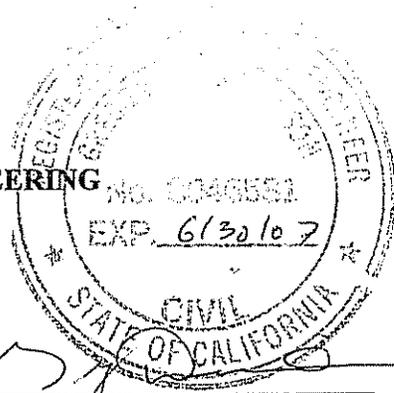


**FOCUSED BASELINE HEALTH RISK ASSESSMENT WORK PLAN  
AMVAC FACILITY - AOC12  
4100 EAST WASHINGTON BOULEVARD  
COMMERCE, CALIFORNIA**

**March 2007**

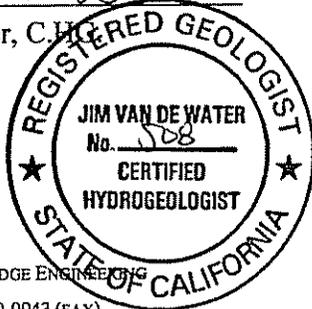
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**FOCUSED BASELINE HEALTH RISK ASSESSMENT WORK PLAN**  
**AMVAC CHEMICAL CORPORATION**



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FOCUSED BASELINE HEALTH RISK ASSESSMENT WORK PLAN

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AMVAC CHEMICAL CORPORATION

## 1.0 INTRODUCTION

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Pacific Edge Engineering (Pacific Edge) presents this work plan for a proposed focused baseline health risk assessment (FBHRA) for AOC12 located at the Amvac Chemical Corporation facility on 4100 East Washington Boulevard in Commerce, California (Site). The Site was divided into Areas of Concern (AOCs) in our August 2002 Site Investigation Plan. AOC12 includes two former RCRA permitted hazardous waste storage units. A BHRA is also proposed for the entire facility which will incorporate data from all AOC's including AOC12.

This focused Work Plan has been prepared to address RCRA closure requirements for two RCRA permitted hazardous waste storage units. The two units comprise AOC12 and include a former drum and container storage pad (Pad) and a 2,500 gallon above ground storage tank (Tank). AMVAC received a Hazardous Waste Facility Permit in 1983 to operate the Pad and Tank. AMVAC operated both units from 1983 until 1988. In 1988, Amvac submitted to the State a permit renewal application, which proposed taking the Pad and Tank out of operation and installing a new Pad and a larger Tank in new locations. Amvac received no response from the State and proceeded with the changes as detailed in the permit application. AMVAC constructed a new process unit at the location of the former Pad and located the new storage tank within the containment of this process unit.

This FBHRA work plan has been prepared to comply with Resource Conservation and Recovery Act (RCRA) Facility Investigation and Site Closure requirements under the provisions of the Expedited Remedial Action Program (ERAP) for the site. ERAP was created by Senate Bill 923 which established Health and Safety Code Chapter 6.85, commencing with Section 25396. On March 27, 1997, Amvac completed the Site Designation process (established by Assembly Bill 2061 in 1995) and was accepted into the ERAP. The State designated the Department of Toxic Substances Control (DTSC) as the lead agency for the Amvac Facility investigation.

### 1.1 THE RISK ASSESSMENT PROCESS

A HRA is an appropriate analytical methodology for determining the potential health risks for any hypothetical individual living or working at a site where a chemical release has or may have occurred (USEPA, 1989; DTSC, 1992). The hypothetical individual that is evaluated in a standard health risk assessment is assumed to have a reasonable maximum exposure by applicable exposure routes. The assumption of potential exposure (by any complete and/or potentially complete exposure pathway) represents a conservative approach. This approach is recommended by regulatory risk assessment guidance in order to make the HRA sufficiently protective of potential receptors.

The HRA process applies the following four evaluation components as the basis for identifying potential health risks posed to current and potential future receptors at a site (USEPA, 1989; DTSC, 1992).

**Data Evaluation/Chemicals of Potential Concern** – Site characterization data are evaluated for risk assessment usability and the chemicals of potential concern (COPCs) are selected.



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**Toxicity Assessment** – Hazard identification and dose-response evaluations are conducted for the COPCs.

**Exposure Assessment** – The routes through which potential exposure to COPCs may occur are identified and the magnitude and duration of the doses that receptors might receive as a result of their potential exposure are estimated.

**Risk Characterization** – The relationship between the estimated dose and the probability of observing an adverse effect is characterized for each COPC. The estimated incremental lifetime cancer risks and the non-cancer hazard indices are calculated.

The FBHRA evaluates potential risks at a specific site, in the absence of any remedial action and is used by risk managers as a basis for making defensible decisions regarding the safety of a particular property, as well as the need for, and level of, remedial actions.

The methodologies to be used in the FBHRA are consistent with standard risk assessment practices and information provided in the following guidance documents:

- USEPA, 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I Human Health Evaluation Manual (Part A), December.
- Cal EPA, Department of Toxic Substances Control (DTSC), 1992. Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities, July.
- California EPA, DTSC, 1994. Preliminary Endangerment Assessment Guidance Manual, January.

## 1.2 REPORT ORGANIZATION

The organization of this report is as follows:

**Section 2.0 Project Background** - a site description and regulatory background discussion (including a summary of previous investigations) are presented.

**Section 3.0 Data Evaluation/Selection of Chemicals of Potential Concern (COPCs)** – the methods to be employed for site data evaluation and the selection of COPCs are discussed.

**Section 4.0 Toxicity Assessment** - the toxicity criteria established by the regulatory agencies are defined and sources of chemical-specific values are identified.

**Section 5.0 Exposure Assessment** - the exposure scenarios and pathways, exposure parameters, exposure point concentrations, and dose calculations are discussed. A preliminary conceptual site model is included.

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**Section 6.0 Risk Characterization** - the methods for estimating the potential incremental lifetime cancer risks and non-cancer hazards, for the identified receptors, are presented.

**Section 7.0 References** - the references cited in the FBHRA work plan are presented.

## 2.0 PROJECT BACKGROUND

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The Amvac facility is located at 4100 East Washington Boulevard, approximately one mile west of the Long Beach Freeway in Commerce, California (Figure 1). The Amvac facility extends west to east from 4070 to 4138 East Washington Boulevard and from 4124 to 4146 Pacific Way (Figure 2). Amvac develops, formulates and manufactures an array of agricultural chemical compounds which are sold in either liquid, powder, or granular form.

