentrations at the Site. Fourteen (14) different SVOCs were identified in soil matrix samples including: acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. DTSC has established that several of these compounds can be found at low concentration as a result of regional and local urban activities. However, due to the elevated concentrations reported for the majority of the SVOCs, the HHSE has conservatively assumed all reported concentrations are associated with past Site activities and thus retained all detected SVOCs as COPCs.

### **3.1.4 PESTICIDES**

As a result of past railroad activities and maintenance, surface soil samples were collected for the measurement of potential residual pesticide concentrations. Soil matrix samples were submitted for analysis using USEPA Method 8081A. Three (3) pesticides were identified: 4,4-DDD, 4,4-DDE, and 4,4-DDT. All three pesticides have been retained as COPCs in this HHSE.

### **3.1.5 POLYCHLORINATED BIPHENYLS**

No polychlorinated biphenyls (PCBs) were found during the completion of Site investigation activities.

### **3.1.6 METALS**

The Site has an extensive operational history of steel manufacturing and machining. Therefore, multiple soil matrix samples were collected for the measurement of potential residual inorganic metals concentrations. Soil matrix samples were submitted for analysis using USEPA Methods 6061B (Title 22 metals) with speciation of hexavalent chromium using USEPA Method 7199. Sixteen (16) inorganic metals were reported present in the surface soils including: antimony, arsenic, barium, beryllium, cadmium, chromium (total), hexavalent chromium, cobalt, copper, lead, mercury, molybdenum, nickel, thallium, vanadium, and zinc.



Since these same metals occur naturally in soils, DTSC recommends that a comparison of reported concentrations and local naturally occurring background concentrations be conducted prior to identifying inorganics as COPCs (Cal/EPA, 1994; 1999). However, a suitable local background data set for comparison to Site concentrations could not be located. Therefore an alternate screening procedure has been utilized for this HHSE.

Reported maximum inorganic concentrations measured at the Site were compared to their corresponding California Human Health Screening Level (CHHSL) for unrestricted residential land use (Cal/EPA, 2005). Soil matrix CHHSLs represent concentrations of constituents in soil that the Cal/EPA consider to be below thresholds of concern for risks to human health under unrestricted land use conditions. These CHHSL values are commonly used to screen sites for potential human health concerns associated with potential soil and/or soil vapor contamination. The presence of a constituent in soil, soil vapor, or indoor air at concentrations below the corresponding CHHSLs can be assumed to not pose a significant health risk to people who may live or work at the subject site (Cal/EPA, 2005). Thus, those inorganics found to be below their corresponding CHHSL were no longer retained as COPCs. Six inorganic metals have been detected at the Site at concentrations exceeding their respective CHHSLs including: arsenic, cadmium, copper, lead, nickel, and thallium. Table 1 summarizes the comparison of maximum inorganic concentrations at the Site and Cal/EPA CHHSLs.

### **3.2 COPCS IN THE HUMAN HEALTH SCREENING EVALUATION**

Based on the evaluation of the constituents detected at the Site, using the criteria presented in the above sections, Table 2 summarizes the Site COPCs and the corresponding media in which they are found.

## **4.0 CONCEPTUAL EXPOSURE SCENARIO(S)**

The conceptual scenario provides the basis for a comprehensive evaluation of the risks to human health by identifying the mechanisms by which receptors may be exposed to residual COPCs. The conceptual exposure scenario traces the Site COPCs in a logical flow from their measured sources through various release mechanisms and exposure routes to potentially affected receptors. Of particular importance, the conceptual exposure scenario identifies which exposure routes are potentially complete under the given land-use scenarios. These significant pathways are evaluated in the quantitative risk assessment for each receptor. The conceptual exposure scenario also facilitates the analysis and screening of exposure pathways likely to be incomplete or insignificant.

### **4.1 LAND USE AND ASSOCIATED EXPOSURE SCENARIOS**

To determine whether the levels of COPCs present at the Site pose a risk to human populations, it is necessary to identify both the populations that may be present at the Site and the pathways through which the potential exposures may occur. The identification of the potentially exposed populations is traditionally based on human activities and land-use patterns at the Site.

The Site is a vacant, former industrial property. As such, no current site users are present. Proposed redevelopment of the Site includes commercial industrial land use. Thus, the populations that will be present at the site include future workers and patrons. While patrons may be present periodically, future workers represent the most sensitive site users as a result of prolonged potential for exposure. Workers are conservatively assumed to be

present at the Site 250 days per year for a period of 25 years in accordance with DTSC guidance (Cal/EPA, 1994; 1999).

While the Site is anticipated to remain commercial industrial in nature, it has been conservatively assumed, in accordance with DTSC guidance (Cal/EPA, 1994; 1999), that future land use may change. Consistent with the DTSC guidance (Cal/EPA, 1994; 1999), it was assumed that the site could be developed for residential land use. Residential receptors are assumed to be present 350 days per year for a period of 30 years.

## 4.2 POTENTIAL TRANSPORT MECHANISMS

Typically, COPC sources can be divided conceptually into two categories: (1) primary sources, such as shallow soils, which are readily available for potential direct receptor exposures, and (2) secondary sources, such as subsurface soil-gases, which are not readily available for receptor exposure and require an intermediate release and transport mechanism before receptors can be exposed. The mechanisms for COPC release and transport from the measured source at the Site are volatilization and particulate emissions.

Volatilization is the mass transfer of an organic constituent from a specific medium (e.g., soil or soil gas) to air. Vapor from volatile constituents moves in the subsurface soil away from the source toward the atmosphere. Environmental factors that affect volatilization include temperature, vapor pressure, Henry's Constant, soil porosity, soil moisture content, soil organic carbon content, depth to contamination, and surface structures. The volatility of a constituent is a function of its vapor pressure, water solubility, and air diffusion coefficient. Among constituents with similar vapor pressures, those with high water solubilities are less likely to become volatile than those with lower solubilities. Generally, constituents with high vapor pressures (greater than  $10^{-3}$  millimeters of mercury [Hg]) or high Henry's Law constants (greater than  $10^{-5}$  atm\*m<sup>3</sup>/mol) can be expected to volatilize readily from water and soil (Cal/EPA, 1994; 1999). The detected VOCs in soil matrix and soil gas samples previously identified in this report have been further evaluated under this transport mechanism in the HHSE.

Dust and soil particulate emissions can result from wind and mechanical erosion (e.g., construction activities). Environmental factors that influence wind erosion are wind speed, moisture content, vegetative cover, soil composition, and surface structures. Chemical and physical properties can also be used to estimate the potential for a constituent to be emitted in dust. Constituents with relatively high organic carbon partition coefficients ( $K_{OC}$  greater than 2000) are more likely to be associated with soil and thus are likely to be sorbed on dust or soil particulate. Metals, SVOCs, and pesticides detected in soils at the site are likely to be transported via this pathway.

## 4.3 EXPOSURE PATHWAYS

Not all release mechanisms lead to complete or significant exposure pathways under the exposure scenarios. This section discusses the potential for the occurrence of each exposure pathway considered at the onset of the HHSE and gives the rationale for the inclusion or exclusion of each in the final determination of risk. Consistent with the Preliminary Endangerment Assessment Guidance Manual (Cal/EPA, 1994; 1999) for conducting an HHSE, it was conservatively assumed that the entire Site is available for receptor use under the default residential and continued commercial industrial exposure scenarios.

### ***4.3.1 INHALATION OF PARTICULATES AND VAPORS***

The inhalation of particulates and vapors from soil and/or soil gas are potentially complete exposure pathways at the site in its current condition. Metals, petroleum hydrocarbons, VOCs, and SVOCs were detected in the soil and soil-vapor samples collected. The possible exposures routes for these compounds include inhalation of non-volatile chemicals that are absorbed onto soil particles (fugitive dust), and inhalation of VOCs as vapors from soil.

