



PORTLAND HARBOR RI/FS  
**EARLY PRELIMINARY REMEDIATION GOALS**

**DRAFT**

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**Prepared for**  
The Lower Willamette Group

**Prepared by**  
Windward Environmental, LLC  
Kennedy/Jenks Consultants  
Integral Consulting Inc.  
Anchor QEA, LLC

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## **LIST OF ACRONYMS**

AOPC	Area of Potential Concern
BERA	baseline ecological risk assessments
BHHRA	baseline human health risk assessment
BPJ	best professional judgment
BSAF	biota-sediment accumulation factor
BSAR	biota-sediment accumulation regression
BTV	background threshold value
COC	chemical of concern
COPC	chemicals of potential concern
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
FWM	Food Web Model
HQ	hazard quotients
LOE	line of evidence
LWG	Lower Willamette Group
OC	organic carbon
PRG	preliminary remediation goal
RI/FS	remedial investigation/feasibility study
TRV	toxicity reference value
TSC	threshold sediment concentrations
TTC	threshold tissue concentration
UCL	upper confidence limit
UPL	upper prediction limit

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## 1.0 INTRODUCTION

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The Lower Willamette Group (LWG) met with the United States Environmental Protection Agency (EPA) and its partners on June 18, 2008 and July 2, 2008 to discuss developing preliminary remediation goals (PRGs) for the Portland Harbor Superfund Site (Site). To maintain an expedited schedule for the remedial investigation and feasibility study (RI/FS) for the Site, the LWG and EPA agreed to develop early PRGs. These early PRGs were developed concurrent with the baseline human health risk assessment (BHHRA) and baseline ecological risk assessments (BERA) for the Site, which will be submitted as part of the Remedial Investigation Report later in 2009.

As agreed during the meetings to discuss PRGs, early PRGs were only developed for sediment. Early PRGs for human health and ecological receptors were developed consistent with the process agreed to during the PRG meetings. Early PRGs were developed where possible for the chemicals listed in the tables provided by EPA in their July 24, 2008 *Confirmation of PRG Agreements in Principle*. As agreed by the LWG and EPA, this document briefly describes the approach that was used to develop the early PRGs.

Also as agreed during PRG meetings, early PRGs represent draft PRGs in advance of the risk assessments. As such, they are approximations of PRGs that would be developed after completion of the baseline risk assessments. Consequently, the early PRGs are incomplete and will likely change later in the project. They are solely risk-based and do not consider detection and quantification limits of contaminants in environmental media. The early PRGs, along with other information, will be used by EPA and LWG to estimate approximate Areas of Potential Concern (AOPCs) for the Site, so that the FS can be started as early as possible.

PRGs will be refined following completion of the baseline risk assessments and during the FS process as more information is developed, including selection of the most appropriate values from the initial broad range of early PRGs to be used in detailed evaluations of remedial alternatives in the FS. Refined PRGs will be used in the FS to identify the types, locations, areas, and volumes of sediment that require remediation and as values against which the performance of remedial action alternatives will be compared. At the end of the FS process, the LWG will recommend cleanup levels for consideration by EPA based on the refined PRGs and the results of the detailed evaluation of remedial alternatives. EPA sets final cleanup levels in the Record of Decision taking into account National Contingency Plan requirements for establishing final remediation goals.

Finally, this document also presents background values developed following methods agreed to with EPA and as proposed by the LWG. These are provided for purposes of comparison to early PRGs, and are presented in Section 4.

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## 2.0 HUMAN HEALTH PRELIMINARY REMEDIATION GOALS

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The human health chemical list for early PRGs was developed by EPA and provided to the LWG on July 24, 2008. This chemical list was intended to be inclusive of chemicals that, at the time of the PRG meetings, were anticipated to be identified as chemicals of concern (COCs) in the BHHRA. COCs are those chemicals that result in a cancer risk greater than  $1 \times 10^{-6}$  or non-cancer hazard quotient greater than 1 for any of the scenarios evaluated in the BHHRA.

Where possible, human health early PRGs were developed for all of the chemicals on the list developed by EPA. However, early PRGs were only developed for the exposure scenarios for which the chemical is anticipated to be identified as a COC in the BHHRA.

As agreed in the PRG meetings, human health early PRGs were developed for specified ranges of exposure assumptions and specified ranges of target risk levels. Early PRGs were developed for target cancer risk levels of  $10^{-4}$ ,  $10^{-5}$ , and  $10^{-6}$  and for a target non-cancer hazard quotient of 1. Additional information on the exposure assumptions used in developing the early PRGs for human health is provided in the following sections.

Human health early PRGs were developed for scenarios involving direct exposure to sediment (i.e., incidental ingestion of and dermal contact with sediment) and for fish and shellfish consumption. For the direct exposure scenarios, sediment PRGs were calculated based on target risk levels and hazard quotients and the intake equations and exposure assumptions from the BHHRA. For fish and shellfish consumption, target tissue levels were calculated based on target risk levels and hazard quotients and the intake equations and exposure assumptions from the BHHRA.

Sediment PRGs for fish and shellfish consumption were derived from the target tissue levels using modeled sediment-tissue relationships. For some chemicals, it was not possible to establish a sediment-tissue relationship, so early PRGs were not developed for those chemicals, if the chemicals were only COCs for fish and shellfish consumption. Additional information on the development of the sediment-tissue relationship models is provided in Appendix A.

The human health early PRGs are entirely risk-based concentration goals, in that they are based only on the exposure assumptions and risk equations from the BHHRA and do not consider background concentrations or technical achievability. As risk-based concentration goals, the human health early PRGs were developed based on the exposure scenarios evaluated in the BHHRA. Therefore, the early PRGs should be applied on a spatial scale consistent with the exposure scenario for which they were derived.

### 2.1 DIRECT EXPOSURE TO SEDIMENT

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Risks resulting from potential direct exposure to sediment will be evaluated in the BHHRA. The sediment direct exposure scenarios evaluated in the BHHRA are based on

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potential exposures to either beach sediment or in-water sediment. The intake equations and exposure assumptions for each of the sediment direct exposure scenarios will be provided in the BHHRA. These equations and exposure assumptions were previously included in the Exposure Point Concentration Calculation Approach and Summary of Exposure Factors (Kennedy/Jenks Consultants 2006), which was approved by EPA.

Human health early PRGs were back-calculated for chemicals identified for direct contact with sediment in the table provided by EPA on July 24, 2008 for those scenarios that are anticipated to result in cancer risks greater than  $1 \times 10^{-6}$  or noncancer hazard quotients greater than 1. Beach sediment PRGs were not calculated for transients, as there are no COCs for transient exposure to beach sediment in the BHHRA. The early PRGs were based on target cancer risks of  $10^{-6}$ ,  $10^{-5}$ , and  $10^{-4}$  and a target noncancer hazard quotient of 1 and the same exposure assumptions as used in the forward risk calculations.

The human health early PRGs for direct exposure are presented in Table 1. The direct exposure PRGs are expressed on a dry weight basis. Because risks to human health from direct sediment contact are evaluated using sediment exposure point concentrations that are calculated on a dry weight basis, it is appropriate to apply sediment PRGs on a dry weight basis for protection of direct exposure to sediment.

## 2.2 FISH AND SHELLFISH CONSUMPTION

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Risks resulting from fish and shellfish consumption will also be evaluated in the BHHRA. The intake equations and exposure assumptions for each of the fish and shellfish consumption scenarios will be provided in the BHHRA. These equations and exposure assumptions were previously included in the Exposure Point Concentration Calculation Approach and Summary of Exposure Factors (Kennedy/Jenks Consultants 2006), which was approved by EPA.

Target tissue levels were back-calculated for chemicals identified for fish and shellfish consumption in the table provided by EPA on July 24, 2008 for those scenarios anticipated in the BHHRA to result in cancer risks greater than  $1 \times 10^{-6}$  or noncancer hazard quotients greater than 1 from ingestion of biota tissue. The target tissue levels were calculated based on target cancer risks of  $10^{-6}$ ,  $10^{-5}$ , and  $10^{-4}$  and a target non-cancer hazard quotient of 1 and the same exposure assumptions as in the forward risk calculations. For the tribal fish consumption scenario, the ingestion rate representing the dietary fraction assumed to consist of only resident fish was used in calculating the target tissue levels. Lead target tissue levels were developed using EPA's Adult Lead Model (ALM) and Integrated Exposure Uptake Biokinetic (IEUBK) blood lead model, which is consistent with the approach for evaluating risks from lead in tissue in the BHHRA. However, there are uncertainties associated with this approach, as the lead models were developed to assess risks from soil exposures.

From the target tissue levels, sediment PRGs were derived using sediment-tissue relationships, as described in Appendix A. For chemicals that were evaluated using the food web model (FWM), two sediment PRGs were derived as requested by EPA: one assuming that the water concentration input to the FWM is equal to the background surface water concentration and the second assuming that the water concentration input to the FWM is equal to zero. Additional information on the use of water concentrations in calculating the sediment PRGs through the FWM is provided in Appendix A.

As agreed during the PRG meetings, ranges of early PRGs for human health were developed for fish and shellfish consumption based on different ingestion rates and differences in bioaccumulation factors between species. For fish consumption, early PRGs were selected for the lowest and highest ingestion rates that will be used in the BHHRA for resident fish consumption (i.e., 17.5 g/day and 142 g/day for adults and 7 g/day and 60 g/day for children). Early PRGs were also selected for the large home range species that will be evaluated in the BHHRA (i.e., carp, black crappie, and brown bullhead) with the lowest and highest bioaccumulation factors, as well as for smallmouth bass. For shellfish consumption, early PRGs were selected for the lowest and highest ingestion rates that will be used in the BHHRA (i.e., 3.3 g/day and 18 g/day).

The human health early PRGs for fish and shellfish consumption are presented in Table 2. Sediment PRGs were derived on a dry weight basis for metals and for organic COCs that were evaluated using the Food Web Model (FWM). Sediment PRGs were derived on an organic carbon normalized basis for organic COCs where biota-sediment accumulation factors (BSAFs) or biota-sediment accumulation regressions (BSARs) were used in deriving the sediment-tissue relationship. Additional information on the concentration basis for the sediment PRGs for fish and shellfish consumption is provided in Appendix A. The sediment PRGs in Table 2 that were derived using the FWM are based on an input water concentration equal to the background surface water concentration. In addition, sediment PRGs derived based on the assumption that the water concentration input to the FWM is zero are presented in Table 3.

### 3.0 ECOLOGICAL PRELIMINARY REMEDIATION GOALS

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Ecological early PRGs were developed based on work in progress on the BERA. Ecological early sediment PRGs were developed for all COC/receptor pairs preliminarily identified through work in progress on the BERA based on:

- The tissue-residue line of evidence (LOE) for benthic invertebrates and fish, and
- The dietary dose assessment LOE for fish and wildlife.

Ecological COCs using the tissue residue LOE were defined as those chemicals of potential concern (COPCs) with hazard quotients (HQs) greater than 1.0 calculated within a relevant exposure area based on measured tissue concentrations and tissue toxicity reference values (TRVs) used in the BERA. For the dietary dose LOE, COCs were defined as those COPCs with HQs greater than 1.0 calculated within a relevant exposure area based on measured tissue concentrations in multiple prey species, measured sediment concentrations and dietary dose TRVs used in the BERA. Because the BERA is a work in progress, the list of COC/receptor pairs for which ecological PRGs were developed, and calculated PRG values are subject to change. In July 2008, EPA provided a list of chemicals for which they requested early PRGs. PRGs were developed for all the chemicals requested by EPA, with the exception of the following: 1) PRGs were not developed for chemicals (or chemical mixtures) that were not evaluated in the BERA for the tissue or dietary dose LOEs<sup>1</sup> (often due to a lack of toxicological data), and 2) PRGs were not developed for chemicals or chemical mixtures that were not identified as a COC for the tissue or dietary dose LOEs<sup>2</sup>.

Table 4 presents the ecological early PRGs. The PRGs presented in Table 4 were generated using BSAFs, BSARs, or the FWM. The FWM was applied assuming water chemical concentrations were equal to background water chemical concentrations. In addition, as requested by EPA, PRGs were also developed using the FWM and assuming no chemical contribution from water (i.e., sediment is the only source of exposure to the modeled organisms) (Table 5). The methods used to derive sediment PRGs based on the tissue-residue and dietary dose LOEs are described below and in Appendix A.

Development of a FWM and BSARs required assumptions about exposure areas of the species modeled. These assumptions impact the development of the bioaccumulation models and therefore the PRGs derived from these models as well as the scales at which the PRGs may be applied. Uncertainties associated with these assumptions will be considered in the bioaccumulation modeling report.

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<sup>1</sup> The following chemicals were not evaluated in the BERA using the tissue or dietary LOEs: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, TPH(total), and TPH (residual).

<sup>2</sup> The following chemicals were not identified as COCs in the BERA using the tissue or dietary LOEs: aluminum, antimony, chromium, nickel, selenium, butylbenzyl phthalate, hexachlorobenzene, total PAHs, total LPAHs, total HPAHs, dieldrin, alpha-hexachlorobenzene, beta-hexachlorobenzene, gamma-hexachlorobenzene, delta-hexachlorobenzene, endrin, sum DDD, sum DDE, sum DDT, heptachlor, heptachlor epoxide, and chlordane (total).