The Amvac facility is located in a heavily developed industrial area. A railroad right-of-way leased to Amvac and a Burlington Northern Santa Fe Railway intermodal container and truck storage facility are located to the south of Amvac. A scaffolding company and a former petroleum oil blending facility are located to the west of Amvac. Several small warehouses and machine shops are located to the east of Amvac and a Union Pacific Railroad container yard and truck facility is located to the north of Amvac, across Washington Boulevard.

The Facility is approximately three acres in size and consists of 10 buildings with several production areas. The Site has been divided into Areas of Concern (AOC) to facilitate site investigation activities. Each AOC including pertinent site structures and site uses are summarized below:

- **AOC01** - Buildings 1 through 3 (Granules Plant)
- **AOC02** - Building 4 (Liquid Product Packaging)
- **AOC03** - Building 5 (Hot Room)
- **AOC04** - Building 7 (Storage, Laboratory, and Reactor Rooms)
- **AOC05** - Building 8 (Offices, Lunch Room, Change Room)
- **AOC06** - Building 9 (Maintenance Shop)
- **AOC07** - Buildings 10 and 11 (Parts House and Office, respectively)
- **AOC08** - USTs T7 through T12 (Closed In-Place USTs)
- **AOC09** - Utility Area (Sewer Pretreatment, Caustic, Water Softening, Boilers, Cooling Tower)
- **AOC10** - Open Areas (Open Areas)
- **AOC11** - Subsurface Anomalous TPH (Subsurface Area of Anomalous TPH Concentrations)
- **AOC12** - RCRA Permitted Units (RCRA permitted hazardous waste storage units)

The entire Facility is paved with asphalt and there are no areas of uncovered soil. The main part of the Facility is comprised of Buildings 5, 7, and 8, the metam sodium and pentachloronitrobenzene (PCNB) production plants, the aboveground tank farm, and storage areas. This area is entirely fenced and access is controlled at each entrance. Directly east of the main part of the Facility are Buildings 1, 2, 3, and 4, which are fenced or gated. Further east are Buildings 9, 10, and 11, to which access is also controlled.

A detailed description for AOC12, including a physical description, historical use summary, and substances of concern, is presented in the following sections. A detailed description of each of the other AOCs is provided in our August 11, 2005 BHRA.



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## 2.1 AOC 12 - RCRA PERMITTED UNITS

### 2.1.1 Physical Description

AOC 12 is comprised of the locations of two RCRA permitted hazardous waste storage units, which are the drum and container storage pad and the 2,500 gallon AST. As discussed in Section 1.3, the pad and tank were permitted in 1983 and their locations were moved in 1988. The location of the bermed concrete pad was removed to make way for the northwestern corner of the metam sodium plant. The empty permitted tank is currently stored at an offsite warehouse and is out of service while hazardous wastes are stored for less than 90 days in another tank located in the metam sodium containment area.

### 2.1.2 Historical Use

Based on review of historical aerial photographs, the pad and tank were installed at Amvac after the Facility was paved in areas which have or may have been used for material storage prior to their installation. The pad was used for greater than 90-day storage of drums and containers of hazardous waste from 1983 to 1988. The pad was removed from its original location in 1988 to make way for the metam sodium plant and a new hazardous waste storage pad (i.e. Pad 8) was constructed to the north and east of the original pad. Pad 8 is currently used for less than 90-day storage of solid hazardous wastes.

The 2,500 gallon hazardous waste storage tank was located near the southwestern corner of Building 7, west of the utility area. In 1988, this tank was removed from service and a 5,000 gallon tank was installed in the metam sodium plant for liquid hazardous waste storage. The original tank is currently empty and stored at an offsite warehouse.

By 1995, Amvac determined that all hazardous wastes generated at the Facility are stored for less than 90 days and that the RCRA-permitted units could be closed. In a letter to Amvac dated January 26, 2001, DTSC stated "*... the closure of the permitted units shall be incorporated as part of the overall site investigation. Consequently DTSC will not initiate the closure process of these 2 units until the site investigation data is evaluated.*"

### 2.1.3 Substances of Concern

Substances of concern previously handled by Amvac at the former hazardous waste pad include the following:

- spent solvents
- oils contaminated with OCPs and organophosphorous pesticides
- spent filters used in pesticide production
- floor sweep and debris
- spent carbon
- contaminated personal protective equipment



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Substances of concern previously handled by Amvac in the former hazardous waste tank include the following:

- *spent scrubber solutions*
- container rinse outs including OCPs and organophosphorous pesticides

### 3.0 SUMMARY OF PREVIOUS INVESTIGATIONS

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Confirmation soil sampling for the Pad and Tank areas was incorporated into our facility-wide December 2002 Site Investigation Plan (SIP). DTSC-approved SIP-related field activities occurred in December 2002 to January 2003 and in December 2004 to January 2005.

The first phase of site investigation was conducted in December 2002 and January 2003. At the former Pad, borings were drilled on all four sides of the perimeter of the former Pad, for a total of four borings. At the former Tank, borings were drilled to the north and south of the former Tank location.

During the second phase of investigation, one soil gas sample was obtained directly below the former Pad at a depth of 5 feet below ground surface and analyzed for volatile organic compounds.

Soil samples from each boring were generally obtained at depths of 2 feet and 8 feet below ground surface. Each sample was analyzed for volatile organic compounds, chlorinated herbicides, organophosphorous pesticides, organochlorine pesticides, carbamates, petroleum hydrocarbons, and pH. The 2-foot sample from the boring north of the former Tank was also analyzed for CAM metals and semi-volatile organic compounds.

Based on results of soil sampling, additional characterization is recommended for moderate levels of total petroleum hydrocarbons near the Pad. Sampling for polycyclical aromatic hydrocarbons at this location is also recommended. Further examination of the soil gas result is recommended, therefore, a recommendation for or against further soil gas sampling cannot be made at this time. A Workplan for additional sampling will be submitted to DTSC for review and approval.

## 4.0 DATA EVALUATION/SELECTION OF CHEMICALS OF POTENTIAL CONCERN

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This section of the FBHRA work plan describes how the site characterization data will be evaluated for use in the FBHRA and presents the technical framework for the selection of chemicals of potential concern.

### 4.1 DATA EVALUATION

Data usability (DU) is the process of assuring or determining that the quality of data generated meets the intended use. USEPA has established a specific guidance framework to provide risk assessors a consistent basis for making decisions about the minimum quality and quantity of environmental analytical data that are sufficient to support HRA decisions (USEPA, 1992a). The DU evaluation specifically addresses procedures for (1) assessing the quality of the environmental analytical data intended for use in HRA and (2) procedures for determining the level of certainty in health risk characterization based on the uncertainty in the environmental analytical data.