The inhalation of soil particulates was evaluated considering outdoor exposure only, as a level of soil particulates indoors is lower than that of outdoor due to greater surface area for particulate settling provided by indoor environments. Accordingly, conclusions developed from an outdoor exposure to particulates is considered protective of indoor exposure to particulates.

Similarly, the inhalation of vapors was evaluated considering indoor air exposures only. The indoor concentrations of vapors resulting from volatile migrations are typically much higher than those outdoors because vapors emitted from soil will be trapped and concentrated in the indoor environment compared to their dispersion and dilution in the outdoor air. Therefore, conclusions developed for indoor exposure to inhalation of vapors would be protective of outdoor exposure to vapors.

### ***4.3.2 SOIL INGESTION***

Future Site users could be exposed to COPCs at the site through the incidental ingestion of soil. Accordingly, soil ingestion represents a complete exposure pathway at the Site, and is included in the HHSE. Soil exposures for the incidental ingestion pathway are limited to surface soils and thus, the COPCs are limited to those COPCs found in this media.

The USEPA (1989) Cal/EPA defines surface soils as the upper 6 inches of soil. However, the DTSC typically considers soils to a depth of 10 feet to pose a potential for direct exposure associated with maintenance and construction activities. Therefore, it was conservatively assumed that soils from as deep as 10 feet would be available for direct exposure. It is unlikely that children, the most sensitive receptor for this pathway, in a residential will dig or ingest soil from below the surface soil depths as defined in this HHSE.

### ***4.3.3 DERMAL CONTACT WITH SOILS***

Future residents could be exposed to COPCs at the site through dermal contact with surface soil, and the subsequent absorption of COPCs present in soil. Accordingly, dermal contact with soil represents a complete exposure pathway at the site and is included in the HHSE.

## **4.4 EXPOSURE ASSESSMENT**

Receptor intake of a COPC depends on various exposure assumptions including, but not limited to, exposure duration, exposure frequency, soil ingestion rate, dermal contact rate, body weight, and averaging time. Exposure assumptions and parameters used in this HHSE for incidental soil ingestion and dermal contact with soil correspond directly to those recommended by the Cal/EPA in the Preliminary Endangerment Assessment Guidance Manual (Cal/EPA, 1994; 1999) and /or DTSC's Human and Ecological Risk Division Note 1. Summary tables presented in Appendix A summarize the exposure parameters used in the calculation of risks for this HHSE.

In addition, to quantify exposures, statistically representative concentrations must be estimated for COPCs in each impacted environmental media at the Site. These COPC exposure point concentrations are assumed equal to the representative concentration in the medium for direct exposures or are predicted by transport modeling for indirect exposures (e.g., indoor air). This section describes the methodologies to be used in the derivation of exposure point concentrations for direct and indirect exposures.

#### **4.4.1 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS IN SOIL**

The estimation of the exposure point concentration of each COPC in soil was determined using the sampling results described in the body of this report. Because this is a screening-level evaluation, and constituent concentrations vary throughout the Site, the maximum detected concentration has been used to estimate potential exposures in accordance with DTSC guidance (Cal/EPA, 1994; 1999). Use of the maximum concentration as the exposure point concentration is extremely conservative, and results in estimates of prolonged exposure that are much greater than would occur across the entire site. However, for screening-purposes only, the use of the maximum concentration provides a baseline for determining whether there are particular areas of the site that may require further investigation. This approach is constant with Cal/EPA guidance (1994; 1999) for screening-level evaluations. Calculation tables presented in Appendix A summarize the exposure point concentrations used in the calculation of risks for this HHSE.

#### **4.4.2 ESTIMATION OF INDOOR AIR CONCENTRATIONS**

As required by the DTSC (Cal/EPA, 2004), the Johnson and Ettinger (1991) model was used to estimate chemical concentrations in indoor air for volatiles under an assumed residential and commercial land use. The model uses measured soil-gas concentrations to estimate the flux of a volatile chemical into an enclosed building. The development and mechanics of the model can be found in the user's guide (Cal/EPA, 2004), which presents a sensitivity analysis indicating that the most important factors affecting indoor air concentrations are the soil water-filled porosity, source-building separation, soil-building pressure differential, and soil permeability to VOC diffusion. Site-specific soil parameters were not collected as part of the Site investigation activities and thus regulatory default soil parameters have been used. In addition, due to the model sensitivity to source depth, the model was run using the maximum detected concentration at each depth interval to ensure that the maximum source was evaluated for this HHSE. The predicted indoor air concentrations resulting from the migration of soil-gas through the soil into a hypothetical overlying residential building are presented in the Attachment A calculation tables. Appendix B presents the model outputs for each of the soil gas COPCs identified at the Site.

The use of the default Johnson and Ettinger model would result in a significant overestimation of potential risk under commercial/industrial land use. The default screening version of the model used in this assessment assumes a 350-day per year exposure for a period of 30 years. This is consistent with default residential exposure parameters used throughout the State (Cal/EPA 1994; 1999). Typically, DTSC assesses commercial/industrial exposures assuming 250 days per year for a period of 25 years. When commercial/industrial exposure parameters are incorporated into the calculations, the projected risks are significantly reduced. In addition, commercial/industrial buildings are typically assumed to have a building air exchange rate of double the value programmed into the residential model (Cal/EPA, 2004). The incorporation of commercial/industrial exchange rates would further reduce the projected risks by an additional factor of two (2). The commercial industrial

receptor presented in Appendix A presents the projected risks as a result of incorporating the commercial/industrial exposure parameters and air exchange rate into the Johnson and Ettinger model. Appendix B presents the model outputs for the commercial industrial scenario for each of the soil gas COPCs identified at the Site.

## 5.0 TOXICITY ASSESSMENT

The objective of this section is to provide information regarding the potential for receptors' exposures to chemicals detected at the Site to cause adverse health effects. More specifically, the section provides a quantitative estimate of the relationship between exposure to COPCs and the resulting probability and/or severity of human biological effects for each COPC.

### 5.1 NON-CARCINOGENIC CONSTITUENTS

For the non-carcinogenic effects of specific constituents (excluding lead), USEPA assumes a dose exists below which no adverse health effects will be seen (USEPA, 1989). Below this "threshold," it is believed exposure to a constituent can be tolerated without adverse effects, and the body burden is not increased. Adverse effects become manifest only when physiologic protective mechanisms are overcome by exposure doses above the threshold.

For oral exposures, the reference dose (RfD), expressed in units of milligrams per kilogram-day (mg/kg-d), represents the daily intake of a constituent (averaged over a year) per kilogram of body weight that is below the effect threshold for that constituent. In essence, the RfD represents the receptor-specific threshold dose. As a threshold dose, USEPA noncarcinogenic exposure is assessed separately for each age group throughout a lifetime of exposure to account for changes in intake and body mass (USEPA, 1989). A RfD is specific to the constituent, route of exposure, and duration over which the exposure occurs.

In developing constituent-specific RfDs, the USEPA reviews all relevant human and animal studies for each constituent and selects the pertinent studies. Each study is evaluated to determine the no-observable-adverse-effect level (NOAEL) or, if data are inadequate for such a determination, the lowest-observable-adverse-effect level (LOAEL). The NOAEL corresponds to a dose (mg/kg-d) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose (mg/kg-d) that can be administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect" (USEPA, 2010). To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to assure protection of human health. Uncertainty factors are applied to account for: (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a constituent (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and (4) derivation of a RfD from the LOAEL rather than the NOAEL. Each of these uncertainties usually results in a safety factor of 10 when the RfD is developed. Thus, the safety factor for an individual COPC could be as high as 10,000. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data (USEPA, 1989).

