

0 indicates incomplete pathway

+ Indicates complete pathway



FORMER DELPHI BATTERY PLANT
 1201 MAGNOLIA AVENUE
 ANAHEIM, CALIFORNIA
 CONCEPTUAL SITE MODEL

FIGURE 1

1. HUMAN HEALTH RISK ASSESSMENT

This report documents a human health risk assessment (HHRA) conducted for the Former Delphi Battery Plant (Site) following U.S. Environmental Protection Agency (EPA), California Environmental Protection Agency (Cal-EPA) Department of Toxic Substances Control (DTSC), and Office of Environmental Health Hazard Assessment (OEHHA) risk assessment guidance, and using reasonable worst-case site-specific exposure assumptions. The Site is located at 1201 Magnolia Avenue in Anaheim, California. The primary guidance documents used are as follows:

- Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties, prepared by Cal-EPA, and dated January 2005 (Cal-EPA, 2005).
- Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil, prepared by the California Office of Environmental Health Hazard Assessment (OEHHA), and dated November 2004 (revised January 2005) (OEHHA, 2005).
- Preliminary Endangerment Assessment (PEA) Guidance Manual, prepared by the Cal-EPA Department of Toxic Substances Control (DTSC), and dated January 1994 (revised June 1999) (DTSC, 1999).
- Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final, prepared by EPA, and dated December 1989 (EPA, 1989).
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, prepared by EPA, and dated December 2002 (EPA, 2002).
- Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, prepared by DTSC, and dated 15 December 2004, revised 7 February 2005 (DTSC, 2005a).
- Human and Ecological Risk Division (HERD) HHRA Note Number 1, Issue: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities, prepared by DTSC, and dated 27 October 2005 (DTSC, 2005b).
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, prepared by EPA, and dated December 2002 (EPA, 2002b).
- ProUCL User's Guide. Version 3.0, prepared by EPA, and dated April 2004 (EPA, 2004).
- Updated Version of California EPA Lead Risk Assessment Spreadsheet Model for Predicting Blood Lead in Children and Adults, Version 7 of the DTSC Lead Risk Assessment Spreadsheet (LeadSpread) Model, BLOOD PB7.xls, prepared by DTSC, and dated 20 March 2000 (DTSC, 2000).

Other guidance used in the development of this HHRA is listed in the reference section.

The objective of this HHRA was to assess whether potential exposure to existing levels of Site-related chemical in pacts in soil and soil gas at the Site could pose potential adverse human health effects to possible future on-site human receptors. Conservative (health-protective) assumptions were used that overestimated the health risk to these receptors. For the purposes of this HHRA, it was assumed that the Site would be redeveloped for commercial/industrial uses. Therefore, the receptors identified in this HHRA are those who could potentially have the greatest exposure to on-site in pacts: the future on-site construction worker, the future on-site commercial/industrial worker inside buildings, and the future on-site commercial/industrial worker outside buildings.

An HHRA is typically conducted in four steps: 1) hazard identification, 2) exposure assessment, 3) toxicity assessment, and 4) risk characterization.

- Hazard identification (Section 1.1) includes data collection and evaluation, and the identification of the chemicals of potential concern (COPCs) at the site.
- Exposure assessment (Section 1.2) includes a study of the most sensitive receptors at the site and their possible exposure pathways (i.e., how they may come into contact with the COPCs at the site). A conceptual site model is developed (i.e., vapor intrusion model) and model input assumptions.
- Toxicity assessment (Section 1.3) includes the identification of the relevant toxicity values for the COPCs.
- Risk characterization (Section 1.4) includes a summary of the estimated human health risk results and the associated risk uncertainties.

These four steps of the HHRA for the Site are described in detail below.

1.1 Hazard Identification

The initial step of the HHRA process is to review the available data to characterize the Site and Site in pacts. The sampling and analysis program implemented at the Site was identified based on Site history, sampling results, DTSC guidance and protocol, and discussions with DTSC project managers and staff. A summary of the results of the investigation activities conducted for the Site is presented in the Facility Investigation Report (Haley & Aldrich, 2007). A list of the detected organic and organic chemicals in various media at the Site is presented in Table I.

In general, the Site-related COPCs evaluated in this HHRA include detected organic chemicals and metals (inorganic chemicals) detected at concentrations above background in the media and depths where potential exposure could occur. The media and depths for which exposure could occur are described in Section 1.2.2. Metals were selected as COPCs following the February 1997 DTSC document entitled *Selecting Inorganic Constituents as Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities, Final Policy*.

1.1.1 Organic Chemicals of Potential Concern

Organic chemicals that were reported above laboratory detection limits in one or more on-soil soil samples obtained within the upper 10 feet of soil were considered COPCs for the HHRA.

1.1.2 Inorganic Chemicals of Potential Concern

Site-related inorganic chemicals were identified based on a review of the PRC Visual Site Inspection/Sampling Visit (VSI) report (1992) and the Current Conditions Report (CCR) (Haley & Aldrich, 2006b). A review of the VSI report and the CCR indicates that Site-related inorganic chemicals associated with historical on-site operations include lead, antimony, arsenic, chromium, mercury, and zinc. To identify the Site-specific background metals concentrations for these chemicals, statistical background metals evaluations were conducted of the Site-specific metal data sets, which included the preparation of:

- Histograms of the untransformed and the log-transformed concentrations measured in soil samples collected across the Site, and
- Probability plots and associated correlation coefficients of these untransformed and log-transformed concentrations.

The above-noted histograms and probability plots are presented in Attachment 1. For each metal, the histograms and probability plots of the Site-specific data set were reviewed to assess whether the untransformed or the log-transformed data best resemble a normal distribution. A normal distribution is depicted as a bell-shaped curve on a histogram, and as a straight line on a probability plot. Once a decision was made regarding which of the untransformed or log-transformed data sets most resembled normal distribution, the probability plot for the associated data set was reviewed to identify the point-of-departure. The point-of-departure is defined as the point at which the background metals population (closest to the origin) diverges from the non-background (impaired) population. If no point-of-departure is evident in the probability plot, the entire data set is considered to be within background. A review of the histograms and probability plots presented in Attachment 1 indicates that the following metals were detected at the Site above naturally occurring background concentrations: antimony, arsenic, chromium, lead, and zinc. The identified points-of-departure are listed in Table II along with background levels in California and the western United States, obtained from various literature sources. A comparison of these values and a review of the distribution of metals concentrations at the Site indicate that the point-of-departure chosen on the probability plot are reasonable estimates of the maximum onsite metals background concentrations.

To verify whether other metals detected at the Site should be considered Site-related inorganic chemicals, the other detected maximum metals concentrations were compared to the background levels presented in Table II. A review of Table II indicates that the maximum concentrations of these other metals are generally less than the reported background concentrations, with the exception of cadmium and molybdenum.

A review of the cadmium results indicates that only three soil samples had detected concentrations. The concentrations of these samples (2.25, 9.5, and 9.6 milligrams per kilogram [mg/kg]) were greater than the literature identified maximum background concentration of 1.7 mg/kg. Since it appears that these detected concentrations are elevated compared to the rest of the cadmium data set, cadmium was considered a COPC in the HHRA.

A review of the molybdenum concentrations across the Site indicates that molybdenum concentrations range up to 13.1 mg/kg. A statistical evaluation, as described above, was conducted for molybdenum to evaluate whether molybdenum may be present on-site at concentrations above site-specific background concentrations. A review of the probability plots (Attachment 1) suggests that there may be a point-of-departure for the molybdenum data at an approximate concentration of 11.1 mg/kg. Samples with concentrations of molybdenum exceeding 11.1 mg/kg include:

- GS0027-SS-001-01 (13.1 mg/kg) at AOI 8
- DP0135-SS-000-01 (11.5 mg/kg) at AOI 26
- DP0115-SS-000-01 (11.4 mg/kg) at AOI 33
- DP0147-SS-005-01 (12.6 mg/kg) at AOI 42

These sample results appear to be only slightly higher than the apparent maximum on-site background concentration of 11.1 mg/kg. Thus, further evaluation was conducted to assess whether these samples also contain elevated Site-related metals concentrations. Based on a review of the sample data, it was concluded that apparently elevated molybdenum results are not collocated with other elevated Site-related chemicals. Therefore, molybdenum was not considered a COPC in the HHRA.

1.2 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of reasonably anticipated human exposure to COPCs on- and off-site. The exposure assessment is based on identified potential on-site and off-site receptors and associated potentially complete exposure pathways that define the conditions of exposure to the COPCs. The receptors and assessment of potentially complete exposure pathways are shown in the Conceptual Site Model (CSM) presented on Figure 1.

Human health risks are estimated for significant complete or potentially complete exposure pathways. For an exposure pathway to be considered complete for an existing receptor or potentially complete for a potential future receptor, it must have the following elements:

- A contaminant source;
- A retention medium and transport mechanism;
- A point of potential human contact with the contaminated medium; and
- An exposure route at the exposure point.

If any of the above required elements are absent, the exposure pathway is considered incomplete (i.e., no exposure will occur) and will have no associated health risks (i.e., health risks will be zero for that exposure pathway). However, even if a pathway is considered potentially complete, it could be considered insignificant if 1) the associated risk is so small, relative to other pathways, that it will not add perceptibly to the total exposure being evaluated or if 2) the potential risk contribution from an insignificant pathway would be trivial (EPA, 1989). Insignificant pathways need not be quantitatively evaluated in the HHRA. Potentially complete exposure pathways are discussed below in Section 1.2.1.

Once the complete and potentially complete exposure pathways are identified, quantification of chemical intake doses for each receptor requires that an estimate be made of:

- Each COPC concentration to which the receptor may be exposed (also referred to as exposure point concentration [EPC]);
- The absorption of each COPC into the human body once exposed via the subject complete and potentially complete exposure pathways;
- Frequency and duration of contact for the complete and potentially complete exposure pathways; and
- The biological characteristics of the receptor.

The components of the exposure assessment are discussed further below.

1.2.1 Conceptual Site Model

The CSM for the Site, presented as Figure 1, identifies the potential chemical exposure pathways (i.e., ways that people could potentially be exposed to the COPCs in soil at the Site). Future redevelopment of the Site includes commercial and industrial uses. Potentially exposed receptors at the Site include on-site construction workers and off-site construction/industrial workers during on-site redevelopment activities, and on-site and off-site commercial/industrial workers after Site redevelopment. Since the greatest concentrations of the Site-related impacts are on-site, the worst-case receptors are those present at the Site. Thus, the human receptors evaluated in this HHRA are the:

- Future on-site construction worker during Site redevelopment activities, and
- Future on-site commercial/industrial worker (inside and outside buildings) after Site redevelopment activities.

On-site workers after Site redevelopment may be both inside and outside buildings during a portion of a given day. Since it is unknown what percentage of the time a worker may be inside versus outside a building, it was conservatively assumed that the on-worker would be both inside and outside a building during the entire 8-hour work day.

The potentially complete soil exposure pathways for the construction worker include soil ingestion, dermal exposure to soil, and inhalation of particulates (as fugitive dust

generated from soil) and organic vapors in ambient air. The potentially complete exposure pathways for the commercial/industrial worker include inhalation of volatile organic compounds (VOCs) in indoor air, soil ingestion, dermal exposure to soil, and inhalation of particulates and organic vapors in ambient air. For the purposes of this HHRA, inhalation of VOCs in ambient air by the on-site commercial/industrial worker was considered insignificant and was not quantitatively evaluated in the HHRA. This is because the majority of the Site will be paved after redevelopment which will limit VOC migration into ambient air, VOC concentrations after dispersing into ambient air will be negligible, and it is assumed that the on-site commercial/industrial worker will inhale VOCs in indoor air from subsurface vapor intrusion into on-site buildings. The remaining potentially complete exposure pathways for both receptors were quantitatively evaluated in this HHRA.