Uncertainty analysis is a fundamental element of each component of HRA. All components of the risk assessment, including the risk characterization estimates, are dependent upon the quality of the site data used as the basis for the risk assessment. Uncertainty in HRA results is addressed in respect to four principal decisions that the HRA assists in evaluating (USEPA, 1992a):

- What are the chemicals present at the site and what are the concentrations for each medium of interest?
- Do the levels of site-related chemicals differ significantly from their background levels?
- Are the analytical data adequate to identify and examine exposure pathways and exposure areas?
- Are the analytical data adequate to characterize potential exposure point concentrations?

The DU evaluation for HRA addresses these questions. USEPA (1992a) provides an explicit set of data quality criteria that are used to determine the usability of site characterization data in the risk assessment process. When appropriately applied, the results of the DU evaluation (1) provide a basis for qualitatively or quantitatively assessing the impacts of uncertainties in the site data as it relates to *certainty in the estimated cancer risks and non-cancer hazards* (“risk estimates”) and (2) ascertain that the data employed in the risk assessment are of adequate quality and quantity to provide scientifically and legally defensible estimates of site-related risks. USEPA guidance identifies the environmental data quality issues that are frequently encountered in risk assessments. The objective of the USEPA guidance is to provide “procedures, minimum requirements, and other information to resolve or minimize the effect of these issues on the assessment of uncertainty in the risk assessment.” (USEPA, 1992a).

Six criteria are used to evaluate data usability for baseline risk assessments (USEPA, 1992b). These criteria are:



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**Criterion I: Reports** – A site characterization report content checklist is generated.

**Criterion II: Documentation** - Verifies that each sample result is related to a specific geographic location.

**Criterion III: Data Sources** - Documents that the analytical methods are appropriate to identify chemicals of potential concern (COPCs) for each exposure area and environmental medium of interest.

**Criterion IV: Analytical Methods and Detection Limits** - Documents that the analytical method can appropriately identify the chemical form or species of interest, and that the sample detection limit is at or below a concentration that is associated with risk benchmark levels (e.g., Preliminary Remediation Goals or “PRGs”).

**Criterion V: Data Review** - The data review of laboratory and method performance includes:

- Evaluation of data completeness,
- Verification of instrument calibration,
- Measurement of laboratory precision using duplicates; measurement of laboratory accuracy using spikes,
- Examination of blanks for contamination,
- Assessment of adherence to method specifications and QC limits, and
- Evaluation of method performance in the sample matrix.

**Criterion VI: Data Quality Indicators** - The data quality indicators (“DQIs”) are evaluated. DQIs address field and analytical data quality aspects as they affect uncertainties in selection of COPCs, EPCs (exposure point concentrations), and risk characterization. The DQIs include completeness, comparability, representativeness, precision, and accuracy.

## 4.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of potential concern (COPCs) are selected to ensure that the risk assessment focuses on those chemicals that are site-related and could significantly contribute to overall site risk (USEPA, 1989). The DTSC (1992, personal communication) and the USEPA (1989) recommend that chemicals be eliminated from the risk assessment only if adequate rationale can be provided and when approved by the regulatory agency project manager.

Where data are adequate and it can clearly be shown that a chemical will contribute negligibly to the overall risk and/or hazard, DTSC approval will be sought for eliminating specific chemicals from the COPC list. Because all COPCs that are defined as volatile organic compounds (VOCs) by DTSC (DTSC, 1994) must be subjected to surface flux rate estimation via fate/transport modeling, a COPC selection approach that is conservative, yet focuses the level of effort of the fate/transport modeling, is justified.

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The following criteria for selecting COPCs (USEPA, 1989, DTSC, 1992) will be considered on a case-by-case basis, in conjunction with DTSC review and approval, to focus the selection of COPCs for each environmental medium of interest.

- 1) **Site-Specific Information:** Historical data concerning potential site-related sources and site-related chemicals/chemical breakdown products will be evaluated to support COPC selection. For metals in soils (if relevant based on historical site activities), DTSC guidance (DTSC, 1997) will be employed to ensure that “background” metals are not carried through the FBHRA.
- 2) **Toxicity:** Any site-related chemical classified as a known human carcinogen (i.e., USEPA Group A, or IARC Group I) or as a known human reproductive or developmental toxicant will be retained as a COPC, with the exception of metals that are statistically shown to be within background concentrations.
- 3) **Toxicity/Exposure Screen:** For each detected analyte, the maximum concentration will be compared with one-tenth of the USEPA Region 9 Preliminary Remediation Goal (PRG).
- 4) **Mobility, Persistence and Bioaccumulation:** Chemical fate and transport properties will be considered in the selection of COPCs.
- 5) **Frequency of Detection:** If a site-related chemical is detected in 5% or more of the samples within an exposure area, the chemical will be retained as a COPC (applicable to a minimum of 20 samples; must be pre-approved by the DTSC project manager).

To support the COPC selection process, all relevant site data that are shown to meet data usability criteria for risk assessment will be summarized and presented in tabular format. Explicit rationale will be provided for chemicals approved by DTSC as appropriate for elimination as COPCs.

## 5.0 TOXICITY ASSESSMENT

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This step of the FBHRA consists of the *characterization of the nature and strength of the evidence of causation as well as the dose-response relationship for each COPC*. Evidence of causation addresses the ability of the chemical to cause toxicity in humans. Dose-response assessment characterizes the relationship between the dose of a chemical and the potential for an adverse health effect in the exposed population. Based on this quantitative dose-response relationship, USEPA and CalEPA have applied the results of the *chemical-specific toxicity assessments to derive numerical toxicity criteria to estimate the likelihood of a specific adverse health effect occurring as a function of exposure*. The methods used to establish the dose-response criteria associated with *evaluating potential chronic (long-term) carcinogenic and non-carcinogenic health impacts* are addressed separately in the following sections.

### 5.1 TOXICITY CRITERIA AND SOURCES

The bulk of our knowledge about the dose-response relationship of chemicals is based on data collected from animal studies and conservative assumptions about what might occur in humans. Conservative mathematical models are used to estimate the potential human carcinogenic and non-carcinogenic responses to substances based on the results of animal studies. The methodologies developed by the regulatory agencies in establishing the toxicity criteria employed in human health risk assessment are recognized as conservative to ensure the protection of sensitive individuals.

### 5.2 NON-CARCINOGENIC HEALTH EFFECTS

It is widely accepted that most biological effects of chemicals occur only after a threshold dose is reached. That is to say, there is a range of doses that exists from zero to some finite value that can be tolerated by an animal or human with essentially no adverse health effects. For the evaluation of chronic non-carcinogenic health effects, CalEPA/Office of Environmental Health Hazard Assessment (CalEPA/OEHHA) Reference Exposure Levels (RELs) (CalEPA/OEHHA, 2005), and USEPA Reference Concentrations (RfCs) and Reference Doses (RfDs) (USEPA, 2005) that incorporate the concept of a biological threshold will be used. The chronic REL, RfC, and RfD are defined as the daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

For subchronic exposure scenarios (e.g., short-term construction worker exposure), ATSDR intermediate Minimal Risk Levels (MRLs, ATSDR, 2004) will be used where available. The MRLs are derived using methods consistent with USEPA methods and are defined as “an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure” (ATSDR, 2004).