For inhalation exposures, reference concentrations (RfC) or chronic reference exposure levels (REL), as maintained in the OEHHA's Toxicity Criteria Database (Cal/EPA, 2010) were utilized. Unit conversions were performed on the RELs to derive corresponding RfC values. In

essence, the RfC represents the receptor-specific threshold concentration. An RfC is specific to the constituent and route of exposure.

The oral RfDs and inhalation RfCs for the non-carcinogenic COPCs are presented in the calculation tables in Appendix A. The sources used for toxicological reference values are the Cal/EPA's Toxicity Criteria Database (Cal/EPA, 2010) the IRIS database (USEPA, 2010), Cal/EPA's Johnson and Ettinger Vapor Intrusion Model (Cal/EPA, 2004), and Regional Screening Levels (USEPA, 2009).

## 5.2 CARCINOGENIC CONSTITUENTS

For oral exposures, the incremental lifetime cancer risk (ILCR) attributed to a carcinogen is calculated as a product of the daily intake (mg/kg-d) and the cancer slope factor (CSF). USEPA's model of carcinogenesis assumes the relationship between exposure to a carcinogen and cancer risk is linear over the entire dose range, except at very high doses (USEPA, 1989). This linearity assumes there is no threshold-of-exposure dose below which harmful effects will not occur. Because of this, carcinogenic effects are considered to be cumulative across age groups when considering lifetime exposures.

CSFs are upper-bound (95 percent upper confidence limit [UCL]) estimates of the increased cancer risk per unit dose, in which risk is expressed as the probability that an individual will develop cancer within his or her lifetime as the result of exposure to a given level of a carcinogen. All cancers or tumors are considered whether or not death results. This approach is inherently conservative because of the no-threshold assumption and the use of the 95 percent UCL of the estimated slope of dose versus cancer risk.

In addition to the CSF, the toxicity information considered in the assessment of potential carcinogenic risk includes a weight-of-evidence classification. USEPA groups constituents according to their potential for carcinogenic effects based on clinical evidence (USEPA, 1989):

- Group A Human carcinogen
- Group B Probable human carcinogen
- Group C Possible human carcinogen
- Group D Insufficient data to classify as a human carcinogen
- Group E Not a human carcinogen

For inhalation exposures, the unit risk factor (URF), expressed in units of micrograms per cubic meter (ug/m<sup>3</sup>), represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to a constituent at a unit concentration of 1 ug/m<sup>3</sup> in air. For example, if a constituent has an URF of 2.0E-06, then a person exposed to a concentration of 1 ug/m<sup>3</sup> continuously for a lifetime would have an increased risk of cancer equal to two in one million. As shown in the example, USEPA assumes carcinogenic inhalation exposures are cumulative from age group to age group over a lifetime of exposure (USEPA, 1989).

The CSFs and URFs for the COPC evaluated in this report are presented in the calculation tables in Appendix A. The sources used for these toxicological reference values are the Cal/EPA's Toxicity Criteria Database (Cal/EPA, 2010) the IRIS database (USEPA, 2010), Cal/EPA's Johnson and Ettinger Vapor Intrusion Model (Cal/EPA, 2004), and Regional Screening Levels (USEPA, 2009).

### **5.3 NON-CARCINOGENIC EVALUATION OF LEAD EXPOSURES**

The noncarcinogenic toxicity of lead has been well characterized through decades of medical observation and scientific research (USEPA, 1993). The primary effects of long-term exposure to levels expected to be encountered in the environment are neurological (involving the nervous system) and hematological (involving the blood). Some of the effects on the blood, particularly changes in the levels of certain blood enzymes and subtle neurobehavioral changes in children, appear to occur at levels so low as to be considered nonthreshold effects. For this reason, the USEPA Reference Dose/Reference Concentration (RfD/RfC) Work Group considered the derivation of an RfC for inhalation exposure, or an RfD for oral exposure, to be inappropriate (USEPA, 1993). The Cal/EPA Office of Environmental Health Hazard Assessment (OEHHA) has recently modified California Human Health Screening Levels (CHHSLs) for lead resulting in the following threshold values: residential - 80 mg/kg in soil and commercial/industrial - 320 mg/kg in soil. These new and lower CHHSLs have been recommended by DTSC for comparison to representative Site lead concentrations. The maximum lead level found at the Site (3,245 mg/kg) is significantly above the residential and commercial industrial CHHSLs.

### **5.4 POTENCY EQUIVALENCE FACTORS**

One approach used to assess the cancer risk of mixtures of structurally related compounds such as polyaromatic hydrocarbons (PAHs) is to characterize the toxicities of these compounds relative to the toxicity of a compound representative of the group. This is known as the potency equivalence factors (PEFs) approach and it takes into account the differing potencies of carcinogenic compounds from structurally related mixtures. This weighting scheme for PAHs was developed by the Air Toxicology and Epidemiology Section of the Office of Environmental Health Hazard Assessment in the document entitled Health Effects of Benzo(a)pyrene (Cal/EPA, 1993). The PAH toxicity values presented in the calculation tables in Appendix A have already been adjusted for toxicity equivalence in accordance with this guidance document. Therefore, no further adjustment is necessary to either toxicity values or exposure point concentrations.

### **5.5 QUANTIFICATION OF DERMAL EXPOSURE RISKS**

Dermal RfDs and CSFs are traditionally derived from the corresponding oral values (USEPA, 1989). However, Cal/EPA recommends that dermal RfDs and CSFs should not be derived; instead, oral RfDs and CSFs should be used in place of derived dermal toxicity values.

## **6.0 RISK CHARACTERIZATION**

This section presents the results and conclusions of the health risk evaluation under the assumed default residential and continued commercial/industrial land use exposure scenarios. The risk characterization represents the final step in the risk assessment process. In this step, the results of the exposure and toxicity assessments are integrated into quantitative estimates of potential health risks. Consistent with Cal/EPA and USEPA risk assessment policy, the potentials for exposure to produce carcinogenic and noncarcinogenic health effects are characterized separately. In health risk assessments two different values are calculated to evaluate potential health impacts: the incremental lifetime cancer risk (ILCR) and the hazard index (HI).

## 6.1 CARCINOGENIC EFFECTS

The ILCR is an upper-bound estimate of the incremental cancer probability for individuals who may have been exposed to Site-related COPCs. An estimate of the potential excess incremental lifetime cancer risk associated with exposure to a carcinogen is obtained by multiplying the average daily exposure concentration of the carcinogen by the chemical-specific risk factors. The estimated excess cancer risk for each COPC is then summed to estimate the total excess cancer risk for the exposed individual. The ILCR is compared to a range of acceptable probabilities to determine whether the potential risk poses an unacceptable health threat. The USEPA currently uses an ILCR of  $10^{-4}$  to  $10^{-6}$  as the range of acceptable risks (USEPA, 1990; 1991). The Cal/EPA has set the acceptable ILCR for unrestricted land use properties at  $10^{-6}$  (Cal/EPA, 1994; 1999). Commercial and non-inhabited properties are often held to a less stringent standard of  $10^{-5}$  (Cal/EPA, 1994; 1999).

Attachment A summarizes the estimated ILCR for default resident and commercial/industrial users at the Site. As indicated, the ILCR posed by the presence of COPCs in the soil matrix and soil-gas is estimated as  $1.3 \times 10^{-3}$  under the default residential exposure scenario and  $1.0 \times 10^{-3}$  under commercial/industrial land use. The primary drivers for the estimated residential and commercial ILCR values are direct contact with soils containing elevated concentrations of arsenic ( $3.9 \times 10^{-4}$  and  $1.9 \times 10^{-4}$ ) and polycyclic aromatic hydrocarbons ( $6.4 \times 10^{-4}$  and  $7.7 \times 10^{-4}$ ). The polycyclic aromatic hydrocarbons include: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Additional residential and commercial risks ( $2.5 \times 10^{-4}$  and  $7.5 \times 10^{-5}$ ) associated with residual soil gas concentrations migrating to indoor air of future dwellings or commercial buildings also exceed typically applied human health threshold limits. The risk drivers for the indoor air pathway are tetrachloroethene ( $2.3 \times 10^{-4}$  and  $7.0 \times 10^{-5}$ ) and trichloroethene ( $1.5 \times 10^{-5}$  and  $4.4 \times 10^{-6}$ ).