To estimate what the potential exposures may be under current and future land use plans, the HHRA risk calculations were conducted using the data collected prior to and during the 2006 Facility Investigation. These data are summarized in the Facility Investigation Report (Haley & Aldrich, 2007) as indicated in Section 1.1.

1.2.2 Exposure Point Concentrations

Deriving estimates of chemical concentrations at points of potential human exposure is necessary for deriving chemical intakes for potentially exposed individuals (i.e., human receptors). These chemical concentrations are referred to as EPCs.

For the purposes of the HHRA, it was assumed exposures to on-site soil would occur with soil present at depths in the upper 10 feet. This assumption is consistent with what is indicated on Page 2-6 of the above-referenced January 2005 Cal-EPA document entitled Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties, which indicates that the CHHSLs are to be applied to soils at depths within the upper 10 feet where direct contact with soils by human receptors during and after redevelopment activities is possible. It was further assumed that potential exposure associated with VOCs in indoor air could be estimated using onsite soil gas data. Soil gas samples were obtained at approximately 5-foot depth intervals between approximately 5 and 20 feet below ground surface (bgs).

A list of the EPCs for the upper 10 feet of soil, ambient air, and for soil gas and indoor air is presented in Table III. The derivation of EPCs is described in the following sections.

1.2.2.1 Overview of EPC Derivation

Development of long-term EPCs from the investigation data collected to date includes an underlying assumption about the representativeness of the data, both temporally and spatially. The EPCs were calculated under the assumption that environmental concentrations would remain constant at the levels detected during the investigation activities for an indefinite period of time. It is, thus, assumed that the data considered representative of current on-site conditions simulates current and future exposure conditions for a receptor having potential exposure to impacted media at the Site.

The operations (i.e., associated with historical on-Site manufacturing activities) resulting in chemical releases at the Site have been removed. So there are no continued sources of chemical releases to the environment. Samples have been collected at locations of the likely highest chemical concentrations at each potential impact area, and the samples have been analyzed for associated COPCs at each of these locations. It is therefore reasonable to assume that samples results represent the highest concentrations at the Site and that concentrations will not increase over time. In actuality, organic chemicals including chemical degradation products naturally degrade in the environment, which results in the reduction of concentrations over time.

The above underlying steady-state assumption is therefore conservative, in that it assumes that no degradation mechanisms will occur. This assumption of steady-state concentrations for each COPC results in a conservative estimation of long-term exposure concentrations.

To simulate a receptor's spatially and temporally integrated exposure, EPA (1992, 1997, 2002b) defines the EPC used to estimate the reasonable maximum exposure (RME) as the 95% upper confidence limit of the arithmetic mean (95% UCL) or the maximum observed concentration, whichever is lower. The arithmetic mean reflects the assumption that exposure by the receptor is averaged as they traverse an area over time. The intent of the RME scenario is to focus the assessment on a conservative exposure that is within the range of exposures. For the purposes of this HHRA, the lower of the maximum and 95% UCL concentrations were assumed to be the EPCs in soil for risk driving chemicals. Maximum Site-wide soil concentrations were assumed to be the EPCs for non-risk driving chemicals, and the maximum Site-wide soil gas concentrations were conservatively used to estimate indoor air concentrations.

The 95% UCLs were calculated using the EPA ProUCL software (Version 3.0, dated April 2004) (EPA, 2004) following the EPA December 2002 guidance document titled Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (EPA, 2002b). The results of these calculations (software output) indicated the EPA recommended 95% UCL concentrations are presented in Attachment 2. The EPA recommended 95% UCL concentrations were used in this HHRA for the chemicals considered to be risk drivers. Where this was the case for a particular metal, the 95% UCL concentration was compared to the maximum Site-specific background concentration. If the 95% UCL concentration was equal to or less than the Site-specific maximum background concentration, the metal concentration was considered to be within background in the HHRA. This was the case for cadmium.

Specific information regarding the estimation of EPCs for the inhalation of fugitive dust and organic vapor concentrations in ambient air and inhalation of volatiles in indoor air is presented below.

1.2.2.2 Fugitive Dust

The COPCs that are relatively nonvolatile compounds can adhere to soil and become airborne due to wind erosion or due to mechanical disturbance such as soil grading operations. Once airborne, these soil particulates generate fugitive dust that can be inhaled. The fugitive dust EPC is estimated by multiplying the COPC EPC in surface soil by the inverse of the particulate emission factor (PEF) relevant to the fugitive dust generating activities.

During on-site construction activities associated with Site redevelopment, fugitive dust may be generated by various activities including not only wind erosion but also by vehicles driven on unpaved roads, trucks dumping excavated soil, dozing, grading, tilling, or similar operations, as noted in the 2002 EPA document (EPA, 2002a). To account for these activities, the PEF during Site redevelopment activities was assumed to be the DTSC-recommended default PEF identified for the construction scenario in the 27 October 2005 DTSC document entitled Human and Ecological Risk Division (HERD) HHRA Note Number 1, Issue: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities (DTSC, 2005b). This PEF value is 1.0×10^6 cubic meters per kilogram (m^3/kg). A site-specific PEF was not derived since specific information regarding the grading activities and types of equipment and earth-moving activities is not known at this time. The above-noted DTSC default PEF is considered by DTSC to be a conservative non-site-specific PEF value for a typical construction scenario.

For the on-site commercial/industrial worker after Site redevelopment, fugitive dust may be generated from wind erosion of exposed surface soil. The PEF default value for wind erosion of $1.316 \times 10^9 m^3/kg$, as identified in the 2005 OEHHA document entitled Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil (OEHHA, 2005), was used in this HHRA as the PEF value for fugitive dust-generating activities after Site redevelopment.

1.2.2.3 Volatiles in Ambient Air

VOCs may volatilize from VOC-impacted soil into the ambient air. Since the majority of the surface soil across the Site will be exposed during on-site redevelopment activities, VOC concentrations in ambient air were estimated for the on-site construction worker during on-site redevelopment activities. However, since the majority of the Site will be paved after redevelopment which will limit VOC migration into ambient air, VOC concentrations in ambient air are considered to be negligible and were not estimated in this HHRA. The EPCs for VOCs in ambient air during redevelopment activities were estimated following equations published by EPA (EPA, 2002a).

The soil volatilization factor (VF) for the construction scenario was calculated using the following equations presented by EPA (2002a) as Equations 5-14 and 5-15:

$$VF_{sc} = \left[\frac{(3.14 \times D_A \times T)^{1/2}}{2 \times \rho_b \times D_A} \right] \times 10^{-4} m^2/cm^2 \times Q/C_{sa} \quad (\text{Equation 1})$$

where

- VF_{sc} = Subchronic volatilization factor (m^3/kg)
- D_A = Apparent diffusivity (cm^2/s , see Equation 2)
- T = Total time over which construction occurs (s, 31,536,000 s = 1 year)
- ρ_b = Dry soil bulk density (g/cm^3 , 1.55 = Site-specific in upper 10 feet, same as used in the Johnson & Ettinger (J&E) vapor intrusion model - see section 1.2.2.4.)
- Q/C_{sa} = Dispersion emission component, ($[g/m^2/s]/[kg/m^3]$, see Equation 3)

$$D_A = \frac{\left[(\Theta_a^{10/3} D_{iH} + \Theta_w^{10/3} D_w) / n^2 \right]}{K_d + \Theta_w + \Theta_w H'} \quad (\text{Equation 2})$$

where

- D_A = Apparent diffusivity (cm^2/s , chemical-specific)
- ρ_b = Dry soil bulk density (g/cm^3 , 1.55 = Site-specific in upper 10 feet)
- α = Air-filled soil porosity (ρ_{air}/ρ_{soil} , 0.247 = Site-specific in upper 10 feet, same as used in the J&E model - see section 1.2.2.4.)
- n = Total soil porosity (ρ_{pore}/ρ_{soil} , 0.42 = Site-specific in upper 10 feet, same as used in the J&E model)
- w = Water-filled soil porosity (ρ_{water}/ρ_{soil} , 0.173 = Site-specific in upper 10 feet, same as used in the J&E model)
- D_i = Diffusivity in air (cm^2/s , chemical-specific)
- H = Henry's Law constant ($atm \cdot m^3/mol$, chemical-specific)
- H' = Dimensionless Henry's Law constant (unitless, chemical-specific)
- D_w = Diffusivity in water (cm^2/s , chemical-specific)
- K_d = Soil-water partition coefficient (cm^3/g) = $K_{oc} \times f_{oc}$

- K_{oc} = Soil organic carbon-water partition coefficient (cm^3/g , chemical-specific)
- f_{oc} = Fraction organic carbon in soil (g/g, 0.006 = default)

$$Q/C_{sa} = A \times \exp\left[\frac{(\ln A_c - B)^2}{C}\right] \quad (\text{Equation 3})$$

where

- A = Unitless constant (2.4538 = default)
- A_c = A real extent of site soil contamination (acres, 21.65 = area of Site)
- B = Unitless constant (17.5660 = default)
- C = Unitless constant (189.0426 = default)

The ambient air concentration was calculated using the following equation:

$$C_a = \frac{C_s}{VF} \quad (\text{Equation 4})$$

where

C_a = ambient air concentration (mg/m^3)

1.2.2.4 Volatiles in Indoor Air

EPCs for volatiles in indoor air were derived using the EPA advanced soil gas (SG-ADV) J&E vapor intrusion model (Version 3.1, dated February 2004) substituting information in the EPA model with the following:

- DTSC-specified soil properties, chemical parameters, and toxicity values included in the 25 January 2005 DTSC version of the screening soil gas (SG-SCREEN) J&E vapor intrusion model, and
- Other model default parameters as specified in the revised 7 February 2005 DTSC vapor intrusion guidance (DTSC, 2005).

In addition, Site-specific information used in the model included information concerning:

- Physical soil characteristics, and

- Soil gas concentrations.

Shallow soil gas samples were collected at 5-foot depth intervals between 5 and 20 feet bgs. Estimated indoor air concentrations were derived from soil gas samples collected at the 5-, 10-, 15-, and 20-foot depths. Human health risk was also estimated for each of these depths.

The physical soil characteristics were identified from a review of the boring logs for the top 20 feet of soil at the Site and physical property testing results for select on-site soil samples. Based on a review of the boring logs, the following generalized lithologic cross-section for the Site was developed for use in the J&E model:

0 to 10 feet bgs (10 feet)	Silty sand
10 - 15 feet bgs (5 feet)	Silt
15 - 20 feet bgs (5 feet)	Sand

Based on a review of the physical property testing results, the average of the data for samples DP0194A_SS_003_01 and DP0194A_SS_007_01 were used as the properties for silt in the J&E model. The average of the data for samples DP0194A_SS_011_01 and DP0194A_SS_017_01 were used as the properties for silty sand in the J&E model, and the J&E model default parameters were used for sand in the J&E model.

The above-noted average soil property data calculations are presented in Table IV. The soil physical property laboratory reports are presented in Attachment 3. The J&E model calculations are presented in Attachment 4.

1.2.3 Estimation of Chemical Intakes

EPA risk assessment guidelines recommend that intake doses be calculated in a manner that will produce risk estimates of the RME scenario (EPA, 1989). The RME considers the upper bound case described by using the 50th or 95th percentile of the actual distribution of most input parameters used to estimate intake doses. The intent of the RME scenario is to focus the risk assessment on conservative exposures that are within the range of possible exposures. Since the RME scenario uses a mixture of upper bound and central tendency assumptions and data, the associated estimated COPC intake is not an average COPC intake, but is intended to be an estimate of the plausible upper-end intake.