For the purposes of establishing the non-cancer health criteria, the threshold dose is estimated from the no-observed adverse effect level (NOAEL) or the lowest-observed adverse effect level



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(LOAEL) determined from human and/or animal studies. The NOAEL is defined as the highest dose at which no adverse effects are observed, while the LOAEL is defined as the lowest dose at which adverse effects are observed. Uncertainty factors are applied to the NOAEL or LOAEL observed in animal studies or human epidemiological studies to establish the chemical-specific REL, RfC, RfD or MRL (the non-cancer toxicity criteria). The non-cancer toxicity criteria are applied in the risk characterization to estimate the potential non-cancer health hazard.

### 5.3 CARCINOGENIC HEALTH EFFECTS

The current approach to carcinogenic risk assessment used by USEPA, CalEPA, and other U.S. regulatory agencies assumes that every exposure to a carcinogen poses a finite probability, however small, of producing a carcinogenic response (i.e., there is no threshold to carcinogenic effects). The linearized multistage (LMS) low dose extrapolation model, or similar model, is applied to high dose data to predict carcinogenic response at low doses. The use of this model is recognized to represent an extremely conservative approach to assessing carcinogenic potency (USEPA, 1986).

Cancer slope factors (CSFs) are derived in most cases from the LMS or similar model. Based on the non-threshold theory for carcinogens, the modeling assumes a carcinogenic risk of zero only at zero dose (i.e., at all doses some risk is assumed to be present). The chemical-specific cancer slope factor, which is expressed in units of (mg/kg-day)<sup>-1</sup>, represents the 95 percent upper confidence limit of the probability of carcinogenic response per unit daily intake of a substance over a lifetime.

The CalEPA Cancer Potency Factors (CalEPA/OEHHA, 2005) will be employed in the FBHRA for purposes of estimating cancer risk.

## 6.0 EXPOSURE ASSESSMENT

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Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure. The definition of exposure (USEPA, 1992b) is “a condition in which a chemical contacts the outer boundary of a human.” The amount of chemical contacted is termed “potential dose.” Potential dose is determined by incorporating assumptions regarding the contact rate with the outer boundary of a human. Actual exposure cannot be determined with certainty as part of the risk assessment process. Accordingly, a hypothetical exposure is conservatively assumed and evaluated based on default regulatory guidance for estimating the potential dose.

*This section identifies the exposure scenarios and discusses the identification of complete and potentially complete exposure pathways. This section also discusses the methods used to estimate dose, including methods for fate/transport modeling, calculation of exposure concentrations, and discussion of the exposure parameters.*

### 6.1 EXPOSURE SCENARIOS

Based on current and potential future land uses for the site, nonresidential (e.g., worker) receptors will be evaluated in the FBHRA. Both chronic commercial/industrial and short-term (sub-chronic) construction/excavation workers will be evaluated. The chronic worker scenario requires that a full time, long-term (e.g., 25 years) onsite worker is evaluated for both indoor and outdoor work locations. The sub-chronic construction/excavation worker will be evaluated for outdoor work locations only (USEPA, 2002). A reasonable maximum exposure (RME) for these receptors will conservatively be evaluated. The RME, as defined by the USEPA, is the “highest exposure that is reasonably expected to occur” and is estimated by using a combination of upperbound values and average values for the exposure parameters (USEPA, 1989, 1995). The RME approach of assessing exposure relies upon conservative assumptions<sup>(1)</sup> for the exposure parameters in order to ensure that the calculated dose is not underestimated. The RME approach is intended to best represent a high-end exposure estimate (i.e., above the 90th percentile of the population distribution) that is within the range of possible exposures (USEPA, 1992b).

### 6.2 CONCEPTUAL SITE MODEL AND POTENTIAL EXPOSURE PATHWAYS

The identification of exposure pathways, environmental media of interest (i.e., exposure points), and COPCs is supported by the conceptual site model (CSM) (USEPA, 1988, 1989). A preliminary and refined (final) CSM for the site will be presented in the FBHRA. The preliminary CSM will be refined following completion of the site characterization and selection of COPCs. For the final CSM, complete and potentially complete exposure pathways will be identified where the following criteria are, or may be, present (USEPA, 1989):

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<sup>1</sup> As defined by USEPA (1992b), “conservative assumptions are those which tend to maximize estimates of exposure or dose, such as choosing a value near the high end of the concentration or intake range.”

- a source and mechanism for chemical release;
- an environmental transport medium (i.e., air, water, soil);
- a point of potential human contact with the medium; and
- a route of exposure (e.g., inhalation, ingestion, dermal contact).

### 6.3 ESTIMATION OF DOSE

Dose is defined as the amount of chemical absorbed into the body over a given period of time (USEPA, 1992b). For non-carcinogenic effects, the dose is averaged over the period of exposure and is referred to as the average daily dose (ADD). For carcinogenic effects, the dose is averaged over a lifetime and is referred to as the lifetime average daily dose (LADD).

Consistent with current USEPA guidance, the following dose equation was used to assess uptake for each direct exposure pathway considered in this assessment:

$$Dose = \frac{C \times IR \times EF \times ED \times B}{BW \times AT}$$

where:

Dose	=	Average Daily Dose (ADD) (mg/kg-day) for noncarcinogens; Lifetime Average Daily Dose (LADD) (mg/kg-day) for carcinogens
C	=	Chemical concentration in environmental medium (mg/kg, mg/m <sup>3</sup> , or mg/L)
IR	=	Intake rate (kg/day, m <sup>3</sup> /day, or L/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
B	=	Bioavailability (fraction)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days) (= ED x 365 day/yr for noncarcinogens; 25,550 days for carcinogens)

Exposure point concentrations and the exposure parameter values are input into pathway-specific versions of this equation to yield dose estimates. The pathway-specific dose equations are presented below (USEPA, 1989).

