RISK ASSESSMENT WORK PLAN
ELECTRO-COATINGS, INC. FACILITY
EMERYVILLE, CALIFORNIA

March 1996

Prepared for

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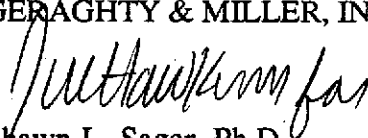Berkeley, California 94710

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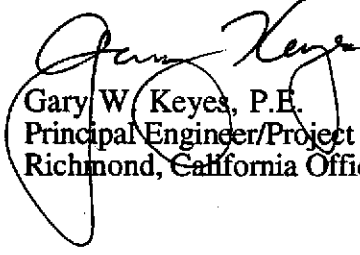# EMERYVILLE, CALIFORNIA

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Geraghty & Miller, Inc. is submitting this work plan to Electro-Coatings, Inc. for work to be performed at the Electro-Coatings, Inc. Emeryville facility. The work plan was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that the work plan meets industry standards in terms of the methods used and the information presented. If you have any questions or comments concerning this report, please contact one of the individuals listed below.

Respectfully submitted,
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1.0   INTRODUCTION

This work plan has been prepared on behalf of Electro-Coatings, Inc. (ECI). The purpose of the work plan is to outline the basic approach and methods for evaluating potential human health and environmental risks at ECI's facility in Emeryville, California. This document provides a brief description and history of the site followed by discussions of site data, exposure assessment, toxicity assessment, and risk characterization. This work plan outlines the risk assessment methodology and assumptions that will be used to evaluate potential risks posed by site-related contaminants at the site. The risk assessment methodology is based on the Risk Assessment Guidance for Superfund (U.S. Environmental Protection Agency [USEPA], 1989a) and conforms to USEPA guidance for baseline risk assessments (USEPA, 1991a,b,c; 1989a,b,c).

The data collected at the site during the various phases were statistically summarized for the development of this risk assessment work plan. The risk assessment will focus on site-related constituents: chlorinated volatile organic compounds (VOCs), nickel, and chromium (total and hexavalent). The baseline risk assessment is based on the assumption that no remedial (corrective) action will take place at the site; therefore, the site will be evaluated as it currently exists.

2.0 SITE CHARACTERIZATION

The ECI facility is in a highly industrialized area of Emeryville, California, north of Interstate 580-Highway 24 and east of Interstate 80 (Figure 1). The site consists of two parcels at 1401 and 1421 Park Avenue (Figure 2). Buildings are adjacent to the northern and eastern property boundaries; parking and paved areas are south and west of the buildings. The site is bordered by Park Avenue to the north, a lumber yard and parking area to the south, a dirt alley with a buried railroad track to the east, and a clothing outlet and a crematorium to the west. The dirt alley east of the site reportedly is scheduled to be improved as an extension of Holden Street between Park Avenue and 40th Street. The Southern Pacific Railroad right-of-way, about 140 feet to the south, is being reconstructed as an extension of 40th Street. Horton Street lies approximately 80 feet west of the site, and San Francisco Bay is approximately 2,500 feet west.

Chrome plating operations began at the site in 1952 and electroless nickel plating began at the site in the late 1950s. ECI became the operator of the site in 1963 when it purchased the assets of the former operator, Industrial Hard Chrome Plating, Inc. Chrome plating ceased at the site in 1989 and nickel plating ceased in mid-1995. The facility is not currently in operation. Trichloroethene (TCE) was used by Industrial Hard Chrome Plating Corporation prior to 1963 and by ECI until 1973, when it was replaced with 1,1,1-trichloroethane (1,1,1-TCA). These solvents were used to vapor-degrease metal parts prior to nickel plating. In 1992, vapor degreasing was discontinued and replaced with a liquid alkaline soak process.

The area surrounding the ECI facility currently is zoned I-C (Custom Manufacturing), which does not allow any residential use of property. In September 1994, the City of Emeryville Zoning Ordinance Revision Committee conducted a public workshop as part of the city's effort to update the land-use policies and design guidelines for the creation of a Revitalization Strategy/Zoning Overlay District for five blocks along Park Avenue, including the ECI facility. The city has expressed the intent to preserve the character of this district while allowing new uses by non-industrial commercial businesses.

2.1 HYDROGEOLOGY

The site generally is underlain by clays and silty clays to approximately 15 feet below ground surface (bgs). The sediments become coarser, consisting of layers of sand and gravel with varying silt and clay content, between about 15 and 30 feet bgs. This coarser zone comprises the water-bearing unit and shallow aquifer. The shallow aquifer is semi-confined to

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confined, with a potentiometric surface roughly 6 to 9 feet bgs and a hydraulic gradient to the west and northwest. Measured aquifer permeability for the shallow aquifer is 28 cubic feet per day per square foot (ft^3/day/ft^2), which is typical for sand and gravel aquifers (ENTRIX, Inc. [ENTRIX], 1994).

Underlying the shallow aquifer is an extensive blue clay with small lenses of sand and gravel. The potentiometric surface of the deeper wells (3A and 18A) reveals a slight vertically downward hydraulic head, while Monitor Well (MW) 20 shows an upward vertical head of about 3 feet above the shallow potentiometric surface. This upward head indicates that groundwater contaminants are not likely to migrate below the shallow aquifer under natural conditions (ENTRIX, 1994).

Groundwater from beneath the site flows to the west and northwest, ultimately discharging into San Francisco Bay. Groundwater is not in use at the site or in the vicinity of the site. Drinking water to the City of Emeryville is provided by the East Bay Municipal Utility District (EBMUD).

2.2 POTENTIAL SOURCE AREAS

Potential contaminant source areas were identified at the site. The chromium waste storage area, directly behind the 1401 Park Avenue building in the southeast corner of the facility, was identified as a likely source of chromium contamination. A leaking concrete vault or tank was reported in that area sometime in either 1974 or 1977 (records are unclear), and groundwater quality data indicate that elevated chromium concentrations probably originated in this area (ENTRIX, 1994). Nickel plating was performed only on the 1421 Park Avenue parcel, and chrome plating was performed only on the 1401 Park Avenue parcel. All metal degreasing operations (associated with the nickel plating operations) were performed in the southwest portion of the facility on the 1421 Park Avenue parcel. TCE was used as the degreasing solvent until 1973, when it was replaced with 1,1,1-TCA. Vapor degreasing was discontinued in 1992. No solvent leaks or spills were reported, but this is the only known potential on-site source of the elevated levels of TCE which were measured in the groundwater. A 500-gallon gasoline underground storage tank (UST) reportedly exists west of the 1421 Park Avenue building. No investigation has been performed to locate or assess the integrity of this UST; however, analytical data have not indicated any detectable quantities of benzene, toluene, ethylbenzene, or xylenes (BTEX), which are commonly found in gasoline. The absence of these constituents indicates that there probably has been no significant release of gasoline at the site.

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3.0 DATA SUMMARY

This section describes the occurrence of constituents detected in environmental media at the site. Prior to statistical analyses, these data were separated into two groups according to medium: 1) on-site groundwater and 2) on-site subsurface soil. The following sections summarize the data reduction procedure and the occurrence of constituents in these media.

3.1 DATA REDUCTION

The data were reduced and analyzed for use in the risk assessment according to the guidelines provided by USEPA (1989a) guidance, as described below:

- Constituents that have never been detected in a data group were eliminated from further analysis for that group;

- All analytical results reported as detections were (J-qualified) used at the reported value, including laboratory estimated data; and

- For constituents within a data group reported as non-detected (non-detects), one-half of the sample quantitation limit (SQL) was used as a proxy concentration rather than using zero or eliminating the data point. In instances where one-half of the SQL exceeded the maximum detected concentration for that constituent in that data group (i.e., as in an unusually high SQL), the maximum detect was used as the proxy value for that non-detect.

The results of the statistical analyses are presented in the constituent occurrence tables (Tables 3-1 [groundwater data] and 3-2 [soil data]). The information in these tables includes, for each detected constituent, the frequency of detection (ratio of the number of detects to the total number of relevant samples in that group), the range of SQLs for non-detects in the data set, the range of detected values, the average detected value, the arithmetic mean, the one-tailed 95% upper confidence level (UCL) on the arithmetic mean (assuming a normal distribution), USEPA Region IX preliminary remediation goals (PRGs), and the exposure point concentration (EPC) to be used in the risk calculations for constituents of potential concern (COPCs). The mean and UCL concentrations were calculated using appropriate proxy concentrations for non-detects.