The exposure parameter assumptions for the selected worst-case receptors are based on conservative default values and are presented in Table V. The exposure values for the on-site construction worker and the on-site commercial/industrial workers were primarily obtained from the 2005 DTSC guidance entitled Human and Ecological Risk Division (HERD) HHRA Note Number 1, Issue: Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities (DTSC, 2005b). Other key guidance documents included the 2002 EPA guidance entitled Supplemental Guidance for Developing Screening Levels for Superfund Sites (EPA 2002a) and the 2005 OEHHA document entitled Human-Exposure-Based Screening Numbers

Developed to Aid in Estimation of Cleanup Costs for Contaminated Soil (OEHHA, 2005).

For noncarcinogenic effects, intake is averaged over the period of exposure and is referred to as the average daily intake (ADI). For carcinogenic effects, the intake is averaged over a lifetime and is referred to as the lifetime average daily intake (LADI). The following general equation was applied to estimate COPC intake for each potentially complete exposure pathway considered in this HHRA:

$$\text{Intake} = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AT} \quad (\text{Equation 5})$$

where

Intake =	ADI (mg/kg-day) for noncarcinogens LADI (mg/kg-day) for carcinogens
C =	EPC of COPC in environmental medium (e.g., mg/kg for soil; or, mg/m ³ in air)
IR =	Intake rate (e.g., mg soil/day; or, m ³ air/day)
EF =	Exposure frequency (days/year)
ED =	Exposure duration (years)
RAF =	Relative absorption factor (i.e., the ratio of bioavailability in the exposure scenario to bioavailability in the exposure situation from which the toxicity criteria is based)
BW =	Body weight (kg)
AT =	Averaging time (days)

A description of the derivation of COPC intake for each of the potentially complete exposure pathways is presented in the following sections.

1.2.3.1 Incidental Ingestion of Soil

The equation used to estimate COPC intake due to incidental ingestion of soil is presented below:

$$\text{Intake} = \frac{CS \times IR \times CF \times EF \times ED \times RAF}{BW \times AT} \quad (\text{Equation 6})$$

where

CS =	EPC of COPC in soil (mg/kg)
IR =	Ingestion rate of soil (mg/day)
CF =	Conversion factor (1 x 10 ⁻⁶ kg/mg)
EF =	Exposure frequency (days/year)

ED	=	Exposure duration (years)
RAF	=	Relative absorption factor (unitless)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

1.2.3.2 Dermal Contact with Soil

The equation used to estimate COPC intake due to dermal contact with soil is presented below :

$$\text{Intake} = \frac{\text{CS} \times \text{AF} \times \text{SA} \times \text{CF} \times \text{EF}_1 \times \text{EF}_2 \times \text{ED} \times \text{ABS}_d}{\text{BW} \times \text{AT}} \quad (\text{Equation 7})$$

where

CS	=	EPC of COPC in soil (mg/kg)
AF	=	Soil adherence factor (mg/cm ² -event)
SA	=	Surface area of exposed skin (cm ²)
CF	=	Conversion factor (1 x 10 ⁻⁶ kg/mg)
EF ₁	=	Exposure frequency (days/year)
EF ₂	=	Contact rate (event/day)
ED	=	Exposure duration (years)
ABS _d	=	Dermal absorption fraction (unitless)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

1.2.3.3 Inhalation of Fugitive Dusts

The equation used to estimate COPC intake due to inhalation of fugitive dust is presented below :

$$\text{Intake} = \frac{\text{CS} \times \text{BR} \times \text{EF} \times \text{ED}}{\text{PEF} \times \text{BW} \times \text{AT}} \quad (\text{Equation 8})$$

where

CS	=	EPC of COPC in soil (mg/kg)
BR	=	Breathing rate (m ³ /day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
PEF	=	Particulate emission fraction (m ³ /kg)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

1.2.3.4 Inhalation of Vapors in Indoor Air or Ambient Air

The equation used to estimate COPC intake due to inhalation of indoor air is presented below :

$$\text{Intake} = \frac{\text{CA} \times \text{BR} \times \text{EF}_1 \times \text{EF}_2 \times \text{ED}}{\text{BW} \times \text{AT}}$$

(Equation 9)

where

CA	=	EPC of COPC in indoor air or ambient air (mg/m ³)
BR	=	Breathing rate (m ³ /hr)
EF ₁	=	Exposure frequency (days/year)
EF ₂	=	Exposure frequency (hours/day)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

1.3 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure to a COPC and the nature and magnitude of adverse health effects that may result from each exposure. For purpose of human health risk assessment, adverse health effects are classified into two broad categories: noncarcinogens and carcinogens. Toxicity values are generally developed based on the threshold approach for noncarcinogenic effects and the non-threshold approach for carcinogenic effects. Toxicity values may be based on epidemiological studies, short-term human studies, or subchronic or chronic animal data. Toxicity values to estimate adverse noncarcinogenic health effects as hazard quotients (HQs) are derived using reference doses (RfDs), and toxicity values to estimate incremental lifetime cancer risks (ILCRs - also typically referred to as excess lifetime cancer risks) are derived using cancer slope factors (SFs).

1.3.1 Adverse Noncarcinogenic Health Effects

It is widely accepted that adverse noncarcinogenic health effects from chemical substances occur only after a threshold dose or intake is reached. For the purposes of establishing a toxicity value for an adverse noncarcinogenic health effect, a threshold dose is usually estimated from the no-observed-adverse-effect-level (NOAEL) or the lowest-observed-adverse-effect-level (LOAEL) determined from chronic or subchronic animal studies. The NOAEL is the highest dose at which no adverse effects are observed, while the LOAEL is the lowest dose at which adverse effects are observed.

Safety factors are applied to the NOAEL or LOAEL observed in animal studies or human epidemiological studies to establish RfDs or "reference concentrations." A reference concentration for inhalation exposures may be converted to an RfD. An RfD is an estimate of a dose level that is not expected to result in adverse health effects in humans, even among the most sensitive members of the population (EPA, 1989). A

subchronic RfD is defined as an acceptable estimated daily exposure over a portion of a lifetime (2 weeks to 7 years), while a chronic RfD is defined as an acceptable daily exposure over an entire lifetime (greater than 7 years) (EPA, 1989). RfDs are expressed as acceptable daily doses in milligrams of chemical per kilogram of body weight per day (mg/kg-day). For the evaluation of exposure to lead, an acceptable blood lead level threshold has been established as described in section 1.4.2.

1.3.2 Carcinogenic Health Effects

Regulatory agencies have generally assumed that carcinogenic agents do not have toxicological thresholds. The dose-response curve used for regulation of carcinogens only predicts zero risk when there is zero dose (i.e., for doses greater than zero, some risk is assumed to be present). Cancer risks from potential human exposures to carcinogenic chemicals are modeled mathematically using either animal or human data.

Cancer risks for exposure to carcinogens are defined in terms of upper bounds on probabilities. The probabilities identify the likelihood of a carcinogenic response in an individual that receives a given dose of a particular chemical (based on mathematical modeling of the animal or human data). Potential carcinogenic effects are expressed as the probability that an individual will develop cancer from a lifetime exposure. This probability is based on projected intakes and chemical specific dose-response data called slope factors (SFs). The SF defines the cancer risk due to average lifetime exposure to one unit of carcinogen (in units of risk per mg/kg-day written as the inverse of mg/kg-day)⁻¹.

To derive SFs, the EPA generally uses the linearized multistage model for low-dose extrapolation. The model is considered to be one of the most conservative models that may be applied and has been recognized by EPA to overpredict ILCRs. Using this model, SFs are derived by calculating the 95% UCL on the slope of the linearized portion of the dose-response curve obtained from the multistage cancer model. Use of the 95% UCL of the slope means that there is only a 5% chance that the probability of a response could be greater than the estimated value of the experimental data used.

1.3.3 Chemical-specific Toxicity Values

Chronic toxicity values for adverse cancer and non-cancer effects were conservatively used to evaluate both chronic and subchronic exposures for each COPC, with the exception of lead. For the identification of California toxicity values, when Cal/EPA toxicity values were not available, EPA toxicity values were used. The hierarchy of toxicity values used to identify the California toxicity values is based on the recommendations in the PEA Guidance Manual (DTSC, 1999), and is as follows:

1. Cal/EPA, OEHHA, Toxicity Criteria Database and August 2005 California Cancer Potency List, <http://www.oehha.ca.gov/risk/chemicalDB/index.asp>
2. Cal/EPA, Air Resources Board (ARB), Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values, 25 April 2005, <http://www.arb.ca.gov/toxics/healthval/healthval.htm>

3. Cal/EPA, OEHHA, Chronic Reference Exposure Levels (RELs) for Airborne Toxicants, February 2005,
http://www.oehha.ca.gov/air/chronic_rels/ATC_hrels.html
4. EPA, Region 9, toxicity values presented in the Preliminary Remediation Goals (PRG) Tables, 20 October 2004,
<http://www.epa.gov/region09/waste/sfund/prg/>

The selected toxicity values for the COPCs are presented in Table VI and are included in the risk calculations spreadsheets presented in Attachments 4 and 5. For the evaluation of exposure to lead, an acceptable blood lead level threshold has been established as described in section 1.4.2.

1.4 Risk Characterization

Risk characterization is the fourth step in the risk assessment process. Risk characterization includes the integration of the toxicity and exposure assessments to provide quantitative and qualitative expressions of risk.

1.4.1 Calculation of Adverse Noncarcinogenic Health Effects – Other Than Lead

The RfD is used in the risk characterization to estimate the potential for adverse noncarcinogenic health effects. The estimated ADI divided by the RfD is referred to as a hazard quotient (HQ). An HQ value greater than 1.0 indicates a chemical dose above the RfD for that pathway, and thus a potential for adverse noncarcinogenic health effects. A total HI is a sum of the HQs for more than one chemical with similar toxicological endpoints. A total HI greater than 1.0 indicates a potential for an adverse noncarcinogenic health effect from exposure to that chemical or chemicals that result in driving the total HI above 1.0.

As a first tier analysis, the HQs (e.g., for all COPCs, regardless of target organ) for each receptor can be summed as the basis for conservatively estimating a screening total HI for that receptor. In this case, it is assumed that each COPC acts by the same mechanism and induces the same effects (EPA, 1989). Typically, additional risk evaluation is undertaken when the HQs for each chemical are summed irrespective of their toxicological endpoints and that total HI exceeds a value of 1.0. Then acceptable target organ-specific total HIs can be calculated for the receptor based on target organs as recommended by EPA (1989).

Equations used to derive HQs and total HI are presented as follows. The HQ compares a receptor's exposure or intake level to the RfD of that COPC and complete pathway (EPA, 1989). To calculate an HQ, the ADI (e.g., upper bound intake averaged over the exposure period) for each COPC is divided by the chemical-specific RfD as shown in the following equation:

$$HQ_{\text{pathway1}} = ADI/RfD \quad (\text{Equation 10})$$

where

HQ _{pathway1}	=	HQ of particular pathway for COPC (unitless)
ADI	=	Average daily intake of COPC (mg/kg-day)
RfD	=	Reference dose of COPC (mg/kg-day)

When using the above equation to estimate the potential for adverse noncancer health effects, both the intake and the RfD must refer to exposures of equivalent duration (e.g., chronic).