A detailed summary of risks by COPC and pathway can be found in Tables A-7 and A-15 of Appendix A.

## 6.2 NON-CARCINOGENIC EFFECTS

The potential health effects resulting from exposure to a noncarcinogenic, hazardous COPC are evaluated by comparing the average daily exposure concentration of the noncarcinogen to the chemical-specific toxicity factors (USEPA, 1989). The ratio of chemical-specific concentration over the toxicity factor is termed the HQ. If the HQ is greater than 1 or "above unity," there may be concern for potential noncarcinogenic health effects. The level of concern increases as the HQ increases above unity, although the two are not linearly related (USEPA, 1989). When receptors are exposed to more than one COPC through multiple pathways, it is useful to develop a total of the HQs known as the hazard index (HI). The HI is also conservatively compared to a threshold level of unity.

Attachment A summarizes the estimated HI for default resident and commercial/industrial users at the Site. As indicated, the HI posed by the presence of COPCs in the soil matrix and soil-gas is estimated as  $2.1 \times 10^{-1}$  under the default residential exposure scenario and  $4.0 \times 10^{-0}$  under commercial/industrial land use. The primary drivers for the estimated residential and commercial ILCR values are direct contact with soils containing elevated concentrations of arsenic ( $7.1 \times 10^{-0}$  and  $1.2 \times 10^{-0}$ ), copper ( $7.6 \times 10^{-0}$  and  $8.3 \times 10^{-1}$ ) and nickel ( $1.4 \times 10^{-0}$  and  $1.7 \times 10^{-1}$ ).



Additional residential and commercial hazards ( $4.9 \times 10^{-0}$  and  $1.8 \times 10^{-0}$ ) associated with residual soil gas concentrations migrating to indoor air of future dwellings or commercial buildings also exceed typically applied human health threshold limits. The risk drivers for the indoor air pathway are tetrachloroethene ( $2.6 \times 10^{-0}$  and  $9.4 \times 10^{-1}$ ) and naphthalene ( $2.3 \times 10^{-0}$  and  $8.2 \times 10^{-1}$ ).

A detailed summary of hazards by COPC and pathway can be found in Tables A-8 and A-15 of Appendix A.

### 6.3 UNCERTAINTY ANALYSIS

Risk assessment includes several uncertainties that warrant discussion. Many of the assumptions used in the risk assessment process, regarding the representativeness of the sampling data, human exposures and chemical toxicity, are conservative. These assumptions frequently reflect 95th percentile or greater values, rather than the typical or average value for a given parameter. The use of these conservative exposure and toxicity assumptions can introduce considerable uncertainty into the risk projections. Some of the assumptions made in the risk assessment, which may contribute to the overall uncertainty in the evaluation, are briefly outlined below.

Risks presented in this HHSE are all based on the assumption that the future Site user would be exposed to the maximum detected concentrations continuously during use of the Site. However, consistent with standard risk assessment guidance, exposures and risks should be based on an estimate of the average concentration to which an individual could be exposed over a given exposure period. The average concentration is used because (1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on average exposures; and (2) the average concentration is most representative of the concentration that would be contacted over a prolonged use of the Site (USEPA, 1992). Therefore, the use of the maximum concentration in this HHSE has likely significantly overestimated the potential risk to future Site users.

The resultant overestimation associated with the use of the maximum detected concentrations has been further exacerbated by the underlying Johnson and Ettinger modeling assumption of infinite source term conditions. Given the limited mass of volatile constituents in the soil vapor at the site based on site characterization findings, it is not likely that the projected flux rate of constituents calculated in the Johnson and Ettinger model could be supported if the mass balance of flux and source were taken into consideration over the entire exposure periods (residential – 30 yrs. and commercial – 25 yrs.).

Uncertainties related to toxicity assessment are inherent in the modeling of dose-response relationships for exposure to constituents and in calculating numerical estimators used to predict health effects with a margin of safety. Examples of inherent uncertainties in numerical estimators include factors incorporated into RfC values and unit risk factors to provide a margin of safety for use in human health assessments. Examples of uncertainties inherent to modeling of dose-response relationships include (1) extrapolation of findings in animal experiments to humans; (2) extrapolation of findings at high exposure levels to low exposure levels; (3) extrapolation of findings from acute exposures to chronic exposures, or from occupational conditions to no occupational or environmental conditions; and (4) extrapolation of findings for oral toxicity values to dermal toxicity values. The level of uncertainty for different constituents varies because information concerning some

constituents and their associated health effects is comparatively scarce, while for others more information is available from health effects studies.

Although it is difficult to quantify the uncertainties associated with all the assumptions made in this HHSE, the use of conservative assumptions is likely to contribute to a substantial overestimate of exposure and, hence, of risk. Language suggested by the USEPA (1989) to explain the effect of using conservative assumptions in regulatory risk assessments is as follows:

*These values are upper-bound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero.*

## 7.0 REFERENCES

California Environmental Protection Agency (OEHHA), 1993. Memorandum from Standards and Criteria Work Group to Cal/EPA Departments, Boards, and Offices, re. California Cancer Potency Factors, Sacramento, CA, May.

California Environmental Protection Agency (Cal/EPA), 1994. Preliminary Endangerment Assessment Guidance Manual, Dept. of Toxic Substances Control, Sacramento, CA.

\_\_\_\_\_, 1999. Reprint: Preliminary Endangerment Assessment Guidance Manual, Dept. of Toxic Substances Control, Sacramento, CA.

\_\_\_\_\_, 2004. Johnson and Ettinger Vapor Intrusion Model, Ver. 2.0 revised 1/21/05, Internet worldwide website [http://165.235.111.242/AssessingRisk/JE\\_Models.cfm](http://165.235.111.242/AssessingRisk/JE_Models.cfm)]

\_\_\_\_\_, 2005. Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties, Office of Environmental Health Hazard Assessment, Sacramento, CA.

\_\_\_\_\_, 2010. Toxicity Criteria Database, Office of Environmental Health Hazard Assessment, March.

Johnson, P.C. and Ettinger, R.A., 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings, Environ. Sci. Technol. 25:1445-1452.

U.S. Environmental Protection Agency (USEPA), 1986. Guidelines for the Health Risk Assessment of Chemical Mixtures, 51 Fed. Reg. 34014, Sept. 26.

\_\_\_\_\_, 1989. Risk Assessment Guidance for Superfund (RAGS), Vol. I, Human Health Evaluation Manual, Part A, Interim Final, Office of Emergency and Remedial Response, EPA/540/1-89/002.

\_\_\_\_\_, 1990. National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, Federal Register, Vol. 55, No. 46, Rules and Regulations, March 8.

\_\_\_\_\_, 1991. Risk Assessment Guidance for Superfund (RAGS), Vol. I, Human Health Evaluation Manual, Part C, Risk Evaluation of Remedial Alternatives, Interim Final, Office of Emergency and Remedial Response, EPA 9285,7-01C.

\_\_\_\_\_, 1992. Guidance on Risk Characterization for Risk Assessors and Risk Managers, Memorandum, Feb. 26.

\_\_\_\_\_, 1993. "Hazardous Substance Data Base (HSDB)," computer database, U.S. EPA, Wash. D.C.

\_\_\_\_\_, 2009. Regional Screening Levels (RSLs) Master Table, Internet worldwide web site [[www.epa.gov/reg3hwmd/risk/human/rbconcentration\\_table/Generic\\_Tables/pdf/master\\_sl\\_table\\_bwrun\\_DECEMBER2009.pdf](http://www.epa.gov/reg3hwmd/risk/human/rbconcentration_table/Generic_Tables/pdf/master_sl_table_bwrun_DECEMBER2009.pdf)].

