ATTACHMENT U-6

SITE-SPECFIC BIOTA UPTAKE AND REGRESSION ANALYSIS

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1. Tissue and Co-Located Soil/Sediment Box Plots and Summary Statistics
2. Tissue and Co-Located Soil/Sediment Regressions

1.0 INTRODUCTION

This attachment describes the development of site-specific bioaccumulation or uptake factors using co-located biota and soil/sediment data from three onsite study areas and from the background area to support a Tier 2 ecological risk assessment (ERA) at the former Casmalia Hazardous Waste Management Facility located in Casmalia, California (the Site). The Tier 2 ERA was conducted to further evaluate exposure pathways, ecological receptors, and chemicals of interest (COIs) identified as having unacceptable risks to ecological receptors at the Site in the Tier 1 ERA. The Tier 2 assessment included the collection of site-specific data to support biota uptake analyses designed to make the assessment more site-specific and less generic. The Screening-level and Tier 1 ERAs relied on modeled/assumed bioaccumulation factors (BAFs) or regressions for uptake of chemicals into prey items (Attachment 1); such assumptions and models are more uncertain in predicting site-specific bioaccumulation than site-specific data given expected differences in chemical form, exposure duration, and other site-specific factors. Measurement of tissue concentrations in organisms at the Site addresses these factors and reduces uncertainty in the resulting risk estimates. Therefore, the primary objectives of this site-specific uptake and regression analyses were to:

- Address data needs identified in the Screening-Level and Tier 1 ERA; and
- Develop relationships between soil/sediment and tissue concentrations for COIs to validate and refine exposure models used in the Tier 2 ERA.

The study areas included in the site-specific evaluation were those which do not have a remedy in place or contemplated and these included the RCRA Canyon/West Canyon Spray Area, the Former Ponds and Pads Area/Remaining Site Areas, and the A-Series Pond. All samples were collected as described in the Sampling and Analysis Plan (SAP; CSC, 2009). This attachment describes the biota uptake and regression analyses that were performed on these data to develop site-specific soil/sediment-to-biota regressions and BAFs for estimating dietary exposures to ecological receptors. Note that data on tissue concentrations in organs (liver and kidney) of small mammals were also collected; these data are described in Attachment 7. Whole body concentrations were calculated prior to analysis using the approach described in Section 3.1.

1.1 Overview of Sampling Approach and Results

This section summarizes the sampling approach that was implemented to collect site-specific tissue and co-located soil/sediment data. The approach is described fully in the SAP (CSC, 2009). Sample locations were selected to represent a range of concentrations for the COIs identified in each terrestrial study area during the Remedial Investigation. Sample locations for the aquatic study area were selected in the field and were biased toward areas with suitable foraging habitat for representative ecological receptors of concern such as dabbling ducks and shorebirds.

1.1.1 Terrestrial Study Areas and Sampling

As described in the Appendix U and the SAP (CSC, 2009), the following chemicals were considered COIs for the terrestrial study areas based on the Tier 1 ERA:

- RCRA Canyon/West Canyon Spray Area
    - Barium;
    - Cadmium;
    - Chromium;
    - Copper;
    - Lead;
    - *Molybdenum*[1]*;*
    - *Vanadium*; and
    - Zinc.

- Former Ponds and Pads/Remaining Onsite Areas
    - Total polychlorinated biophenyls (PCBs);
    - Dichlorodiphenyldicloroethane (DDE); and
    - Total dichlorodiphenyltrichloroethane (DDT).

From the RCRA Canyon/West Canyon Spray Area, each type of food/prey sample was targeted at five sample locations (Figure U.A6-1). The individual organisms were composited and analyzed for the COIs listed above as a single sample representing that specific location (i.e., in this study area, five unique data points were targeted for each type of food/prey sample)[2]. The food/prey items from this study area included:

- Plants (grass and shrub samples were collected separately, where available);
- Soil Invertebrates; and
- Small mammals.

Targeted plant and soil invertebrate samples were collected from all the five locations at the RCRA Canyon/West Canyon Spray Area; mammals could be collected from only four out of five targeted locations (Table U.A6-1).

From the Former Ponds and Pads/Remaining Onsite Areas, each type of food/prey sample was targeted at seven sample locations (Figure U.A6-1). Subsamples were composited at each location and submitted for analysis as one single sample representing that specific location (i.e., in this study area, seven unique data points were targeted for each type of food/prey sample). Although metals were not considered COIs at the Former Ponds and Pads/Remaining Onsite Areas, samples were submitted for metals analysis in addition to the COIs listed above where sufficient sample mass could be obtained. The food/prey items from this study area included:

- Plants; and
- Soil Invertebrates.