For each receptor, the HQ of each pathway for the COPC is then summed to calculate the total HQ for that COPC as shown in the following equation:

$$\text{TotalHQ} = \text{HQ}_{\text{pathway1}} + \text{HQ}_{\text{pathway2}} + \dots + \text{HQ}_{\text{pathway n}}$$

(Equation 11)

where

TotalHQ	=	Summed HQs for COPC (unitless)
HQ _{pathway1}	=	HQ for particular pathway for COPC (unitless)

For simultaneous exposures to a receptor by several COPCs, a total HI is calculated as the sum of the HQs for each COPC by:

$$\text{TotalHI} = \text{HQ}(\text{COPC}_1) + \text{HQ}(\text{COPC}_2) + \dots + \text{HQ}(\text{COPC}_n)$$

(Equation 12)

where

TotalHI	=	Total Hazard Index
TotalHQ (COPC _n)	=	Sum of HQs for that COPC

1.4.2 Calculation of Adverse Noncarcinogenic Health Effects for Lead

Potential human health effects from exposure to lead are typically inferred from blood lead levels, rather than intake and, as such, are not amenable to the HQ/HI approach described in Section 1.4.1. Health risk from exposure to lead for the on-site construction worker and commercial/industrial worker was conservatively evaluated based on the default risk assumptions presented in the Version 7 of the DTSC Lead Risk Assessment Spreadsheet (LeadSpread) Model (DTSC, 2000) [included in Attachment 6] and the EPA Integrated Exposure Uptake Biokinetic Model for Lead (IEUBK) derived Region IX industrial soil preliminary remediation goal (PRG) (EPA, 2002a).

The blood lead concentration identified as acceptable, for both children and adults, is 10 micrograms per deciliter (µg/dL) (DTSC 1993, 1999) and will be applied to high end (i.e., RME) exposure estimates. While the LeadSpread Model calculates estimated 90th, 95th, 98th and 99th percentile blood lead concentrations, the DTSC identifies the

99th percentile blood lead as a "point of departure" (e.g., remedial actions are not warranted when predicted blood lead levels are at or below 10 µg/dL). The occupational worker threshold concentration identified in the LeadSpread Model using the DTSC default assumptions is 3,475 mg/kg. The DTSC also refers to the EPA IEUBK Model for adult receptor risk evaluations. The industrial soil PRG for lead based on the EPA IEUBK Model is 800 mg/kg. In addition, it should be noted that the California hazardous waste criterion for lead, as defined by the Total Threshold Limit Concentration (TTLIC), specified in California Code of Regulations (CCR) Title 22, is 1,000 mg/kg. For the purposes of this risk assessment, a lead concentration of 800 mg/kg was selected as the acceptable health-based lead target concentration for occupational workers.

1.4.3 Calculation of Cumulative Incremental Lifetime Cancer Risk

The SF is used in the risk characterization to estimate the cancer risk. The SF multiplied by the LADI is referred to as an ILCR. For each COPC identified as a potential human carcinogen, the theoretical upper bound ILCR for a particular receptor is the sum of the calculated ILCRs for each COPC.

To calculate an ILCR, the LADI (e.g., upper bound intake averaged over a lifetime) for each COPC is multiplied by the chemical-specific SF as shown in the following equation:

$$\text{ILCR} = (\text{LADI}) \times (\text{SF}) \quad (\text{Equation 13})$$

where

ILCR	=	Incremental lifetime cancer risk for COPC, also referred to as excess lifetime cancer risk (unitless)
LADI	=	Lifetime average daily intake of COPC (mg/kg-day)
SF	=	Slope factor of COPC (mg/kg-day) ⁻¹

For each receptor, the ILCR of each pathway for the COPC is then summed to calculate the ILCR for that COPC as shown in the following equation:

$$\text{ILCR}_{\text{COPC}} = \text{ILCR}_{\text{pathway1}} + \text{ILCR}_{\text{pathway2}} + \dots + \text{ILCR}_{\text{pathway}_n} \quad (\text{Equation 14})$$

where

ILCR _{COPC}	=	Summed ILCR for COPC (unitless)
ILCR _{pathway1}	=	ILCR for particular pathway for COPC (unitless)

If a receptor is exposed to several carcinogens, the following equation is used to sum cancer risks:

$$\text{Cumulative ILCR} = \text{ILCR (COPC}_1) + \text{ILCR (COPC}_2) + \dots + \text{ILCR (COPC}_n)$$

(Equation 15)

where

Cumulative ILCR = Total risk of cancer incidence for all COPCs
 ILCR (COPC_n) = Individual COPC ILCR

1.4.4 Acceptable Risk Thresholds

Estimates of the Site-specific noncancer HI and cumulative ILCR are compared to acceptable target levels by risk managers. There is some variability in acceptable cumulative ILCRs established by various regulatory agencies, although the acceptable target level for HIs is generally less than or equal to 1.0 and most target cumulative ILCRs considered acceptable lie within the risk range of 10^{-6} to 10^{-4} .

Total Noncancer Hazard Index - The HI evaluation process typically occurs in two steps. First, the HQs for all COPCs are added and compared to an acceptable target total HI. If the calculated value is greater than the acceptable target level, then for the second step only total HQs for those compounds considered to have additive adverse noncarcinogenic health effects are summed to refine the HI estimate.

An HI of less than 1.0 indicates that it is unlikely that adverse human health effects will occur during a lifetime in an exposed population, including sensitive subpopulations (EPA, 1989). Most environmental programs employ an HI of unity (i.e., 1) as an acceptable target for risk decisions. The most explicit directive comes from the federal Superfund program (EPA, 1990), which is Cal/EPA policy as well. This directive specifies an HI of 1.0 as the acceptable target for risk management decisions, as well as the acceptable target risk to be achieved in designing remedial responses. This noncancer risk threshold was used in this HHRA as the acceptable total HI to assess whether exposure to COPCs at the Site may pose an adverse noncarcinogenic effect.

Cumulative Incremental Lifetime Cancer Risk - Potential risk estimates between 10^{-6} and 10^{-4} require risk management decisions based on site-specific land use/exposure scenarios and may require remediation (EPA, 1990). Risk estimates that are greater than 10^{-4} generally require remediation to reduce potential exposures.

A cumulative ILCR of 10^{-6} to 10^{-4} corresponds to theoretical probability of 1 chance in 1 million to 1 chance in ten thousand, which is in addition to or in excess of the background cancer risk. The conservatism of such risk increments is enhanced by the fact that risk is typically expressed as an upper bound ILCR. That is, true risk is anticipated to lie somewhere between zero and the upper bound risk estimated in the risk characterization (EPA, 1989).

Potential risk estimates between 10^{-6} and 10^{-4} require risk management decisions based on site-specific land use/exposure scenarios and may or may not require remediation or mitigation. It is generally widely accepted in the regulatory community that risk

estimates that are equal to or less than 10^{-6} do not require remediation or mitigation measures. Risk estimates that are greater than 10^{-4} generally require remediation or mitigation to reduce potential exposures. California Proposition 65 (1986, Safe Drinking Water and Toxic Enforcement Act of 1986, Proposition 65, Health and Safety Code Section 25249.5 et seq.) requires specific notification and warning for exposure to carcinogens above the "no significant risk level," which is based on a 10^{-5} excess lifetime cancer risk. In addition, the EPA, under the RCRA Corrective Action Environmental Indicators (EI) program (EPA, 2005), indicates that "For the purposes of making Current Human Exposure under Control EI determinations with respect to vapor intrusion, EPA generally recommends the use of 10^{-5} levels for carcinogens (incremental individual lifetime cancer risk), and a Hazard Quotient (HQ) of 1 for non-cancer risk." Within this range of acceptable risk values, the Cal/EPA and EPA typically default to an acceptable cumulative ILCR threshold of 10^{-5} in risk management decision making for occupational receptors (e.g., on-site construction worker and commercial/industrial worker). This cumulative ILCR threshold was used in this HHRA as the acceptable cumulative ILCR to assess whether exposure to COPCs at the Site may pose an unacceptable cancer risk.

1.4.5 Summary of Risk Characterization Results

The risk characterization results for the on-site construction worker, the on-site commercial/industrial worker inside buildings, and the on-site commercial/industrial worker outside buildings are summarized below and in Table VII. The associated risk calculations are presented in Attachments 4 and 5.

1.4.5.1 On-site Construction Worker

Based on the results of this HHRA for the future on-site construction worker, the cumulative ILCR is 7×10^{-4} , and the total HI is 455. The cumulative ILCR is greater than the acceptable cumulative ILCR threshold of 1×10^{-5} , and the total HI is greater than the acceptable total HI of 1.0. In addition, the highest measured lead concentration in soil at the Site is 643,891 mg/kg, which is greater than the acceptable health-based lead threshold of 800 mg/kg for occupational workers. Therefore, mitigation is necessary to protect the on-site construction worker.

1.4.5.2 On-site Commercial/Industrial Worker

Based on the results of this HHRA for the future on-site commercial/industrial worker, the cumulative ILCR is 5×10^{-3} , and the total HI is 122, which included the highest of the estimated risks for inhaling indoor air concentrations from subsurface vapor intrusion. The cumulative ILCR is greater than the acceptable cumulative ILCR threshold of 1×10^{-5} , and the total HI is greater than the acceptable total HI of 1.0.

The estimated pathway-specific risks for inhaling indoor air using soil gas data collected at approximately:

- 5 feet bgs are a cumulative ILCR of 2×10^{-5} and a total HI is 1.8,

- 10 feet bgs are a cumulative ILCR of 2×10^{-6} and a total HI is 0.091,
- 15 feet bgs are a cumulative ILCR of 3×10^{-6} and a total HI is 0.21, and
- 20 feet bgs are a cumulative ILCR of 2×10^{-6} and a total HI is 0.11.

Only the cumulative ILCR at 5 feet bgs is greater than the acceptable cumulative ILCR threshold of 1×10^{-5} , and only the total HI at 5 feet bgs is greater than the acceptable total HI of 1.0. Therefore, mitigation is necessary to protect the on-site commercial/industrial worker 5-foot soil gas sample data. The HHRA results for the other deeper depths do not warrant mitigation activities. In addition, the highest measured lead concentration in soil at the Site is 643,891 mg/kg, which is greater than the acceptable health-based lead threshold of 800 mg/kg for occupational workers.

In general, based on the results of this HHRA for the future on-site commercial/industrial worker, mitigation is necessary to protect the on-site commercial/industrial worker.

1.4.6 Uncertainty Analysis

It should be noted that the above risk estimates are conservative estimates of potential future health risks. The EPA and DTSC guidance documents for risk assessment provide a systematic means for organizing, analyzing, and presenting information on the nature and magnitude of risk to public health posed by chemical exposures. Despite the advanced state of current risk assessment methodology, uncertainties and limitations are inherent in the risk assessment process. In an attempt to minimize the consequences of uncertainty, regulatory guidance typically relies on the use of conservative estimates of adverse health effects in the absence of strong scientific data. Because multiple conservative assumptions are used, the overall risk characterization results are much more likely to overestimate the potential risk rather than to underestimate it.

The risk estimates presented herein are likely overestimates of risk for the following reasons:

- Use of the maximum concentrations assumes that a person would be exposed to a maximum concentration during their entire exposure duration, which is unlikely. It is more realistic to assume that a person may be exposed to representative average concentrations. Thus, the use of maximum concentrations overestimates risk.
- It is also assumed that COPC concentrations would remain constant over time. It is more likely that, due to natural degradation processes, organic COPC concentrations would decrease over time. Thus, estimated organic COPC intakes would decrease over time, which would result in lower risk estimates than presented herein.
- Risk assessments require assumptions in order to assess potential human exposure. This HHRA includes assumptions about general characteristics and potential patterns of human exposure. RME exposures were calculated to provide some measure of the range and uncertainty in potential exposures. The

RM E case is developed to provide an upper bound on exposure. For instance, it was conservatively assumed that an on-site construction worker would be at the Site for a period of 250 days over a period of one year, when it is likely more realistic that the longest any one particular construction worker (e.g., grader, electrician, plumber) would be on site is significantly less. Because RM E estimates are based on a combination of conservative assumptions, the estimates likely overpredict exposures that would generally be encountered.