### 3.1 TISSUE-RESIDUE EXPOSURE

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Risks to benthic invertebrate and fish will be evaluated in the BERA using a tissue residue LOE<sup>3</sup>. Sediment PRGs were calculated based on the benthic invertebrate or fish tissue-residue TRVs that will be presented in the BERA. Sediment PRGs were not developed for LOE involving mussels or multiplate epibenthic tissue because the data were insufficient (i.e., there were not enough samples) for the development of sediment-tissue models. Also, these invertebrate samples were collected from the overlying water column, so the development of sediment-tissue models is less appropriate than for benthic invertebrates collected on or within the sediment. The methods used to calculate the tissue residue LOE PRGs are presented in Appendix A.

### 3.2 FISH AND WILDLIFE DIETARY EXPOSURE

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Risks to fish and wildlife receptors will be evaluated in the BERA using a dietary dose LOE. Dietary risks (i.e., risks estimated based on exposure from dietary consumption) will be estimated using receptor-specific exposure parameters (e.g., body weight, ingestion rates) and diet composition. Sediment PRGs were calculated based on threshold tissue concentrations (TTCs) in prey from the BERA that were derived using ecological receptor-specific exposure assumptions (i.e., body weight, ingestion rates) and dietary dose TRVs that will be presented in the BERA<sup>4</sup>. Because the dietary dose approach assumes the ingestion of multiple prey species, sediment PRGs for each COC/receptor pair are presented as a range estimated by assuming ingestion of each prey species separately. Sediment PRGs were not developed for mussels or multiplate epibenthic prey for the reasons given in Section 3.1. The methods used to calculate the prey tissue PRGs for COC/receptor pairs using the dietary dose LOE are presented in Appendix A.

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<sup>3</sup> PRGs for benthic invertebrates based on other LOEs will be developed following completion of the BERA.

<sup>4</sup> Sediment PRGs were calculated using TTCs in prey; however, the dietary dose LOE also accounts for incidentally ingested sediment. Threshold sediment concentrations (TSCs) were derived using ecological receptor-specific exposure assumptions and dietary dose TRVs. Sediment PRGs derived using TTCs were compared to TSCs to ensure that sediment PRGs were also protective of incidental sediment exposure in the diet.

## 4.0 BACKGROUND CHEMICAL CONCENTRATIONS IN SURFACE SEDIMENT

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Because background chemical concentrations may provide information that is relevant for risk management and establishing PRGs, this section briefly summarizes the analysis of background values in surface sediment performed for the RI/FS. Various statistical techniques – ranging from point values (e.g., upper-bound estimates of central tendency and upper background threshold values), to hypothesis testing to compare whether background and Site data are drawn from the same population – are available to compare background and site concentrations in the context of PRG development.

The analysis summarized here focuses on the results of background central tendency upper-bound estimates (e.g., the 95<sup>th</sup> percentile upper confidence limit [UCL] on the mean) and upper background threshold value (BTV, e.g., the 95<sup>th</sup> percentile upper prediction limit [UPL]) calculations performed for the RI. At the direction of EPA, the LWG developed background estimates using the EPA statistical software package ProUCL Version 4.0 and its supporting technical guidance document (Singh and Singh 2007). A more detailed presentation of the development of background chemical concentrations will be provided in Section 7 of the draft RI report. That presentation will address several elements of the analysis that are not covered here, including a review of the available background data sets that meet project data quality requirements, maps of background sample locations, data preprocessing procedures, additional graphical and statistical evaluations, and much more extended and detailed discussion of the outlier identification process.

### 4.1 REFERENCE AREA AND DATA SET SELECTION

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For the Portland Harbor RI/FS, the upriver reach of the Lower Willamette River, extending from RM 15.3 to RM 28.5, was selected, in consultation with EPA, Oregon Department of Environmental Quality (DEQ), and the tribes, as the reference area for sediments. Sediment data sets for this reach that met the data quality requirements of the risk assessments (i.e., Category 1, QA Level 2) were included in the background data set. The list of chemicals to be evaluated in the background analysis was derived from the chemical lists developed in consultation with EPA for initial PRG development (“Working PRG List”) and Food Web Modeling (“FWM ICs”). These lists were further refined by screening the maximum concentration of each chemical in the background data set against sediment screening values used in the BHHRA and BERA; chemicals that did not exceed the screening values were not considered further in the background evaluation, because the results of the screening are sufficient to conclude that background concentrations of these chemical are below levels of potential concern for human health or ecological risk. Background values were estimated on a dry weight basis and, for hydrophobic organic chemicals, also on an organic carbon (OC)-normalized basis. Hydrophobic organic chemicals are primarily associated with (i.e., adsorbed to) the OC fraction in sediment. The bioavailability of organic chemicals is inversely related to sediment OC content, i.e., if a high OC sediment and low OC sediment have the same

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dry-weight sediment concentration of an organic chemical, the bioavailability of that chemical will be lower in the high OC sediment than the low OC sediment.

Further, because PRGs derived using the FWM for non-polar, hydrophobic organic chemical will be expressed on a dry-weight basis, the dry-weight background values were also adjusted to reflect the differences between the mean organic carbon content of surface sediments in the background (RM 15.3-28.5) reach and the study area. These estimates, termed OC-equivalent dry-weight values, were calculated as follows to achieve consistency with the measurement basis underlying the risk-based PRGs derived using the FWM:

$$C_{dw,eq} = C_{dw,bgrnd} \times \frac{TOC_{SA}}{TOC_{bgrnd}}$$

Where:

$C_{dw,eq}$  = OC-equivalent dry-weight sediment concentration

$C_{dw,bgrnd}$  = Dry-weight background sediment concentration

$TOC_{SA}$  = Study Area surface sediment mean TOC (1.71%)

$TOC_{bgrnd}$  = Background surface sediment mean TOC (1.11%).

## 4.2 OUTLIER IDENTIFICATION

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A key element of developing an appropriate background data set is to ensure that the data set is as free as possible of data points that are not representative of the background conditions of interest for a given project. In urbanized or other developed settings such as the upriver reach of the Lower Willamette River, a reference areas may be influenced by local point sources (e.g., shoreline industrial facilities and overwater structures) as well as diverse non-point sources of chemicals (e.g., atmospheric deposition and storm runoff from a range of land use types), resulting in the presence of high-biasing outliers that are not representative of background. The ProUCL Technical Guide (Singh and Singh 2007) recognizes that this type of complexity may exist in CERCLA contexts and therefore provides the following guidance regarding the importance of professional judgment in the identification and disposition of high-biasing outliers:

“[T]he decision regarding the proper disposition of outliers (e.g., to include or not to include outliers in statistical analyses; or to collect additional verification samples) should be made by members of the project team and experts familiar with site and background conditions.”

To support decisions about the disposition of outliers in the Portland Harbor RI/FS process, outlier identification was performed in two steps: (i) identification of *potential outliers* using classical statistical and graphical analysis tools available in ProUCL, and

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(ii) further investigation of all potential outliers using multiple lines of evidence to identify *primary outliers* that are determined to be unrepresentative of background conditions and should be removed from the background data set. (Note: the outlier identification process described here addresses only potential high-biasing outliers and does not consider the possible existence of statistical outliers at the lower end of the background concentration range.)

Potential outliers identified using the graphical and statistical tools in ProUCL are listed in Appendix B: Tables BG-1 (dry weight basis) and BG-2 (OC-normalized basis).

For potential outliers at locations near known or potential point sources (e.g., paper mills, overwater structures) and where chemical evidence suggested the probability of a release from that source, those potential outliers *and all related compounds at that location* were removed from the data set regardless of their magnitude. For example, if one or more individual PCB congeners or PAHs were identified as potential outliers at a station proximal to a known source, then that station was considered source influenced, and *all* PCB or PAH data for that station was removed from the background data set.

For potential outliers that could not be tied to a known or suspected source, the following lines of evidence were considered in a best professional judgment (BPJ) evaluation of primary outliers:

- The presence (or absence) of sharp breaks in slope and/or well-separated observations at the upper end of the quantile range on a Q-Q plot.
- Co-occurrence of potential outliers for multiple chemicals at single stations.
- The magnitude of the potential outlier compared to the full data set, expressed as the outlier:mean ratio; potential outliers with an outlier:mean ratio approaching an order of magnitude were examined closely in conjunction with other lines of evidence to assess whether the value represents a primary outlier.
- Variability in chemical concentrations at closely clustered locations or between field replicates; spatial clusters of potential outliers suggest the presence of a local chemical source, while heterogeneity in concentrations over a small spatial scale suggests that the potential outlier could simply reflect the heterogeneity in background concentrations expected in suburban/urban river systems.

This BPJ evaluation resulted in the identification of additional primary outliers that, while not linked to known or suspected sources, do not appear to be representative of the background data set. Appendix B, Tables BG-1 and BG-2 list the full set of primary outliers that were identified and removed from the background data set.<sup>5</sup>

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<sup>5</sup> In discussions held during the fall of 2008 regarding identification of primary outliers, the LWG and EPA reached different conclusions in the case of two chemical groups—total PCB Aroclors and total DDx. Specifically, the LWG concluded that the four potential outliers for total PCB Aroclors in the vicinity of RM 16 and RM 17 do not rise to the level of primary outliers, because (i) the outlier:mean ratios are relatively low (ranging from 3.76 to

#### 4.2.1 Estimation of Sediment Background Central Tendency and BTVs

Estimates of background central tendency and BTV were generated in ProUCL Version 4.0, as outlined below:

- 1) Upper-Bound Central Tendency Estimates
  - a) Import data set at ND=DL.
  - b) Use ProUCL to calculate the 95th percentile upper confidence limit on the mean (95 UCL) or other appropriate central tendency statistic (e.g., 97.5 UCL) as recommended by ProUCL. Because all data sets contained multiple detection limits and/or were nonparametric, the Kaplan-Meier statistic recommended by ProUCL for the appropriate underlying distribution was selected.
  
- 2) Background Threshold Values (Upper Prediction Limits)
  - a) Import data set at ND=DL.
  - b) Use ProUCL to calculate the 95th percentile upper prediction limit (UPL95). Because all data sets contained multiple detection limits and/or were nonparametric, the 95% Kaplan-Meier UPL was selected in all cases, as recommended by ProUCL.

As discussed previously, dry-weight equivalent background concentrations were calculated by multiplying the dry weight background concentrations by the ratio of  $TOC_{SA}:TOC_{bgmd}$ .

Tables 6, 7, and 8 present these UCL and UPL values, on a dry weight, OC-equivalent dry-weight, and OC-normalized basis, respectively. It is recommended that the UPL value be used for background comparisons, but the UCL value is provided for context. Additional information related to calculating these and related statistics are presented in Appendix B: Tables BG-3 and BG-4. As discussed previously, two sets of statistics are provided for total PCB Aroclors and total DDx, reflecting EPA's and the LWG's different decisions on the identification of primary outliers for these chemicals.

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6.09); (ii) samples co-located with and nearby the potential outlier locations are significantly lower, indicating a high degree of spatial heterogeneity in this reach; and (iii) no local source of PCB releases to this reach has been identified. In contrast, the EPA concluded that the potential outliers may indicate the influence of a local, albeit unknown, PCB release. For total DDx, the LWG concluded that the two potential outliers located near Cedar Island upstream of RM 23 are not potential outliers for the same set of reasons identified above for PCB Aroclors, whereas EPA concluded that these two potential outliers may reflect the influence of an unknown localized DDx release. To resolve these differences, EPA and LWG agreed (Wyatt 2008, pers. comm.) that the background analysis in the draft RI will present background estimates both with (LWG case) and without (EPA case) these potential outliers retained in the data set. Another element of the resolution is that EPA and DEQ will work to identify what specific point sources may have influenced PCB concentrations in the RM 16 to RM 17 reach and total DDx concentrations in the vicinity of Cedar Island.