[1] Molybdenum and vanadium were not identified as COIs in the SAP. The constituents were identified subsequent to the submittal of the SAP while addressing comments on the Tier 1 ERA provided by the regulatory Agencies.
[2] Where possible, “pure” samples consisting of a single taxon were preferentially submitted for analysis. In cases where sufficient sample mass could not be achieved for an individual taxon, taxa were composited.

Targeted soil invertebrate and plant[3] samples were collected from all seven locations at the Former Ponds and Pads/Remaining Onsite Areas (Table U.A6-1). Sufficient mass of plant samples were collected to submit these samples for metals analysis. Conversely, soil invertebrate sample masses were below the desired amount and these samples were not submitted for metals analysis.

The specific approaches that were used to collect terrestrial samples from these two study areas are presented in the SAP (CSC, 2009). Soil samples were collected using existing standard operating procedures (SOPs) developed for the Remedial Investigation and presented in Appendix A for the Remedial Investigation (RI)/Feasibility Study (FS) Work Plan (CSC, 2004). As described in the SAP (CSC, 2009) discrete soil samples were paired with plant samples for the bioaccumulation analysis and composite soil samples were paired with the tissue samples for the mobile receptors, soil invertebrate and small mammals, to more accurately represent potential exposure.

Additionally, five soil and food/prey sample locations were targeted from background to assess incremental risk associated with exposure to COIs at the Site (Figure U.A6-2). The food/prey items from this study area included:

- Plants;
- Soil Invertebrates; and
- Small mammals.

Targeted plant and soil invertebrate samples were collected from all five background locations; sufficient small mammals could be collected from any of the targeted locations (Table U.A6-1). The background area was comprised primarily of grassland which may have provided less suitable small mammal habitat relative to the habitat present in RCRA Canyon/West Canyon Spray Area.

1.1.2 Aquatic Study Area and Sampling

As described in Appendix U and the SAP (CSC, 2009), the following chemical was considered a COI for the aquatic study area:

- A-Series Pond
    - Selenium

For the A-Series Pond, five sediment and food/prey sample locations were targeted (Figure U.A6-1). The food/prey item from this study area was aquatic invertebrates. All aquatic invertebrate samples were comprised of damselfly larvae (Odonata; Table U.A6-1). Water boatmen (Hemiptera) were also targeted for collection to represent water column invertebrates; however, adequate sample mass could not be achieved in a reasonable time frame due to small organisms sizes. Aquatic invertebrates were collected using methods described in the SAP (CSC, 2009). Sediment samples were collected according to existing SOPs developed for the RI and provided in Appendix A of the RI/FS Work Plan (CSC, 2004). Background sediment and

[3] Grass was not present at FPP-05 and a grass sample could not be submitted. Grass samples were submitted for 6 of the 7 targeted locations.

aquatic invertebrate samples were not collected because the area immediately surrounding the Site is arid, and the availability of suitable water bodies are not readily available.

2.0 UPTAKE AND REGRESSION ANALYSIS APPROACH

An uptake relationship can be represented by either (1) an BAF or (2) a regression equation. For the Tier 2 ERA, both a BAF and a regression were developed for each COI and tissue/prey item pair. The more appropriate and representative BAF or regression was then selected to represent soil/sediment-to-biota uptake for the Tier 2 ERA.

Soil and sediment data were reported in milligrams per kilogram (mg/kg) dry weight and tissue results for plants, soil invertebrates, small mammals, and aquatic invertebrates were reported in mg/kg wet weight.

The following approach was used to develop a BAF and a regression for each COI:

- Exploratory data analysis:
  - Data distributions were evaluated using box plots and summary statistics (presented as Sub-attachment 1 of this attachment).
  - Box plots were also used to qualitatively evaluate the relationship between soil and tissue data as well as differences in COI concentration by media across study areas and the background location.
- Uptake analysis:
  - All co-located biota tissue and soil/sediment data were compiled;
  - Non-detects were excluded from the evaluation;
  - Grass and shrub tissue concentrations were found to be similar based on the exploratory data analysis step; therefore, samples were combined into a single "plant" data set;
  - Study area and background data sets were pooled, where feasible, to increase sample size; and
  - A BAF was calculated as the median value of the ratio of co-located biota tissue concentration to soil/sediment concentration;
  - Log10 transformed biota tissue and soil/sediment data were plotted to evaluate relationships between tissue and soil/sediment[4]. Uptake regressions are presented in Sub-attachment 2; each regression was analyzed for:
    - Significance (p-value) – The significance of the fit (the correlation between the concentration of COI in soil and biota tissue) was determined by statistical analysis (F-statistic). A regression with a p-value less than 0.05 was considered significant;
    - Goodness of fit (R^2) – The goodness of fit of data for a regression is indicated by the R^2 and the higher the R^2 value, the better the fit. If the R^2 was 0.4, the regression was assumed to be a good fit; and
    - Visual evaluation of plots – Regressions that were marginally significant or had marginal R^2 values were evaluated visually to assess the most appropriate measure of bioavailability.