- Toxicity values used in risk assessments present overestimates of the potential toxicity of these chemicals to humans. Assumptions used to develop toxicity values include the addition of safety factors to account for uncertainties associated with extrapolating high doses to low doses where chronic environmental exposures would occur, and to account for uncertainties associated with the use of laboratory animal studies to assess potential toxicity to human receptors.

1.5 Development of Remediation Criteria

The acceptable risk thresholds identified herein were exceeded in the HHRA for each of the future on-site receptors. The COPCs with EPCs that contributed the most to the risk threshold exceedances, referred to as risk drivers, were identified. Target exposure point concentrations (target EPCs) were derived for the chemical risk drivers, and either identified maximum chemical concentrations, or maximum chemical concentrations in the 95% UCL dataset as the cumulative risk-based remediation criterion.

The cumulative risk-based remediation criterion for lead was further lowered to provide an additional factor of safety to protect public health, and the cumulative risk-based remediation criterion for lead was further lowered to address potential concerns that "hot spots" of arsenic impacted soil may be left in place after completion of remediation activities.

1.5.1 Derivation of Cumulative Risk-Based Remediation Criteria

Target EPCs were derived by lowering the concentrations of these risk drivers in the HHRA calculations until the risk thresholds were met for each of the receptors. These lowered EPC concentrations were identified as the target EPCs. From these target EPCs, the cumulative risk-based remediation criteria were derived as follows:

1. The remediation criterion for select chemicals (total PCBs, antimony, and arsenic) where the 95% UCL concentration was used as the EPC was calculated by re-deriving the 95% UCL concentration after eliminating elevated COPC concentrations in the dataset until the 95% UCL concentration was equal to or less than the target EPC. The remediation criterion was set as the highest concentration in the dataset where the target EPC (95% UCL concentration) was met. In that case, after remediation, the 95% UCL concentration of the residual concentrations of those COPCs would meet the target EPC; however, some residual concentrations at the subject site could exceed the target EPC.
2. The remediation criterion was set as equal to the target EPC for chemicals (hexavalent chromium, and some organic chemicals) where the maximum concentration was used as the

EPC and for select chemicals (PAHs and lead) where the 95% UCL concentration was used as the EPC.

The calculations presenting the derivation of these cumulative risk-based remediation criteria are presented in the Attachment 7.

1.5.2 Additional Evaluation of Remediation Criteria for Lead

For lead, the risk-based remediation criterion developed using the Lead Spread Model is 6,650 mg/kg, based on the post-remediation calculated 95% UCL concentration. However, Delphi has decided to set the remediation criteria to 800 mg/kg as the remediation criterion for lead at the Site to be consistent with the EPA Region IX industrial soil PRG.

1.5.3 Additional Evaluation of Remediation Criteria for Arsenic

For arsenic, an additional evaluation was conducted to address potential concern that "hot spots" may be left in place after completion of remediation activities. Based on the above remediation criteria derivation methodology, the cumulative risk-based remediation criterion for arsenic is 21.9 milligrams per kilogram (mg/kg). To evaluate whether this potential "hot spot" concern may be valid, the target EPCs were compared to the cumulative risk-based remediation criterion for each chemical risk driver. These remediation criteria were also compared to the residual concentrations that would be left in place after remediation of areas where sample results exceed the cumulative risk-based remediation criteria. A table of these comparisons is presented as Table V III.

Figures G 1 through G 11 were created to illustrate the identification of possible "spot hot" locations. These figures show :

- The locations of sample points (in red) that will be remediated based on concentrations of COPCs exceeding of the cumulative risk-based remediation criteria,
- The locations of sample points (in purple) with arsenic concentrations between the target EPC and the cumulative risk-based remediation criterion, that will be remediated due to interpretation as being within a "hot spot" (i.e., soil samples that contain arsenic concentrations greater than approximately 10 mg/kg),
- The locations of sample points (in blue) have concentrations of COPCs between the target EPCs and the cumulative risk-based remediation criteria that are not proposed for remediation, and
- The locations of sample points (in green) have concentrations of COPCs below the cumulative risk-based remediation criteria and that therefore would remain in place.

As noted in Figures G 1 through G 11 and on Table V III, additional remediation activities beyond what would be warranted by the cumulative risk-based remediation criterion are proposed to reduce residual arsenic concentrations at the Site to 9.05 mg/kg. These additional locations (highlighted in purple) include:

- Ten additional sample locations (which contain thirteen soil samples), and

- Sixteen additional soil sample locations at shallower or deeper depth at locations where remediation was proposed based on concentrations of other COPCs exceeding the cumulative risk-based remediation criterion.

Based on this evaluation, the remediation criterion for arsenic was revised to 9.05 mg/kg.

No additional remediation is proposed specifically for antimony and total PCBs. However, because these chemicals and other chemicals are, in some cases, co-located with elevated arsenic concentrations, additional excavation of antimony and PCB in impacted soils will be conducted as part of those remediation activities.

1.5.4 Summary of Remediation Criteria

The proposed remediation criteria are presented in Table IX. Note that the remediation criteria for soil is applicable for the upper 10 feet of soil, and the remediation criteria for soil gas is applicable to depths less than 15 feet bgs.

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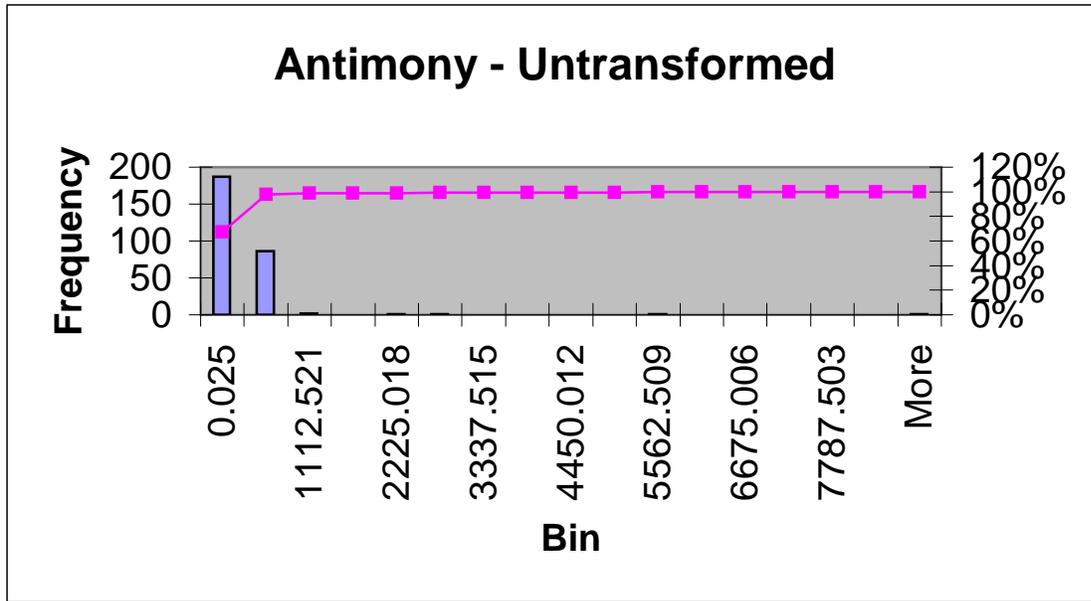
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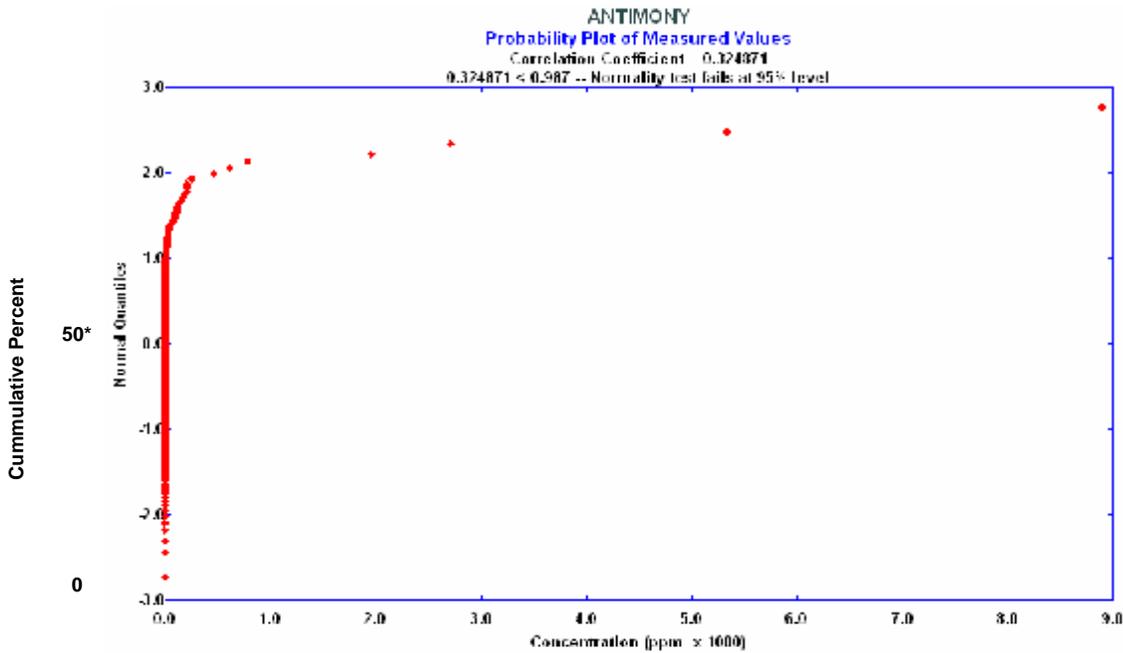
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ATTACHMENT 1
BACKGROUND METALS EVALUATION



Histogram generated using Microsoft Excel Version 2002.