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## 5.0 REFERENCES

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# TABLES

Table 1. Human Health Early PRGs for Direct Exposure to Sediment

Chemical	Exposure Route:		Beach Sediment (Direct Contact)							In-Water Sediment (Direct Contact)					
	Receptor:	Units of PRGs	Dockside Worker	Transient	Adult Recreational Beach User	Child Recreational Beach User	High Frequency Fisher	Low Frequency Fisher	Tribal Fisher	In-water Worker	Low Frequency Fisher	High Frequency Fisher	Tribal Fisher	Diver in Wet Suit	Diver in Dry Suit
			Target Risk Level												
<b>Metals</b>															
Arsenic	10 <sup>-6</sup> Risk	mg/kg dw			2.8E+00	9.5E-01	1.7E+00	2.5E+00	4.3E-01			1.5E+01	3.9E+00		
Arsenic	10 <sup>-5</sup> Risk	mg/kg dw			2.8E+01	9.5E+00	1.7E+01	2.5E+01	4.3E+00			1.5E+02	3.9E+01		
Arsenic	10 <sup>-4</sup> Risk	mg/kg dw			2.8E+02	9.5E+01	1.7E+02	2.5E+02	4.3E+01			1.5E+03	3.9E+02		
Arsenic	HQ = 1	mg/kg dw			5.4E+02	3.7E+01	3.2E+02	4.9E+02	1.9E+02			2.9E+03	1.7E+03		
<b>PAHs</b>															
Benzo(a)anthracene	10 <sup>-6</sup> Risk	mg/kg dw	6.9E+00								2.5E+01	1.6E+01	4.2E+00	2.6E+01	
Benzo(a)anthracene	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+01								2.5E+02	1.6E+02	4.2E+01	2.6E+02	
Benzo(a)anthracene	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+02								2.5E+03	1.6E+03	4.2E+02	2.6E+03	
Benzo(a)anthracene	HQ = 1	mg/kg dw													
Benzo(a)pyrene	10 <sup>-6</sup> Risk	mg/kg dw	6.9E-01		6.6E-02	1.6E-01		4.2E-02	8.6E+00	2.5E+00	1.6E+00	4.2E-01	2.6E+00	1.3E+01	
Benzo(a)pyrene	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+00		6.6E-01	1.6E+00		4.2E-01	8.6E+01	2.5E+01	1.6E+01	4.2E+00	2.6E+01	1.3E+02	
Benzo(a)pyrene	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+01		6.6E+00	1.6E+01		4.2E+00	8.6E+02	2.5E+02	1.6E+02	4.2E+01	2.6E+02	1.3E+03	
Benzo(a)pyrene	HQ = 1	mg/kg dw													
Benzo(b)fluoranthene	10 <sup>-6</sup> Risk	mg/kg dw	6.9E+00							2.5E+01	1.6E+01	4.2E+00	2.6E+01		
Benzo(b)fluoranthene	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+01							2.5E+02	1.6E+02	4.2E+01	2.6E+02		
Benzo(b)fluoranthene	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+02							2.5E+03	1.6E+03	4.2E+02	2.6E+03		
Benzo(b)fluoranthene	HQ = 1	mg/kg dw													
Dibenzo(a,h)anthracene	10 <sup>-6</sup> Risk	mg/kg dw	6.9E-01							2.5E+00	1.6E+00	4.2E-01	2.6E+00		
Dibenzo(a,h)anthracene	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+00							2.5E+01	1.6E+01	4.2E+00	2.6E+01		
Dibenzo(a,h)anthracene	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+01							2.5E+02	1.6E+02	4.2E+01	2.6E+02		
Dibenzo(a,h)anthracene	HQ = 1	mg/kg dw													
Indeno(1,2,3-cd)pyrene	10 <sup>-6</sup> Risk	mg/kg dw	6.9E+00							2.5E+01	1.6E+01	4.2E+00	2.6E+01		
Indeno(1,2,3-cd)pyrene	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+01							2.5E+02	1.6E+02	4.2E+01	2.6E+02		
Indeno(1,2,3-cd)pyrene	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+02							2.5E+03	1.6E+03	4.2E+02	2.6E+03		
Indeno(1,2,3-cd)pyrene	HQ = 1	mg/kg dw													
Total cPAH	10 <sup>-6</sup> Risk	mg/kg dw	6.9E-01		2.7E-01	6.6E-02	1.6E-01	2.4E-01	4.2E-02	8.6E+00	2.5E+00	1.6E+00	4.2E-01	2.6E+00	1.3E+01
Total cPAH	10 <sup>-5</sup> Risk	mg/kg dw	6.9E+00		2.7E+00	6.6E-01	1.6E+00	2.4E+00	4.2E-01	8.6E+01	2.5E+01	1.6E+01	4.2E+00	2.6E+01	1.3E+02
Total cPAH	10 <sup>-4</sup> Risk	mg/kg dw	6.9E+01		2.7E+01	6.6E+00	1.6E+01	2.4E+01	4.2E+00	8.6E+02	2.5E+02	1.6E+02	4.2E+01	2.6E+02	1.3E+03
Total cPAH	HQ = 1	mg/kg dw													
<b>PCBs</b>															
Total PCBs	10 <sup>-6</sup> Risk	mg/kg dw								8.6E+00	5.7E+00	1.5E+00	8.8E+00		
Total PCBs	10 <sup>-5</sup> Risk	mg/kg dw								8.6E+01	5.7E+01	1.5E+01	8.8E+01		
Total PCBs	10 <sup>-4</sup> Risk	mg/kg dw								8.6E+02	5.7E+02	1.5E+02	8.8E+02		
Total PCBs	HQ = 1	mg/kg dw								1.5E+02	9.8E+01	5.9E+01	1.3E+02		
Total PCB TEQ	10 <sup>-6</sup> Risk	mg/kg dw									8.8E-05	2.3E-05			
Total PCB TEQ	10 <sup>-5</sup> Risk	mg/kg dw									8.8E-04	2.3E-04			
Total PCB TEQ	10 <sup>-4</sup> Risk	mg/kg dw									8.8E-03	2.3E-03			
Total PCB TEQ	HQ = 1	mg/kg dw									4.9E-03	3.0E-03			
<b>Dioxin/Furans</b>															
Total Dioxin TEQ	10 <sup>-6</sup> Risk	mg/kg dw								6.3E-04	2.6E-04	1.7E-04	4.5E-05	5.2E-04	1.5E-03
Total Dioxin TEQ	10 <sup>-5</sup> Risk	mg/kg dw								6.3E-03	2.6E-03	1.7E-03	4.5E-04	5.2E-03	1.5E-02
Total Dioxin TEQ	10 <sup>-4</sup> Risk	mg/kg dw								6.3E-02	2.6E-02	1.7E-02	4.5E-03	5.2E-02	1.5E-01
Total Dioxin TEQ	HQ = 1	mg/kg dw								1.2E-02	1.4E-02	9.7E-03	5.8E-03	2.4E-02	7.0E-02

Notes:  
 COC = chemical of concern  
 HQ = hazard quotient  
 PRG = preliminary remediation goal  
 mg/kg dw = milligrams per kilogram on a dry weight basis  
 PRG not developed because analyte is not evaluated for the non-cancer endpoint.  
 PRG not developed because analyte is not a chemical of concern for this scenario.

Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:	Units of PRGs	Fish Consumption															
	Receptor:		Adult Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Adult Fish Consumption, Single Species Diet - Smallmouth Bass		Child Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Child Fish Consumption, Single Species Diet - Smallmouth Bass		Tribal Adult Fish Consumption, Multi-species Diet <sup>b</sup>		Tribal Child Fish Consumption, Multi-species Diet <sup>c</sup>	
	Ingestion Rate (g/day):		17.5		142		17.5	142	7		60		7	60	86.8 <sup>c</sup>		36.2 <sup>c</sup>	
	Target Risk Level		Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum
<b>Metals</b>																		
Antimony	10 <sup>-6</sup> Risk	mg/kg dw																
Antimony	10 <sup>-5</sup> Risk	mg/kg dw																
Antimony	10 <sup>-4</sup> Risk	mg/kg dw																
Antimony <sup>d</sup>	HQ = 1	mg/kg dw						NC	NC					NC	NC	NC	NC	NC
Arsenic	10 <sup>-6</sup> Risk	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Arsenic	10 <sup>-5</sup> Risk	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Arsenic	10 <sup>-4</sup> Risk	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Arsenic	HQ = 1	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Lead <sup>d</sup>	5% prob - 10 ug/dl	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Mercury	10 <sup>-6</sup> Risk	mg/kg dw																
Mercury	10 <sup>-5</sup> Risk	mg/kg dw																
Mercury	10 <sup>-4</sup> Risk	mg/kg dw																
Mercury	HQ = 1	mg/kg dw	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Selenium	10 <sup>-6</sup> Risk	mg/kg dw																
Selenium	10 <sup>-5</sup> Risk	mg/kg dw																
Selenium	10 <sup>-4</sup> Risk	mg/kg dw																
Selenium	HQ = 1	mg/kg dw						NC	NC					NC	NC			
Zinc	10 <sup>-6</sup> Risk	mg/kg dw																
Zinc	10 <sup>-5</sup> Risk	mg/kg dw																
Zinc	10 <sup>-4</sup> Risk	mg/kg dw																
Zinc	HQ = 1	mg/kg dw								NC	NC	NC	NC					
<b>PAHs<sup>e, f</sup></b>																		
Benzo(a)anthracene	10 <sup>-6</sup> Risk	mg/kg-OC						NC	NC									
Benzo(a)anthracene	10 <sup>-5</sup> Risk	mg/kg-OC						NC	NC									
Benzo(a)anthracene	10 <sup>-4</sup> Risk	mg/kg-OC						NC	NC									
Benzo(a)anthracene	HQ = 1	mg/kg-OC																
Benzo(a)pyrene	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC					NC	NC	NC	NC	NC
Benzo(a)pyrene <sup>g</sup>	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC					NC	NC	NC	NC	NC
Benzo(a)pyrene <sup>g</sup>	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC					NC	NC	NC	NC	NC
Benzo(a)pyrene	HQ = 1	mg/kg-OC																
Benzo(b)fluoranthene	10 <sup>-6</sup> Risk	mg/kg-OC																
Benzo(b)fluoranthene	10 <sup>-5</sup> Risk	mg/kg-OC																
Benzo(b)fluoranthene	10 <sup>-4</sup> Risk	mg/kg-OC																
Benzo(b)fluoranthene	HQ = 1	mg/kg-OC																
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-6</sup> Risk	mg/kg-OC																
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-5</sup> Risk	mg/kg-OC																
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-4</sup> Risk	mg/kg-OC																
Benzo(k)fluoranthene	HQ = 1	mg/kg-OC																
Dibenzo(a,h)anthracene	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC									
Dibenzo(a,h)anthracene	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC									
Dibenzo(a,h)anthracene	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC									
Dibenzo(a,h)anthracene	HQ = 1	mg/kg-OC																
Indeno(1,2,3-cd)pyrene	10 <sup>-6</sup> Risk	mg/kg-OC																
Indeno(1,2,3-cd)pyrene	10 <sup>-5</sup> Risk	mg/kg-OC																
Indeno(1,2,3-cd)pyrene	10 <sup>-4</sup> Risk	mg/kg-OC																
Indeno(1,2,3-cd)pyrene	HQ = 1	mg/kg-OC																