\_\_\_\_\_, 2010. Integrated Risk Information System (IRIS) database, January.

**TABLE 1**  
**METALS COPC IDENTIFICATION \***

Detected Constituent	Freq. of Det.	Max Detected	CHHSL	COPC?
	mg/kg			
antimony	10/92	16	30	No
arsenic	55/133	154	0.07	Yes
barium	92/92	233	5200	No
beryllium	10/92	0.86	150	No
cadmium	13/133	10	1.7	No
chromium – total	133/133	114	10000	No
chromium – hex	2/75	0.7	17	No
cobalt	82/92	17	660	No
copper	133/133	23139	3000	Yes
lead	106/137	3245	150	Yes
mercury	8/133	5.7	18	No
molybdenum	11/92	16	380	No
nickel	129/133	2152	1600	Yes
thallium	1/133	19	5	Yes
vanadium	91/92	138	530	No
zinc	92/92	3088	23000	No

Notes:

mg/kg – milligrams per kilogram

\* – soils screening is limited to a depth of 10' below ground surface

CHHSL – Cal/EPA 2005

**TABLE 2**  
**SUMMARY OF COPC BY MEDIA**

Detected Constituent	Surface Soils	Soil Gas
1,1,1-trichloroethane		X
1,1-dichloroethane		X
1,1-dichloroethene		X
4,4-DDD	X	
4,4-DDE	X	
4,4-DDT	X	
acenaphthene	X	
acenaphthylene	X	
anthracene	X	
arsenic	X	
benzo(a)anthracene	X	
benzo(a)pyrene	X	
benzo(b)fluoranthene	X	
benzo(g,h,i)perylene	X	
benzo(k)fluoranthene	X	
cadmium	X	
carbon tetrachloride		X
chloroform		X
chrysene	X	
copper	X	
dibenzo(ah)anthracene	X	
dichlorodifluoromethane		X
ethylbenzene	X	
fluoranthene	X	
indeno(1,2,3-cd)pyrene	X	
lead	X	
naphthalene	X	X
nickel	X	
phenanthrene	X	
pyrene	X	
tetrachloroethene	X	X
thallium	X	
toluene	X	X
trichloroethene	X	X
trichlorofluoromethane		X
xylenes	X	

February 26, 2014

Mr. Mohammad Estiri, Ph.D.  
Eco & Associates, Inc.  
1855 W. Katella Ave.  
Orange, CA 92867

**Subject: Soil Vapor Risk-Based Screening Levels**  
Former Southland Steel Facility  
5959, 5969, 6011, 6161, and 6169 Alameda Street  
Huntington Park, California

Dear Dr. Estiri:

Equipoise Corporation (Equipoise) is pleased to present the following Soil Vapor Risk-Based Screening Levels (RBSLs) in support of ongoing assessment activities for the former Southland Steel Facility (the Site) located at 5959, 5969, 6011, 6161, and 6169 Alameda Street in the City of Huntington Park, California. In accordance with California Environmental Protection Agency (Cal/EPA) recommendations that potential human health risks associated with indoor air be evaluated at sites where volatile organic compounds (VOCs) are present (Cal/EPA, 2011), Equipoise has prepared the following conservative screening values for previously identified risk driving constituents [tetrachloroethene (PCE) and trichloroethene (TCE)] associated with the theoretical future migration of soil vapors to indoor air at the Site under continued commercial industrial land use conditions.

This screening assessment has been prepared in a manner consistent with federal, state, and local risk assessment guidelines. These guidelines include the Cal/EPA Department of Toxic Substances Control (DTSC) guidance documents *Guidance for Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air*, dated October, 2011; and the *Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities* dated July, 1992, and the United States Environmental Protection Agency's (USEPA) *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final*, dated December, 1989).

The following summarizes the use of a regulatory-approved model to develop conservative, site-specific risk screening values for the risk driving constituents in soil vapor samples previously collected at the Site. Specifically, site-specific risk-based screening values are modeled using the Johnson and Ettinger Vapor Intrusion Model as maintained by Cal/EPA (2014) in support of ongoing remedial activities.

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## **Johnson & Ettinger Vapor Intrusion Modeling**

The Johnson and Ettinger model contains a database of over 100 common volatile contaminants found at regulated sites throughout California. Cal/EPA has established a default set of conservative parameters for use in the Johnson and Ettinger Vapor Intrusion Model (SG-SCREEN) for use at sites under Cal/EPA oversight. These default assumptions include parameters for a hypothetical residential 24-hour exposure assuming a non-diminishing source (Cal/EPA, 2011). The default residential exposure parameters used in the SG-SCREEN model assumes a 24-hour, 350 day per year exposure for a period of 30 years. This is consistent with conservative residential exposure screening parameters used throughout the State (Cal/EPA 1994; updated 1999); however, these assumptions are not consistent with continued commercial industrial land use conditions as anticipated at the Site. Workers at commercial industrial sites are typically assumed by Cal/EPA to be on site 250 days per year for a period of 25 years. These alternate commercial industrial exposure parameter values have been applied directly as input in the model for the development of site-specific risk screening values.

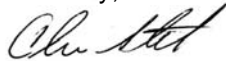
The model conservatively assumes a 24-hour exposure time resulting in a total of 20 m<sup>3</sup> of air inhaled per day. This default inhalation rate reflects a conservative residential pattern of daily activity including sleep. However, assuming an inhalation rate of 6.67 m<sup>3</sup> per work day based on a typical 8-hour commercial industrial exposure time would not be conservative, since the derived value assumes the same average inhalation rate as derived from a 24-hour day which included sleep. A more reasonable average inhalation rate would be 10 m<sup>3</sup> per work-day given a likely increased activity rate during the 8-hour period. The incorporation of this inhalation rate as a function of exposure time would result in a correction factor of two (2). Since the screening model does not have a method of inputting this inhalation/exposure time value into the model, the interim projected site-specific risk screening values must be manually corrected (increased) by a factor of two (2) to reflect commercial industrial exposure conditions.

Additional modeling corrections are necessary for the development of a regulatory acceptable commercial industrial scenario. Commercial/industrial buildings are typically assumed to have a building air exchange rate of double the value programmed into the screening model (Cal/EPA, 2011). Since the screening model does not have a method of inputting this regulatory accepted air exchange value into the model, the interim projected site-specific risk screening values must be manually corrected (increased) by a factor of two (2) to reflect the regulatory default commercial industrial air exchange rate of 1.

As an infinite source, screening-model that describes the vertical migration of sub-surface soil vapors into an overlying building, the Johnson and Ettinger model results are sensitive to the initial depth of the source concentration. In the soil vapor sampling efforts completed to date at the Site, soil vapors have been measured at varying depths between 5 and 125 feet below ground surface (bgs) with the predominate sampling being conducted between 5 and 15 feet bgs. Due to the model sensitivity to source depth and the projected use of the resultant risk-based screening levels for the identification of potential source excavation areas, Nexus Environmental Services ran the screening model at depth intervals of 5 and 10 feet bgs to ensure that vapor flux sources were evaluated in the potential excavation zone.

Table 1 summarizes the modeling input parameters used for the development of site-specific risk screening values for each depth interval. Table 2 summarizes the resultant constituent-specific risk screening values by depth as back-calculated for the Site assuming continued commercial industrial land use and risk management conditions (hazard index = 1 and lifetime cancer risk =  $1 \times 10^{-5}$ ). The Johnson & Ettinger Vapor Intrusion Model spreadsheet printouts for the calculation of these values at a commercial industrial risk management level of  $1 \times 10^{-5}$  and/or a hazard index of unity (1) are presented in Appendix A.