[4] Bioaccumulation is nonlinear and the rate of accumulation decreases at higher concentrations of contaminants in soil (e.g., Suter et al., 2000). Nonlinear regression methods may be used; however, log-transforming the data allows for simple linear regression analyses. All soil/sediment and tissue data were log-transformed prior to analysis to facility data analysis and interpretation regardless of underlying data distributions (i.e., normal, log-normal, etc.).

The most appropriate and representative contaminant uptake regression or BAF for each COI and tissue type was selected for further evaluation based on the approach described above. A regression equation is generally preferred to a BAF to represent soil/sediment-to-biota uptake as it accounts for differing degrees of uptake at various ranges of soil concentrations. If the analysis was considered a good correlation, based on significance and goodness of fit, the regression equation was selected to represent uptake for the Tier 2 ERA. However, if the regression analysis was not considered to be a good correlation, based on significance or goodness of fit, the median BAF was selected to represent uptake for the Tier 2 ERA. A limited number of exceptions were made to this decision framework based on the visual evaluation of the regression plots. Each of these exceptions is discussed in the appropriate section below.

All BAFs developed for the Tier 2 ERA were on a wet-weight basis. Wet-weight BAFs were paired with food/prey item ingestion rates expressed on a wet weight basis in the exposure assessment of the Tier 2 ERA. Using wet-weight tissue concentrations can introduce uncertainty in the regression modeling; this is further discussed in Section 4. In this analysis, lipid-normalized tissue concentrations were not evaluated be lipid content in tissue did not vary significantly. Lipid content ranged from 3.4 to 4.5% in small mammals, from 4.7 to 7.5% in soil invertebrates, and from 1.6 to 2.6% in aquatic invertebrates. Lipids were not analyzed for in plant tissue samples. The low variability in lipid content was not expected to significantly change the COI relationships in tissue.

2.1 Outlier Analysis

Outliers were assessed using a visual evaluation of the regressions. Values that were near or outside the 95% prediction intervals of the regression were considered suspected outliers and the regression was reanalyzed with the suspected outliers removed from the data set. If the removal of the suspected outlier improved the significance and/or goodness of fit of the regression, then the regression determined by excluding the suspected outlier was selected to represent uptake for the Tier 2 ERA.

3.0 Methods and Results

This section summarizes the methods used to develop site-specific BAFs and regressions for each tissue type. As discussed earlier, the most appropriate measure of uptake, BAF or regression, was selected to represent uptake in the Tier 2 ERA for each COI and tissue type. BAFs and regression were developed using all available onsite study area and background data. For soil and sediment, surface (0 to 6 inches below ground surface [bgs]) sample results were used to develop BAFs and regressions.

3.1 Small Mammals

Five composite small mammal samples were collected from four locations within RCRA Canyon/West Canyon Spray Area (Figure U.A6-1). No small mammals were trapped from location RC-01. However, sufficient sample mass was achieved at RC-04 to submit two composite small mammal samples.

As previously mentioned, concentrations were also determined in kidney and liver tissue. Whole body concentrations were calculated prior to analysis using tissue-specific concentrations for the kidneys, liver, and remaining tissue (i.e., all tissue remaining after the liver and kidney tissue was removed) and the fractional weight of each tissue type.

Uptake regressions for COIs and mammal tissue are presented in Sub-attachment 2. Table U.A6-2 summarizes the BAFs and regressions for uptake of COIs by mammals.

Table U.A6-2. Small Mammal Uptake Analysis Summary

Analyte	Pair Count	Minimum BAF	Maximum BAF	Median BAF	Equation	R^2	p-value
Barium	5	0.00268	0.0674	**0.00548**	log(y) = 0.263log(x) + 0.108	0.140	0.535
Cadmium	5	0.0203	0.202	**0.0534**	log(y) = 0.145log(x) - 1.059	0.0404	0.746
Chromium	5	0.00348	0.0164	**0.00536**	log(y) = 0.090log(x) - 0.575	0.0077	0.888
Copper	5	0.0535	0.322	**0.295**	log(y) = -0.032log(x) + 0.564	0.0299	0.781
Lead	5	0.00397	0.0192	**0.00970**	log(y) = 0.672log(x) - 1.727	0.529	0.164
Molybdenum	5	0.149	0.496	**0.198**	log(y) = 0.806log(x) - 0.635	0.0597	0.692
Vanadium	4	0.00138	0.00353	**0.00160**	log(y) = -1.379log(x) + 1.097	0.102	0.680
Zinc	4	0.402	0.723	**0.668**	log(y) = 0.154log(x) + 1.140	0.580	0.239