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Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:	Units of PRGs	Fish Consumption															
	Receptor:		Adult Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Adult Fish Consumption, Single Species Diet - Smallmouth Bass		Child Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Child Fish Consumption, Single Species Diet - Smallmouth Bass		Tribal Adult Fish Consumption, Multi-species Diet <sup>b</sup>		Tribal Child Fish Consumption, Multi-species Diet <sup>c</sup>	
	Ingestion Rate (g/day):		17.5		142		17.5	142	7		60		7	60	86.8 <sup>c</sup>		36.2 <sup>c</sup>	
	Target Risk Level		Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum
<b>Phalates and SVOCs</b>																		
Bis(2-ethylhexyl)phthalate	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Bis(2-ethylhexyl)phthalate	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Bis(2-ethylhexyl)phthalate	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Bis(2-ethylhexyl)phthalate	HQ = 1	mg/kg-OC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Hexachlorobenzene	10 <sup>-6</sup> Risk	mg/kg-OC	3.7E-01	1.2E-01	4.6E-02	1.5E-02	NC	NC	1.0E+00	3.2E-01	1.2E-01	3.8E-02	NC	NC	3.2E-02	1.0E-02	1.9E-01	6.2E-02
Hexachlorobenzene	10 <sup>-5</sup> Risk	mg/kg-OC	3.7E+00	1.2E+00	4.6E-01	1.5E-01	NC	NC	1.0E+01	3.2E+00	1.2E+00	3.8E-01	NC	NC	3.2E-01	1.0E-01	1.9E+00	6.2E-01
Hexachlorobenzene	10 <sup>-4</sup> Risk	mg/kg-OC	3.7E+01	1.2E+01	4.6E+00	1.5E+00	NC	NC	1.0E+02	3.2E+01	1.2E+01	3.8E+00	NC	NC	3.2E+00	1.0E+00	1.9E+01	6.2E+00
Hexachlorobenzene	HQ = 1	mg/kg-OC	2.0E+02	6.6E+01	2.5E+01	8.1E+00	NC	NC	1.1E+02	3.5E+01	1.3E+01	4.1E+00	NC	NC	4.1E+01	1.3E+01	2.1E+01	6.8E+00
Pentachlorophenol	10 <sup>-6</sup> Risk	mg/kg-OC																
Pentachlorophenol	10 <sup>-5</sup> Risk	mg/kg-OC																
Pentachlorophenol	10 <sup>-4</sup> Risk	mg/kg-OC																
Pentachlorophenol	HQ = 1	mg/kg-OC																
<b>PCBs</b>																		
PCB-126 <sup>i</sup>	10 <sup>-6</sup> Risk	mg/kg dw	<0	<0	<0	<0	<0	<0	6.0E-07	2.4E-07	<0	<0	<0	<0	<0	<0	<0	<0
PCB-126 <sup>i</sup>	10 <sup>-5</sup> Risk	mg/kg dw	3.3E-06	3.1E-06	<0	<0	4.1E-07	<0	1.0E-05	7.5E-06	7.8E-07	4.2E-07	2.6E-06	<0	<0	<0	2.5E-07	2.5E-07
PCB-126 <sup>i</sup>	10 <sup>-4</sup> Risk	mg/kg dw	4.2E-05	2.2E-05	4.3E-06	3.8E-06	1.2E-05	7.0E-07	1.2E-04	4.9E-05	1.2E-05	8.6E-06	3.6E-05	3.2E-06	1.0E-06	1.0E-06	1.1E-05	1.1E-05
PCB-126 <sup>i</sup>	HQ = 1	mg/kg dw	2.3E-05	1.4E-05	2.1E-06	2.0E-06	6.4E-06	1.7E-08	1.2E-05	8.3E-06	9.1E-07	5.7E-07	3.0E-06	<0	1.6E-06	1.6E-06	3.8E-07	3.8E-07
Total PCBs	10 <sup>-6</sup> Risk	mg/kg dw	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0
Total PCBs	10 <sup>-5</sup> Risk	mg/kg dw	9.2E-03	1.3E-03	<0	<0	<0	<0	3.2E-02	1.2E-02	<0	<0	4.4E-03	<0	<0	<0	<0	<0
Total PCBs	10 <sup>-4</sup> Risk	mg/kg dw	1.3E-01	6.0E-02	1.2E-02	2.8E-03	3.0E-02	<0	3.7E-01	1.7E-01	3.9E-02	1.5E-02	8.7E-02	5.9E-03	3.8E-04	3.8E-04	2.7E-02	2.7E-02
Total PCBs	HQ = 1	mg/kg dw	1.9E-02	6.0E-03	<0	<0	1.1E-03	<0	8.0E-03	8.0E-04	<0	<0	<0	<0	<0	<0	<0	<0
<b>Dioxin/Furans</b>																		
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-6</sup> Risk	mg/kg dw	<0	<0	<0	<0	<0	<0	6.5E-09	<0	<0	<0	1.1E-07	<0	<0	<0	<0	<0
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-5</sup> Risk	mg/kg dw	5.4E-07	2.5E-07	<0	<0	1.1E-06	<0	2.4E-06	2.2E-06	3.3E-08	<0	3.9E-06	1.5E-07	<0	<0	4.0E-07	4.0E-07
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-4</sup> Risk	mg/kg dw	2.8E-05	1.2E-05	7.4E-07	4.5E-07	2.0E-05	1.4E-06	1.7E-04	4.2E-05	3.2E-06	2.6E-06	7.0E-05	4.8E-06	8.8E-07	8.8E-07	9.2E-06	9.2E-06
2,3,4,7,8 PCDF <sup>f</sup>	HQ = 1	mg/kg dw	9.5E-06	5.6E-06	2.9E-07	4.9E-08	9.9E-06	6.2E-07	2.9E-06	2.5E-06	5.5E-08	<0	4.5E-06	1.9E-07	1.3E-06	1.3E-06	4.8E-07	4.8E-07
<b>Pesticides</b>																		
Aldrin	10 <sup>-6</sup> Risk	mg/kg dw	6.9E-03	1.4E-03	8.4E-04	1.7E-04												
Aldrin	10 <sup>-5</sup> Risk	mg/kg dw	7.0E-02	1.4E-02	8.6E-03	1.8E-03												
Aldrin	10 <sup>-4</sup> Risk	mg/kg dw	7.0E-01	1.4E-01	8.6E-02	1.8E-02												
Aldrin	HQ = 1	mg/kg dw	1.5E+00	3.1E-01	1.9E-01	3.8E-02												
Dieldrin	10 <sup>-6</sup> Risk	mg/kg dw	<0	<0	<0	<0	<0	<0	9.3E-04	<0	<0	<0	<0	<0	<0	<0	<0	<0
Dieldrin	10 <sup>-5</sup> Risk	mg/kg dw	7.2E-03	2.5E-03	<0	<0	3.5E-03	<0	2.2E-02	1.0E-02	1.3E-03	<0	1.3E-02	<0	<0	<0	1.1E-03	1.1E-03
Dieldrin	10 <sup>-4</sup> Risk	mg/kg dw	8.4E-02	4.3E-02	9.2E-03	3.6E-03	5.2E-02	4.8E-03	2.3E-01	1.2E-01	2.5E-02	1.2E-02	1.4E-01	1.5E-02	3.1E-03	3.1E-03	2.8E-02	2.8E-02
Dieldrin	HQ = 1	mg/kg dw	2.9E-01	1.5E-01	3.5E-02	1.7E-02	1.8E-01	2.1E-02	1.6E-01	8.1E-02	1.7E-02	7.7E-03	9.7E-02	9.7E-03	3.8E-02	3.8E-02	1.8E-02	1.8E-02
Heptachlor	10 <sup>-6</sup> Risk	mg/kg dw	3.1E-02	5.4E-03	3.8E-03	6.7E-04			8.3E-02	1.5E-02	9.6E-03	1.7E-03			1.2E-03	1.2E-03	7.4E-03	7.4E-03
Heptachlor	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-01	5.4E-02	3.8E-02	6.7E-03			8.3E-01	1.5E-01	9.6E-02	1.7E-02			1.2E-02	1.2E-02	7.4E-02	7.4E-02
Heptachlor	10 <sup>-4</sup> Risk	mg/kg dw	3.1E+00	5.4E-01	3.8E-01	6.7E-02			8.3E+00	1.5E+00	9.6E-01	1.7E-01			1.2E-01	1.2E-01	7.4E-01	7.4E-01
Heptachlor	HQ = 1	mg/kg dw	3.0E+01	5.2E+00	3.7E+00	6.5E-01			1.6E+01	2.8E+00	1.9E+00	3.3E-01			2.8E+00	2.8E+00	1.4E+00	1.4E+00
Heptachlor Epoxide	10 <sup>-6</sup> Risk	mg/kg dw	3.0E-03	2.2E-03	2.4E-04	1.5E-04												
Heptachlor Epoxide	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-02	2.3E-02	3.7E-03	2.7E-03												
Heptachlor Epoxide	10 <sup>-4</sup> Risk	mg/kg dw	3.1E-01	2.3E-01	3.8E-02	2.8E-02												
Heptachlor Epoxide	HQ = 1	mg/kg dw	1.6E-01	1.2E-01	1.9E-02	1.4E-02												
alpha-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw	2.0E-02	3.8E-03	2.2E-03	4.5E-04			5.4E-02	1.0E-02	6.0E-03	1.2E-03			7.8E-04	7.8E-04		
alpha-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw	2.0E-01	3.9E-02	2.5E-02	4.7E-03			5.4E-01	1.0E-01	6.3E-02	1.2E-02			8.4E-03	8.4E-03		
alpha-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw	2.0E+00	3.9E-01	2.5E-01	4.8E-02			5.4E+00	1.0E+00	6.3E-01	1.2E-01			8.5E-02	8.5E-02		
alpha-Hexachlorocyclohexane	HQ = 1	mg/kg dw	4.3E+02	8.3E+01	5.4E+01	1.0E+01			2.3E+02	4.5E+01	2.7E+01	5.2E+00			4.3E+01	4.3E+01		
beta-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw	NC	NC	NC	NC	4.1E-01	5.1E-02	NC	NC	NC	NC	1.1E+00	1.3E-01	4.3E-03	4.3E-03		

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Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:	Units of PRGs	Fish Consumption															
	Receptor:		Adult Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Adult Fish Consumption, Single Species Diet - Smallmouth Bass		Child Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Child Fish Consumption, Single Species Diet - Smallmouth Bass		Tribal Adult Fish Consumption, Multi-species Diet <sup>b</sup>		Tribal Child Fish Consumption, Multi-species Diet <sup>c</sup>	
	Ingestion Rate (g/day):		17.5		142		17.5	142	7		60		7	60	86.8 <sup>c</sup>		36.2 <sup>c</sup>	
	Target Risk Level		Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum
beta-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw	NC	NC	NC	NC	4.1E+00	5.1E-01	NC	NC	NC	NC	1.1E+01	1.3E+00	4.3E-02	4.3E-02		
beta-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw	NC	NC	NC	NC	4.1E+01	5.1E+00	NC	NC	NC	NC	1.1E+02	1.3E+01	4.3E-01	4.3E-01		
beta-Hexachlorocyclohexane	HQ = 1	mg/kg dw	NC	NC	NC	NC	1.9E+02	2.4E+01	NC	NC	NC	NC	1.0E+02	1.2E+01	4.6E+00	4.6E+00		
gamma-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw	2.8E-01	2.3E-02	3.4E-02	2.8E-03												
gamma-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw	2.8E+00	2.3E-01	3.4E-01	2.8E-02												
gamma-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw	2.8E+01	2.3E+00	3.4E+00	2.8E-01												
gamma-Hexachlorocyclohexane	HQ = 1	mg/kg dw	3.9E+01	3.2E+00	4.8E+00	4.0E-01												
Total Chlordane	10 <sup>-6</sup> Risk	mg/kg dw	2.1E-02	8.5E-03	1.9E-03	1.5E-04	7.4E-03	5.6E-05	5.9E-02	2.4E-02	6.1E-03	1.9E-03	2.1E-02	1.6E-03	<0	<0	4.9E-03	4.9E-03
Total Chlordane	10 <sup>-5</sup> Risk	mg/kg dw	2.2E-01	9.4E-02	2.7E-02	1.1E-02	8.3E-02	9.3E-03	5.9E-01	2.5E-01	6.9E-02	2.9E-02	2.2E-01	2.5E-02	8.8E-03	8.8E-03	5.8E-02	5.8E-02
Total Chlordane	10 <sup>-4</sup> Risk	mg/kg dw	2.2E+00	9.5E-01	2.7E-01	1.2E-01	8.3E-01	1.0E-01	5.9E+00	2.5E+00	6.9E-01	3.0E-01	2.2E+00	2.6E-01	9.7E-02	9.7E-02	5.8E-01	5.8E-01
Total Chlordane	HQ = 1	mg/kg dw	1.7E+00	7.1E-01	2.0E-01	8.7E-02	6.3E-01	7.6E-02	8.9E-01	3.8E-01	1.0E-01	4.4E-02	3.3E-01	3.8E-02	1.7E-01	1.7E-01	8.7E-02	8.7E-02
Sum DDD	10 <sup>-6</sup> Risk	mg/kg dw	2.6E-02	1.0E-02	2.4E-03	3.9E-04	8.1E-03	1.6E-04	7.1E-02	2.9E-02	7.5E-03	2.5E-03	2.3E-02	1.9E-03	1.6E-04	1.6E-04	5.8E-03	5.8E-03
Sum DDD	10 <sup>-5</sup> Risk	mg/kg dw	2.7E-01	1.1E-01	3.2E-02	1.3E-02	8.9E-02	1.0E-02	7.2E-01	3.0E-01	8.3E-02	3.5E-02	2.4E-01	2.7E-02	1.0E-02	1.0E-02	6.7E-02	6.7E-02
Sum DDD	10 <sup>-4</sup> Risk	mg/kg dw	2.7E+00	1.1E+00	3.3E-01	1.4E-01	9.0E-01	1.1E-01	7.2E+00	3.0E+00	8.4E-01	3.5E-01	2.4E+00	2.8E-01	1.1E-01	1.1E-01	6.8E-01	6.8E-01
Sum DDD	HQ = 1	mg/kg dw	1.4E+00	5.8E-01	1.7E-01	7.1E-02	4.6E-01	5.6E-02	7.4E-01	3.1E-01	8.5E-02	3.6E-02	2.5E-01	2.8E-02	1.3E-01	1.3E-01	6.9E-02	6.9E-02
Sum DDE	10 <sup>-6</sup> Risk	mg/kg dw	3.0E-03	7.4E-04	<0	<0	<0	<0	1.1E-02	5.0E-03	<0	<0	1.1E-03	<0	<0	<0	<0	<0
Sum DDE	10 <sup>-5</sup> Risk	mg/kg dw	4.5E-02	2.3E-02	4.1E-03	1.3E-03	8.8E-03	<0	1.2E-01	6.6E-02	1.3E-02	6.1E-03	2.6E-02	1.6E-03	8.2E-05	8.2E-05	9.1E-03	9.1E-03
Sum DDE	10 <sup>-4</sup> Risk	mg/kg dw	4.7E-01	2.5E-01	5.6E-02	2.9E-02	1.0E-01	1.1E-02	1.2E+00	6.7E-01	1.4E-01	7.7E-02	2.8E-01	3.1E-02	1.6E-02	1.6E-02	1.1E-01	1.1E-01
Sum DDE	HQ = 1	mg/kg dw	3.4E-01	1.8E-01	4.0E-02	2.1E-02	7.4E-02	7.7E-03	1.8E-01	9.6E-02	2.0E-02	9.7E-03	3.9E-02	3.1E-03	2.9E-02	2.9E-02	1.4E-02	1.4E-02
Sum DDT	10 <sup>-6</sup> Risk	mg/kg dw	3.0E-02	1.8E-02	2.4E-03	1.1E-03	1.1E-02	1.1E-04	8.2E-02	5.0E-02	8.2E-03	4.7E-03	3.1E-02	2.4E-03	3.0E-04	3.0E-04	8.8E-03	8.8E-03
Sum DDT	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-01	1.9E-01	3.7E-02	2.2E-02	1.2E-01	1.4E-02	8.3E-01	5.2E-01	9.6E-02	5.9E-02	3.3E-01	3.7E-02	1.6E-02	1.6E-02	1.0E-01	1.0E-01
Sum DDT	10 <sup>-4</sup> Risk	mg/kg dw	3.1E+00	1.9E+00	3.8E-01	2.4E-01	1.2E+00	1.5E-01	8.3E+00	5.2E+00	9.7E-01	6.0E-01	3.3E+00	3.8E-01	1.7E-01	1.7E-01	1.0E+00	1.0E+00
Sum DDT	HQ = 1	mg/kg dw	2.3E+00	1.4E+00	2.8E-01	1.7E-01	8.9E-01	1.1E-01	1.2E+00	7.5E-01	1.4E-01	8.7E-02	4.7E-01	5.4E-02	2.9E-01	2.9E-01	1.5E-01	1.5E-01