The UCL is a statistical number calculated using the following formula:

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$$UCL_{95} = \bar{x} + \frac{s \times t_{0.05,n-1}}{\sqrt{n}}$$

where:

n	sample size (number of data points);
s	sample standard deviation;
$t_{0.05,\,n-1}$	0.05 critical value for the t_{n-1} distribution;
UCL_{95}	95% upper confidence level for the mean; and
$\bar{x}$	sample mean (average).

Assuming the samples were selected randomly from the site, statistical theory asserts that there is a 95% probability that the true mean concentration for the site lies below the UCL concentration. A high level of confidence (95%) is used to compensate for the uncertainty involved in representing the site conditions with a finite number of samples.

3.2 OCCURRENCE IN GROUNDWATER SAMPLES

Groundwater samples have been collected at the site since 1977. In samples collected prior to March 1985, analyses were performed only for total and hexavalent chromium. Since March 1985, groundwater samples have been analyzed for chlorinated solvents, and most were also analyzed for total and hexavalent chromium. All available data were included in the statistical analyses to select COPCs and to calculate the UCLs for those COPCs.

Table 3-1 presents occurrence information for constituents detected in groundwater samples collected at the site. Samples collected from MW-1, MW-2, MW-8, and MW-21 are designated as background and were not included in the site-related data. As shown in the table, 10 VOCs, all classified as chlorinated solvents, were detected in the on-site groundwater. 1,2-Dichlorobenzene (1,2-DCB) was detected in only 1 of 18 samples, and chlorobenzene was detected in only 2 of 18 samples. Neither of these two constituents was detected in the background wells. These constituents were detected only in the most recent sampling event (April 1995). All other VOCs listed in the table were detected in 12 or more on-site samples and also were detected in the background wells. Tetrachloroethene (also known as perchloroethene [PCE]) was the only VOC detected at higher concentrations in the background wells than in the on-site wells. Chromium was detected as hexavalent chromium in 62 of 89 samples and as total chromium (hexavalent and trivalent) in 86 of 99 samples. The site-related mean and UCL for total chromium are elevated above the background concentrations.

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Hexavalent chromium was not detected in the five background samples analyzed for that parameter.

3.3   OCCURRENCE IN SOIL SAMPLES

Six soil samples collected by Geraghty & Miller in May 1995 and 53 soil samples collected by various consultants on behalf of ECI from 1980 through 1985, and summarized by ENTRIX in its "Summary of Site Conditions" in 1994 (ENTRIX, 1994), were used to represent current site conditions. The samples reported by ENTRIX, although collected more than 10 years ago, were included to improve the representation of chromium contamination at the site. Geraghty & Miller collected two subsurface soil samples from each of three locations at the site: 1) the piping manifold area, 2) beneath the former vapor degreaser, and 3) the former chromium storage area. Four of the Geraghty & Miller samples (the piping manifold and vapor degreaser samples) were analyzed for VOCs and for nickel. The samples from the former chromium storage area were analyzed for total and hexavalent chromium. All of the samples reported by ENTRIX were analyzed for total chromium, and 10 of those samples were also analyzed for hexavalent chromium.

Table 3-2 presents the analytical results for the subsurface soil samples. Five chlorinated VOCs were detected in the Geraghty & Miller soil samples. 1,1,1-TCA and vinyl chloride were detected only once in the four samples, and 1,1-dichloroethane (1,1-DCA) and TCE were detected twice. cis-1,2-Dichloroethene (cis-1,2-DCE) was detected in all four samples. Total chromium and nickel were detected in all samples analyzed for those parameters. Hexavalent chromium was detected in 4 of 12 samples, but was not detected in either of the samples collected by Geraghty & Miller from the former chromium storage area. The normal background concentration of chromium in soils in the San Francisco area ranges from 100 to 2,000 milligrams per kilogram (mg/kg). The national average is 54 mg/kg (USGS, 1984). For nickel, the normal background concentration range is 30 to 700 mg/kg, and the national average is 19 mg/kg (USGS, 1984). The maximum detected concentration for total chromium at this site (6,700 mg/kg) exceeds the USGS range, but the maximum detected nickel concentration (310 mg/kg) is within the USGS background range for this area.

3.4   SELECTION OF CONSTITUENTS OF POTENTIAL CONCERN

Identification of the COPCs for the human-health risk assessment was accomplished following USEPA (1989a) guidance. The term "constituent of potential concern" does not indicate that risk is attributable to the constituent discussed at the concentration detected during

sampling. The term is used to describe those constituents on which the risk assessment will focus. Conclusions concerning risk should be made only following the quantitative risk assessment.

The occurrence data and the USEPA Region IX PRGs in Tables 3-1 and 3-2 were used to select the COPCs for the risk assessment. Table 3-1 presents the USEPA Region IX PRGs for tap water (USEPA, 1995). Use of tap water PRGs for the selection of COPCs at this site is very conservative, since there is no ingestion of or direct exposure to groundwater in the area. Comparison of the maximum detected concentrations to the USEPA Region IX PRGs indicates that all detected concentrations of chlorobenzene, 1,2-DCB, and 1,1-DCA were below the PRGs for those constituents. Therefore, those three constituents were eliminated from the list of COPCs for the groundwater. Table 3-2 presents the USEPA Region IX PRGs for industrial soil (USEPA, 1995). Comparison of those PRGs to the maximum detected concentrations in soil indicates that all detected concentrations for 1,1-DCA, cis-1,2-DCE, 1,1,1-TCA, and nickel were below the PRGs for those constituents. Therefore, these constituents were eliminated from the list of COPCs for soil. Table 3-3 presents the list of COPCs for the sampled media (groundwater and soil) at the site.

4.0 TOXICITY ASSESSMENT

Risk associated with exposure to chemical constituents is a function of the toxicity and exposure dose. In assessing human-health risks, a distinction is made between non-carcinogenic and carcinogenic effects. This section discusses these two categories of toxic effects and the toxicity values used to calculate human-health risk.

4.1 GENERAL TOXIC EFFECTS

A distinction is made between carcinogenic and non-carcinogenic effects. For potential carcinogens, the current regulatory guidelines (USEPA, 1989a) use an extremely conservative approach in which it is assumed that any level of exposure to a carcinogen hypothetically could cause cancer. This is contrary to the traditional toxicological approach, which still is applied to non-carcinogenic chemicals where finite thresholds are identified, below which toxic effects have not occurred. This traditional approach still is applied to non-carcinogenic chemicals.

4.2 NON-CARCINOGENIC EFFECTS

For many non-carcinogenic effects, protective mechanisms must be overcome before the 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 dose, the exposure route, and the duration of exposure. Chemicals may exhibit their toxic effects at the point of application or contact (local effect), or they may exhibit systemic effects after they have been distributed throughout the body. Most chemicals that produce systemic toxicity do not cause similar degrees of toxicity in all organs; rather, they exhibit the major toxicity on one or two target organs. The non-carcinogenic effects can be estimated by comparing a calculated exposure dose to a toxicity value for each individual chemical constituent. A discussion of the toxicity values to be used in the risk assessment is included in Section 4.4.

4.3 CARCINOGENIC EFFECTS

The induction of cancer in humans and in animals by chemicals proceeds through a complex series of reactions and processes. As with non-carcinogenic effects, chemicals may exhibit their toxic effects at the point of application or contact (local effect), or they may exhibit systemic effects after they have been distributed throughout the body. In the case of carcinogens, the target organ is the site of tumor formation.

Chemical constituents are classified as known, probable, or possible human carcinogens based on a 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).

4.4 TOXICITY VALUES

Toxicity values for non-carcinogenic and carcinogenic effects have been developed for many chemicals. When applied to calculated exposure doses, these values can yield an estimate of the potential risk to human health.