Note: BAFs or regression selected for the Tier 2 ERA are bolded
x = concentration in soil (mg/kg, dry weight)
y = concentration in small mammal tissue (mg/kg, wet weight)

Review of the small mammal uptake analyses presented in Table U.A6-2 above and following the approach described in Section 2 for selecting appropriate and representative uptake regression or BAF for each COI revealed that:

- None of the regressions were statistically significant ($p > 0.05$) or were good fits ($R^2 < 0.4$); and
- The median BAF was selected as the most appropriate measure of mammal uptake for all COIs.

3.2 Soil Invertebrates

A total of 17 soil invertebrate samples were collected from 17 locations; 5 locations from the RCRA Canyon/West Canyon Spray Area, 7 locations from the Former Ponds and Pads/Remaining Onsite Areas, and 5 locations from background. Samples collected from the RCRA Canyon/West Canyon Spray Area were analyzed for metals, samples collected from the Former Ponds and Pads/Remaining Onsite Areas were analyzed for metals, pesticides, and PCBs, and samples collected from background were analyzed for metals and pesticides. Where possible, samples from study areas and background were pooled to increase sample size. Uptake regressions for COIs and soil invertebrate tissue are presented in Sub-attachment 2. Table U.A6-3 summarizes the BAFs and regressions for uptake of COIs by soil invertebrates.

Table U.A6-3. Soil Invertebrate Uptake Analysis Summary

Analyte	Pair Count	Minimum BAF	Maximum BAF	Median BAF	Equation	R^2	p-value
Barium	9	0.00920	0.0308	0.0145	**log(y) = 0.883log(x) - 1.526**	0.929	<0.0001
Cadmium	10	0.0603	0.529	0.255	**log(y) = 0.387log(x) - 0.661**	0.550	0.0141
Chromium	10	0.00433	0.0144	0.00709	**log(y) = 0.792log(x) - 1.783**	0.526	0.0177
Copper	9	0.0850	0.613	**0.406**	log(y) = 0.092log(x) + 0.613	0.171	0.268
Lead	10	0.00319	0.00923	0.00580	**log(y) = 0.744log(x) - 1.970**	0.740	0.00140
Molybdenum	10	0.100	0.600	**0.337**	log(y) = -0.616log(x) - 0.211	0.420	0.0427
Vanadium	10	0.00216	0.00771	**0.00296**	log(y) = 0.622log(x) - 1.855	0.0168	0.721
Zinc	9	0.287	1.12	**0.796**	log(y) = -0.038log(x) + 1.576	0.00640	0.838
Total DDT	6	0.655	28.4	**5.40**	log(y) = 0.019log(x) - 1.348	0.00340	0.912
Total PCB	7	0.00594	0.179	**0.0154**	log(y) = 0.223log(x) - 2.318	0.362	0.153
Avian PCB TEQ	7	0.0348	1.39	0.0854	**log(y) = 0.216log(x) - 4.015**	0.484	0.0826
Mammalian PCB TEQ	7	0.0470	0.544	0.0805	**log(y) = 0.375log(x) - 3.968**	0.822	0.00480

Note: BAFs or regression selected for the Tier 2 ERA are bolded
x = concentration in soil (mg/kg, dry weight)
y = concentration in small mammal tissue (mg/kg, wet weight)
TEQ = toxicity equivalent

Review of the soil invertebrate uptake analyses presented in Table U.A6-3 above and following the approaches described in Section 2 for selecting appropriate and representative COI uptake regression or BAF for each COI revealed that:

- For barium, cadmium, chromium, lead, and mammalian PCB, toxicity equivalent (TEQ) regressions were statistically significant ($p < 0.05$) and were good fits ($R^2 > 0.4$) and were selected as the most appropriate measure of uptake.
    - The regression for Avian PCB TEQ was marginally significant ($p = 0.0826$); however, visual evaluation of the plot (Figure 2-10 of Sub-attachment 2) indicated the data provided good coverage over the range of detected concentrations. Additionally, tissue estimates based on both the median BAF and regression were plotted to ass the relationship between tissue concentrations estimated from the median BAF relative to the underlying data (Figure U.A6-3). This evaluation indicated that the tissue estimates based on the median BAF do not correspond well with the underlying data by underestimating concentrations at the low end of the soil concentration range and overestimating tissue concentrations at the high end of the soil concentration range. Therefore, the regression was selected as the most appropriate measure of uptake.
    - The regression for molybdenum was statistically significant ($p = 0.0427$); however, since the slope of the regression was negative (Figure 2-7 of Sub-attachment 2) the median BAF was selected as the most appropriate measure of uptake; and
- The median BAF was selected as the most appropriate measure of uptake for copper, molybdenum (as discussed above), vanadium, zinc, total DDT, and total PCBs.