Notes:

- BSAF = biota-sediment accumulation factor
- BSAR = biota-sediment accumulation regression
- COC = chemical of concern
- HQ = hazard quotient
- PRG = preliminary remediation goal
- mg/kg dw = milligrams per kilogram on a dry weight basis
- mg/kg-OC = milligrams per kilogram on an organic carbon normalized basis

- a For chemicals evaluated using the food web model, the water concentration input to the food web model is assumed to be equal to the background surface water concentration. OC-normalized PRGs were developed for organic COCs where BSAFs/BSARs were used in deriving the sediment-tissue relationship.
- b For multispecies diet PRGs based on BSAR/Fs (see Table 1 of Appendix A), the range of PRGs is inclusive only of those fish for which BSAR/Fs could be developed. For multispecies diet PRGs based on the FWM, a single PRG was developed through the FWM based on the assumption that each of the resident species for human consumption (i.e., black crappie, brown bullhead, carp, and smallmouth bass) represents one quarter of the diet.
- c The ingestion rates used to develop PRGs for the Tribal multi-species fish consumption scenarios are based on the dietary fraction of fish that consists of resident fish species.
- d Antimony and lead were identified as COCs based on detections in smallmouth bass. Because a sediment-tissue relationship could not be developed for smallmouth bass, PRGs were not calculated for other fish species.
- e PRGs were not developed for PAHs in fish due to weak sediment-tissue relationships. PAHs contribute less than 1 percent of the cumulative cancer risk from fish consumption.
- f PRGs were developed for individual cPAHs instead of total cPAH for shellfish consumption due to differences in bioaccumulation for individual cPAHs.
- g PRGs for clam 10-4 risk for 3.3. g/day and 18 g/day ingestion rates and for crayfish 10-5 and 10-4 risk for 3.3. g/day and 18 g/day ingestion rates were extrapolated outside the range of data.
- h PRGs for all risk levels and ingestion rates were extrapolated outside the range of data.
- i PRG developed for PCB congener 126 as surrogate for PCB TEQ for fish and shellfish consumption.
- j PRG developed for 2,3,4,7,8 PCDF as surrogate for dioxin/furan TEQ for fish and shellfish consumption.

	PRG not developed because analyte is not evaluated for the cancer endpoint.
	PRG not developed because analyte is not evaluated for the non-cancer endpoint.
	PRG not developed because analyte is not a chemical of concern for this scenario.
NC	Analyte is a chemical of concern for this scenario, but a PRG was not calculated because a sediment-tissue relationship could not be established. See Appendix A for additional details.

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Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:		Shellfish Consumption			
	Receptor: Ingestion Rate (g/day):	Units of PRGs	Adult Shellfish Consumption - Clam		Adult Shellfish Consumption - Crayfish	
			3.3	18	3.3	18
			Target Risk Level			
<b>Metals</b>						
Antimony	10 <sup>-6</sup> Risk	mg/kg dw				
Antimony	10 <sup>-5</sup> Risk	mg/kg dw				
Antimony	10 <sup>-4</sup> Risk	mg/kg dw				
Antimony <sup>d</sup>	HQ = 1	mg/kg dw				
Arsenic	10 <sup>-6</sup> Risk	mg/kg dw	NC	NC	NC	NC
Arsenic	10 <sup>-5</sup> Risk	mg/kg dw	NC	NC	NC	NC
Arsenic	10 <sup>-4</sup> Risk	mg/kg dw	NC	NC	NC	NC
Arsenic	HQ = 1	mg/kg dw	NC	NC	NC	NC
Lead <sup>d</sup>	5% prob - 10 ug/dl	mg/kg dw				
Mercury	10 <sup>-6</sup> Risk	mg/kg dw				
Mercury	10 <sup>-5</sup> Risk	mg/kg dw				
Mercury	10 <sup>-4</sup> Risk	mg/kg dw				
Mercury	HQ = 1	mg/kg dw				
Selenium	10 <sup>-6</sup> Risk	mg/kg dw				
Selenium	10 <sup>-5</sup> Risk	mg/kg dw				
Selenium	10 <sup>-4</sup> Risk	mg/kg dw				
Selenium	HQ = 1	mg/kg dw				
Zinc	10 <sup>-6</sup> Risk	mg/kg dw				
Zinc	10 <sup>-5</sup> Risk	mg/kg dw				
Zinc	10 <sup>-4</sup> Risk	mg/kg dw				
Zinc	HQ = 1	mg/kg dw				
<b>PAHs<sup>e, f</sup></b>						
Benzo(a)anthracene	10 <sup>-6</sup> Risk	mg/kg-OC	1.4E+01	8.1E-01	NC	NC
Benzo(a)anthracene	10 <sup>-5</sup> Risk	mg/kg-OC	7.3E+02	4.1E+01	NC	NC
Benzo(a)anthracene	10 <sup>-4</sup> Risk	mg/kg-OC	3.7E+04	2.0E+03	NC	NC
Benzo(a)anthracene	HQ = 1	mg/kg-OC				
Benzo(a)pyrene	10 <sup>-6</sup> Risk	mg/kg-OC	2.2E+00	1.3E-01	2.2E+02	4.0E+01
Benzo(a)pyrene <sup>g</sup>	10 <sup>-5</sup> Risk	mg/kg-OC	1.0E+02	5.9E+00	2.3E+03	4.1E+02
Benzo(a)pyrene <sup>g</sup>	10 <sup>-4</sup> Risk	mg/kg-OC	4.7E+03	2.8E+02	2.4E+04	4.3E+03
Benzo(a)pyrene	HQ = 1	mg/kg-OC				
Benzo(b)fluoranthene	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Benzo(b)fluoranthene	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Benzo(b)fluoranthene	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Benzo(b)fluoranthene	HQ = 1	mg/kg-OC				
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-6</sup> Risk	mg/kg-OC	1.6E+03	1.5E+02	NC	NC
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-5</sup> Risk	mg/kg-OC	4.2E+04	3.8E+03	NC	NC
Benzo(k)fluoranthene <sup>h</sup>	10 <sup>-4</sup> Risk	mg/kg-OC	1.1E+06	1.0E+05	NC	NC
Benzo(k)fluoranthene	HQ = 1	mg/kg-OC				
Dibenzo(a,h)anthracene	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Dibenzo(a,h)anthracene	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Dibenzo(a,h)anthracene	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Dibenzo(a,h)anthracene	HQ = 1	mg/kg-OC				
Indeno(1,2,3-cd)pyrene	10 <sup>-6</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Indeno(1,2,3-cd)pyrene	10 <sup>-5</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Indeno(1,2,3-cd)pyrene	10 <sup>-4</sup> Risk	mg/kg-OC	NC	NC	NC	NC
Indeno(1,2,3-cd)pyrene	HQ = 1	mg/kg-OC				

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Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:		Shellfish Consumption			
	Receptor: Ingestion Rate (g/day):	Units of PRGs	Adult Shellfish Consumption - Clam		Adult Shellfish Consumption - Crayfish	
			3.3	18	3.3	18
			Target Risk Level			
<b>Phalates and SVOCs</b>						
Bis(2-ethylhexyl)phthalate	10 <sup>-6</sup> Risk	mg/kg-OC				
Bis(2-ethylhexyl)phthalate	10 <sup>-5</sup> Risk	mg/kg-OC				
Bis(2-ethylhexyl)phthalate	10 <sup>-4</sup> Risk	mg/kg-OC				
Bis(2-ethylhexyl)phthalate	HQ = 1	mg/kg-OC				
Hexachlorobenzene	10 <sup>-6</sup> Risk	mg/kg-OC				
Hexachlorobenzene	10 <sup>-5</sup> Risk	mg/kg-OC				
Hexachlorobenzene	10 <sup>-4</sup> Risk	mg/kg-OC				
Hexachlorobenzene	HQ = 1	mg/kg-OC				
Pentachlorophenol	10 <sup>-6</sup> Risk	mg/kg-OC			NC	NC
Pentachlorophenol	10 <sup>-5</sup> Risk	mg/kg-OC			NC	NC
Pentachlorophenol	10 <sup>-4</sup> Risk	mg/kg-OC			NC	NC
Pentachlorophenol	HQ = 1	mg/kg-OC			NC	NC
<b>PCBs</b>						
PCB-126 <sup>i</sup>	10 <sup>-6</sup> Risk	mg/kg dw	3.4E-06	<0	1.2E-06	<0
PCB-126 <sup>i</sup>	10 <sup>-5</sup> Risk	mg/kg dw	4.5E-05	7.2E-06	1.9E-05	2.9E-06
PCB-126 <sup>i</sup>	10 <sup>-4</sup> Risk	mg/kg dw	4.8E-04	8.5E-05	1.8E-04	3.4E-05
PCB-126 <sup>i</sup>	HQ = 1	mg/kg dw	2.6E-04	4.6E-05	1.0E-04	1.9E-05
Total PCBs	10 <sup>-6</sup> Risk	mg/kg dw	4.4E-02	3.0E-03	2.2E-02	<0
Total PCBs	10 <sup>-5</sup> Risk	mg/kg dw	4.9E-01	8.6E-02	2.8E-01	4.6E-02
Total PCBs	10 <sup>-4</sup> Risk	mg/kg dw	5.0E+00	9.1E-01	2.8E+00	5.1E-01
Total PCBs	HQ = 1	mg/kg dw	8.5E-01	1.5E-01	4.8E-01	8.3E-02
<b>Dioxin/Furans</b>						
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-6</sup> Risk	mg/kg dw	2.4E-06	1.3E-07	2.0E-06	8.0E-08
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-5</sup> Risk	mg/kg dw	4.8E-05	5.4E-06	3.7E-05	4.5E-06
2,3,4,7,8 PCDF <sup>f</sup>	10 <sup>-4</sup> Risk	mg/kg dw	9.1E-04	1.1E-04	6.2E-04	7.8E-05
2,3,4,7,8 PCDF <sup>f</sup>	HQ = 1	mg/kg dw	4.3E-04	5.0E-05	3.0E-04	3.8E-05
<b>Pesticides</b>						
Aldrin	10 <sup>-6</sup> Risk	mg/kg dw	1.2E-02	2.3E-03	3.5E-02	6.5E-03
Aldrin	10 <sup>-5</sup> Risk	mg/kg dw	1.2E-01	2.3E-02	3.5E-01	6.5E-02
Aldrin	10 <sup>-4</sup> Risk	mg/kg dw	1.2E+00	2.3E-01	3.5E+00	6.5E-01
Aldrin	HQ = 1	mg/kg dw	2.7E+00	5.0E-01	7.7E+00	1.4E+00
Dieldrin	10 <sup>-6</sup> Risk	mg/kg dw	1.0E-02	7.7E-04	1.6E-02	1.4E-03
Dieldrin	10 <sup>-5</sup> Risk	mg/kg dw	1.1E-01	1.9E-02	1.8E-01	3.1E-02
Dieldrin	10 <sup>-4</sup> Risk	mg/kg dw	1.1E+00	2.0E-01	1.8E+00	3.3E-01
Dieldrin	HQ = 1	mg/kg dw	3.9E+00	7.1E-01	6.2E+00	1.1E+00
Heptachlor	10 <sup>-6</sup> Risk	mg/kg dw				
Heptachlor	10 <sup>-5</sup> Risk	mg/kg dw				
Heptachlor	10 <sup>-4</sup> Risk	mg/kg dw				
Heptachlor	HQ = 1	mg/kg dw				
Heptachlor Epoxide	10 <sup>-6</sup> Risk	mg/kg dw	2.2E-02	4.0E-03	5.3E-02	9.6E-03
Heptachlor Epoxide	10 <sup>-5</sup> Risk	mg/kg dw	2.2E-01	4.1E-02	5.3E-01	9.7E-02
Heptachlor Epoxide	10 <sup>-4</sup> Risk	mg/kg dw	2.2E+00	4.1E-01	5.3E+00	9.7E-01
Heptachlor Epoxide	HQ = 1	mg/kg dw	1.1E+00	2.1E-01	2.7E+00	4.9E-01
alpha-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw				
alpha-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw				
alpha-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw				
alpha-Hexachlorocyclohexane	HQ = 1	mg/kg dw				
beta-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw				