For a given chemical, the dose or concentration that elicits no effect when evaluating the most sensitive response (the adverse effect which occurs at the lowest dose) in the most sensitive species is referred to as the "no observed effect level" (NOEL). The NOEL is used to establish non-carcinogenic toxicity values (called reference doses [RfDs] for oral or dermal exposures and reference concentrations [RfCs] for inhalation exposure). Available RfDs and RfCs for the COPCs are presented in Table 4-1. The RfD and RfC are estimates of a daily exposure level that is unlikely to cause non-carcinogenic health effects. Therefore, exposure levels must exceed a threshold dose to produce toxic effects. Chronic RfDs and RfCs are used to assess long-term exposures ranging from 7 years to a lifetime. Subchronic RfDs and RfCs are used to evaluate the potential for adverse health effects associated with exposure to chemicals during a period of a few days to 7 years. Subchronic RfDs are used to evaluate potential excavation worker exposure.

While the RfD is an estimated dose of a chemical that will not cause adverse health effects, the RfC is an estimated concentration in air that will not cause adverse health effects. The RfC considers the dynamics of the respiratory system, diversity between species, and the difference in physicochemical properties of chemical constituents. Therefore, parameters such as deposition, clearance mechanisms, and the physicochemical properties of the inhaled agent are considered in the determination of the effective dose delivered to the target organ. RfD and RfC values used in this risk assessment were obtained from Integrated Risk Information System (IRIS) (1995) and Health Effects Assessment and Summary Tables (HEAST) (USEPA, 1994a).

Currently, the USEPA uses the linearized multistage model for extrapolating cancer risk from high doses associated with occupational exposure or laboratory animal studies to low doses typically associated with environmental exposures. The model provides a 95% upper-bound 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 an ingested dose. Inhalation exposures are evaluated using the unit risk factor (UR_i). Available CSFs and UR_is for the carcinogenic COPCs are presented in Table 4-2. The unit risk is the expected excess cancer risk resulting from continuous, lifetime exposure to air containing 1 microgram per cubic meter ($\mu g/m3$) of the chemical constituent. CSFs and inhalation unit risks used in this risk assessment are taken from IRIS (1995) or HEAST (USEPA, 1994a). CSFs and UR_is 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 and UR_is are not derived for subchronic and chronic exposure periods.

Whenever possible, route-specific toxicity values are used; however, toxicity values for dermal exposure are not available (appropriate toxicity data are scarce). Therefore, the oral toxicity values are used to estimate potential risks due to dermal exposure as well as oral exposure. Dermal absorption factors (used to estimate dermal absorption from soil) and permeability constants (used to estimate dermal absorption from water) for the COPCs at this site are presented in Table 4-3.

If additional COPCs are identified during the course of this investigation, the latest toxicity values available through IRIS or HEAST will be used. If toxicity values are not available from the above sources, a literature search will be conducted to determine if the available database is adequate to support a quantitative risk assessment. Documentation for any toxicity values derived from the literature will be provided in an appendix.

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5.0 EXPOSURE ASSESSMENT

This section addresses the potential for human and ecological exposure to constituents detected in groundwater and soil in the vicinity of the site and identifies the exposure pathways to be considered in the risk assessment. An exposure pathway is considered complete only if the potential exists for a receptor to directly contact released constituents or when a mechanism exists for the released constituents to be transported to a receptor. Without exposure, there is no risk; therefore, the exposure assessment is one of the key elements of a risk assessment.

An exposure pathway is defined by four elements: 1) a source or 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) a receptor exposure route at the exposure point. The purpose of the exposure assessment is to identify the reasonable maximum exposure (RME) for each potential receptor. The RME is defined by the USEPA (1989a) as the maximum exposure that is reasonably expected to occur at a site. Typically, this involves measuring or estimating constituent concentrations at the expected exposure points, contact rates, exposure frequencies, and exposure durations. Determining the RME requires the use of site data and professional judgment. In many cases, standard, conservative USEPA default exposure assumptions are used.

RME EPCs typically are based on the lesser of the UCL or maximum detected concentration (USEPA, 1989a) and are assumed to remain constant over the expected exposure period; however, environmental fate and transport data may be used to provide a more thorough estimate of EPCs. The physical and chemical properties of COPCs affect intermediate transfer rates, migration to off-site exposure points, and future concentrations. A summary of the relevant physical and chemical properties of the COPCs, as well as a discussion of potential migration pathways, will be included in the final risk assessment report.

5.1 CONCEPTUAL SITE MODEL

The purpose of the conceptual site model is to provide an overview of the release sources, release mechanisms, exposure pathways, exposure points, and potential receptors. Both current and future site conditions are considered in the conceptual model.

Past metal-plating activities at the site are presumed to have served as a source of chlorinated solvent and metal contamination at the site (see Section 2.2, Potential Source

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Areas). A leaking concrete vault or tank, reported sometime in 1974 or 1977, may have released chromium waste to the environment. Solvents (primarily TCE and 1,1,1-TCA) were used at the site until 1992. No solvent leaks or spills have been reported at the site; however, these and other solvents have been detected in on-site soil and groundwater.

Currently, groundwater is not used onsite or in the vicinity of the site, and no mechanism for contact with constituents in the groundwater exists. Therefore, no current exposure pathway exists for on-site or off-site groundwater. However, groundwater from the site probably discharges to San Francisco Bay (approximately 2,500 feet west of the site), which is a potential exposure point for aquatic life in the bay. The ecological risk assessment will evaluate this exposure pathway qualitatively and semi-quantitatively by comparing potential release concentrations for the bay to appropriate aquatic-life criteria.

Potential exposure pathways for current and future site workers will be considered in the risk assessment. It will be assumed that, at some time in the future, subsurface soil will be brought to the surface in such a manner that future on-site workers could regularly come into contact with the affected soils. Therefore, site worker exposure to soils via incidental ingestion (oral), dermal contact, and inhalation of released vapors and particulates to ambient air will be evaluated in the risk assessment. A second site worker exposure pathway involves the transport of volatile constituents from groundwater and subsurface soil into a building occupied by the worker. This vapor intrusion pathway will be evaluated using a peer-reviewed vapor transport model published by Johnson and Ettinger (1991).

A hypothetical future potential exposure pathway is represented by an excavation worker working on redevelopment of the property coming into direct contact with soil and with groundwater, due to its semi-shallow nature (generally 6 to 9 feet across the site). While direct contact with groundwater at this depth by an excavation worker is unlikely, this hypothetical future exposure pathway will be considered by the risk assessment as a conservative measure in evaluating potential future risk at the site.

In summary, potentially complete future soil exposure pathways include hypothetical future site worker and excavation worker exposure to subsurface soils, assuming redevelopment of the site results in subsurface soils being brought to the surface. Other potentially complete exposure pathways include site worker exposure to indoor air affected by vapor intrusion of volatile constituents from subsurface soil and groundwater, and direct contact exposure to shallow groundwater by a hypothetical excavation worker.

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5.2 EXPOSURE PATHWAYS, ASSUMPTIONS, AND EQUATIONS

This section presents the exposure assumptions that are used to estimate average daily intakes and risks posed by the COPCs identified in Section 3.0 (see Table 5-1). Unless otherwise noted in Table 5-1, standard USEPA default exposure assumptions were used where appropriate; however, site data and professional judgment were used to develop some exposure assumptions. Standard default exposure values for excavation workers are lacking for many of the exposure parameters; therefore, professional judgment was used regarding exposure frequency, exposure duration, and skin surface area contacting soil or groundwater. The exposure assumptions are consistent with the RME concept currently recommended by the USEPA (1989a).

A basic assumption underlying all exposure calculations was that the EPCs would remain constant throughout the exposure period. Natural attenuation processes were not considered. Therefore, using the lesser of the current maximum detected concentration or the UCL concentration as the representative EPC over the entire exposure period should result in a conservative estimate (i.e., overestimation) of exposure.

5.2.1   On-Site Worker

5.2.1.1   Surface Soil

The potential exists for the site to be redeveloped in the future. As part of the redevelopment of the site, subsurface soils could be brought to the surface. If the subsurface soils were brought to the surface, future site workers could be exposed to the affected surface soil through incidental ingestion, dermal contact, and vapor/particulate inhalation. Hypothetical future site worker exposure assumptions for surface soil exposure reflect current USEPA default values (USEPA, 1989a,b; 1991a,b; 1992a; 1995). The exposure assumptions for hypothetical future site workers exposed to surface soil are listed below and summarized in Table 5-1.