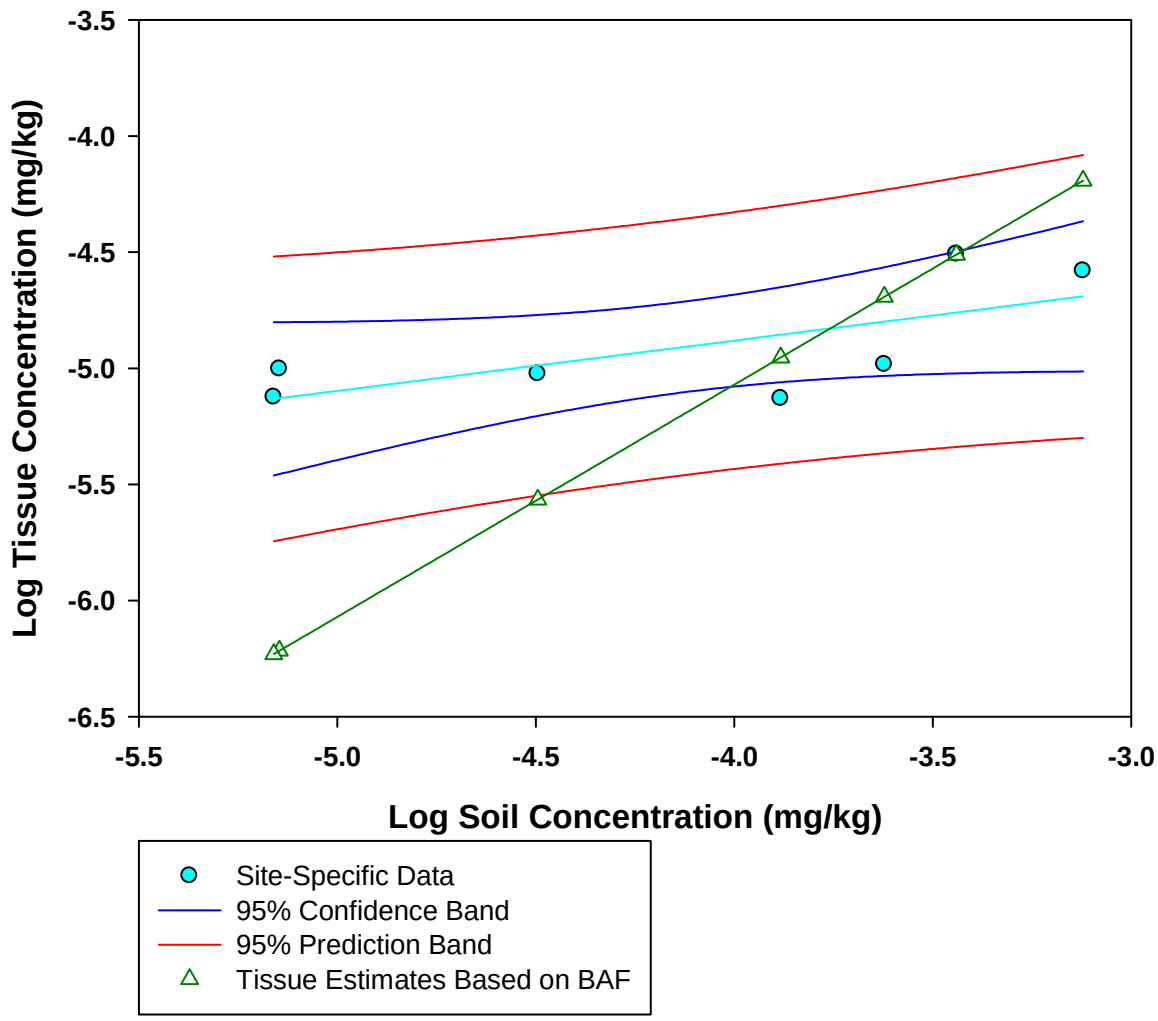

Figure U.A6-3. Median BAF and regression soil-to-invertebrate uptake model results for avian PCB TEQ.