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Table 2. Human Health Early PRGs for Fish and Shellfish Consumption<sup>a</sup>

Chemical	Exposure Route:	Units of PRGs	Shellfish Consumption			
	Receptor:		Adult Shellfish Consumption - Clam		Adult Shellfish Consumption - Crayfish	
	Ingestion Rate (g/day):		3.3	18	3.3	18
	Target Risk Level					
beta-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw				
beta-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw				
beta-Hexachlorocyclohexane	HQ = 1	mg/kg dw				
gamma-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw				
gamma-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw				
gamma-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw				
gamma-Hexachlorocyclohexane	HQ = 1	mg/kg dw				
Total Chlordane	10 <sup>-6</sup> Risk	mg/kg dw				
Total Chlordane	10 <sup>-5</sup> Risk	mg/kg dw				
Total Chlordane	10 <sup>-4</sup> Risk	mg/kg dw				
Total Chlordane	HQ = 1	mg/kg dw				
Sum DDD	10 <sup>-6</sup> Risk	mg/kg dw	5.8E-01	1.1E-01	5.4E-01	9.7E-02
Sum DDD	10 <sup>-5</sup> Risk	mg/kg dw	5.8E+00	1.1E+00	5.4E+00	9.8E-01
Sum DDD	10 <sup>-4</sup> Risk	mg/kg dw	5.8E+01	1.1E+01	5.4E+01	9.8E+00
Sum DDD	HQ = 1	mg/kg dw	3.0E+01	5.5E+00	2.8E+01	5.1E+00
Sum DDE	10 <sup>-6</sup> Risk	mg/kg dw	2.2E-01	3.9E-02	9.4E-02	1.6E-02
Sum DDE	10 <sup>-5</sup> Risk	mg/kg dw	2.2E+00	4.1E-01	9.6E-01	1.7E-01
Sum DDE	10 <sup>-4</sup> Risk	mg/kg dw	2.3E+01	4.1E+00	9.6E+00	1.8E+00
Sum DDE	HQ = 1	mg/kg dw	1.6E+01	3.0E+00	7.0E+00	1.3E+00
Sum DDT	10 <sup>-6</sup> Risk	mg/kg dw	3.3E-01	5.9E-02	2.2E-01	3.9E-02
Sum DDT	10 <sup>-5</sup> Risk	mg/kg dw	3.3E+00	6.1E-01	2.2E+00	4.0E-01
Sum DDT	10 <sup>-4</sup> Risk	mg/kg dw	3.3E+01	6.1E+00	2.2E+01	4.0E+00
Sum DDT	HQ = 1	mg/kg dw	2.4E+01	4.4E+00	1.6E+01	2.9E+00

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Table 3. Human Health Early PRGs for Fish and Shellfish Consumption with Water Equal to Zero in the FWM<sup>a</sup>

Chemical	Exposure Route:  Receptor:  Ingestion Rate (g/day):  Target Risk Level	Units of PRGs	Fish Consumption														Shellfish Consumption				
			Adult Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Adult Fish Consumption, Single Species Diet - Smallmouth Bass		Child Fish Consumption, Single Species Diet - Large Home-Range Resident Fish				Child Fish Consumption, Single Species Diet - Smallmouth Bass		Tribal Adult Fish Consumption, Multi-species Diet <sup>b</sup>	Tribal Child Fish Consumption, Multi-species Diet <sup>b</sup>	Adult Shellfish Consumption - Clam		Adult Shellfish Consumption - Crayfish		
			17.5		142		17.5	142	7		60		7	60	86.8 <sup>c</sup>	36.2 <sup>c</sup>	3.3	18	3.3	18	
			Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum	Low Bioaccum	High Bioaccum							
<b>PCBs</b>																					
PCB-126 <sup>d</sup>	10 <sup>-5</sup> Risk	mg/kg dw	6.4E-07	4.0E-07	1.3E-07	4.7E-08	1.1E-07	1.2E-08	1.4E-06	1.1E-06	2.6E-07	1.2E-07	3.1E-07	3.2E-08	1.5E-08	9.6E-08	4.5E-06	8.1E-07	2.2E-06	4.2E-07	
PCB-126 <sup>d</sup>	10 <sup>-5</sup> Risk	mg/kg dw	4.1E-06	3.9E-06	7.5E-07	4.9E-07	1.2E-06	1.4E-07	1.1E-05	8.3E-06	1.6E-06	1.3E-06	3.4E-06	3.6E-07	1.6E-07	1.1E-06	4.6E-05	8.3E-06	2.0E-05	3.9E-06	
PCB-126 <sup>d</sup>	10 <sup>-4</sup> Risk	mg/kg dw	4.3E-05	2.3E-05	5.1E-06	4.5E-06	1.3E-05	1.5E-06	1.2E-04	5.0E-05	1.3E-05	9.4E-06	3.7E-05	3.9E-06	1.8E-06	1.2E-05	4.8E-04	8.6E-05	1.8E-04	3.5E-05	
PCB-126 <sup>d</sup>	HQ = 1	mg/kg dw	2.4E-05	1.5E-05	2.9E-06	2.8E-06	7.2E-06	8.1E-07	1.3E-05	9.0E-06	1.7E-06	1.4E-06	3.8E-06	4.0E-07	2.4E-06	1.2E-06	2.6E-04	4.7E-05	1.0E-04	2.0E-05	
Total PCBs	10 <sup>-5</sup> Risk	mg/kg dw	1.4E-03	6.5E-04	1.7E-04	8.0E-05	3.4E-04	4.2E-05	3.7E-03	1.7E-03	4.3E-04	2.0E-04	9.2E-04	1.1E-04	5.4E-05	3.2E-04	5.0E-02	9.2E-03	2.8E-02	5.2E-03	
Total PCBs	10 <sup>-4</sup> Risk	mg/kg dw	1.4E-02	6.5E-03	1.7E-03	8.0E-04	3.4E-03	4.2E-04	3.7E-02	1.7E-02	4.3E-03	2.0E-03	9.2E-03	1.1E-03	5.4E-04	3.2E-03	5.0E-01	9.2E-02	2.8E-01	5.2E-02	
Total PCBs	10 <sup>-4</sup> Risk	mg/kg dw	1.4E-01	6.5E-02	1.7E-02	8.0E-03	3.4E-02	4.2E-03	3.7E-01	1.7E-01	4.3E-02	2.0E-02	9.2E-02	1.1E-02	5.4E-03	3.2E-02	5.0E+00	9.2E-01	2.8E+00	5.2E-01	
Total PCBs	HQ = 1	mg/kg dw	2.4E-02	1.1E-02	2.9E-03	1.4E-03	5.9E-03	7.3E-04	1.3E-02	6.0E-03	1.5E-03	7.0E-04	3.2E-03	3.7E-04	2.1E-03	1.1E-03	8.6E-01	1.6E-01	4.8E-01	8.9E-02	
<b>Dioxin/Furans</b>																					
2,3,4,7,8 PCDF <sup>e</sup>	10 <sup>-5</sup> Risk	mg/kg dw	3.6E-08	6.1E-09	2.5E-09	1.3E-10	6.8E-08	5.1E-09	1.2E-07	3.7E-08	8.2E-09	7.2E-10	2.3E-07	1.6E-08	3.4E-09	3.1E-08	2.6E-06	3.0E-07	2.2E-06	2.8E-07	
2,3,4,7,8 PCDF <sup>e</sup>	10 <sup>-5</sup> Risk	mg/kg dw	6.6E-07	4.1E-07	4.7E-08	8.9E-09	1.2E-06	8.9E-08	2.5E-06	2.3E-06	1.5E-07	4.9E-08	4.0E-06	2.8E-07	5.8E-08	5.4E-07	4.9E-05	5.6E-06	3.7E-05	4.7E-06	
2,3,4,7,8 PCDF <sup>e</sup>	10 <sup>-4</sup> Risk	mg/kg dw	2.8E-05	1.2E-05	8.5E-07	6.1E-07	2.1E-05	1.5E-06	1.7E-04	4.2E-05	3.3E-06	2.8E-06	7.0E-05	4.9E-06	1.0E-06	9.3E-06	9.1E-04	1.1E-04	6.2E-04	7.8E-05	
2,3,4,7,8 PCDF <sup>e</sup>	HQ = 1	mg/kg dw	9.6E-06	5.7E-06	4.1E-07	2.1E-07	1.0E-05	7.5E-07	3.1E-06	2.6E-06	1.7E-07	6.0E-08	4.6E-06	3.2E-07	1.4E-06	6.1E-07	4.3E-04	5.0E-05	3.0E-04	3.8E-05	
<b>Pesticides</b>																					
Aldrin	10 <sup>-5</sup> Risk	mg/kg dw	7.0E-03	1.4E-03	8.6E-04	1.8E-04											1.2E-02	2.3E-03	3.5E-02	6.5E-03	
Aldrin	10 <sup>-5</sup> Risk	mg/kg dw	7.0E-02	1.4E-02	8.6E-03	1.8E-03											1.2E-01	2.3E-02	3.5E-01	6.5E-02	
Aldrin	10 <sup>-4</sup> Risk	mg/kg dw	7.0E-01	1.4E-01	8.6E-02	1.8E-02											1.2E+00	2.3E-01	3.5E+00	6.5E-01	
Aldrin	HQ = 1	mg/kg dw	1.5E+00	3.1E-01	1.9E-01	3.8E-02											2.7E+00	5.0E-01	7.7E+00	1.4E+00	
Dieldrin	10 <sup>-6</sup> Risk	mg/kg dw	8.5E-04	4.5E-04	1.1E-04	5.6E-05	5.4E-04	6.7E-05	2.3E-03	1.2E-03	2.7E-04	1.4E-04	1.4E-03	1.7E-04	4.9E-05	3.0E-04	1.1E-02	2.1E-03	1.8E-02	3.3E-03	
Dieldrin	10 <sup>-5</sup> Risk	mg/kg dw	8.5E-03	4.5E-03	1.1E-03	5.6E-04	5.4E-03	6.7E-04	2.3E-02	1.2E-02	2.7E-03	1.4E-03	1.4E-02	1.7E-03	4.9E-04	3.0E-03	1.1E-01	2.1E-02	1.8E-01	3.3E-02	
Dieldrin	10 <sup>-4</sup> Risk	mg/kg dw	8.5E-02	4.5E-02	1.1E-02	5.6E-03	5.4E-02	6.7E-03	2.3E-01	1.2E-01	2.7E-02	1.4E-02	1.4E-01	1.7E-02	4.9E-03	3.0E-02	1.1E+00	2.1E-01	1.8E+00	3.3E-01	
Dieldrin	HQ = 1	mg/kg dw	2.9E-01	1.6E-01	3.6E-02	1.9E-02	1.9E-01	2.3E-02	1.6E-01	8.3E-02	1.8E-02	9.7E-03	9.9E-02	1.2E-02	4.0E-02	2.0E-02	3.9E+00	7.1E-01	6.2E+00	1.1E+00	
Heptachlor	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-02	5.4E-03	3.8E-03	6.7E-04			8.3E-02	1.5E-02	9.6E-03	1.7E-03			1.2E-03	7.4E-03					
Heptachlor	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-01	5.4E-02	3.8E-02	6.7E-03			8.3E-01	1.5E-01	9.6E-02	1.7E-02			1.2E-02	7.4E-02					
Heptachlor	10 <sup>-4</sup> Risk	mg/kg dw	3.1E+00	5.4E-01	3.8E-01	6.7E-02			8.3E+00	1.5E+00	9.6E-01	1.7E-01			1.2E-01	7.4E-01					
Heptachlor	HQ = 1	mg/kg dw	3.0E+01	5.2E+00	3.7E+00	6.5E-01			1.6E+01	2.8E+00	1.9E+00	3.3E-01			2.8E+00	1.4E+00					
Heptachlor Epoxide	10 <sup>-6</sup> Risk	mg/kg dw	3.1E-03	2.3E-03	3.9E-04	2.8E-04											2.2E-02	4.1E-03	5.3E-02	9.7E-03	
Heptachlor Epoxide	10 <sup>-5</sup> Risk	mg/kg dw	3.1E-02	2.3E-02	3.9E-03	2.8E-03											2.2E-01	4.1E-02	5.3E-01	9.7E-02	
Heptachlor Epoxide	10 <sup>-4</sup> Risk	mg/kg dw	3.1E-01	2.3E-01	3.9E-02	2.8E-02											2.2E+00	4.1E-01	5.3E+00	9.7E-01	
Heptachlor Epoxide	HQ = 1	mg/kg dw	1.6E-01	1.2E-01	2.0E-02	1.4E-02											1.1E+00	2.1E-01	2.7E+00	4.9E-01	
alpha-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw	2.0E-02	3.9E-03	2.5E-03	4.8E-04			5.4E-02	1.0E-02	6.3E-03	1.2E-03			8.5E-04						
alpha-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw	2.0E-01	3.9E-02	2.5E-02	4.8E-03			5.4E-01	1.0E-01	6.3E-02	1.2E-02			8.5E-03						
alpha-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw	2.0E+00	3.9E-01	2.5E-01	4.8E-02			5.4E+00	1.0E+00	6.3E-01	1.2E-01			8.5E-02						
alpha-Hexachlorocyclohexane	HQ = 1	mg/kg dw	4.3E+02	8.3E+01	5.4E+01	1.0E+01			2.3E+02	4.5E+01	2.7E+01	5.2E+00			4.3E+01						
beta-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw					4.1E-01	5.1E-02					1.1E+00	1.3E-01	4.3E-03						
beta-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw					4.1E+00	5.1E-01					1.1E+01	1.3E+00	4.3E-02						
beta-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw					4.1E+01	5.1E+00					1.1E+02	1.3E+01	4.3E-01						
beta-Hexachlorocyclohexane	HQ = 1	mg/kg dw					1.9E+02	2.4E+01					1.0E+02	1.2E+01	4.6E+00						
gamma-Hexachlorocyclohexane	10 <sup>-6</sup> Risk	mg/kg dw	2.8E-01	2.3E-02	3.4E-02	2.8E-03															
gamma-Hexachlorocyclohexane	10 <sup>-5</sup> Risk	mg/kg dw	2.8E+00	2.3E-01	3.4E-01	2.8E-02															
gamma-Hexachlorocyclohexane	10 <sup>-4</sup> Risk	mg/kg dw	2.8E+01	2.3E+00	3.4E+00	2.8E-01															
gamma-Hexachlorocyclohexane	HQ = 1	mg/kg dw	3.9E+01	3.2E+00	4.8E+00	4.0E-01															
Total Chlordane	10 <sup>-6</sup> Risk	mg/kg dw	2.2E-02	9.5E-03	2.7E-03	1.2E-03	8.4E-03	1.0E-03	5.9E-02	2.5E-02	6.9E-03	3.0E-03	2.2E-02	2.6E-03	9.8E-04	5.9E-03					
Total Chlordane	10 <sup>-5</sup> Risk	mg/kg dw	2.2E-01	9.5E-02	2.7E-02	1.2E-02	8.4E-02	1.0E-02	5.9E-01	2.5E-01	6.9E-02	3.0E-02	2.2E-01	2.6E-02	9.8E-03	5.9E-02					
Total Chlordane	10 <sup>-4</sup> Risk	mg/kg dw	2.2E+00	9.5E-01	2.7E-01	1.2E-01	8.4E-01	1.0E-01	5.9E+00	2.5E+00	6.9E-01	3.0E-01	2.2E+00	2.6E-01	9.8E-02	5.9E-01					
Total Chlordane	HQ = 1	mg/kg dw	1.7E+00	7.1E-01	2.1E-01	8.8E-02	6.3E-01	7.7E-02	8.9E-01	3.8E-01	1.0E-01	4.5E-02	3.4E-01	3.9E-02	1.7E-01	8.8E-02					
Sum DDD	10 <sup>-5</sup> Risk	mg/kg dw	2.7E-02	1.1E-02	3.3E-03	1.4E-03	9.0E-03	1.1E-03	7.2E-02	3.0E-02	8.4E-03	3.6E-03	2.4E-02	2.8E-03	1.1E-03	6.8E-03	5.8E-01	1.1E-01	5.4E-01	9.8E-02	
Sum DDD	10 <sup>-5</sup> Risk	mg/kg dw	2.7E-01	1.1E-01	3.3E-02	1.4E-02	9.0E-02	1.1E-02	7.2E-01	3.0E-01	8.4E-02	3.6E-02	2.4E-01	2.8E-02	1.1E-02	6.8E-02	5.8E+00	1.1E+00	5.4E+00	9.8E-01	
Sum DDD	10 <sup>-4</sup> Risk	mg/kg dw	2.7E+00	1.1E+00	3.3E-01	1.4E-01	9.0E-01	1.1E-01	7.2E+00	3.0E+00	8.4E-01	3.6E-01	2.4E+00	2.8E-01	1.1E-01	6.8E-01	5.8E+01	1.1E+01	5.4E+01	9.8E+00	
Sum DDD	HQ = 1	mg/kg dw	1.4E+00	5.8E-01	1.7E-01	7.2E-02	4.6E-01	5.7E-02	7.4E-01	3.1E-01	8.6E-02	3.7E-02	2.5E-01	2.9E-02	1.4E-01	7.0E-02	3.0E+01	5.5E+00	2.8E+01	5.1E+00	
Sum DDE	10 <sup>-6</sup> Risk	mg/kg dw	4.7E-03	2.5E-03	5.8E-04	3.1E-04	1.0E-03	1.3E-04	1.3E-02	6.7E-03	1.5E-03	7.8E-04	2.8E-03	3.3E-04	1.8E-04	1.1E-03	2.3E-01	4.1E-02	9.6E-02	1.8E-02	
Sum DDE	10 <sup>-5</sup> Risk	mg/kg dw	4.7E-02	2.5E-02	5.8E-03	3.1E-03	1.0E-02	1.3E-03	1.3E-01	6.7E-02</											