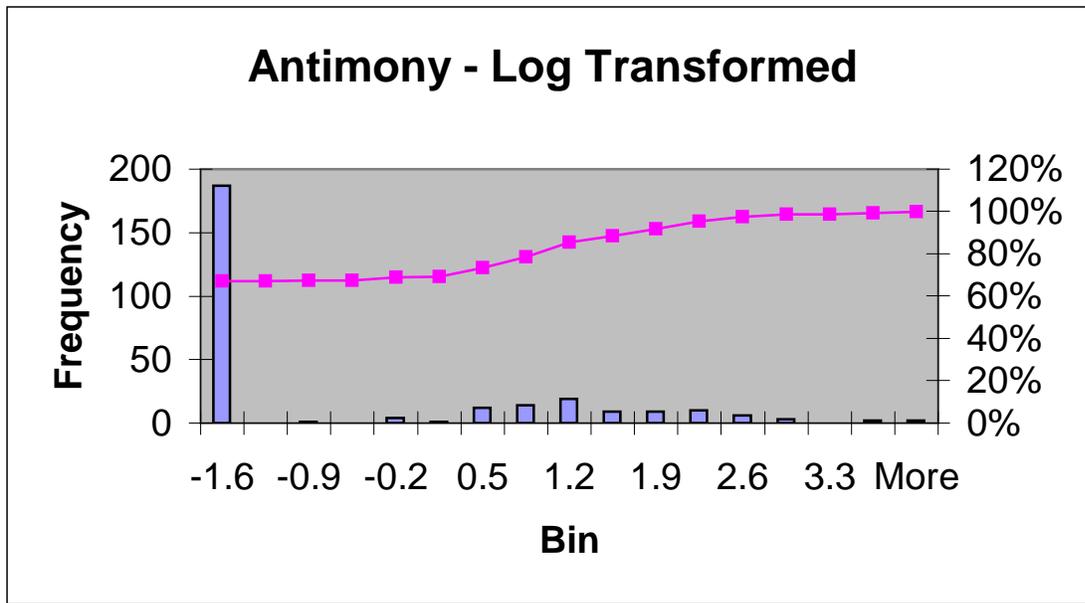
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

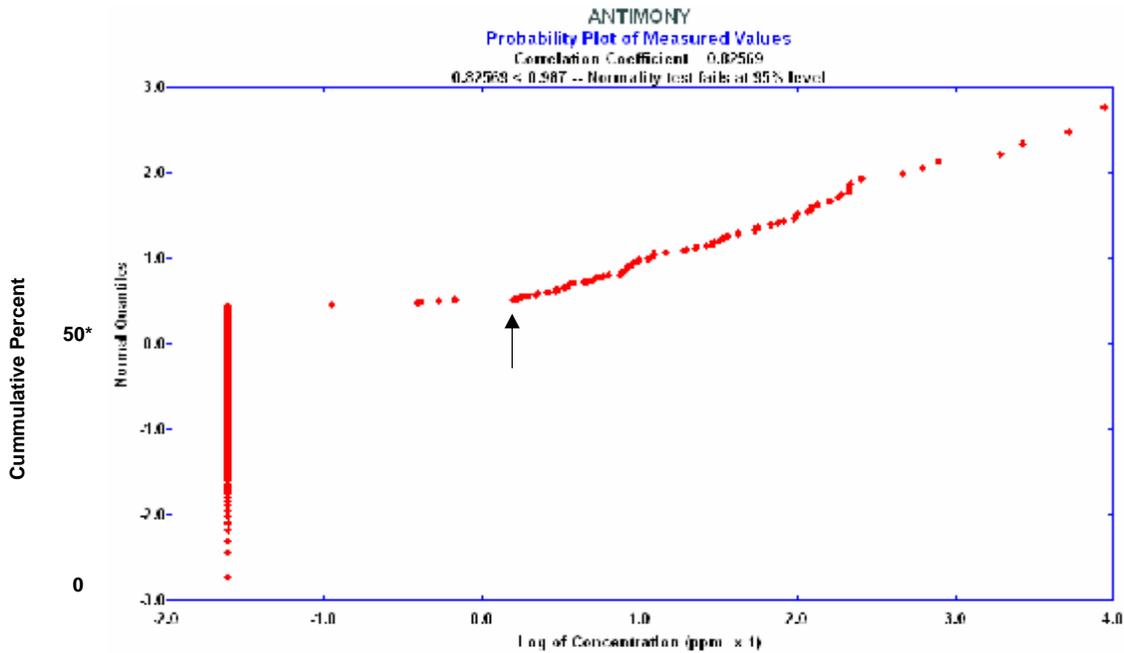
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that the antimony background concentration is 1.6 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



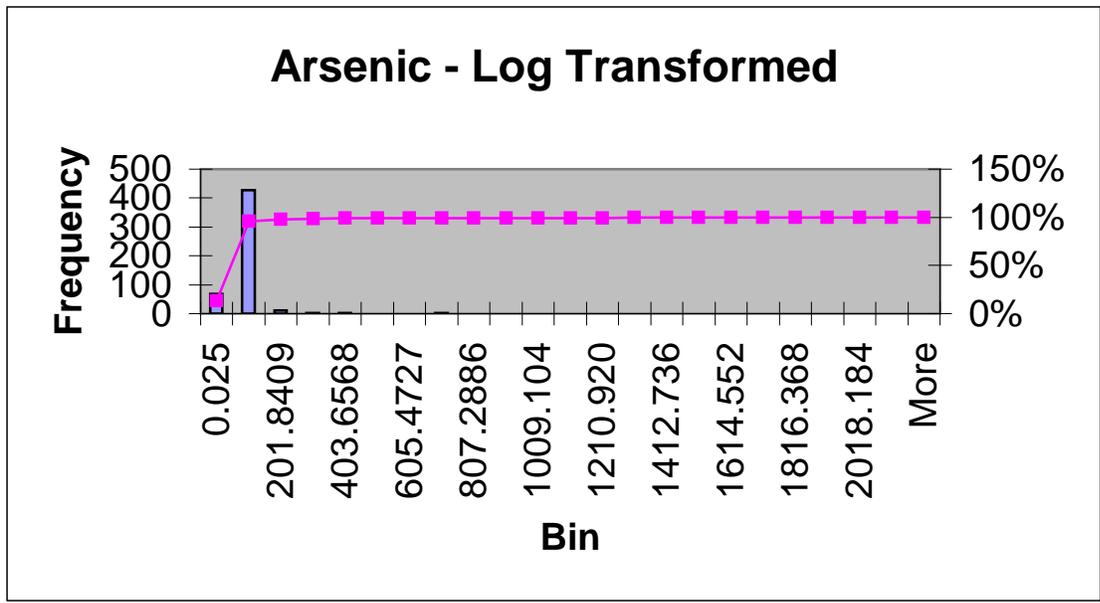
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

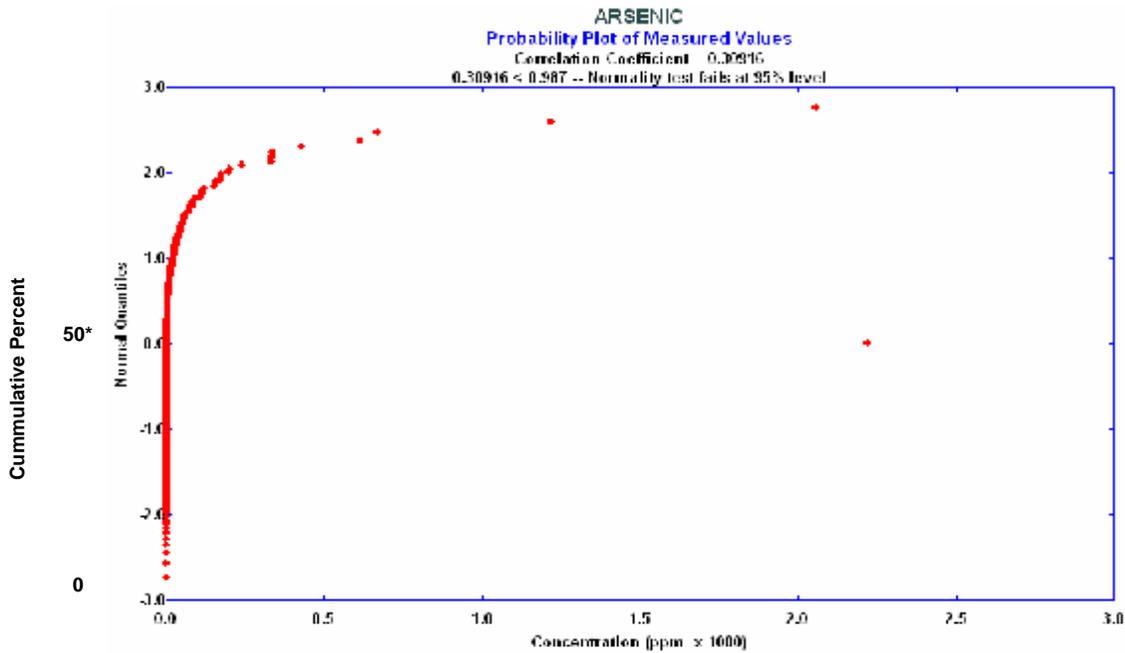
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that the antimony background concentration is 1.6 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



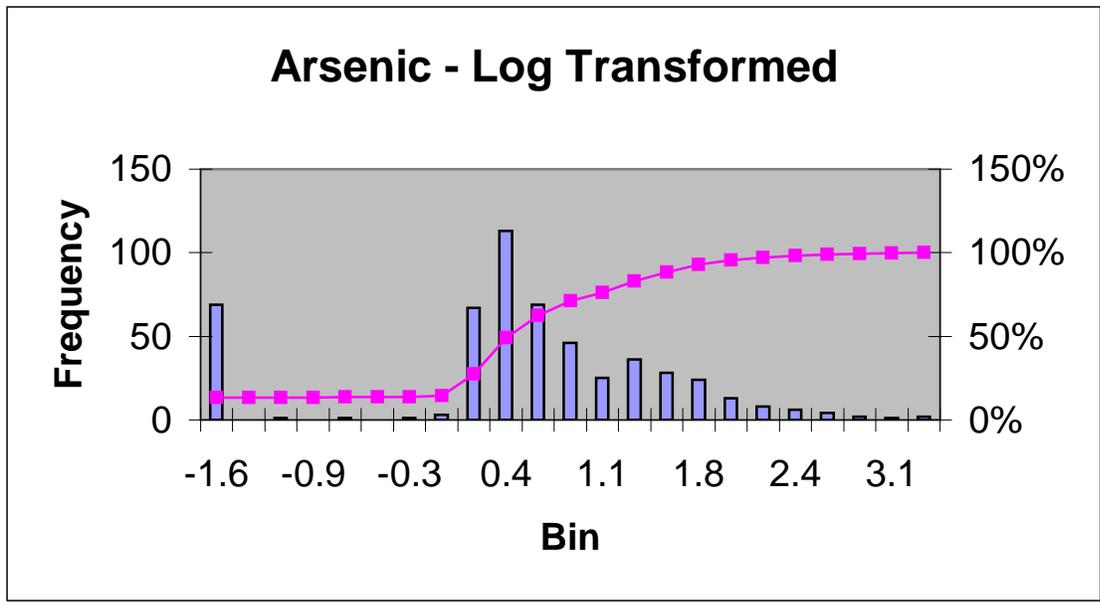
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

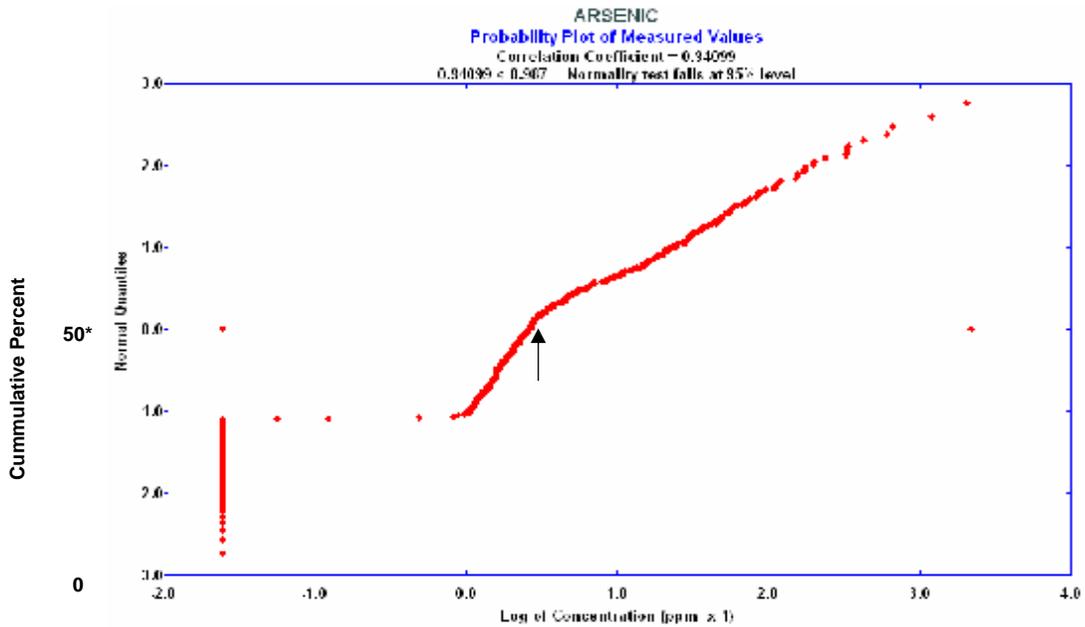
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that arsenic background concentration is 5.6 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