3.3 Plants

As discussed in Section 1.1.1, two types of plant tissue were collected, grass and shrub, to evaluate COI uptake in plants. A total of 31 plant samples were collected from 17 locations; 5 locations from the RCRA Canyon/West Canyon Spray Area, 7 locations from the Former Ponds and Pads/Remaining Onsite Areas, and 5 locations from background. Samples collected from the RCRA Canyon/West Canyon Spray Area were analyzed for metals, samples collected from the Former Ponds and Pads/Remaining Onsite Areas were analyzed for metals, pesticides, and PCBs, and samples collected from background were analyzed for metals and pesticides. Where possible, samples from study areas and background were pooled to increase sample size. As mentioned in Section 2, concentrations of COIs in grass and shrub were similar, and therefore, data for these two tissue types were also pooled for the analysis. Uptake regressions

for COIs and plant tissue are presented in Sub-attachment 2. Table U.A6-4 summarizes the BAFs and regressions for uptake of COIs by plants.

Table U.A6-4. Plant Uptake Analysis Summary

Analyte	Pair Count	Minimum BAF	Maximum BAF	Median BAF	Equation	R^2	p-value
Barium	31	0.0000834	0.316	**0.0124**	log(y) = -0.177log(x) + 0.927	0.0388	0.288
Cadmium	30	0.0257	1.94	0.257	**log(y) = 0.599log(x) - 0.664**	0.131	0.0493
Chromium	30	0.000886	0.00554	**0.00261**	log(y) = 0.076log(x) - 0.988	0.00670	0.667
Copper	30	0.0330	0.366	**0.129**	log(y) = 0.396log(x) - 0.159	0.196	0.0144
Lead	29	0.000385	0.0137	**0.00292**	log(y) = 0.041log(x) - 1.603	0.00390	0.747
Molybdenum	31	0.0188	1.70	**0.283**	log(y) = -0.577log(x) - 0.238	0.0413	0.273
Vanadium	12	0.00119	0.00432	**0.00145**	log(y) = 0.809log(x) - 2.419	0.0544	0.466
Zinc	30	0.115	0.592	**0.207**	log(y) = 0.412log(x) + 0.383	0.0804	0.129
Total DDT	6	0.0361	0.422	0.116	**log(y) = 0.687log(x) - 1.353**	0.636	0.0575
Total PCB	12	0.000025	0.0097	0.00019	**log(y) = 0.152log(x) - 4.384**	0.348	0.0435
Avian PCB TEQ	12	0.00025	0.077	0.0021	**log(y) = 0.183log(x) - 5.993**	0.420	0.0227
Mammalian PCB TEQ	12	0.0000142	0.139	**0.00072**	log(y) = 0.528log(x) - 5.412	0.266	0.0859

Note: BAFs or regression selected for the Tier 2 ERA are bolded
x = concentration in soil (mg/kg, dry weight)
y = concentration in small mammal tissue (mg/kg, wet weight)
TEQ = toxicity equivalent

Review of the plant uptake analyses presented in Table U.A6-4 above and following the approach described in Section 2 for selecting appropriate and representative uptake regression or BAF for each COI revealed that:

- For cadmium, Total PCBs, and avian PCB TEQ, regressions were statistically significant ($p < 0.05$) and were good fits ($R^2 > 0.4$);
    - The regression for Total DDT was marginally significant ($p = 0.0575$); however, visual evaluation of the plot (Figure 2-12 of Sub-attachment 2) indicated the data provided good coverage over the range of detected concentrations. Additionally, tissue estimates based on both the median BAF and regression were plotted to ass the relationship between tissue concentrations estimated from the median BAF relative to the underlying data (Figure U.A6-4). This evaluation indicated that the tissue estimates based on the median BAF correspond well with the underlying data and both the regression and the median BAF are suitable for

estimating uptake. Since regressions are the preferred over BAFs as discussed in Section 2.0, the regression was selected as the most appropriate measure of uptake.

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  - The regression for copper was significant (p = 0.0144); however, the fit was poor (R^2 = 0.196) and visual evaluation of the plot (Figure 2-5 of Sub-attachment 2) indicated the data were clustered at either end of the range of detected concentrations; therefore, the median BAF was selected as the most appropriate measure of uptake;
  - The regression for molybdenum was statistically significant (p = 0.0427); however, since the slope of the regression was negative (Figure 2-10 of Sub-attachment 2), the median BAF was selected as the most appropriate measure of uptake; and
- The median BAF was selected as the most appropriate measure of uptake for barium, chromium, copper (as discussed above), lead, molybdenum, vanadium, zinc, and mammalian PCB TEQ.