1) Body weight of 70 kg (USEPA, 1991a);
2) Exposure frequency of 250 days per year (USEPA, 1991a);
3) Exposure period of 25 years (USEPA, 1991a);
4) Daily exposure time of 8 hours per day (USEPA, 1991a);
5) Soil ingestion rate of 50 milligrams per day (mg/day) (USEPA, 1991b);

6) Soil adherence rate of 0.2 milligrams per square centimeter per day ($mg/cm^2/day$) (USEPA, 1995);

7) Exposed skin surface area of 3,160 square centimeters (cm^2) for the skin surface area of the face, neck, hands, and lower arms (USEPA, 1992a);

8) Averaging period of 70 years for carcinogenic effects and 25 years for non-carcinogenic effects (USEPA, 1989a); and

9) Constituent-specific dermal absorption efficiencies.

The equations that will be used to estimate site-worker exposure to soil are shown in Table 5-2.

5.2.1.2 Groundwater and Subsurface Soil

Groundwater in the vicinity of the site currently is not used for any purpose, and there are no known plans for any future use of groundwater in this area. Therefore, there is negligible potential for direct exposure to groundwater contaminants at or near the site. However, volatile constituents were detected in the groundwater, and the potential exists for those COPCs to migrate to the soil surface and enter the indoor air of a building occupied by site workers. Volatile COPCs from subsurface soil also may affect indoor air via the vapor intrusion pathway. To evaluate this potential exposure pathway, a vapor intrusion model derived by Johnson and Ettinger (1991) will be used. The equations used to estimate potential indoor air concentrations and associated risks for a site worker are presented in Table 5-3. The exposure assumptions for a site worker are as follows:

1) Body weight of 70 kg (USEPA, 1991a);

2) Exposure frequency of 250 days per year (USEPA, 1991a);

3) Exposure period of 25 years (USEPA, 1991a);

4) Daily exposure time of 8 hours per day (USEPA, 1991a); and

5) Averaging period of 70 years for carcinogenic effects and 25 years for non-carcinogenic effects (USEPA, 1989a).

It will be assumed that exposure occurs within the smallest current on-site building, since that assumption results in the most conservative (highest) exposure conditions. Vapors are assumed to enter the building through a 0.5-centimeter (cm) crack around the foundation perimeter at the floor/wall seam. Model parameters representing the building in which exposure occurs are as follows:

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1) Building dimensions of 50 feet by 110 feet, with a ceiling height of 10 feet.

2) Building air exchange rate of 1 volume per hour (hr^{-1}).

3) Building foundation thickness of approximately 6 inches (15 cm).

4) Depth to groundwater from the building floor equal to 6 feet (approximately 180 cm); depth to contaminated soil equal to 2 feet (60 cm).

5) Indoor-to-outdoor pressure difference of 5 grams per centimeter per second-squared (g/cm/sec^2).

Application of the vapor intrusion model requires knowledge of certain soil parameters which affect the movement of vapors through the soil (i.e., soil bulk density, total porosity, and moisture content). Currently, site-specific values for these soil parameters are not available. Therefore, representative literature values which best represent the clays and silty clays encountered in the upper 15 feet of soil at the site will be used.

5.2.2 Hypothetical Excavation Worker

5.2.2.1 Soil Exposure

The potential exists for excavation workers to be exposed to constituents in subsurface soil at the site during future excavation activities. Construction and contracting firms report that the time required to install building footings or build a foundation varies depending on the size of the building and other site-specific factors. Excavation activities associated with installing underground cables or piping would require less time than installing a building foundation. An exposure duration of 6 weeks is expected to be a RME exposure duration for a hypothetical future excavation worker at the site. The exposure assumptions for the hypothetical future site worker exposed to soil and groundwater are listed below and summarized in Table 5-1.

1) Body weight of 70 kg (USEPA, 1991a);

2) Exposure frequency of 5 days per week (professional judgment);

3) Exposure period of 6 weeks (professional judgment);

4) Daily exposure time of 8 hours per day (USEPA, 1991a);

5) Soil ingestion rate of 480 mg/day (USEPA, 1991a);

6) Soil adherence rate of 0.2 mg/cm^2/day (USEPA, 1995);

7) Exposed skin surface area of 3,160 cm^2 for the skin surface area of the face, neck, hands, and lower arms (USEPA, 1992a);

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8) Averaging period of 70 years for carcinogenic effects and 6 weeks for non-carcinogenic effects (USEPA, 1989a); and

9) Constituent-specific dermal absorption efficiencies.

The equations that will be used to estimate excavation worker exposure to soil are shown in Table 5-2.

5.2.2.2 Groundwater Exposure

During future excavation activities, hypothetical future excavation workers could come in contact with groundwater. The depth to groundwater is approximately 6 to 9 feet bgs; therefore, an assumption of any future excavation reaching groundwater is very conservative (protective). Exposure assumptions for excavation workers presented earlier remain the same, except that the exposed skin surface area is assumed to be 1,980 cm^2, representing exposure of the arms and hands. Table 5-4 shows the equations that will be used to estimate excavation worker exposure to groundwater through incidental ingestion, dermal contact, and inhalation of released vapors into a 1 square meter (m^2) area surrounding the worker. The following exposure parameters will be applied in the evaluation of this pathway:

1) Body weight of 70 kg (USEPA, 1991a);

2) Exposure frequency of 5 days per week (professional judgment);

3) Exposure period of 6 weeks (professional judgment);

4) Daily exposure time of 8 hours per day (USEPA, 1991a);

5) Incidental groundwater ingestion rate of 0.01 L/day (professional judgment);

6) Exposed skin surface area of 1,980 cm^2 for the skin surface area of the arms and hands (USEPA, 1992a);

7) Averaging period of 70 years for carcinogenic effects and 6 weeks for non-carcinogenic effects (USEPA, 1989a); and

8) Constituent-specific dermal permeability constants.

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6.0 RISK CHARACTERIZATION

As stated in a previous section, 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 the excess lifetime cancer risk (ELCR) (for Class A, B, or C carcinogens). HQs and ELCRs, calculated for all COPCs for each receptor and exposure pathway, will be presented and summarized in this section of the final risk assessment report. A brief discussion of HQs, ELCRs, and the criteria for interpreting these values is provided below.

The HQ is the ratio of the estimated exposure dose and the RfD or RfC. If the HQ exceeds 1, there may be concern for potential non-carcinogenic effects. However, the HQ does not provide the probability of an adverse effect as does the ELCR. An HQ greater than 1 indicates that the estimated exposure dose for that constituent exceeds the RfD, but it does not necessarily imply that adverse health effects will occur, because RfDs typically are set an order of magnitude or more below the NOEL (as discussed in Section 4.4). Furthermore, the level of concern does not increase linearly with increasing HQs, because RfDs have different levels of confidence, are based on different toxic effects, and do not consider the slope of the dose-response curve. HQs may be summed to derive the hazard index (HI). Current regulatory methodology (USEPA, 1989a) advises summing HIs across exposure routes for all media to derive a "Total Site HI." However, if the HI exceeds 1, constituents may be grouped according to critical toxic effects, and HIs may be calculated separately for each effect.

The ELCR is an estimate of the increased risk or probability of developing cancer and is an indication of the increased risk that may result from exposure to affected media. The ELCR is an upper-bound estimate; therefore, it is likely that the true risk is less than that predicted by the model. Current regulatory methodology assumes that ELCRs can be summed across routes, media of exposure, and COPCs to derive a "Total Site Risk" (USEPA, 1989a). ELCRs in the target range of 10^{-4} to 10^{-6} generally do not require remediation (USEPA, 1991c).

7.0 ECOLOGICAL RISK ASSESSMENT

The objectives of the ecological risk assessment are to 1) evaluate data collected at the site to determine potential site-related ecological effects, and 2) determine whether further evaluation is warranted based on the results of the first objective.