Sincerely,



Christopher Stoker  
Principal Risk Assessor  
Equipoise Corporation



## REFERENCES

California Environmental Protection Agency (Cal/EPA) 1992, Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities, Dept. of Toxic Substances Control, Office of Science Advisor, Sacramento, CA.

California Environmental Protection Agency (Cal/EPA) 1994, updated 1999, Reprint: Preliminary Endangerment Assessment Guidance Manual, Dept. of Toxic Substances Control, Sacramento, CA.

California Environmental Protection Agency (Cal/EPA) 2005, updated 2009, Soil-Gas-Screening Numbers for Volatile Chemicals below Buildings Constructed with Engineered Fill below Sub-slab Gravel, Office of Environmental Health Hazard Assessment, Sacramento, CA.

California Environmental Protection Agency (Cal/EPA), 2011. Guidance for Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Dept. of Toxic Substances Control, Sacramento, CA.

California Environmental Protection Agency (Cal/EPA), 2014. Johnson & Ettinger Vapor Intrusion Screening Model for Soil Vapors, [http://www.dtsc.ca.gov/AssessingRisk/JE\\_Models.cfm](http://www.dtsc.ca.gov/AssessingRisk/JE_Models.cfm), Department of Toxic Substance Control, January 2014.

U.S. Environmental Protection Agency (EPA) 1989, Risk Assessment Guidance for Superfund (RAGS), Vol. I, Human Health Evaluation Manual, Part A, Interim Final, Office of Emergency and Remedial Response, EPA/540/1-89/002.

## ***TABLES***

**TABLE 1**  
**SUMMARY OF INPUT PARAMETERS FOR**  
**JOHNSON AND ETTINGER MODELING**  
**FORMER SOUTHLAND STEEL SITE**

Parameter	Units	Value	Source
Depth below grade of enclosed space floor	cm	15	Default, J&E Model
Soil gas sampling depth below grade	cm	152.4 , 304.8	Equivalent to 5 and 10 feet
Average soil temperature	°C	24	Default, J&E Model
Vadose zone soil dry bulk density	g/cm <sup>3</sup>	1.5	Default, J&E Model
Vadose zone soil total porosity	unitless	0.43	Default, J&E Model
Vadose zone soil water-filled porosity	unitless	0.15	Default, J&E Model
Enclosed space floor length	cm	1000	Default, J&E Model
Enclosed space floor width	cm	1000	Default, J&E Model
Enclosed space ceiling height	cm	243.84	Default, J&E Model
Average vapor flow rate into building	L/minute	5	Default, J&E Model
Indoor air exchange rate	1/hour	1	DTSC, 2011
Target lifetime cancer risk (commercial)	unitless	1x10 <sup>-5</sup>	DTSC, 2011
Target noncarcinogenic Hazard	unitless	1	DTSC, 2011
Averaging time (carcinogenic)	years	70	DTSC, 2011
Averaging time (noncarcinogenic)	years	25	DTSC, 2011
Exposure duration	years	25	DTSC, 2011
Exposure frequency	days/year	250	DTSC, 2011

DTSC - Department of Toxic Substances Control, default from the *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air*, October 2011.

g/cm<sup>3</sup> = grams per cubic centimeter

L/minute = Liters per minute

**TABLE 2**  
**RISK-BASED SCREENING LEVELS BY DEPTH**  
**FORMER SOUTHLAND STEEL FACILITY**

Constituents	Interim Modeled Values		Commercial	Commercial	Commercial RBSLs		Driving Toxic Endpoint
	5 ft. bgs.	10 ft. bgs.	ET Factor	AER Factor	5 ft. bgs.	10 ft. bgs.	
Tetrachloroethene	8.9	15	2x	2x	35.6	60	C
Trichloroethene	3.4	5.9	2x	2x	13.6	23.6	NC

Notes:

Units in micrograms per liter (ug/L)

Target thresholds of HI = 1, cancer risk = 1E-05

RBSL - Risk-based screening level

Exposure parameters -ED = 25 years, EF = 250 days per year

ET Adjustment - Exposure time/inhalation rate adjustment to reflect work day (2x model default)

AER Adjustment - Air exchange rate adjusted to reflect commercial rate (2x model default)

C- Carcinogenic endpoint

NC - Noncarcinogenic endpoint

***ATTACHMENT A  
SG-SCREEN OUTPUT FILES  
COMMERCIAL INDUSTRIAL***

***5 FOOT DEPTH  
INTERVAL***

DATA ENTRY SHEET

SG-SCREEN  
PA Version 2.0; 04/

Reset to Defaults

DTSC  
Vapor Intrusion Guidance  
Interim Final 12/04  
(last modified 12/6/2011)

Soil Gas Concentration Data				
ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., $C_g$ ( $\mu\text{g}/\text{m}^3$ )	OR	ENTER Soil gas conc., $C_g$ (ppmv)	Chemical
127184	8.90E+03			Tetrachloroethylene

MORE  
↓

ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (15 or 200 cm)	ENTER Soil gas sampling depth below grade, $L_s$ (cm)	ENTER Average soil temperature, $T_s$ ( $^{\circ}\text{C}$ )	OR	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined vadose zone soil vapor permeability, $k_v$ ( $\text{cm}^2$ )
15	152.4	24			1.00E-08

MORE  
↓

ENTER Vadose zone SCS soil type Lookup Soil Parameters	ENTER Vadose zone soil dry bulk density, $\rho_b^A$ ( $\text{g}/\text{cm}^3$ )	ENTER Vadose zone soil total porosity, $n^V$ (unitless)	ENTER Vadose zone soil water-filled porosity, $\theta_w^V$ ( $\text{cm}^3/\text{cm}^3$ )	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) $Q_{\text{soil}}$ (L/m)
	1.5	0.43	0.15	5

MORE  
↓

ENTER Averaging time for carcinogens, $AT_C$ (yrs)	ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	25	25	250

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, $D_a$ ( $\text{cm}^2/\text{s}$ )	Diffusivity in water, $D_w$ ( $\text{cm}^2/\text{s}$ )	Henry's law constant at reference temperature, H ( $\text{atm}\cdot\text{m}^3/\text{mol}$ )	Henry's law constant reference temperature, $T_R$ ( $^{\circ}\text{C}$ )	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ ( $\text{cal}/\text{mol}$ )	Normal boiling point, $T_B$ ( $^{\circ}\text{K}$ )	Critical temperature, $T_C$ ( $^{\circ}\text{K}$ )	Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RfC ( $\text{mg}/\text{m}^3$ )	Molecular weight, MW ( $\text{g}/\text{mol}$ )
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	5.9E-06	3.5E-02	165.83

END



INTERMEDIATE CALCULATIONS SHEET

Source-building separation, $L_T$ (cm)	Vadose zone soil air-filled porosity, $\theta_a^v$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone effective total fluid saturation, $S_{te}$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone soil intrinsic permeability, $k_i$ ( $\text{cm}^2$ )	Vadose zone soil relative air permeability, $k_{rg}$ ( $\text{cm}^2$ )	Vadose zone soil effective vapor permeability, $k_v$ ( $\text{cm}^2$ )	Floor-wall seam perimeter, $X_{crack}$ (cm)	Soil gas conc., ( $\mu\text{g}/\text{m}^3$ )	Bldg. ventilation rate, $Q_{building}$ ( $\text{cm}^3/\text{s}$ )
137.4	0.280	#N/A	#N/A	#N/A	1.00E-08	4,000	8.90E+03	3.39E+04

Area of enclosed space below grade, $A_B$ ( $\text{cm}^2$ )	Crack-to-total area ratio, $\eta$ (unitless)	Crack depth below grade, $Z_{crack}$ (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (atm·m <sup>3</sup> /mol)	Henry's law constant at ave. soil temperature, $H'_{TS}$ (unitless)	Vapor viscosity at ave. soil temperature, $\mu_{TS}$ (g/cm-s)	Vadose zone effective diffusion coefficient, $D_v^{eff}$ ( $\text{cm}^2/\text{s}$ )	Diffusion path length, $L_d$ (cm)
1.00E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	5.62E-03	137.4