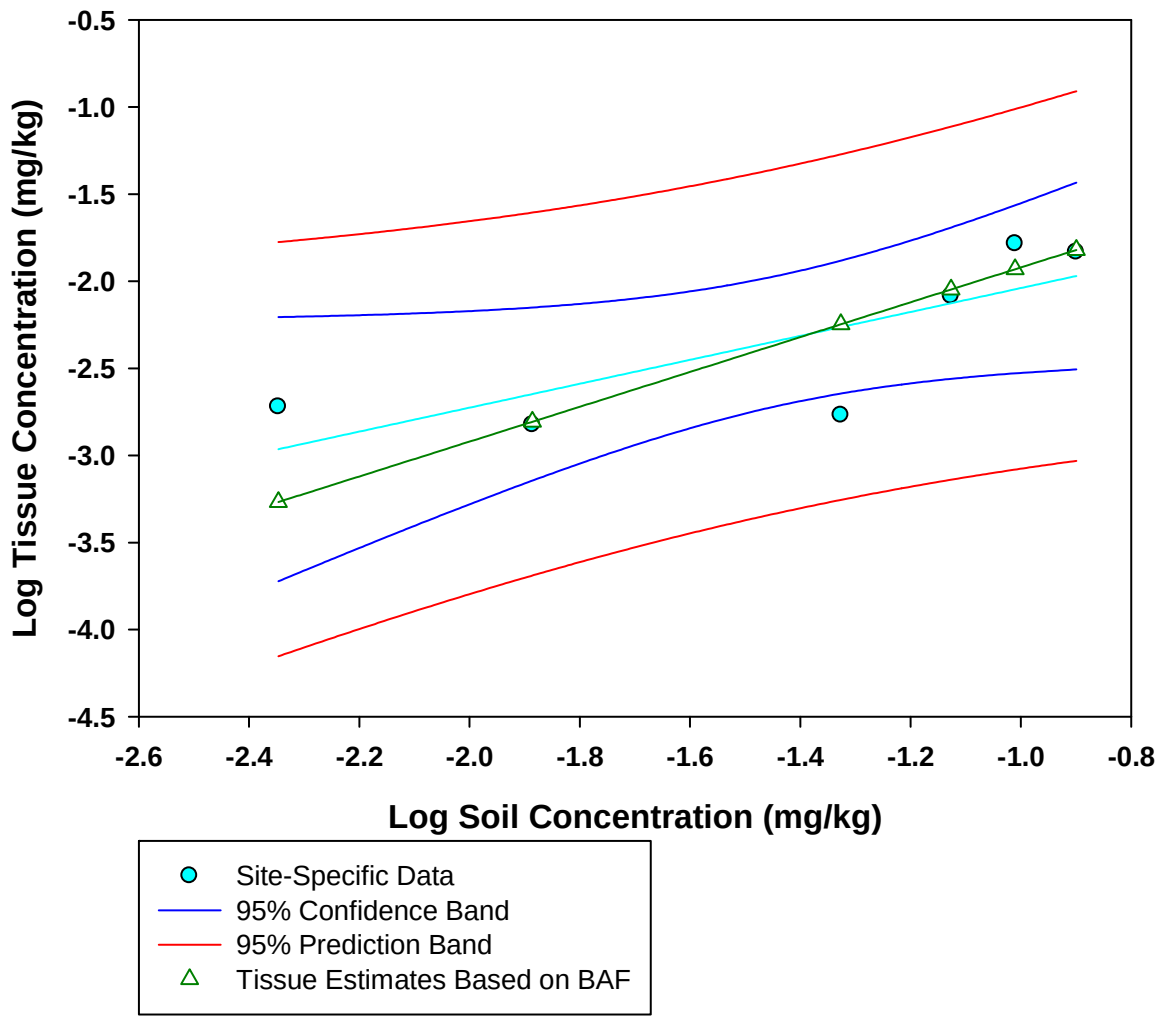

Figure U.A6-4. Median BAF and regression soil-to-plant uptake model results for Total DDT.

3.4 Aquatic Invertebrates

A total of 6 aquatic invertebrate samples were collected from 5 locations in the A-Series Pond. A representative background location could not be identified and aquatic invertebrate uptake was based on samples collected from the A-Series Pond only which were analyzed for metals. The uptake regression for selenium and aquatic invertebrate tissue is presented in Sub-attachment 2. Table U.A6-5 summarizes the BAF and regression for uptake of selenium by aquatic invertebrates.

Table U.A6-5. Aquatic Invertebrate Uptake Analysis Summary

Analyte	Pair Count	Minimum BAF	Maximum BAF	Median BAF	Equation	R^2	p-value
Selenium	6	0.192	0.54375	**0.3037**	log(y) = -0.177log(x) - 0.008	0.222	0.346

Note: BAFs or regression selected for the Tier 2 ERA are bolded
x = concentration in soil (mg/kg, dry weight)
y = concentration in small mammal tissue (mg/kg, wet weight)

Review of the aquatic invertebrate uptake analysis presented in Table U.A6-5 above and following the approach described in Section 2 for selecting an appropriate and representative uptake regression or BAF for selenium revealed that:

- The aquatic invertebrate regression for selenium was not significant (p = 0.346) or a good fit (R^2 = 0.222). Additionally, the slope of the regression was negative (Figure 2-14 of Sub-attachment 2). Therefore, the median BAF was selected as the most appropriate measure of uptake.