**Table 6. Upriver Surface Sediment Central Tendency and Upper Threshold Statistics, Dry Weight Concentrations, Primary Outliers Removed.**

Chemical	Units	Upper Threshold Statistic - UPL	Central Tendency Statistic - UCL
<b>Metals</b>			
Aluminum	mg/kg	3.38E+04	2.49E+04
Arsenic	mg/kg	3.97E+00	3.01E+00
Chromium	mg/kg	3.21E+01	2.38E+01
Copper	mg/kg	3.73E+01	2.59E+01
Mercury	mg/kg	5.32E-02	3.37E-02
Nickel	mg/kg	2.61E+01	2.14E+01
Zinc	mg/kg	1.10E+02	7.90E+01
<b>Butyltins</b>			
Tributyltin ion	mg/kg	NC	NC
<b>PAHs</b>			
Benzo(a)anthracene	mg/kg	1.57E-02	6.94E-03
Benzo(a)pyrene	mg/kg	1.53E-02	7.09E-03
Benzo(b)fluoranthene	mg/kg	2.02E-02	9.32E-03
Benzo(k)fluoranthene	mg/kg	1.05E-02	4.60E-03
Dibenzo(a,h)anthracene	mg/kg	3.20E-03	1.70E-03
Indeno(1,2,3-cd)pyrene	mg/kg	1.14E-02	5.70E-03
Naphthalene	mg/kg	6.21E-03	3.36E-03
Total cPAH	mg/kg	2.28E-02	1.10E-02
<b>SVOCs</b>			
Bis(2-ethylhexyl) phthalate	mg/kg	1.18E-01	6.72E-02
Hexachlorobenzene	mg/kg	2.79E-02	1.70E-02
<b>PCBs</b>			
PCB077	mg/kg	2.52E-05	1.08E-05
PCB126	mg/kg	3.92E-06	2.01E-06
Total PCBs <sup>a</sup>	mg/kg	1.70E-02	6.85E-03
PCB TEQ - Mammals 2006	mg/kg	6.06E-07	3.76E-07
<b>Dioxins/Furans</b>			
2,3,4,7,8-Pentachlorodibenzofuran	mg/kg	5.00E-07	1.48E-07
TCDD TEQ - Mammals 2006	mg/kg	2.16E-06	1.25E-06
<b>Pesticides</b>			
Aldrin	mg/kg	3.39E-04	2.67E-04
alpha-Hexachlorocyclohexane	mg/kg	NC	NC
beta-Hexachlorocyclohexane	mg/kg	1.05E-03	4.46E-04
Dieldrin	mg/kg	2.15E-04	1.37E-04
gamma-Hexachlorocyclohexane	mg/kg	NC	NC
Heptachlor	mg/kg	NC	NC
Heptachlor epoxide	mg/kg	NC	NC
Sum DDD	mg/kg	1.31E-03	6.89E-04
Sum DDE	mg/kg	1.72E-03	9.51E-04
Sum DDT	mg/kg	1.10E-03	5.44E-04
Total Chlordane	mg/kg	6.98E-04	3.80E-04
Total DDx - EPA case	mg/kg	3.03E-03	1.64E-03
Total DDx - LWG case	mg/kg	3.59E-03	1.85E-03

**Notes:**

<sup>a</sup> Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

NC - not calculated due to low detection frequency

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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**This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.**

**Table 7. Upriver Surface Sediment Central Tendency and Upper Threshold Statistics, OC-Equivalent Dry Weight Concentrations, Primary Outliers Removed.**

Chemical	Units	Upper Threshold Statistic - UPL	Central Tendency Statistic - UCL
<b>Butyltins</b>			
Tributyltin ion	mg/kg	NC	NC
<b>PAHs</b>			
Benzo(a)anthracene	mg/kg	2.42E-02	1.07E-02
Benzo(a)pyrene	mg/kg	2.36E-02	1.09E-02
Benzo(b)fluoranthene	mg/kg	3.10E-02	1.44E-02
Benzo(k)fluoranthene	mg/kg	1.61E-02	7.08E-03
Dibenzo(a,h)anthracene	mg/kg	4.92E-03	2.61E-03
Indeno(1,2,3-cd)pyrene	mg/kg	1.75E-02	8.77E-03
Naphthalene	mg/kg	9.57E-03	5.18E-03
Total cPAH	mg/kg	3.52E-02	1.70E-02
<b>SVOCs</b>			
Bis(2-ethylhexyl) phthalate	mg/kg	1.82E-01	1.03E-01
Hexachlorobenzene	mg/kg	4.30E-02	2.61E-02
<b>PCBs</b>			
PCB077	mg/kg	3.88E-05	1.66E-05
PCB126	mg/kg	6.04E-06	3.09E-06
Total PCBs <sup>a</sup>	mg/kg	2.62E-02	1.05E-02
PCB TEQ - Mammals 2006	mg/kg	9.34E-07	5.79E-07
<b>Dioxins/Furans</b>			
2,3,4,7,8-Pentachlorodibenzofuran	mg/kg	7.70E-07	2.28E-07
TCDD TEQ - Mammals 2006	mg/kg	3.32E-06	1.93E-06
<b>Pesticides</b>			
Aldrin	mg/kg	5.22E-04	4.11E-04
alpha-Hexachlorocyclohexane	mg/kg	NC	NC
beta-Hexachlorocyclohexane	mg/kg	1.62E-03	6.87E-04
Dieldrin	mg/kg	3.31E-04	2.11E-04
gamma-Hexachlorocyclohexane	mg/kg	NC	NC
Heptachlor	mg/kg	NC	NC
Heptachlor epoxide	mg/kg	NC	NC
Sum DDD	mg/kg	2.02E-03	1.06E-03
Sum DDE	mg/kg	2.65E-03	1.47E-03
Sum DDT	mg/kg	1.69E-03	8.38E-04
Total Chlordane	mg/kg	1.08E-03	5.85E-04
Total DDx - EPA case	mg/kg	4.66E-03	2.52E-03
Total DDx - LWG case	mg/kg	5.53E-03	2.85E-03

**Notes:**

<sup>a</sup> Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

NC - not calculated due to low detection frequency

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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**Table 8. Upriver Surface Sediment Central Tendency and Upper Threshold Statistics, OC-normalized Concentrations, Primary Outliers Removed.**

Chemical	Units	Upper Threshold Statistic - UPL	Central Tendency Statistic - UCL
<b>Butyltins</b>			
Tributyltin ion	mg/kgOC	NC	NC
<b>PAHs</b>			
Benzo(a)anthracene	mg/kgOC	1.99E+00	8.25E-01
Benzo(a)pyrene	mg/kgOC	1.90E+00	1.03E+00
Benzo(b)fluoranthene	mg/kgOC	2.55E+00	1.11E+00
Benzo(k)fluoranthene	mg/kgOC	1.93E+00	9.69E-01
Dibenzo(a,h)anthracene	mg/kgOC	7.95E-01	4.11E-01
Indeno(1,2,3-cd)pyrene	mg/kgOC	1.68E+00	7.10E-01
Naphthalene	mg/kgOC	8.78E-01	4.21E-01
Total cPAH	mg/kgOC	5.05E+00	2.52E+00
<b>SVOCs</b>			
Bis(2-ethylhexyl) phthalate	mg/kgOC	1.15E+01	6.86E+00
Hexachlorobenzene	mg/kgOC	7.92E+00	4.62E+00
<b>PCBs</b>			
PCB077	mg/kgOC	2.17E-03	1.01E-03
PCB126	mg/kgOC	3.63E-04	1.81E-04
Total PCBs <sup>a</sup>	mg/kgOC	1.58E+00	6.94E-01
PCB TEQ - Mammals 2006	mg/kgOC	5.55E-05	3.77E-05
<b>Dioxins/Furans</b>			
2,3,4,7,8-Pentachlorodibenzofuran	mg/kgOC	7.83E-06	3.62E-06
TCDD TEQ - Mammals 2006	mg/kgOC	5.45E-04	3.62E-04
<b>Pesticides</b>			
Aldrin	mg/kgOC	2.10E-02	1.59E-02
alpha-Hexachlorocyclohexane	mg/kgOC	NC	NC
beta-Hexachlorocyclohexane	mg/kgOC	1.16E-01	4.67E-02
Dieldrin	mg/kgOC	2.32E-02	1.16E-02
gamma-Hexachlorocyclohexane	mg/kgOC	NC	NC
Heptachlor	mg/kgOC	NC	NC
Heptachlor epoxide	mg/kgOC	NC	NC
Sum DDD	mg/kgOC	1.04E-01	5.98E-02
Sum DDE	mg/kgOC	1.28E-01	8.30E-02
Sum DDT	mg/kgOC	7.94E-02	3.73E-02
Total Chlordane	mg/kgOC	6.20E-02	3.34E-02
Total DDT - EPA case	mg/kgOC	2.40E-01	1.59E-01
Total DDx - LWG case	mg/kgOC	2.58E-01	1.65E-01