The steps followed in the ecological risk assessment reflect those outlined in the *Framework for Ecological Risk Assessment* (USEPA, 1992b) and *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Review Draft* (USEPA, 1994b).

The ecological risk assessment involves the compilation and review of available environmental quality information (i.e., results of groundwater, soil, and surface-water investigations) to determine potential exposure of ecological receptors to site-related constituents. A major goal of the evaluation is to determine the potential for complete ecological exposure pathways at the site or whether further investigation of ecological effects is warranted.

Results of previous sampling and analysis of media at the site are compared with available criteria and/or standards to preliminarily determine potential ecological risks. Criteria and standards used include state and federal ambient water-quality criteria (AWQC) and literature-derived toxicity values. Those constituents that exceed available comparison values will be included as preliminary constituents of ecological concern (COECs).

A preliminary review of the available data indicates that potential exposure of ecological receptors to affected media exists only in San Francisco Bay. The depth to groundwater beneath the site is approximately 6 to 9 feet bgs. Ecological receptors would not be directly exposed to groundwater beneath the site, but could be indirectly exposed to groundwater as it discharges to San Francisco Bay.

The potential for ecological receptors to be exposed to vapors released from soil and groundwater, and to migrate to the ground surface at the site, is expected to be minimal, based on the presence of pavement and buildings across the majority of the site. Surface soil (0 to 2 feet bgs) is not a medium of concern for site impacts at the site. It is unlikely that ecological receptors would be exposed to site-impacted subsurface soils, which range from 2 to 11 feet bgs at the site. Therefore, no exposure pathways for ecological receptors exist for soils.

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Based on these indications, no complete exposure pathways exist for ecological receptors other than aquatic life in San Francisco Bay. Therefore, the ecological risk assessment will consist of a semi-quantitative comparison of potential site-related concentrations released to San Francisco Bay with applicable aquatic life criteria.

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Table 3-1. Occurrence Summary for Groundwater Samples, Electro-Coatings, Inc., Emeryville, California.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Average Detect	Mean	UCL	Region IX PRG	EPC	Background Mean **
VOCs									
Chlorobenzene	2 / 18	0.0005 - 0.1 *	0.012 - 0.031	0.022	0.0076	0.012	0.039	–	ND (< 0.001)
1,2-Dichlorobenzene	1 / 18	0.0005 - 0.1 *	0.017	0.017	0.0052	0.0076	0.37	–	ND (< 0.001)
1,1-Dichloroethane	12 / 50	0.0005 - 0.1 *	0.0012 - 0.042	0.013	0.0080	0.011	0.810	–	0.0046
1,1-Dichloroethene	17 / 50	0.0005 - 0.05	0.0016 - 3.8	0.41	0.14	0.28	0.000046	0.28	0.0041
cis-1,2-Dichloroethene	15 / 18	0.0005 - 0.0005	0.005 - 2.4	0.28	0.23	0.47	0.061	0.47	0.046
trans-1,2-Dichloroethene	30 / 50	0.0005 - 0.1	0.0031 - 2.299	0.19	0.12	0.20	0.12	0.20	0.13
Tetrachloroethene	27 / 50	0.0005 - 0.1	0.0015 - 0.081	0.016	0.013	0.017	0.0011	0.017	0.022
1,1,1-Trichloroethane	20 / 50	0.0005 - 0.05	0.00066 - 6.5	0.46	0.19	0.41	1.3	0.41	0.016
Trichloroethene	50 / 55	0.0005 - 0.0005	0.0035 - 22	2.6	2.4	3.5	0.0016	3.5	0.35
Vinyl chloride	14 / 48	0.0005 - 0.1	0.0022 - 0.42	0.10	0.035	0.058	0.00002	0.058	0.0083
Metals									
Chromium (total)	86 / 99	0.001 - 0.05	0.014 - 892	140	120	160	NA	160	23
Chromium (hexavalent)	62 / 76	0.005 - 0.5	0.014 - 877	160	130	170	0.18	170	ND (< 0.005 - 0.02)

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

*   For non-detects with one-half the SQL greater than the maximum detected concentration, the maximum detect (rather than SQL/2) was used as the proxy concentration.

**   Background data were collected from MW-1, MW-2, MW-8, and MW-21.

--   Not a constituent of potential concern in this medium.

EPC   Exposure point concentration (lesser of the UCL and the maximum detected concentration) for the constituents of potential concern.

Mean   Arithmetic average of the total number of samples, using proxy concentrations for non-detects.

NA   Not available.

PRG   Preliminary Remediation Goal; USEPA Region IX PRGs for tap water (USEPA, 1995).

SQL   Practical sample quantitation limit.

UCL   95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-2. Occurrence Summary for Soil Samples, Electro-Coatings, Inc., Emeryville, California.

Constituent	Frequency Detects / Total	Range of SQLs Min - Max	Range of Detects Min - Max	Average Detect	Mean	UCL	Region IX PRG	EPC
VOCs								
1,1-Dichloroethane	2 / 4	0.5 - 1.0	0.18 - 0.86	0.52	0.45	0.81	3,000	--
cis-1,2-Dichloroethene	4 / 4	NA	2.6 - 10	4.9	4.9	9.0	200	--
1,1,1-Trichloroethane	1 / 4	0.1 - 1.0 *	0.15	0.15	0.10	0.17	3,000	--
Trichloroethene	2 / 4	0.1 - 0.10	22 - 37	30	15	36	17	36
Vinyl chloride	1 / 4	0.2 - 2.0 *	0.20	0.20	0.18	0.23	0.011	0.20
Semi-VOCs								
Chromium (total)	55 / 55	NA	24.1 - 6,700	510	510	810	450	810
Chromium (hexavalent)	4 / 12	0.2 - 5.0	0.4 - 91	34	12	26	64	26
Nickel	4 / 4	NA	34 - 310	140	140	290	34,000	--

Concentrations are reported in milligrams per kilogram (mg/kg).

*	For non-detects with one-half the SQL greater than the maximum detected concentration, the maximum detect (rather than SQL/2) was used as the proxy concentration.
--	Not a constituent of potential concern in this medium.
EPC	Exposure point concentration (lesser of the UCL and the maximum detected concentration) for the constituents of potential concern.
Mean	Arithmetic average of the total number of samples, using proxy concentrations for non-detects.
NA	Not available.
ND	Not detected.
PRG	Preliminary Remediation Goal; USEPA Region IX PRGs for industrial soil (USEPA, 1995).
SQL	Practical sample quantitation limit.
UCL	95 percent upper confidence limit (one-tailed) on the mean, assuming a normal distribution.

Table 3-3. Constituents of Potential Concern, Electro-Coatings, Inc., Emeryville California.

Constituent	Medium	
	Groundwater	Soil
VOCs		
1,1-Dichloroethene	X	–
cis-1,2-Dichloroethene	X	–
trans-1,2-Dichloroethene	X	–
Tetrachloroethene	X	–
1,1,1-Trichloroethane	X	–
Trichloroethene	X	X
Vinyl chloride	–	X
Metals		
Chromium (total)	X	X
Chromium (hexavalent)	X	–

–   Not a constituent of potential concern for that medium.
X   Constituent of potential concern for that medium.

Table 4-1. Oral Reference Doses, Inhalation Reference Concentrations, Target Sites, and Confidence Levels for Constituents of Potential Concern, Electro-Coatings, Inc., Emeryville, California.

| Constituent | RfDo (mg/kg/day) | | RfC (mg/m³) | | Target Sites | | Confidence Level/ |
	Subchronic	Chronic	Subchronic	Chronic	Oral	Inhalation	Uncertainty Factor
VOCs							
1,1-Dichloroethene	9.0E-03	9.0E-03	NA	NA	liver	NA	medium/1000
cis-1,2-Dichloroethene	1.0E-01	1.0E-02	NA	NA	red blood cells	NA	NA/3000
trans-1,2-Dichloroethene	2.0E-01	2.0E-02	NA	NA	serum enzymes	NA	low/1000
Tetrachloroethene	1.0E-01	1.0E-02	NA	NA	liver	NA	medium/1000
1,1,1-Trichloroethane	NA	NA	1.0E+00	1.0E+00	NA	liver	NA
Trichloroethene	6.0E-03	6.0E-03	NA	NA	liver	NA	low/3000
Vinyl chloride	NA	NA	NA	NA	NA	NA	NA
Inorganics							
Chromium (trivalent) *	1.0E+00	1.0E+00	NA	NA	liver	NA	low/100
Chromium (hexavalent)	2.0E-02	5.0E-03	NA	NA	NR	NA	low/500

References: IRIS, 1995; USEPA, 1994 (HEAST), USEPA, 1992 (issue paper for 1,1,1-TCA); USEPA, undated for: RfDo for TCE.