#### 6.3.1 Incidental Ingestion of Soil

Dose via ingestion of soil is calculated according to the following equation:

$$Dose = \frac{C_{soil} \times IR \times CF \times EF \times ED \times B \times FI}{BW \times AT}$$

where:

Dose	=	Average Daily Dose (ADD) (mg/kg-day) for noncarcinogens;
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		Lifetime Average Daily Dose (LADD) (mg/kg-day) for carcinogens
C <sub>soil</sub>	=	Soil concentration (mg/kg)
IR	=	Soil ingestion rate (mg/day)
CF	=	Conversion factor (10 <sup>-6</sup> kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
B	=	Bioavailability (fraction)
FI	=	Fraction ingested (fraction)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days) (= ED x 365 days/yr for noncarcinogens; 25,550 days for carcinogens)

### 6.3.2 Dermal Contact with Soil

Dose via dermal contact with soil is calculated according to the following equation:

$$Dose = \frac{C_{soil} \times SA \times AF \times B \times CF \times EF \times ED}{BW \times AT}$$

where:

Dose	=	Average Daily Dose (ADD) (mg/kg-day) for noncarcinogens; Lifetime Average Daily Dose (LADD) (mg/kg-day) for carcinogens
C <sub>soil</sub>	=	Soil concentration (mg/kg)
SA	=	Surface area of exposed skin (cm <sup>2</sup> )
AF	=	Soil to skin adherence factor (mg/cm <sup>2</sup> -day)
B	=	Bioavailability (fraction)
CF	=	Conversion factor (10 <sup>-6</sup> kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days) (= ED x 365 days/yr for noncarcinogens; 25,550 days for carcinogens)

### 6.3.3 Inhalation of Particulates

Dose via inhalation of particulate-bound chemical is calculated according to the following equation:

$$Dose = \frac{C_{soil} \times IR \times EF \times ED}{PEF \times BW \times AT}$$

where:

Dose	=	Average Daily Dose (ADD) (mg/kg-day) for noncarcinogens; Lifetime Average Daily Dose (LADD) (mg/kg-day) for carcinogens
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$C_{soil}$	=	Concentration in soil (mg/kg)
IR	=	Inhalation rate (m <sup>3</sup> /day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
PEF	=	Particulate emission factor (m <sup>3</sup> /kg) (USEPA, 1996)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days) (= ED x 365 days/yr for noncarcinogens; 25,550 days for carcinogens)

### 6.3.4 Inhalation of VOCs

Dose via inhalation of VOCs is calculated according to the following equation:

$$Dose = \frac{C_{air} \times IR \times EF \times ED}{BW \times AT}$$

where:

Dose	=	Average Daily Dose (ADD) (mg/kg-day) for noncarcinogens; Lifetime Average Daily Dose (LADD) (mg/kg-day) for carcinogens
$C_{air}$	=	Concentration in air (mg/m <sup>3</sup> )
IR	=	Intake rate (m <sup>3</sup> /day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days) (= ED x 365 days/yr for noncarcinogens; 25,550 days for carcinogens)

### 6.3.5 Ingestion of Groundwater

In accordance with USEPA guidance (USEPA, 1991), Maximum Contaminant Levels (“MCLs”) will be used to evaluate whether remedial action is warranted for ground water. Although doses for ground-water COPCs will not be calculated per se, dose is accounted for in the calculation of the MCL.<sup>[2]</sup>

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<sup>2</sup> <http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/process.htm> (a California Department of Health Services webpage last updated May 6, 2005) states “Health and Safety Code §116365(a) requires the Department of Health Services (DHS), while placing primary emphasis on the protection of public health, to establish a contaminant's maximum contaminant level (MCL) at a level as close as is technically and economically feasible to its public health goal (PHG). The PHG—established by Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA)—is the contaminant's concentration in drinking water that does not pose any significant risk to health, derived from a human health risk assessment.”

As part of the MCL process, DHS evaluates the technical and economic feasibility of regulating a chemical contaminant. Technical feasibility includes an evaluation of commercial laboratories' ability to analyze for and detect the chemical in drinking water, the costs of monitoring, and the costs of treatment required to remove it. Costs are required by law to be considered whenever MCLs are adopted.”



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## 6.4 EXPOSURE PARAMETERS

The exposure parameter values (often termed exposure factors) to be used in the dose estimation will be based on the most recent human exposure factors guidance (USEPA, 1997a, 2000, 2001, 2002). The default RME exposure parameter values for the chronic worker and sub-chronic worker are presented in Table 1. This table may be modified following identification of COPCs and finalization of the CSM.

## 6.5 EXPOSURE POINT CONCENTRATIONS

The exposure point concentration (EPC) is used in the dose equation to determine chemical intake rate. The EPC is the representative concentration of a COPC in an environmental medium that is potentially contacted by a receptor (e.g., chronic or sub-chronic worker). It is defined as “the arithmetic average of the concentration that is contacted over the exposure period” (USEPA, 1989). To ensure that the estimate of the arithmetic average is conservative, it is recommended that a statistically-based upper confidence limit (UCL) on the mean concentration be employed as the EPC. In accordance with USEPA guidance, the EPC will be represented as the 95 percent UCL on the mean concentration within an exposure area. The statistical methods to be applied as the basis for RME EPCs for direct contact pathways (e.g., direct contact with soil and groundwater) and as the basis for particulate inhalation EPCs will be consistent with current USEPA guidance (Singh et al., 1997). Consistent with current USEPA guidance (Singh et al. 1997), if normality tests reject the null hypothesis that the data set for an exposure area is normally distributed, the statistical method of bootstrapping<sup>3</sup> will be used to estimate the 95% UCL.

VOC EPCs in indoor air will be estimated using the USEPA implementation of the “Johnson & Ettinger Model” (J&E model) (Johnson, P. and R. Ettinger, 1991 and USEPA, 2004). The soil gas version of the J&E model will be used as appropriate. The J&E model incorporates both convective and diffusive mechanisms for estimating the transport of vapors emanating from either subsurface soil or groundwater into indoor spaces. Inputs to the J&E model include concentration, chemical properties of the contaminant, saturated and unsaturated zone soil properties, and structural properties of the building. Detailed information regarding the model is provided in the USEPA User’s Guide (USEPA, 2004). The major assumptions/limitations of the J&E model are as follows (USEPA, 2004):

- 1) Contaminant vapors enter the structure primarily through cracks and openings in the walls and foundation.

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<sup>3</sup> Non-parametric bootstrapping is a method that is used when the data distributions do not lend themselves to direct parametric analysis. Using the bootstrapping method, estimates of parameters of interest, such as a mean and standard deviation, are obtained from the data through re-sampling with replacement. Many (hundreds or thousands) of re-samples are obtained, each of which leads to unique estimates of the parameters of interest. This re-sampling, or non-parametric bootstrap approach, yields a distribution of the parameters of interest, from which various statistics can be obtained directly.