4.0 Uncertainty Analysis

Uncertainty plays an important role in risk-based decision making, and therefore, needs to be incorporated into the assessment. Although site-specific uptake regressions and BAFs developed for this assessment may be useful in predicting potential risks to ecological receptors, they may not accurately quantify exposures. Two separate analyses, regressions and BAFs, were used to determine the relationship between soil/sediment-bound COIs and ecological receptors. The uncertainties related to both of the analyses are discussed below.

Regression analysis using log transformed data estimated a relationship between co-located soil/sediment and tissue data. These regression plots were then evaluated for adequate goodness of fit and significant relationships between the soil/sediment and biota tissue data sets. This evaluation was conducted since soil/sediment-to-tissue uptake can vary from location to location, particularly because of the physical conditions of the soil which may impact uptake into biota. Physical parameters such as pH, grain size distribution, and organic matter in soil introduce variability in uptake rates which makes it difficult to establish the regression relationship. Uncertainty regarding the appropriateness of regressions was addressed by rejecting plots that do not possess adequate goodness of fit and significant relationships ($p > 0.05$). However, these criteria were used in conjunction with visual examinations of data distribution and best professional judgment, and therefore, the appropriateness of these tests and the selected accept/reject criteria may be a source of uncertainty.

Significant variability in goodness of fit ($R^2 < 0.4$) also indicates uncertainty that COI concentrations in tissue biota are linked to COI concentration in soil. In large complex biological systems, there are other sources of uptake, particularly for metals, outside of soil/sediment contamination related to former activities at the Site. This uptake analysis conservative assumes that there is a direct relationship between soil-bound constituents and tissue concentrations.

Uptake was based on median BAFs calculated using site-specific data to quantify bioaccumulation when regression plots were rejected based on the aforementioned criteria. BAFs are simple ratios and assume that accumulation is linear and constant across all soil concentrations; therefore they do not account for changing uptake rates with varying soil concentrations, which is documented in many species. This uncertainty is why regression models are generally recommended over median BAFs for estimating bioaccumulation. However, BAFs are considered the next best uptake estimation tool when regressions are deemed inappropriate for use based on the aforementioned criteria.

The uptake analysis was conducted using tissue data reported on a wet weight basis rather than on a dry weight basis. Evaluating tissue data on a wet weight basis is representative of the basis of organisms being consumed by higher trophic level organisms in the environment. However, evaluating tissue data on a wet weight basis introduced uncertainty into the bioaccumulation analysis because moisture content of plants and animals can vary between organisms and can also vary within individual organisms over time. The result of this uncertainty is that tissue concentrations reported on a wet weight basis may be more variable than tissue concentrations reported on a dry weight basis thus reducing the goodness of fit of the regressions and possibly resulting in insignificant relationships. An evaluation of site-

specific moisture content indicated that, with the exception of grasses, moisture content of tissue samples was not highly variable (Table U.A6-6).

Table U.A6-6. Summary of Moisture Content for Small Mammal, Soil Invertebrate, Plant, and Aquatic Invertebrate Samples

Sample Composition	Average	Minimum	Maximum	Standard Deviation
Small Mammals				
Deer Mouse	71.9	68.2	75.9	3.14
Deer/Harvest Mouse	74.2	72.2	76.6	2.21
Pocket Mouse	73.9	70.9	76.1	2.00
Soil Invertebrates				
Beetle	49.1	41.8	55.2	4.42
Multiple taxa	61.7	57.5	67.5	3.38
Plants				
Grass	52.5	27.9	76.1	15.2
Shrub	68.8	63.1	80.2	4.22
Aquatic Invertebrates				
Damselfly Larvae	78.0	75.6	80.1	1.49

5.0 RECOMMENDATIONS

Based on the uptake analyses described in this attachment, the site-specific biota uptake regressions and BAFs bolded in Tables U.A6-2 through U.A6-5 were recommended for use in the Tier 2 ERA to predict potential exposures and risks to ecological receptors at the Site.

6.0 REFERENCES

CSC. 2004. *Casmalia Site Remediation RI/FS Work Plan. Prepared for U.S. EPA Region 9. San Francisco, CA.* Casmalia Steering Committee. June. 439 pp.

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