* Chromium (trivalent) used to represent total chromium.

mg/kg/day Milligrams per kilogram per day.
mg/m³ Milligrams per cubic meter.
NA Not available.
NR None reported.
RfC Inhalation reference concentration.
RfDo Oral reference dose.

Table 4-2.   Oral Cancer Slope Factors, Inhalation Unit Risks, Tumor Sites, and USEPA Cancer Classifications for Constituents of Potential Concern, Electro-Coatings, Inc., Emeryville, California.

Constituent	Oral CSF (kg-day/mg)	Inhalation Unit Risk (m³/µg)	Tumor site		USEPA Classification
			Oral	Inhalation	
VOCs					
1,1-Dichloroethene	6.0E-01	5.0E-05	adrenal gland	kidney	C
Tetrachloroethene	5.2E-02	5.8E-07	liver	liver	C-B2
Trichloroethene	1.1E-02	1.7E-06	liver	lung	C-B2
Vinyl chloride	1.9E+00	8.4E-05	lung	liver	A
Inorganics					
Chromium (hexavalent)	NAP	1.2E-02	NA	lung	A

References: IRIS (1995); USEPA (1994a; undated [TCE and PCE]).

CSF   Cancer slope factor.
kg-day/mg   Kilograms-day per milligram.
m³/µg   Cubic meters per microgram.
NA   Not available.
NAP   Not applicable, since it is carcinogenic by inhalation.
PCE   Tetrachloroethene.
TCE   Trichloroethene.

Table 4-3.   Dermal Absorption Efficiencies and Permeability Constants for Constituents of Potential Concern, Electro-Coatings, Inc., Emeryville, California.

Constituents	Dermal Absorption Factor [a]	Permeability Constant [b] (cm/hour)	
VOCs			
1,1-Dichloroethene	0.1	1.6E-02	
cis-1,2-Dichloroethene	0.1	1.0E-02	
trans-1,2-Dichloroethene	0.1	1.5E-02	[c]
Tetrachloroethene	0.1	4.8E-02	
1,1,1-Trichloroethane	0.1	1.7E-02	
Trichloroethene	0.1	1.6E-02	
Vinyl chloride	0.1	7.3E-03	
Inorganics			
Chromium	0.01	1.6E-04	[d]

a   USEPA (1995).
b   USEPA (1992a).
c   Calculated using the adjusted Bronaugh equation (USEPA 1992a).
d   Assumed equal to the estimated permeability constant for water (USEPA 1992a).

Table 5-1. Receptor-Specific Exposure Parameters, Electro-Coatings, Inc., Emeryville, California.

Parameter	(units)	Site Worker		Excavation Worker	
		Surface Soil	Vapor Intrusion	Subsurface Soil	Groundwater
APc	(days)	25,550	25,550	25,550	25,550
APnc	(days)	9,125	9,125	42	42
BW	(kg)	70	70	70	70
EF	(days/year)	250	250	–	–
EF	(days/week)	–	–	5	5
EP	(years)	25	25	–	–
EP	(weeks)	–	–	6	6
ET	(hours/day)	8	8	8	8
IR_s	(mg/day)	50	–	480	–
IRw	(L/day)	–	–	–	0.01
SSA	(cm^2)	3,160	–	3,160	1,980

References: USEPA (1989a,b; 1991a,b; 1992a)

APc	Averaging period for cancer risk.
APnc	Averaging period for non-cancer risk.
BW	Body weight.
cm^2	Square centimeters.
EF	Exposure frequency.
EP	Exposure period.
ET	Exposure time.
IRs	Incidental ingestion rate of soil.
IRw	Incidental ingestion rate of groundwater during excavation work.
kg	Kilogram.
L	Liter.
mg	Milligram.
SSA	Exposed skin surface area.

Table 5-2.   Risk Equations for Worker Exposure to Soil, Electro-Coatings, Inc., Emeryville, California

Oral:

$$\text{ELCR}_O \text{ or } \text{HQ}_O = \frac{\text{EPC}_S \times \text{IR}_S \times \text{EF} \times \text{EP}}{(10^6 \text{ mg/ kg}) \times \text{BW} \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times [(1/\text{CSF}_O) \text{ or } \text{RfD}_O]}$$

Dermal:

$$\text{ELCR}_d \text{ or } \text{HQ}_d = \frac{\text{EPC}_s \times \text{SSA} \times \text{SAR} \times \text{ABS} \times \text{EF} \times \text{EP}}{(10^6 \text{ mg/ kg}) \times \text{BW} \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times [(1/\text{CSF}_a) \text{ or } \text{RfD}_a]}$$

Inhalation:

$$\text{ELCR}_i \text{ or } \text{HQ}_i = \frac{\text{EPC}_S \times (1/\text{VF or } 1/\text{PEF}) \times \text{ET} \times \text{EF} \times \text{EP}}{(24 \text{ hr/ day}) \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times \left[\left(\dfrac{0.001 \text{ mg/ } \mu g}{\text{UR}_i} \right) \text{ or RfC} \right]}$$

where:

$$\text{VF} = \text{Q/C} \times \frac{(3.1416 \times \alpha \times T)^{1/2}}{2 \times \text{Dei} \times \text{Pa} \times \text{Kas}} \times (0.0001 \text{ m}^2/\text{cm}^2) \qquad \text{for volatiles}$$

$$\text{PEF} = \text{Q/C} \times \frac{3,600 \text{ sec/ hr}}{\text{RPF} \times (1-\text{G}) \times (\text{Um/ Ut})^3 \times \text{F}_X} \qquad \text{for non-volatiles}$$

$$\text{Q/ C} = \left(\exp \left\{ \left[(0.1004 \times \ln[\text{A}]) - 5.3466 \right] + (2.92 \times \text{sY}) \right\} \right)^1$$

$$\text{sY} = 0.02685 \times \left(0.25 + \frac{[\ln(\text{A}) - 11.0509]^2}{26.3608} \right)$$

$$\alpha = \frac{\text{Dei} \times \text{Pa}}{\text{Pa} + [\rho s \times (1 - \text{Pa})/ \text{Kas}]}$$

$$\text{Dei} = \text{Di} \times (\text{Pa}^{3.33}/ \text{Pt}^2)$$

$$\text{Kas} = \text{H}/ (\text{RT} \times \text{Kd})$$

CANCER RISK:

$$\text{ELCR} = \text{ELCR}_O + \text{ELCR}_d + \text{ELCR}_i$$

NON-CANCER RISK:

$$\text{HI} = \text{HQ}_O + \text{HQ}_d + \text{HQ}_i$$

where:

a   Alpha; calculation intermediate (cm^2/sec).

A   Contiguous area of contamination (m^2).

ABS   Dermal absorption efficiency.

AP_C Averaging period for cancer effects (days).

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Table 5-2.   Risk Equations for Worker Exposure to Soil, Electro-Coatings, Inc., Emeryville, California

AP_{NC} Averaging period for non-cancer effects (days) (EP x 365 days/year for a site worker; EP x 7 days/week for an excavation worker) .

BW   Body weight (kg).

CSF   Cancer slope factor for oral (CSF_o) or dermal (adjusted to an absorbed dose, CSF_a) exposure (kg-day/mg; inverse of mg/kg/day).

Dei   Effective diffusivity (cm^2/sec).

Di   Diffusivity in air (cm^2/sec).

EF   Exposure frequency (days/year for a site worker; days/week for an excavation worker).

ELCR   Excess lifetime cancer risk (unitless).

EPCs   Exposure point concentration in soil (mg/kg).

EP   Exposure period (years for a site worker; weeks for an excavation worker).

ET   Exposure time (hours/day).