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- 2) Convective transport occurs primarily within the building zone of influence and vapor velocities decrease rapidly with increasing distance from the structure.
  - 3) Diffusion dominates vapor transport between the source of contamination and the building zone of influence.
  - 4) All vapors originating from below the building will enter the building unless the floors and walls are perfect barriers.
  - 5) All soil properties in any horizontal plane are homogenous.
  - 6) The contaminant is homogeneously distributed within the zone of contamination.
  - 7) The areal extent of contamination is greater than that of the building floor in contact with the soil.<sup>[4]</sup>
  - 8) Vapor transport occurs in the absence of convective water movement within the soil column (i.e., evaporation or infiltration), and in the absence of mechanical dispersion.
  - 9) The model does not account for transformation processes (e.g., biodegradation, hydrolysis, etc.).
  - 10) The soil layer in contact with the structure floor and walls is isotropic with respect to permeability.
  - 11) Both the building ventilation rate and the difference in dynamic pressure between the interior of the structure and the soil surface are constant values.

VOC EPCs in outdoor air will be quantitatively assessed using the numerical code VLEACH (Ravi and Johnson, 1997) and an analytical mixing cell ("box") model. VLEACH is a one-dimensional (vertical) finite-difference (numerical) code that simulates fate and transport in the unsaturated zone. More specifically, VLEACH calculates the flux of VOCs upward from the subsurface through the ground surface, as well as downward toward the water table. Soil gas concentrations will be used as input to VLEACH to the maximum depth available.<sup>[5]</sup> At greater depths, soil matrix and ground-water data will be used to complete the input concentration profile required by VLEACH. The one-dimensional nature of VLEACH is inherently conservative as it simulates the shortest distance between the impacted unsaturated zone soils and exposure point, thus maximizing predicted concentrations in outdoor air. Attenuation due to

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<sup>4</sup> For those areas where the lateral (areal) extent of contamination ( $A_C$ ) is less than the areal dimensions of the site-specific or default building ( $A_B$ ), the J&E model-predicted indoor air concentration will be multiplied by  $A_C/A_B$  to arrive at the site-specific indoor air exposure point concentration (EPC).

<sup>5</sup> VLEACH requires the user to input contaminant mass in terms of soil matrix concentrations. The computational algorithm within VLEACH will be used to convert the measured soil gas concentrations to the model-required soil matrix concentrations. Specifically, the output of the VLEACH-generated 'profile' file will be used to convert the measured soil gas concentration to the model-required soil matrix concentration.



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lateral deflection and lateral diffusion arising from concentration gradients conceptually identical to those used by VLEACH to simulate vertical diffusion are conservatively ignored when using a one-dimensional code such as VLEACH.

The outdoor air model is a “mixing cell” model based on the principle of mass balance. The model calculates concentrations in the air by mixing the volatile emissions, as estimated using VLEACH, with ambient air. Thus, the output of VLEACH serves as the input to the outdoor air model. The ambient air is introduced in the form of wind. Specifically, the outdoor air model is:

$$C_{a-out} = \frac{Q_{volatile} \times A}{v \times w \times h}$$

where:  $C_{a-out}$  is the concentration in outdoor air (i.e., the outdoor air EPC) in grams per cubic feet (g/ft<sup>3</sup>).  
 $Q_{volatile}$  is the VLEACH-calculated upward volatile flux (‘emission rate’) from the unsaturated zone through the ground surface in micrograms per square meter per second (g/ft<sup>2</sup>-yr).  
 $A$  is the plan-view area through which simulated volatile vapors are emitted in ft<sup>2</sup>.  
 $v$  is the wind velocity parallel to the ground surface in ft/yr.  
 $w$  is the width through which the wind blows in ft.  
 $h$  is the height of the atmospheric mixing zone in ft.

## 7.0 RISK CHARACTERIZATION

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This section addresses methods to be used for estimating the human health risks and hazards associated with exposure to COPCs. Section 7.1 discusses estimation methods for incremental lifetime cancer risks, and Section 7.2 discusses estimation methods for non-cancer hazards. The manner in which the uncertainty analysis will be conducted is presented in Section 7.3.

### 7.1 INCREMENTAL LIFETIME CANCER RISK

Calculation of incremental lifetime carcinogenic risk (ILCR) associated with exposure to COPCs will be performed using the following three steps:

**Step 1:** Calculate ILCR posed by an individual COPC via a given exposure pathway.

ILCR probabilities will be estimated using USEPA CSFs that describe the relationship between intake doses and carcinogenic responses:

$$ILCR = LADD \times CSF$$

where:

$$\begin{aligned} LADD &= \text{Lifetime average daily chemical-specific dose calculated for an exposure pathway (mg/kg/day)} \\ CSF &= \text{Cancer Slope Factor (mg/kg-day)}^{-1} \end{aligned}$$

**Step 2:** Sum of ILCRs for all COPCs via a given pathway to arrive at a cancer risk for that exposure pathway ( $ILCR_{pw}$ ).

Once ILCRs have been calculated for each COPC for a selected pathway, all ILCRs will be added to arrive at a  $ILCR_{pw}$ :

$$ILCR_{pw} = \sum_{COPCs} ILCR$$

**Step 3:** Sum of  $ILCR_{pw}$  to arrive at an overall receptor-specific carcinogenic risk ( $ILCR_{recep}$ ).

$$ILCR_{recep} = \sum_{pathways} ILCR$$

For the worker receptors,  $ILCR_{pws}$  will be summed to arrive at total incremental lifetime cancer risk. Calculations will be prepared listing each COPC, its corresponding CSF, and the result of the risk calculation. The risk contributions for each COPC and for each pathway will be summarized and a total receptor risk presented.



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## 7.2 NON-CARCINOGENIC HAZARD

The potential for non-carcinogenic hazards resulting from exposure to COPCs may also be viewed as a three-step process (for each receptor):

**Step 1:** Calculate hazard quotients (HQs) for individual COPCs for a given exposure pathway.

The potential for non-carcinogenic adverse health effects resulting from exposure to COPCs is estimated first by calculating the HQ. To calculate HQ, the estimated exposure intake of a single COPC via a single pathway is compared with the chemical and pathway specific RfD. The HQ is calculated using the following equation:

$$HQ = \frac{ADD}{RfD}$$

Where:

- ADD = Average daily chemical-specific dose calculated for an exposure pathway (mg/kg/day)
- RfD = Reference dose: daily exposure level expected not to produce appreciable adverse health effects (mg/kg/day)

**Step 2:** Sum COPC-specific HQs for a given pathway to arrive at a pathway-specific hazard index ( $HI_{pw}$ )

Once HQs have been calculated for each COPC for a selected pathway, all HQs are added to arrive at a  $HI_{pw}$ :

$$HI_{pw} = \sum_{COPCs} HQ$$

**Step 3:** Sum  $HI_{pw}$  to arrive at an overall receptor HI ( $HI_{recep}$ ).

Pathway-specific  $HI_{pw}$ s are added for each receptor to obtain a total receptor  $HI_{recep}$ . If  $HI_{recep}$  is less than or equal to one, non-carcinogenic adverse health effects are not expected.

$$HI_{recep} = \sum_{pathways} HI$$

If the total hazard index for all COPCs exceeds one (unity), segregation of hazard indices will be considered. In such cases, if toxicological data are available to support identification of all of the major effects and target organs for each COPC, then COPCs will be classified according to target organ(s) or mechanism of action in accordance with USEPA (1989). The HI contributions for each COPC and for each pathway will be summarized and a total receptor HIs will be presented.