Convection path length, $L_p$ (cm)	Source vapor conc., $C_{source}$ ( $\mu\text{g}/\text{m}^3$ )	Crack radius, $r_{crack}$ (cm)	Average vapor flow rate into bldg., $Q_{soil}$ ( $\text{cm}^3/\text{s}$ )	Crack effective diffusion coefficient, $D^{crack}$ ( $\text{cm}^2/\text{s}$ )	Area of crack, $A_{crack}$ ( $\text{cm}^2$ )	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, $\alpha$ (unitless)	Infinite source bldg. conc., $C_{building}$ ( $\mu\text{g}/\text{m}^3$ )
15	8.90E+03	1.25	8.33E+01	5.62E-03	5.00E+03	7.73E+12	8.09E-04	7.20E+00

Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RFC ( $\text{mg}/\text{m}^3$ )
5.9E-06	3.5E-02

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.0E-05	1.4E-01

MESSAGE SUMMARY BELOW:

END

DATA ENTRY SHEET

SG-SCREEN  
PA Version 2.0; 04/

Reset to Defaults

DTSC  
Vapor Intrusion Guidance  
Interim Final 12/04  
(last modified 12/6/2011)

Soil Gas Concentration Data				
ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., $C_g$ ( $\mu\text{g}/\text{m}^3$ )	OR	ENTER Soil gas conc., $C_g$ (ppmv)	Chemical
79016	3.43E+03			Trichloroethylene

MORE  
↓

ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (15 or 200 cm)	ENTER Soil gas sampling depth below grade, $L_s$ (cm)	ENTER Average soil temperature, $T_s$ ( $^{\circ}\text{C}$ )	OR	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined vadose zone soil vapor permeability, $k_v$ ( $\text{cm}^2$ )
15	152.4	24			1.00E-08

MORE  
↓

ENTER Vadose zone SCS soil type Lookup Soil Parameters	ENTER Vadose zone soil dry bulk density, $\rho_b^A$ ( $\text{g}/\text{cm}^3$ )	ENTER Vadose zone soil total porosity, $n^V$ (unitless)	ENTER Vadose zone soil water-filled porosity, $\theta_w^V$ ( $\text{cm}^3/\text{cm}^3$ )	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) $Q_{\text{soil}}$ (L/m)
	1.5	0.43	0.15	5

MORE  
↓

ENTER Averaging time for carcinogens, $AT_C$ (yrs)	ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	25	25	250

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, $D_a$ ( $\text{cm}^2/\text{s}$ )	Diffusivity in water, $D_w$ ( $\text{cm}^2/\text{s}$ )	Henry's law constant at reference temperature, H ( $\text{atm}\cdot\text{m}^3/\text{mol}$ )	Henry's law constant reference temperature, $T_R$ ( $^\circ\text{C}$ )	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ ( $\text{cal}/\text{mol}$ )	Normal boiling point, $T_B$ ( $^\circ\text{K}$ )	Critical temperature, $T_C$ ( $^\circ\text{K}$ )	Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RfC ( $\text{mg}/\text{m}^3$ )	Molecular weight, MW ( $\text{g}/\text{mol}$ )
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	4.1E-06	2.0E-03	131.39

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, $L_T$ (cm)	Vadose zone soil air-filled porosity, $\theta_a^v$ (cm <sup>3</sup> /cm <sup>3</sup> )	Vadose zone effective total fluid saturation, $S_{te}$ (cm <sup>3</sup> /cm <sup>3</sup> )	Vadose zone soil intrinsic permeability, $k_i$ (cm <sup>2</sup> )	Vadose zone soil relative air permeability, $k_{rg}$ (cm <sup>2</sup> )	Vadose zone soil effective vapor permeability, $k_v$ (cm <sup>2</sup> )	Floor-wall seam perimeter, $X_{crack}$ (cm)	Soil gas conc., ( $\mu\text{g}/\text{m}^3$ )	Bldg. ventilation rate, $Q_{building}$ (cm <sup>3</sup> /s)
137.4	0.280	#N/A	#N/A	#N/A	1.00E-08	4,000	3.43E+03	3.39E+04

Area of enclosed space below grade, $A_B$ (cm <sup>2</sup> )	Crack-to-total area ratio, $\eta$ (unitless)	Crack depth below grade, $Z_{crack}$ (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (atm·m <sup>3</sup> /mol)	Henry's law constant at ave. soil temperature, $H'_{TS}$ (unitless)	Vapor viscosity at ave. soil temperature, $\mu_{TS}$ (g/cm-s)	Vadose zone effective diffusion coefficient, $D_v^{eff}$ (cm <sup>2</sup> /s)	Diffusion path length, $L_d$ (cm)
1.00E+06	5.00E-03	15	8,382	9.80E-03	4.02E-01	1.80E-04	6.16E-03	137.4

Convection path length, $L_p$ (cm)	Source vapor conc., $C_{source}$ ( $\mu\text{g}/\text{m}^3$ )	Crack radius, $r_{crack}$ (cm)	Average vapor flow rate into bldg., $Q_{soil}$ (cm <sup>3</sup> /s)	Crack effective diffusion coefficient, $D^{crack}$ (cm <sup>2</sup> /s)	Area of crack, $A_{crack}$ (cm <sup>2</sup> )	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, $\alpha$ (unitless)	Infinite source bldg. conc., $C_{building}$ ( $\mu\text{g}/\text{m}^3$ )
15	3.43E+03	1.25	8.33E+01	6.16E-03	5.00E+03	5.57E+11	8.60E-04	2.95E+00

Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RFC (mg/m <sup>3</sup> )
4.1E-06	2.0E-03

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
3.0E-06	1.0E+00

MESSAGE SUMMARY BELOW:

END

***10 FOOT DEPTH  
INTERVAL***

DATA ENTRY SHEET

SG-SCREEN  
PA Version 2.0; 04/

Reset to Defaults

DTSC  
Vapor Intrusion Guidance  
Interim Final 12/04  
(last modified 12/6/2011)

Soil Gas Concentration Data				
ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., $C_g$ ( $\mu\text{g}/\text{m}^3$ )	OR	ENTER Soil gas conc., $C_g$ (ppmv)	Chemical
127184	1.50E+04			Tetrachloroethylene

MORE  
↓

ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (15 or 200 cm)	ENTER Soil gas sampling depth below grade, $L_s$ (cm)	ENTER Average soil temperature, $T_s$ ( $^{\circ}\text{C}$ )	OR	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined vadose zone soil vapor permeability, $k_v$ ( $\text{cm}^2$ )
15	304.8	24			1.00E-08

MORE  
↓

ENTER Vadose zone SCS soil type  Lookup Soil Parameters	ENTER Vadose zone soil dry bulk density, $\rho_b^A$ ( $\text{g}/\text{cm}^3$ )	ENTER Vadose zone soil total porosity, $n^V$ (unitless)	ENTER Vadose zone soil water-filled porosity, $\theta_w^V$ ( $\text{cm}^3/\text{cm}^3$ )	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) $Q_{\text{soil}}$ (L/m)
	1.5	0.43	0.15	5

MORE  
↓

ENTER Averaging time for carcinogens, $AT_C$ (yrs)	ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	25	25	250

END



CHEMICAL PROPERTIES SHEET

Diffusivity in air, $D_a$ ( $\text{cm}^2/\text{s}$ )	Diffusivity in water, $D_w$ ( $\text{cm}^2/\text{s}$ )	Henry's law constant at reference temperature, H ( $\text{atm}\cdot\text{m}^3/\text{mol}$ )	Henry's law constant reference temperature, $T_R$ ( $^\circ\text{C}$ )	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ ( $\text{cal}/\text{mol}$ )	Normal boiling point, $T_B$ ( $^\circ\text{K}$ )	Critical temperature, $T_C$ ( $^\circ\text{K}$ )	Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RfC ( $\text{mg}/\text{m}^3$ )	Molecular weight, MW ( $\text{g}/\text{mol}$ )
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	5.9E-06	3.5E-02	165.83