F_X Function of Ut/Um (0.0497) (unitless); $F_X = 0.18 \times [8x^3 + 12x] \times \exp[-(x^2)]$, where x = 0.886 x (Ut/Um).

Foc   Fraction organic carbon in soil (unitless).

G   Fraction of vegetative cover (unitless); conservatively assumed as zero.

H   Henry's Law Constant (atm-m^3/mol).

HI   Hazard index (unitless); sum of the HQs.

HQ   Hazard quotient (unitless).

IR_S Ingestion rate of soil (mg/day).

Kas   Soil-air partition coefficient (g soil/cm3 air).

Kd   Soil-water partition coefficient (cm^3/g or mL/g). Kd is calculated as Foc x Koc for organics.

Koc   Organic carbon partition coefficient (cm^3/g or mL/g).

Pa   Air-filled soil porosity (unitless).

PEF   Particulate emission factor (m^3/kg) for non-volatile constituents (Henry's Law Constant less than 10^{-5} atm-m^3/mol or molecular weight greater than 200 grams per mole).

Pt   Total soil porosity (unitless).

rs   True soil or particle density (2.65 g/cm^3).

Q/C   Emission flux per unit concentration (g/m^2/sec)/(kg/m^3).

RfC   Reference concentration for inhalation exposure (mg/m^3).

RPF   Respirable particle fraction (0.036 g/m^2/hr) (USEPA 1991b).

RT   Product of the ideal gas constant (8.206 x 10^{-5} atm-m^3/mol/K) and the Kelvin temperature (298 K at 25 ºC) = 0.02445 atm-m^3/mol.

SAR   Soil adherence rate (mg/cm^2/day).

SSA   Exposed skin surface area (cm^2).

sY   Intermediate value for calculation of Q/C.yyy

UR_i Unit cancer risk for inhalation exposure (m^3/mg).

Um   Wind speed (m/sec).

Ut   Equivalent threshold value of windspeed at 10 meters (12.8 m/sec).

VF   Volatilization factor (m3/kg) for volatile constituents (Henry's Law Constant greater than 10^{-5} atm-m^3/mol and molecular weight less than 200 grams per mole).

x   Intermediate value in calculation of PEF; x = 0.886 x (Ut/Um).

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Table 5-3.   Risk Equations for Inhalation Exposure via Vapor Intrusion to Indoor Air, Electro-Coatings, Inc., Emeryville, California.

Vapor Intrusion from Groundwater:

$$EPC_{air} = C_{gw} \times \left(1,000\,L/\,m^3\right) \times \frac{H}{RT} \times \alpha$$

Vapor Intrusion from Subsurface Soil:

$$EPC_{air} = \left[\frac{C_{soil}}{Koc \times Foc}\right] \times \left(1,000\,L/\,m^3\right) \times \frac{H}{RT} \times \alpha$$

where:

$$\alpha = \frac{\dfrac{D_{eff}\ A_B}{Q_b\ L_T} \times \exp\!\left(\dfrac{Q_{soil}\ L_{crack}}{D_{crack}\ A_{crack}}\right)}{\exp\!\left(\dfrac{Q_{soil}\ L_{crack}}{D_{crack}\ A_{crack}}\right) + \dfrac{D_{eff}\ A_B}{Q_b\ L_T} + \left(\left[\dfrac{D_{eff}\ A_B}{Q_{soil}\ L_T}\right] \times \left[\exp\!\left(\dfrac{Q_{soil}\ L_{crack}}{D_{crack}\ A_{crack}}\right) - 1\right]\right)}$$

$$D_{eff} = D_{air} \times \left[\frac{(\varepsilon_T - \theta_m \rho_b)^{3.33}}{\varepsilon_T^2}\right]$$

$$Q_{soil} = \frac{2\pi \times \Delta P \times k_v \times X_{crack}}{\mu \times \ln(2\,Z_{crack}\,/\,r_{crack})}$$

CANCER RISK:

$$ELCR = EPC_{air} \times \left(\frac{ET \times EF \times EP}{(24\,hr/\,day) \times AP_C}\right) \times \left(\frac{UR_i}{0.001\,mg/\,\mu g}\right)$$

NON-CANCER RISK:

$$HQ = EPC_{air} \times \left(\frac{ET \times EF \times EP}{(24\,hr/\,day) \times AP_{NC}}\right) \times \frac{1}{RfC}$$

where:

α Attenuation coefficient (unitless) $\cong C_b/\,C_o$ where C_b is the concentration in the building air and C_o is the soil vapor concentration at the soil/groundwater interface (in the same concentration units).

A_B Soil contact area of the building (5,110,000 cm^2).

A_{crack} Area of vapor infiltration (4,900 cm^2); representing a 0.5-cm crack around the building circumference at the floor/wall seam.

AP_C Averaging period for cancer effects (days).

AP_{NC} Averaging period for non-cancer effects (days); EP $\times$ 365 days/year.

C_{gw} Constituent concentration in groundwater (mg/L).

C_{soil} Constituent concentration in subsurface soil (mg/kg).

D_{air} Constituent diffusivity in air (cm^2/sec).

D_{crack} Effective vapor-phase diffusion coefficient through the crack (cm^2/s); assumed to be equal to D_{eff}.

D_{eff} Effective vapor-phase diffusion coefficient in the soil (cm^2/sec).

ε_T Total soil porosity (unitless).

EP   Exposure period (years).

EPC_{air} Calculated exposure point concentration in indoor air (mg/cm^3).

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Table 5-3.   Risk Equations for Inhalation Exposure via Vapor Intrusion to Indoor Air, Electro-Coatings, Inc., Emeryville, California.

EF   Exposure frequency (days/year).
ET   Exposure time (hours/day).
Foc   Fraction organic carbon in the soil (unitless).
H   Henry's Law Constant (atm-m^3/mol).
L_{crack} Depth of the crack (thickness of the foundation) (cm); 6 inches (15 cm) (Johnson and Ettinger 1991).
L_T Depth to groundwater from the building floor (cm).
Q_b Building ventilation rate (cm^3/sec); calculated as the air exchange rate (sec^{-1}) × building volume (cm^3).
Q_{soil} Volumetric flow rate of soil gas into the building (cm^3/sec).
Koc   Organic carbon partition coefficient (cm^3/g = L/kg).
k_v Soil permeability to vapor flow (cm^2).
m   Vapor viscosity at 20 °C (1.8 × 10^{-4} g/cm/sec) (Johnson and Ettinger 1991).
_P   Indoor-outdoor pressure difference (building underpressure) (5 g/cm/sec^2).
r_b Bulk soil density (g/cm^3).
r_{crack} Crack width (cm); assumed value of 0.5 cm (Johnson and Ettinger 1991).
RfC   Reference concentration for inhalation exposure (mg/m^3).
RT   Product of the ideal gas constant (8.206 × 10^{-5} atm-m^3/mol/K) and the absolute temperature (298 K) = 0.02445 atm-m^3/mol at 25 °C (298 K).
q_m Moisture content of the soil (cm^3 of water/g of soil).
UR_i Unit cancer risk for inhalation exposure (m^3/mg).
X_{crack} Length of crack (9,800 cm).
Z_{crack} Depth of crack below ground surface (15 cm).

Table 5-4.   Risk Equations for Excavation Worker Exposure to Groundwater, Electro-Coatings, Inc., Emeryville, California.