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### 7.3 UNCERTAINTY ANALYSIS

A qualitative uncertainty analysis will be conducted which will discuss the level of confidence in each of the FBHRA components as follows (USEPA, 1989):

**Site Characterization Data** – the level of confidence in the Site characterization data and the potential for the data to introduce uncertainties in the selection of COPCs and estimation of EPCs will be discussed. The DU evaluation framework (USEPA, 1992a), discussed earlier, will be used as the basis for this component of the uncertainty analysis.

**Selection of COPCs** – the potential for failure to identify COPCs will be discussed. Information regarding Site history and Site activities, the conceptual Site model, and the analytical data (e.g., specific analytical methods and method detection limits) will be discussed as the basis for this component of the uncertainty analysis.

**Toxicity Assessment** – uncertainties associated with toxicity values will be discussed. This component of the uncertainty analysis will include discussion of high-to-low dose extrapolations, short term exposure to long term exposure extrapolations, animal-to-human extrapolations, and consideration of sensitive individuals.

**Exposure Assessment** – the potential for underestimation of EPCs will be evaluated using the USEPA DU framework (USEPA, 1992a). Confidence in exposure parameter values will be discussed based on information provided in the USEPA Exposure Factors Handbook (USEPA, 1997a). Additionally, uncertainties associated with the application of fate transport models employed will be discussed. Exposure parameters that contribute most significantly to ILCR and HI estimates will be identified and discussed.

**Risk Characterization** – in order to place the risk estimates in proper perspective, uncertainties in each of the BLRA steps will be summarized and the risk assessment assumptions for which the risk estimates are most sensitive (“important Site-specific uncertainty factors” [USEPA, 1989]) will be discussed in terms of potential for underestimation of risk.

## 8.0 REFERENCES

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# *Tables*

**Table 1. Exposure Parameters**

	Indoor (Chronic) Worker	Notes	Outdoor (Chronic) Worker	Notes	Excavation (Sub-chronic) Worker	Notes
<b>General Parameters</b>						
Exposure Frequency (EF); in days/year	250	a	225	a	60	b
Exposure Duration (ED); in years	25	a	25	a	1	a
Body Weight (BW); in kg	70	a	70	a	70	a
Averaging Time (AT); in days	25.550	c, d	25.550	c, d	365	c, f
	9,125	c, e	9.125	c, e		

	Indoor (Chronic) Worker	Notes	Outdoor (Chronic) Worker	Notes	Excavation (Sub-chronic) Worker	Notes
<b>Dermal Contact</b>						
Absorption Fraction (ABS); unitless	Pathway not applicable	a	Chemical-specific	g	Chemical-specific	g
Surface Area (SA); in cm <sup>2</sup> /event			3,300	a	3,300	a
Adherence Factor (AF); in mg/cm <sup>2</sup>			0.2	a	0.3	a
Event Frequency (EF); in events/day			1	a	1	a

	Indoor (Chronic) Worker	Notes	Outdoor (Chronic) Worker	Notes	Excavation (Sub-chronic) Worker	Notes
<b>Soil Ingestion</b>						
Ingestion Rate (IR); in mg/day	50	a	100	a	330	a
Fraction Ingested (FI); unitless	1	i	1	i	1	i
Bioavailability (Bio); unitless	1	i	1	i	1	i

	Indoor (Chronic) Worker	Notes	Outdoor (Chronic) Worker	Notes	Excavation (Sub-chronic) Worker	Notes
<b>Inhalation (Particulates)</b>						
Inhalation Rate (IR); in m <sup>3</sup> /day	20	a	20	a	20	a
Particulate Emission Factor (PEF); in m <sup>3</sup> /kg	1.32E+09	h	1.32E+09	h	1.32E+09	h

	Indoor (Chronic) Worker	Notes	Outdoor (Chronic) Worker	Notes	Excavation (Sub-chronic) Worker	Notes
<b>Inhalation (Vapors)</b>						
Inhalation Rate (IR); in m <sup>3</sup> /day	20	a	20	a	20	a

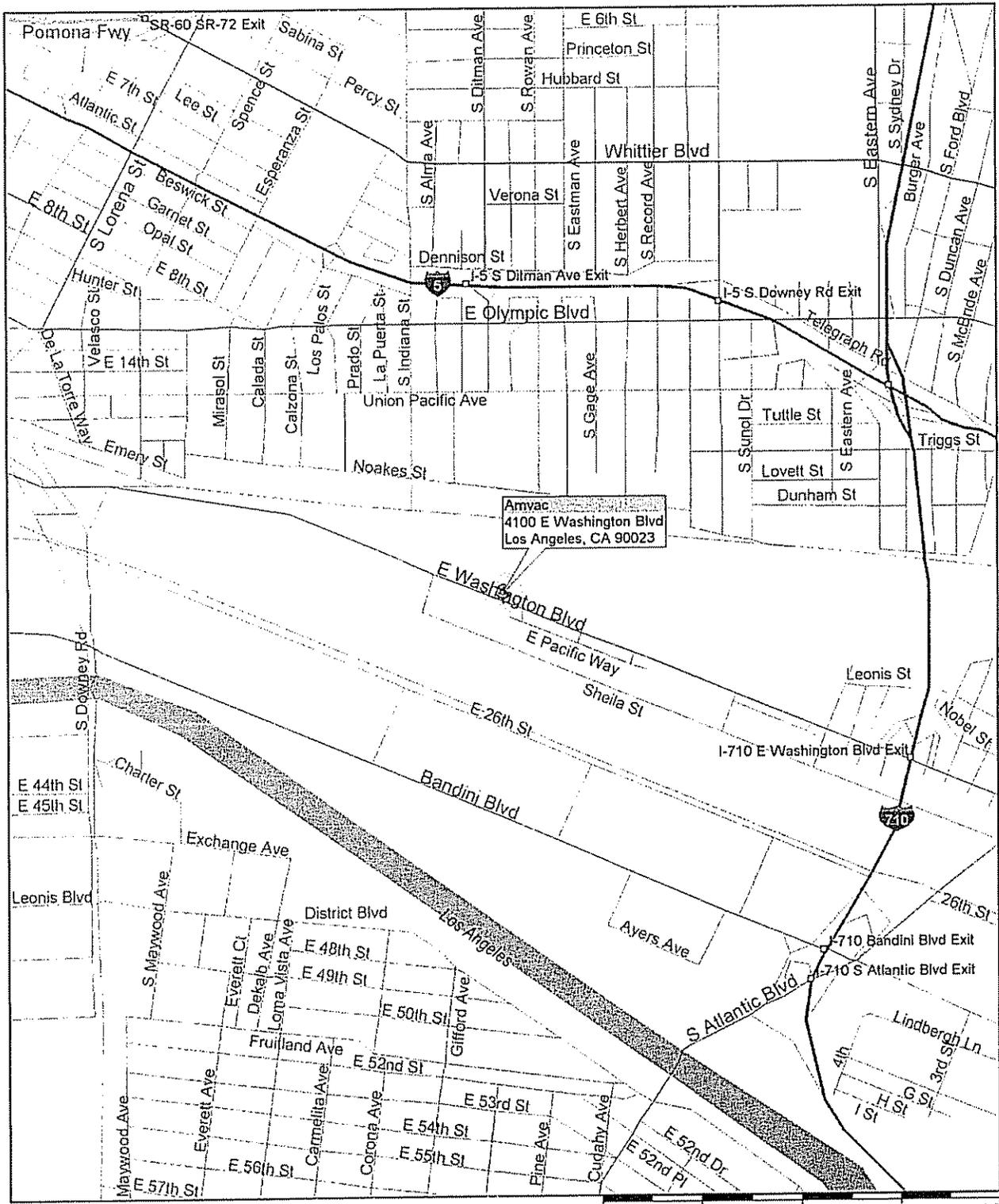
The values listed in this table are default values obtained from the various guidances referenced below. Company policy mandates that current workers, depending on their function, maintain and don personal protective equipment (e.g., coveralls, gloves, and respirators) thus significantly reducing chemical exposure. Exposure parameters for current workers will be furnished in a separate deliverable.