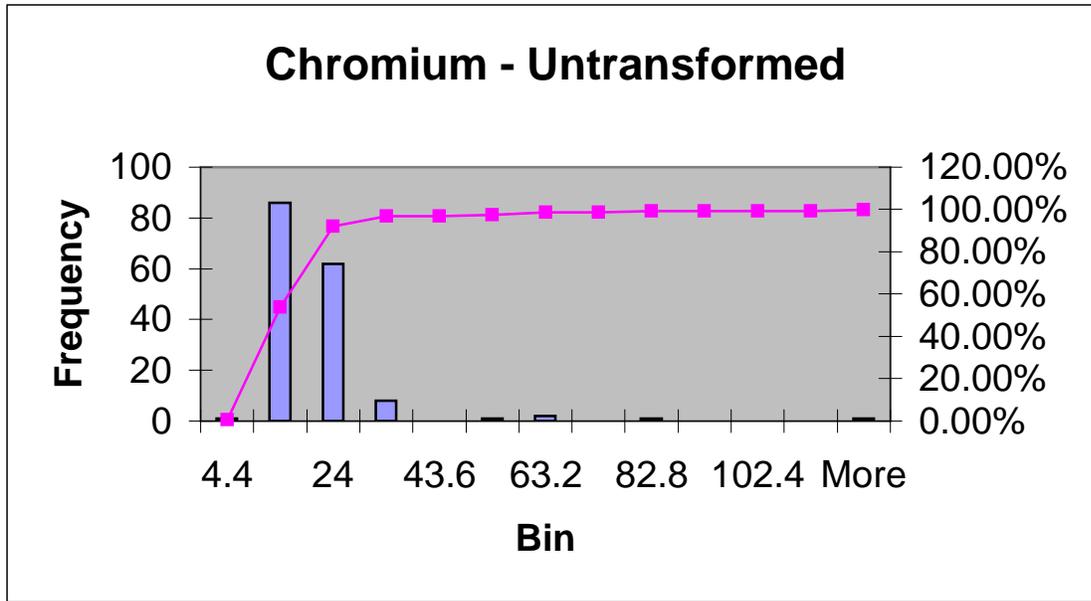
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

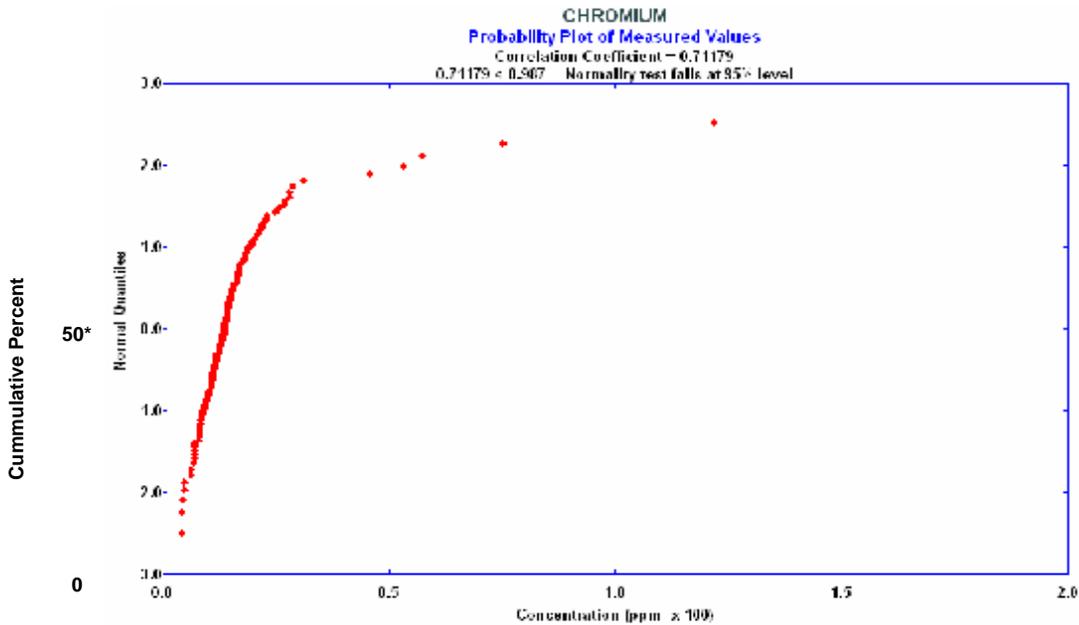
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that arsenic background concentration is 5.6 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



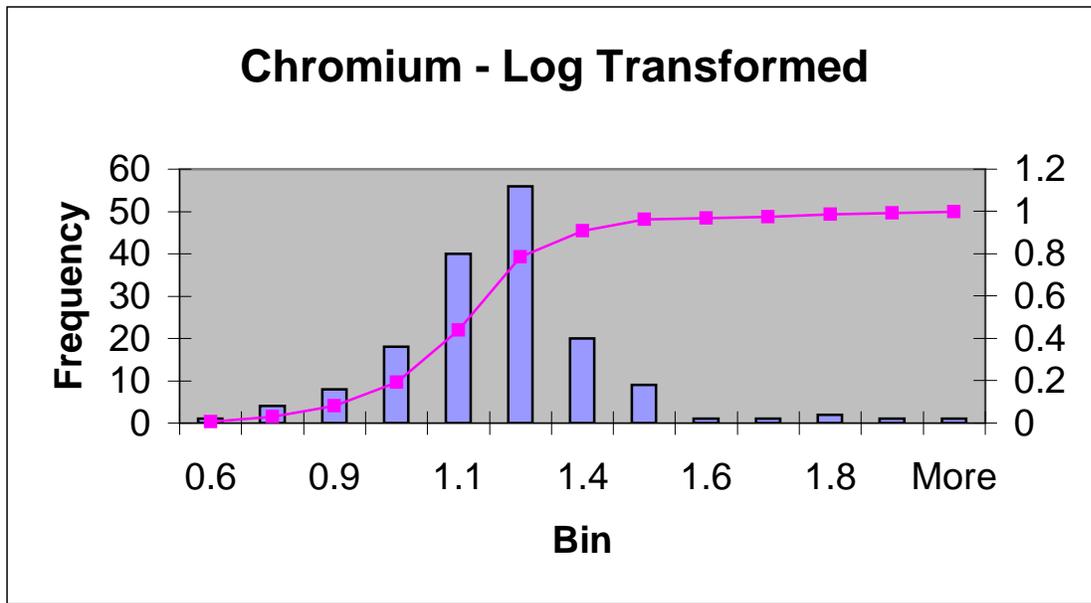
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

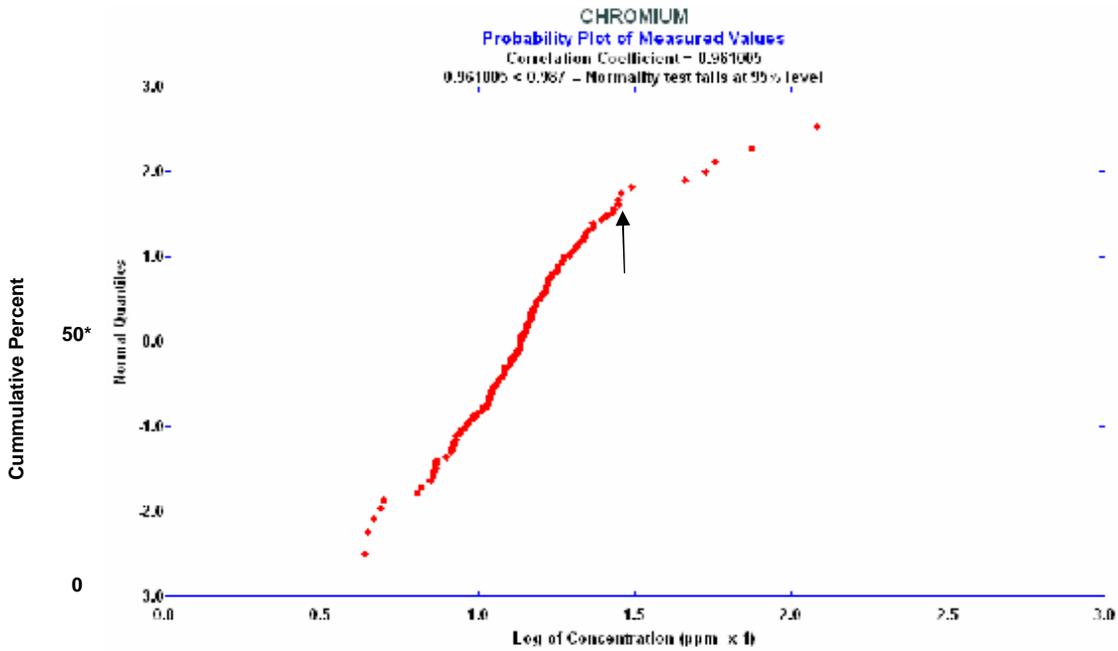
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that chromium background concentration is 31.2 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



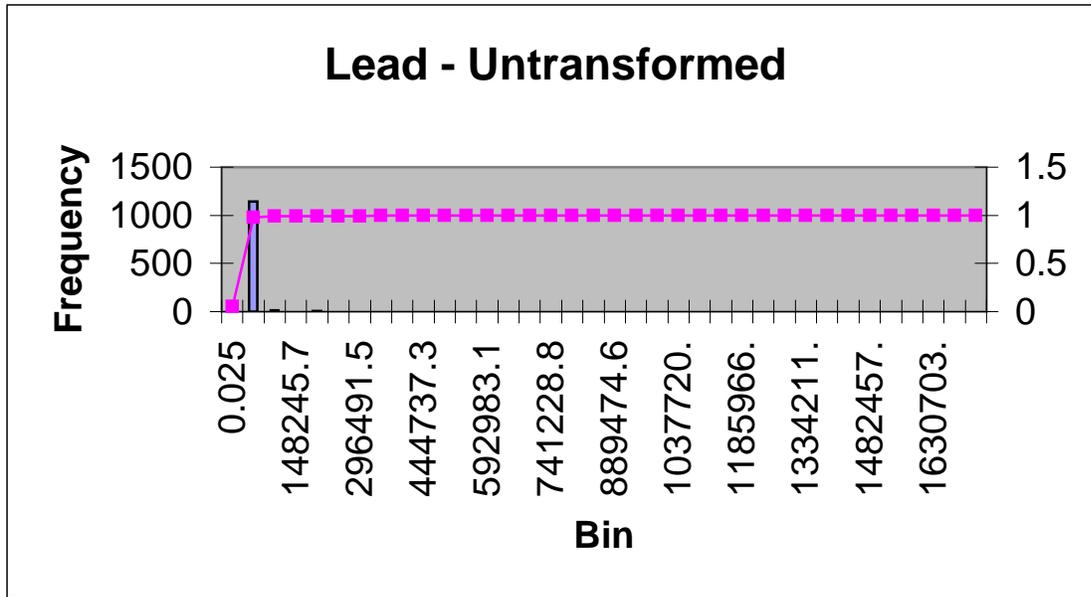
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