ROUTE-SPECIFIC RISKS:

Oral:

$$\text{ELCR}_o \text{ or } \text{HQ}_o = \frac{\text{EPCgw} \times \text{IR}_w \times \text{EF} \times \text{EP}}{\text{BW} \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times [(1/\text{CSF}_o) \text{ or } \text{RfD}_o]}$$

Dermal:

$$\text{ELCR}_d \text{ or } \text{HQ}_d = \frac{\text{EPCgw} \times \text{SSA} \times \text{PC} \times (0.001\text{L}/\text{cm}^3) \times \text{ET} \times \text{EF} \times \text{EP}}{\text{BW} \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times [(1/\text{CSF}_a) \text{ or } \text{RfD}_a]}$$

Inhalation:

$$\text{ELCR}_i \text{ or } \text{HQ}_i = \frac{\text{EPC}_V \times \text{ET} \times \text{EF} \times \text{EP}}{(24\,\text{hr}/\text{day}) \times (\text{AP}_C \text{ or } \text{AP}_{NC}) \times \left[\left(\frac{0.001\text{mg}/\mu\text{g}}{\text{UR}_i}\right) \text{ or } \text{RfC}\right]} \text{ where:}$$

$$\text{EPC}_V = \frac{\text{EPCgw} \times (10^3\ \text{L}/\text{m}^3)}{1/k_l + [\text{RT}/(k_g \times \text{H})]} \times \frac{\text{SA}}{\text{Hb} \times \text{Wb} \times \text{U}}$$

CANCER RISK:
$$\text{ELCR} = \text{ELCR}_o + \text{ELCR}_d + \text{ELCR}_i$$

NON-CANCER RISK:
$$\text{HI} = \text{HQ}_o + \text{HQ}_d + \text{HQ}_i$$

where:

|	
AP_c	Averaging period for cancer effects (days).
AP_{NC}	Averaging period for non-cancer effects (days); EP × 7 days/week.
BW	Body weight (kg).
CSF	Cancer slope factor for oral (CSF_o) or dermal (adjusted to an absorbed dose, CSF_a) exposure (kg-day/mg; inverse of mg/kg/day).
EF	Exposure frequency (days/week).
ELCR	Excess lifetime cancer risk (unitless).
ET	Exposure time (hours/day).
EP	Exposure period (weeks).
EPCgw	Exposure point concentration in groundwater (mg/L).
EPC_V	Exposure point concentration in the vapor phase (mg/m^3).
H	Henry's Law Constant (atm-m^3/mol).
Hb	Height of mixing zone (2 m).
HI	Hazard index (unitless); sum of the HQs.
HQ	Hazard quotient (unitless).
IR_w	Incidental ingestion rate of groundwater during excavation (L/day).
k_g	Gas-phase mass transfer coefficient (m/sec) ~ (8.3 × 10^{-3} m/sec) × [(18 g/mol)/MW]$^{1/2}$.
k_l	Liquid-phase mass transfer coefficient (m/sec) ~ (5.6 × 10^{-5} m/sec) × [(44 g/mol)/MW]$^{1/2}$.
MW	Molecular weight (g/mol).
PC	Permeability constant (cm/hour).
RfC	Reference concentration for inhalation exposure (mg/m^3).
RfD	Reference dose for oral (RfD_o) or dermal (adjusted to an absorbed dose, RfD_a) exposure (mg/kg/day).

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Table 5-4.   Risk Equations for Excavation Worker Exposure to Groundwater, Electro-Coatings, Inc., Emeryville, California.

RT   Product of the universal gas constant ($R = 8.206 \times 10^{-5}$ atm-m³/mol/K) and the relevant Kelvin temperature ($T = 293$ K); $RT = 0.02404$ atm-m³/mol.

SA   Source area (1 m²).

SSA   Exposed skin surface area (cm²).

U   Mean wind speed (m/sec); assumed 1 m/sec in the excavation pit.

UR_i Unit cancer risk for inhalation exposure (m³/mg).
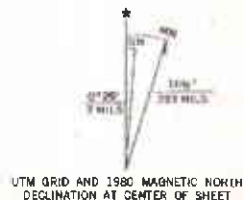
Wb   Width of mixing zone (1 m).
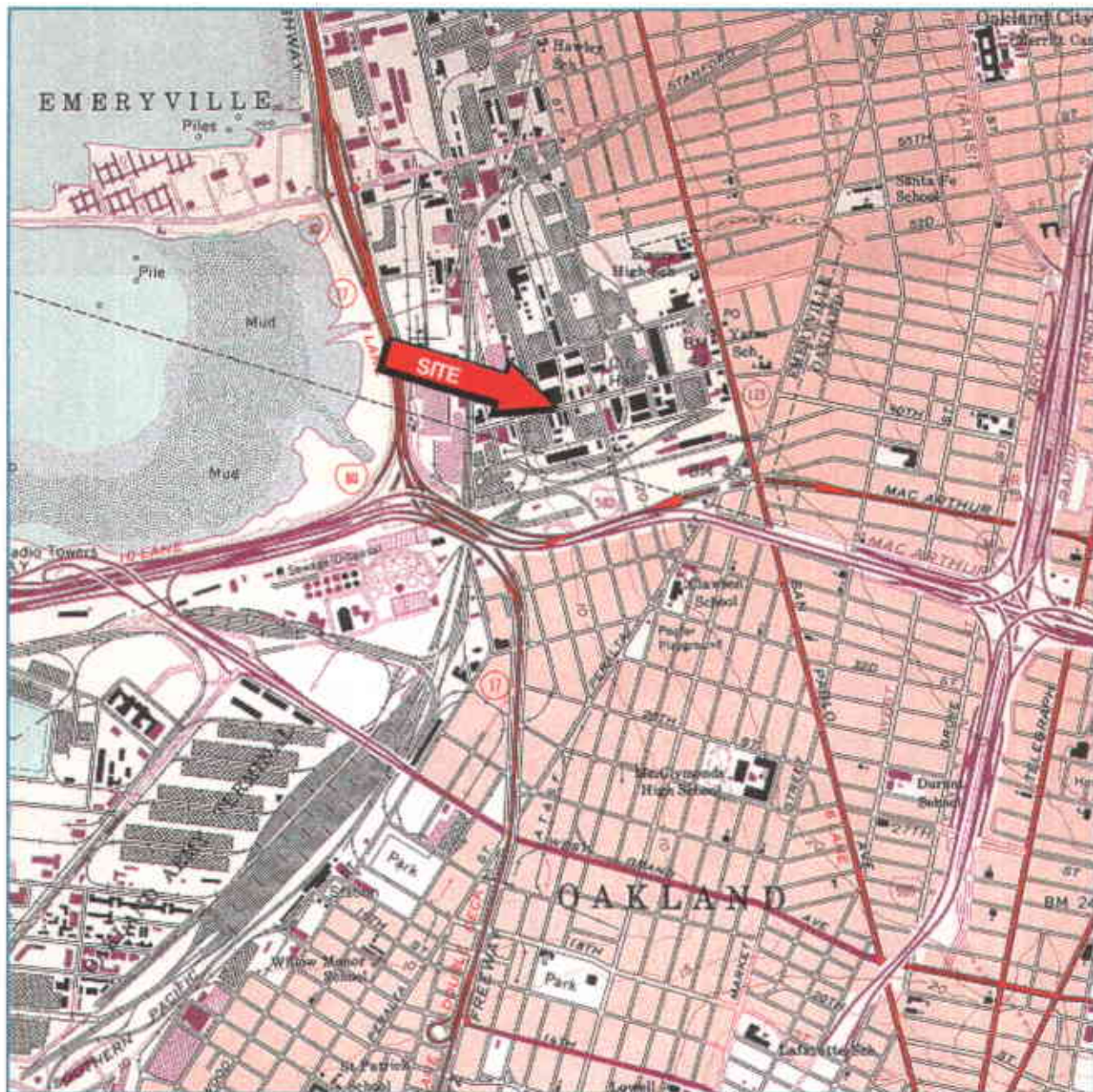
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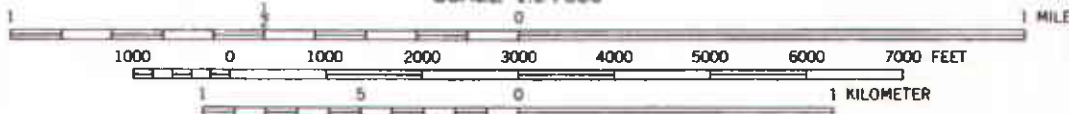
CONTOUR INTERVAL 20 FEET

UTM GRID AND 1980 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

Reference: U.S.G.S. 7.5-minute Quadrangle Oakland West, California, 1959 photorevised 1980.

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Environmental Services
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Project No. RC0304.000

SITE LOCATION MAP
Electro-Coatings, Inc.
1401 and 1421 Park Avenue
Emeryville, California

FIGURE

1

SITE PLAN
Electro-Coatings, Inc.
1401 and 1421 Park Avenue
Emeryville, California

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FIGURE
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