- a - From USEPA, 2002
- b - 30-day exposure frequency will also be evaluated
- c - From USEPA, 1989
- d - For cancer endpoint (USEPA, 1989).
- e - For noncancer endpoint (USEPA, 1989)
- f - Cancer endpoint not applicable since ED is only 1 year per USEPA, 2002.
- g - To be determined following selection of COPCs
- h - Default value.
- i - Value shown is a default value. Chemical-specific values may be assigned following selection of COPCs

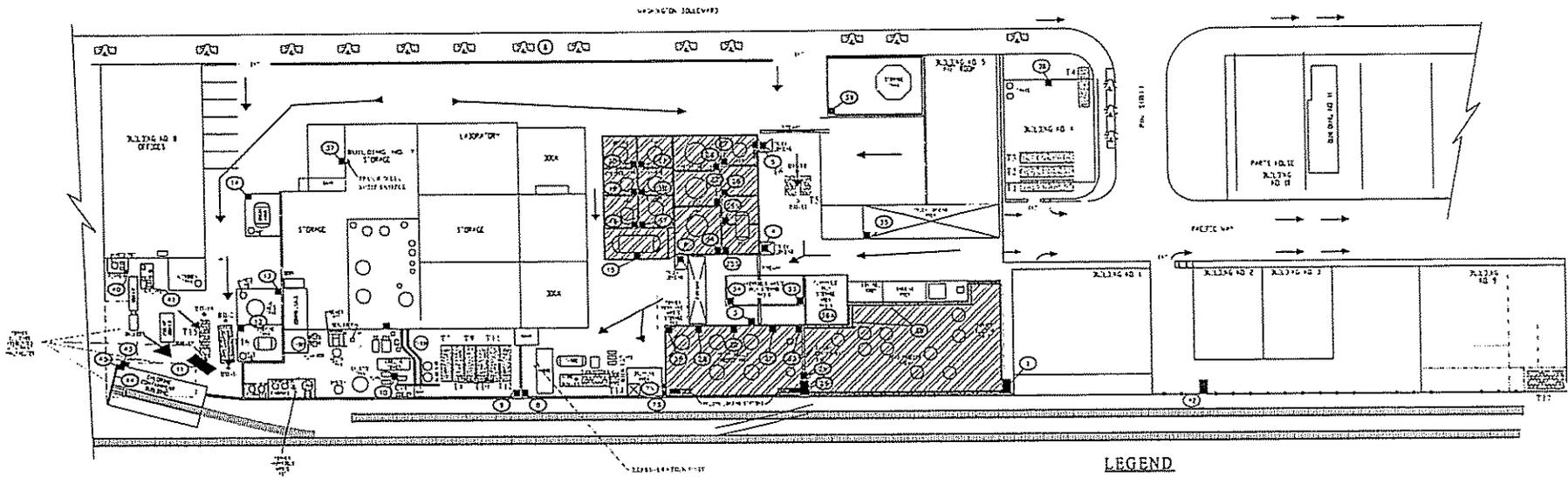


# *Figures*

**FIGURE 1**  
**SITE LOCATION MAP**



Microsoft Expedia  
**Streets98**



**LEGEND**

- LOCATION OF INDICATED SLUMP AND NUMBER
- DIRECTIONAL FLOW OF DRAINAGE
- BORING ASSOCIATED WITH LST CLOSURE
- DEFERRED INVESTIGATION AREA
- UNDERGROUND STORAGE TANK - CLOSED BY EXCAVATION
- UNDERGROUND STORAGE TANK - CLOSED IN PLACE

**SCALE**

1" = 30'

REV	DATE	DESCRIPTION	BY	APPROVED
1	11/24/04	CONDUCTED SOIL WELL SURVEY/ADDED BORINGS TO LAND TANK/ADDED WELLS TO ACCESS	GRD	GRD
2	02/24/05	MOVED SOIL VAPOUR/SUPPLEMENTAL SOIL BORING LOC	GRD	GRD
3	03/03/05	ADDED SOIL VAPOUR/SUPPLEMENTAL SOIL BORING LOC	GRD	GRD
4	03/23/05	REVISED BORING LOCATIONS BASED ON 11/21/04 317	GRD	GRD
5	03/23/05	ADDED NEW BASELAYER WITH BUMPS/SURFACE FLOW	GRD	GRD
6	04/08/05	ADDED TANK LOCATION (1111) FORMATTING	GRD	GRD
7	07/29/05	ADDED WELL SAMPLE/TANK LOCATION	YLR	GRD

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APPROVED: _____		N:\E\m\33\sp\5\6\04\W\estphal 11_24_04\Tech\Drawn\Figures\0005_3317	FIGURE 1