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, $L_T$ (cm)	Vadose zone soil air-filled porosity, $\theta_a^v$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone effective total fluid saturation, $S_{te}$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone soil intrinsic permeability, $k_i$ ( $\text{cm}^2$ )	Vadose zone soil relative air permeability, $k_{rg}$ ( $\text{cm}^2$ )	Vadose zone soil effective vapor permeability, $k_v$ ( $\text{cm}^2$ )	Floor-wall seam perimeter, $X_{crack}$ (cm)	Soil gas conc., ( $\mu\text{g}/\text{m}^3$ )	Bldg. ventilation rate, $Q_{building}$ ( $\text{cm}^3/\text{s}$ )
289.8	0.280	#N/A	#N/A	#N/A	1.00E-08	4,000	1.50E+04	3.39E+04

Area of enclosed space below grade, $A_B$ ( $\text{cm}^2$ )	Crack-to-total area ratio, $\eta$ (unitless)	Crack depth below grade, $Z_{crack}$ (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (atm·m <sup>3</sup> /mol)	Henry's law constant at ave. soil temperature, $H'_{TS}$ (unitless)	Vapor viscosity at ave. soil temperature, $\mu_{TS}$ (g/cm-s)	Vadose zone effective diffusion coefficient, $D_v^{eff}$ ( $\text{cm}^2/\text{s}$ )	Diffusion path length, $L_d$ (cm)
1.00E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	5.62E-03	289.8

Convection path length, $L_p$ (cm)	Source vapor conc., $C_{source}$ ( $\mu\text{g}/\text{m}^3$ )	Crack radius, $r_{crack}$ (cm)	Average vapor flow rate into bldg., $Q_{soil}$ ( $\text{cm}^3/\text{s}$ )	Crack effective diffusion coefficient, $D^{crack}$ ( $\text{cm}^2/\text{s}$ )	Area of crack, $A_{crack}$ ( $\text{cm}^2$ )	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, $\alpha$ (unitless)	Infinite source bldg. conc., $C_{building}$ ( $\mu\text{g}/\text{m}^3$ )
15	1.50E+04	1.25	8.33E+01	5.62E-03	5.00E+03	7.73E+12	4.64E-04	6.96E+00

Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RFC ( $\text{mg}/\text{m}^3$ )
5.9E-06	3.5E-02

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
1.0E-05	1.4E-01

MESSAGE SUMMARY BELOW:

END

DATA ENTRY SHEET

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PA Version 2.0; 04/

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Soil Gas Concentration Data				
ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., $C_g$ ( $\mu\text{g}/\text{m}^3$ )	OR	ENTER Soil gas conc., $C_g$ (ppmv)	Chemical
79016	5.90E+03			Trichloroethylene

MORE  
↓

ENTER Depth below grade to bottom of enclosed space floor, $L_F$ (15 or 200 cm)	ENTER Soil gas sampling depth below grade, $L_s$ (cm)	ENTER Average soil temperature, $T_s$ ( $^{\circ}\text{C}$ )	OR	ENTER Vadose zone SCS soil type (used to estimate soil vapor permeability)	ENTER User-defined vadose zone soil vapor permeability, $k_v$ ( $\text{cm}^2$ )
15	304.8	24			1.00E-08

MORE  
↓

ENTER Vadose zone SCS soil type Lookup Soil Parameters	ENTER Vadose zone soil dry bulk density, $\rho_b^A$ ( $\text{g}/\text{cm}^3$ )	ENTER Vadose zone soil total porosity, $n^V$ (unitless)	ENTER Vadose zone soil water-filled porosity, $\theta_w^V$ ( $\text{cm}^3/\text{cm}^3$ )	ENTER Average vapor flow rate into bldg. (Leave blank to calculate) $Q_{\text{soil}}$ (L/m)
	1.5	0.43	0.15	5

MORE  
↓

ENTER Averaging time for carcinogens, $AT_C$ (yrs)	ENTER Averaging time for noncarcinogens, $AT_{NC}$ (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	25	25	250

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, $D_a$ ( $\text{cm}^2/\text{s}$ )	Diffusivity in water, $D_w$ ( $\text{cm}^2/\text{s}$ )	Henry's law constant at reference temperature, H ( $\text{atm}\cdot\text{m}^3/\text{mol}$ )	Henry's law constant reference temperature, $T_R$ ( $^\circ\text{C}$ )	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ ( $\text{cal}/\text{mol}$ )	Normal boiling point, $T_B$ ( $^\circ\text{K}$ )	Critical temperature, $T_C$ ( $^\circ\text{K}$ )	Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RfC ( $\text{mg}/\text{m}^3$ )	Molecular weight, MW ( $\text{g}/\text{mol}$ )
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	4.1E-06	2.0E-03	131.39

END

INTERMEDIATE CALCULATIONS SHEET

Source-building separation, $L_T$ (cm)	Vadose zone soil air-filled porosity, $\theta_a^v$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone effective total fluid saturation, $S_{te}$ ( $\text{cm}^3/\text{cm}^3$ )	Vadose zone soil intrinsic permeability, $k_i$ ( $\text{cm}^2$ )	Vadose zone soil relative air permeability, $k_{rg}$ ( $\text{cm}^2$ )	Vadose zone soil effective vapor permeability, $k_v$ ( $\text{cm}^2$ )	Floor-wall seam perimeter, $X_{crack}$ (cm)	Soil gas conc., ( $\mu\text{g}/\text{m}^3$ )	Bldg. ventilation rate, $Q_{building}$ ( $\text{cm}^3/\text{s}$ )
289.8	0.280	#N/A	#N/A	#N/A	1.00E-08	4,000	5.90E+03	3.39E+04

Area of enclosed space below grade, $A_B$ ( $\text{cm}^2$ )	Crack-to-total area ratio, $\eta$ (unitless)	Crack depth below grade, $Z_{crack}$ (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, $H_{TS}$ (atm- $\text{m}^3/\text{mol}$ )	Henry's law constant at ave. soil temperature, $H'_{TS}$ (unitless)	Vapor viscosity at ave. soil temperature, $\mu_{TS}$ (g/cm-s)	Vadose zone effective diffusion coefficient, $D_v^{eff}$ ( $\text{cm}^2/\text{s}$ )	Diffusion path length, $L_d$ (cm)
1.00E+06	5.00E-03	15	8,382	9.80E-03	4.02E-01	1.80E-04	6.16E-03	289.8

Convection path length, $L_p$ (cm)	Source vapor conc., $C_{source}$ ( $\mu\text{g}/\text{m}^3$ )	Crack radius, $r_{crack}$ (cm)	Average vapor flow rate into bldg., $Q_{soil}$ ( $\text{cm}^3/\text{s}$ )	Crack effective diffusion coefficient, $D^{crack}$ ( $\text{cm}^2/\text{s}$ )	Area of crack, $A_{crack}$ ( $\text{cm}^2$ )	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, $\alpha$ (unitless)	Infinite source bldg. conc., $C_{building}$ ( $\mu\text{g}/\text{m}^3$ )
15	5.90E+03	1.25	8.33E+01	6.16E-03	5.00E+03	5.57E+11	5.00E-04	2.95E+00

Unit risk factor, URF ( $\mu\text{g}/\text{m}^3$ ) <sup>-1</sup>	Reference conc., RFC ( $\text{mg}/\text{m}^3$ )
4.1E-06	2.0E-03

END

RESULTS SHEET

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
3.0E-06	1.0E+00

MESSAGE SUMMARY BELOW:

END