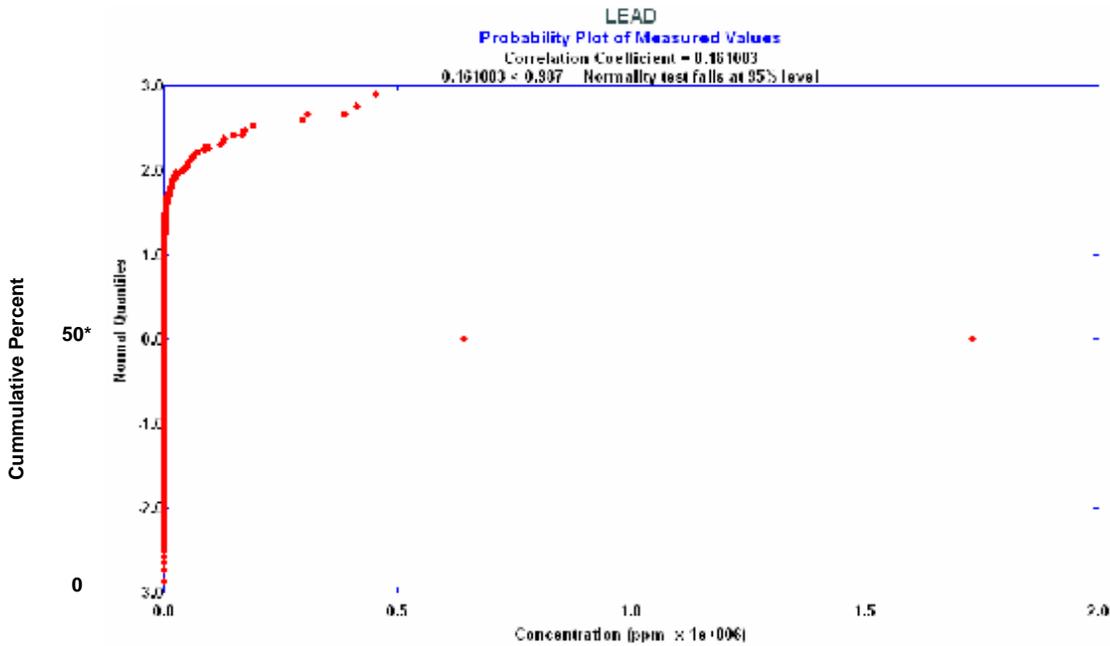
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that chromium background concentration is 31.2 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



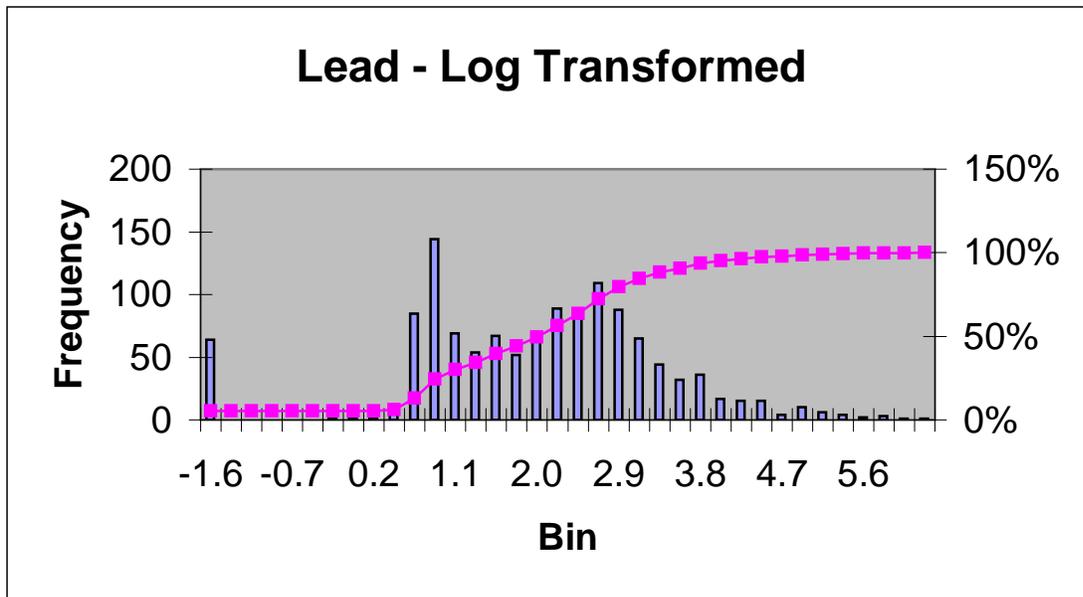
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

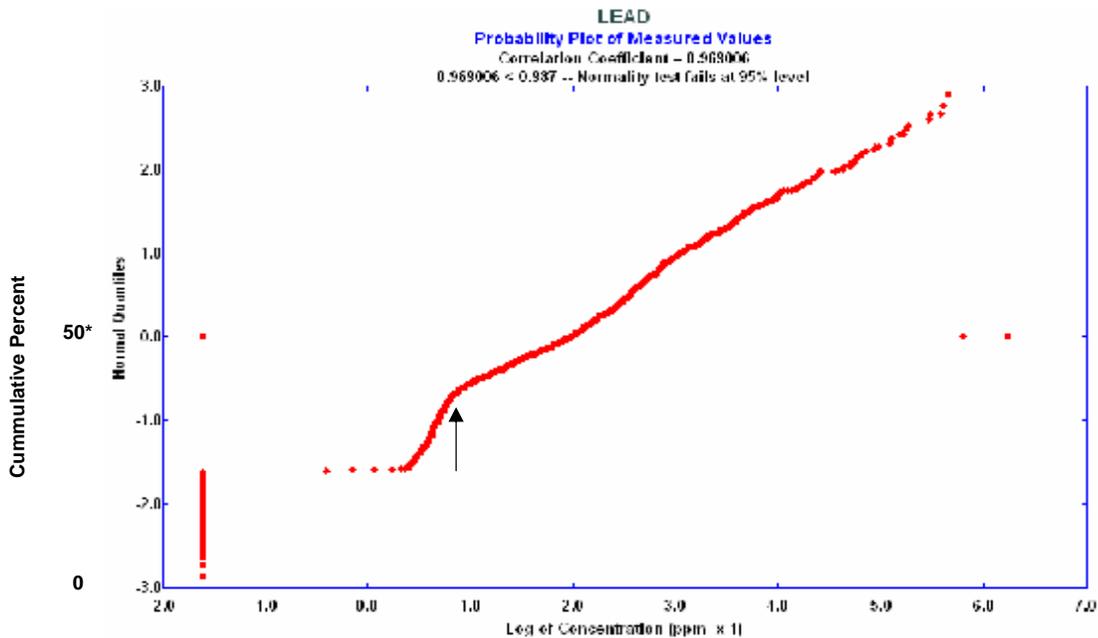
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that lead background concentration is 9 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



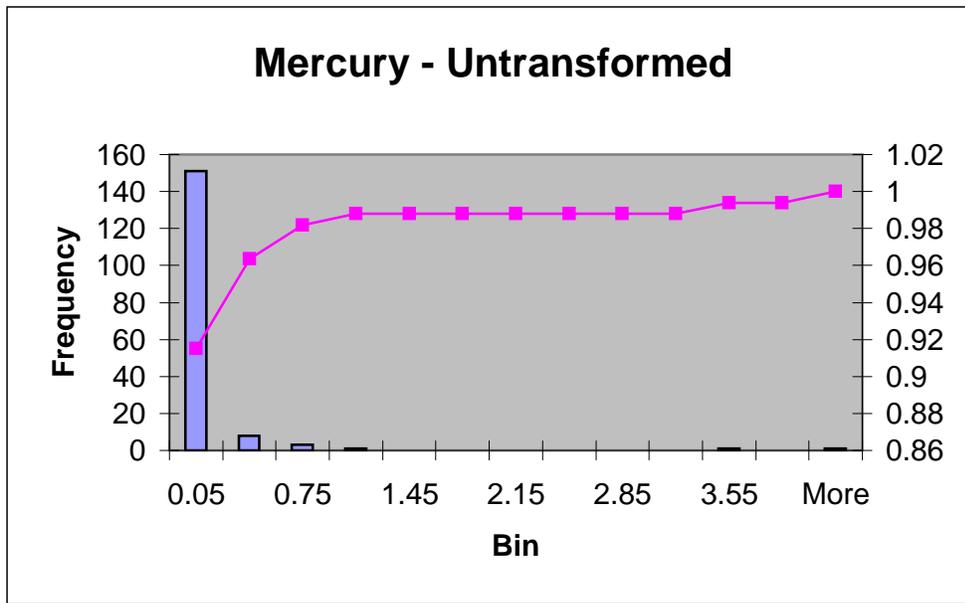
Probability plot generated using ChemStat Version 6.1, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

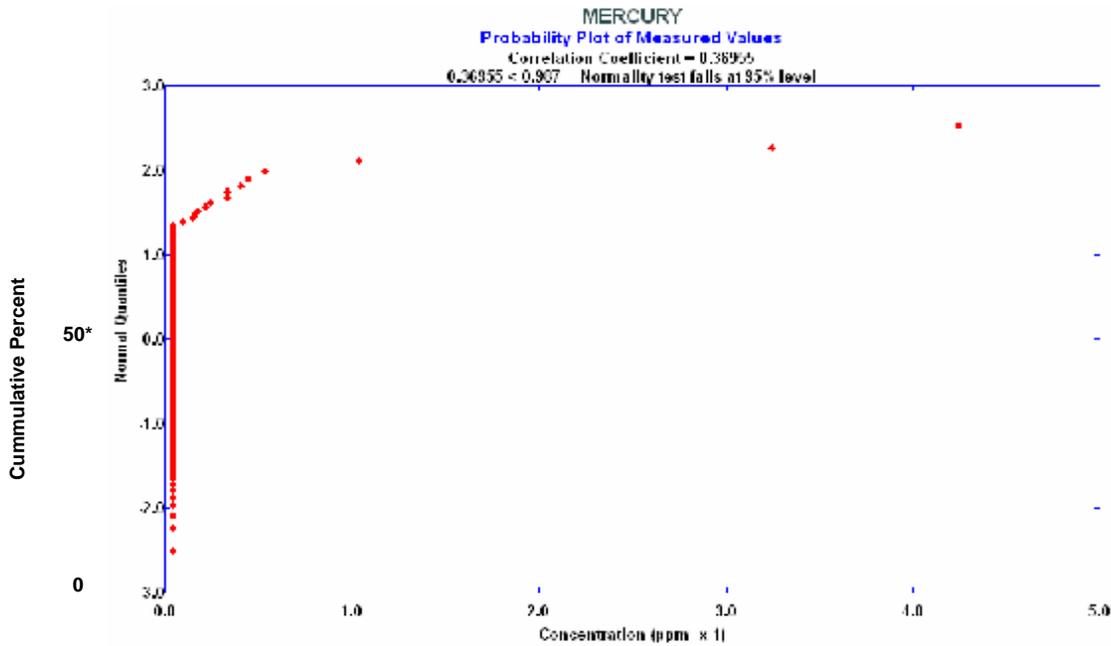
EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that lead background concentration is 9 mg/kg.



Histogram generated using Microsoft Excel Version 2002.



Probability plot generated using ChemStat Version 6.0, which complies with 1989 and 1992 United States Environmental Protection Agency (USEPA) statistical guidance documents.

* Median = 0.0 Normal Quantile or 0.5 (50%) Percentile

EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA, Facilities, Interim Final Guidance. PB89-151047. April.

EPA, 1992. Statistical Training Course for Ground Water Monitoring Data Analysis. EPA530-R-93-003.

Decision: Based on a review of the log transformed data, it was concluded that the mercury concentrations are within background.