**Notes:**

<sup>a</sup> Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

NC - not calculated due to low detection frequency

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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**APPENDIX A**  
**EARLY PRG DEVELOPMENT METHODS**

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Attachment 1 TEQ Surrogates for PRG Development

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## 1.0 MODEL DEVELOPMENT FOR EARLY PRGS

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“Early” preliminary remediation goals (PRGs) are being calculated for the Portland Harbor remedial investigation/feasibility study (RI/FS) to accommodate the US Environmental Protection Agency’s (EPA’s) request for tools to conduct preliminary and exploratory analyses of environmental data collected from the study area and other areas. For the calculation of early preliminary remediation goals (early PRGs) for sediment, the relationships between chemical concentrations in sediment and tissue were evaluated using either the food web model (FWM) or through development of biota-sediment accumulation factors (BSAFs) or biota-sediment accumulation regressions (BSARs).<sup>6</sup> An acceptable tissue chemical concentration is determined (based on back-calculation from a toxicity reference value [TRV] or risk estimate) and then a model (the FWM, BSAR, or BSAF) is used to estimate the sediment concentration (i.e., the sediment PRG) that will result from that tissue concentration.

The FWM is the preferred approach for PRG development because it is a mechanistic model and includes uptake of chemicals from water as an independent exposure pathway. The FWM was applied for all chemicals for which it was appropriate (i.e., hydrophobic organic chemicals). For all other chemicals, an attempt was made to develop a BSAR/F model.

The general approach for the FWM is presented in Appendix E of the *Portland Harbor RI/FS: Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report* (Integral et al. 2007). The model has since been updated using more recently collected data and refinements of a few key parameters. The revised FWM will be described in detail in the bioaccumulation modeling report. Section 2 of this document presents the preliminary chemicals of concern (COCs) for which early PRGs development was desired and whether the FWM or a BSAR/F modeling approach was employed. Section 3 presents the methods used to develop and select BSAFs and BSARs. Some of the special approaches described for BSAR/Fs were also used in application of the FWM (i.e., approach for chemicals mixtures with toxicity equivalents and exposure area assumptions for species with home ranges smaller than the site). Section 4 presents a discussion of how the BSAR/Fs and FWM were used to calculate early PRGs. Section 5 presents the references.

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<sup>6</sup> EPA’s guidance on estimating BSAFs (Burkhard 2006) includes regression modeling as a BSAF estimation technique for developing BSAFs. Here BSARs and BSAFs have been distinguished to emphasize a very important difference between the two, which is that BSARs are able to account for the background contribution to tissue residues (i.e., the contribution not associated with exposure to co-located contaminated sediment), whereas BSAFs are not. The ability to account for background becomes very important when deriving PRGs because the error introduced by not accounting for background becomes larger when extrapolating to lower sediment concentrations. BSAFs also assume a linear relationship and therefore may obscure bioaccumulation that is governed by a nonlinear relationship.

## 2.0 PRELIMINARY COCS FOR WHICH FWM OR BSAR/F DEVELOPMENT WAS ATTEMPTED

Table 1 presents a list of the preliminary human health and ecological COCs and identifies whether development of the FWM or a BSAR/F was attempted for use in early PRG development. The FWM is the preferred approach because it is a mechanistic model and can explicitly account for water contribution to chemical concentrations in tissue. The FWM is appropriate for modeling hydrophobic organic chemicals (Arnot and Gobas 2004). If a chemical was identified as an ecological preliminary COC or human health preliminary COC based on risk associated with any one species and the FWM could not be applied for a given chemical-species combination, BSAR and BSAF development for that chemical-species combination was attempted. Early PRGs were not developed for all chemical-species combinations, only those associated with risk estimates of concern (i.e., HQs > 1 or upper bound cancer risk estimates greater than one in one million). Note that the COCs for the human and ecological risk assessments differed (Table 1). The general methodology for PRG development using the FWM has been previously described (Integral et al. 2007). Details of the refined FWM will be provided in the bioaccumulation modeling report. The general BSAR/F development methodology is presented in Section 3.0.

Table 1. Preliminary COCs for which FWM or BSAR/F Development was Attempted

Chemical	Human Health PRGs	BERA PRGs <sup>a</sup>
<b>Metals</b>		
Antimony	BSAR/F	
Arsenic	BSAR/F	BSAR/F
Cadmium		BSAR/F
Copper		BSAR/F
Lead	BSAR/F	BSAR/F
Mercury	BSAR/F	BSAR/F
Selenium	BSAR/F	
Zinc	BSAR/F	BSAR/F
<b>PAHs</b>		
Benzo(a)anthracene	BSAR/F	
Benzo(a)pyrene	BSAR/F	BSAR/F
Benzo(b)fluoranthene	BSAR/F	
Benzo(k)fluoranthene	BSAR/F	
Chrysene	BSAR/F	
Dibenzo(a,h)anthracene	BSAR/F	
Indeno(1,2,3-cd)pyrene	BSAR/F	
Total cPAHs <sup>b</sup>	BSAR/F	
<b>Phthalates</b>		
BEHP	BSAR/F	BSAR/F
Dibutyl phthalate		BSAR/F
<b>SVOCs</b>		
Hexachlorobenzene	BSAR/F	

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Table 1. Preliminary COCs for which FWM or BSAR/F Development was Attempted

Chemical	Human Health PRGs	BERA PRGs <sup>a</sup>
Pentachlorophenol	BSAR/F	
<b>Butyltins</b>		
Tributyltin		BSAR/F
<b>PCBs</b>		
Total PCBs	FWM	FWM
PCB TEQ (birds) <sup>d</sup>		FWM
PCB TEQ (mammals) <sup>d</sup>	FWM	FWM
<b>Dioxins and Furans</b>		
Dioxin/furan TEQ (birds) <sup>d</sup>	FWM	FWM
Dioxin/furan TEQ (mammals) <sup>d</sup>	FWM	FWM
<b>Pesticides</b>		
Aldrin	FWM	FWM
Total chlordane	FWM	
Sum DDD	FWM	
Sum DDE	FWM	FWM
Sum DDT	FWM	
Total DDTs		FWM
Dieldrin	FWM	
alpha-HCH	FWM	
beta-HCH	FWM	
gamma-HCH	FWM	
Heptachlor	FWM	
Heptachlor epoxide	FWM	

<sup>a</sup> Total TEQs (the sum of the PCB TEQ and the dioxin TEQ for birds and mammals) were calculated in the BERA, but no PRGs will be calculated for total TEQ. (PRGs are available for both the PCB TEQ and dioxin TEQ).

<sup>b</sup> The surrogate for total cPAHs is benzo[a]pyrene

<sup>c</sup> The surrogate for PCB TEQ (birds) is PCB077 and the surrogate for PCB TEQ (mammals) is PCB126.

<sup>d</sup> The surrogate for Dioxin/Furan TEQ (birds and mammals) is 2,3,4,7,8-PCDF

BEHP – bis(2-ethylhexyl) phthalate

HCH – hexachlorocyclohexane

BERA – baseline ecological risk assessment

PAH – polycyclic aromatic hydrocarbon

BSAR/F – biota-sediment accumulation regression or biota sediment accumulation factor

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

COC – chemical of concern

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### 3.0 EVALUATION OF BSARS AND BSAFS

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PRGs, and therefore BSAR/Fs were only developed for chemical exposure scenario combinations that were identified as COCs. For example, a chemical that could not be modeled using the FWM might be a COC based on human consumption of clams but may not be a COC for human consumption of fish or any ecological risk scenario. In this case, a BSAR/F might only be developed for clams (and no other species). For chemicals for which the FWM could not be applied (see Table 1), BSAR/Fs were used to estimate early PRGs when a linear relationship between co-located sediment and tissue concentrations could be established based on data collected for the baseline risk assessments. The BSAR assumes a relationship between the concentration of a bioaccumulative chemical in sediment and that measured in tissue. Frequently, the relationship between tissue and sediment concentrations is calculated as the ratio of tissue and sediment concentrations (BSAF) rather than as a BSAR. However, BSARs were preferred for the following reasons:

- BSAFs based on a simple ratio between sediment and tissue chemical concentrations do not allow for the possibility of background contributions to tissue from non-sediment sources.
- BSAFs are just a special case of BSARs (i.e., linear equations with the intercept forced to equal zero), so regression modeling will produce a BSAF if justified by the data.<sup>7</sup>

For species whose home range is smaller than the site (and therefore have multiple sets of paired data for co-located tissue and sediment chemical concentration [i.e., benthic invertebrates, sculpin, and smallmouth bass]), sediment-biota relationships were evaluated to determine if BSARs were justified (Section 3.3). For large-home-range species (which lacked multiple sets of co-located sediment and tissue chemical concentration data [i.e., black crappie, brown bullhead, and carp<sup>8</sup>]), BSAFs were developed based on ratios of sediment and tissue chemical concentrations, as appropriate (Section 3.4).

#### 3.1 SPECIAL APPROACH FOR CHEMICAL MIXTURES WITH TOXICITY EQUIVALENTS

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Some of the preliminary COCs identified in the human health and ecological risk assessments are actually mixtures that incorporate both concentration and toxicity information (i.e., bird polychlorinated biphenyl [PCB] toxic equivalent [TEQ], bird dioxin/furan TEQ, mammal PCB TEQ, and mammal dioxin/furan TEQ). Selection of a single chemical as a surrogate for these mixtures allowed a BSAR or BSAF based on that individual chemical to be used for PRG development. This selection process and development of regression relationships to relate the surrogates to the TEQ are described in

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<sup>7</sup> In cases where the data support a zero-intercept, the averaging approach (Burkhard 2006) may be used instead of the zero-intercept regression model to set the BSAF. The choice between the averaging model and regression model should take into account an analysis of the two models' residuals.

<sup>8</sup> BSAFs were also developed for peamouth, largescale sucker, and northern pikeminnow for one chemical (lead). These species were part of the dietary line of evidence for birds in the ecological risk assessment.

detail in Attachment 1. Briefly, data on TEQ concentrations and concentrations of TEQ constituents (unadjusted for toxicity) were evaluated to identify an individual surrogate chemical for each TEQ. Based on this evaluation, the following chemicals were selected as surrogates for PCB and dioxin TEQs in FWM and BSAR and BSAF development:

- PCB TEQ (birds): PCB-077
- PCB TEQ (mammals): PCB-126
- Dioxin TEQ (birds): 2,3,4,7,8-pentachlorodibenzofuran
- Dioxin TEQ (mammals): 2,3,4,7,8-pentachlorodibenzofuran

The regression equations that relate each of these congeners to its respective TEQ are presented in Attachment 1 for each species. These equations were used to calculate PRGs for PCB and dioxin TEQs in terms of their surrogate chemical. The application of these regressions for development of PRGs is discussed in further detail in Section 4.

### **3.2 EXPOSURE AREA CONSIDERATIONS FOR DIFFERENT SPECIES**

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Development of the FWM and BSARs required assumptions about exposure areas of the species modeled. These assumptions impact the development of the bioaccumulation models and therefore the PRGs derived from these models, as well as the scales at which the PRGs may be applied. Uncertainties associated with these assumptions will be considered in the bioaccumulation modeling report.

For benthic invertebrate BSAR development and FWM application at spatial scales smaller than site wide, each tissue sample included had a paired co-located sediment sample (i.e., the sediment chemical concentration in the co-located sediment sample was assumed to describe the sediment exposure for a given tissue sample). For BSAF development for black crappie, carp, and brown bullhead, the exposure area for each species was assumed to be site-wide (i.e., the site-wide spatially weighted average concentration [SWAC] was used to characterize sediment exposure for any given chemical). This is consistent with telemetry studies of several of these fish in the Lower Willamette River indicating home ranges larger than the study area (Friesen 2005; Pribyl et al. 2005). For sculpin and smallmouth bass, this was not assumed.

Sculpin and smallmouth bass are expected to have exposure areas larger than single point estimates (as used for the benthic invertebrates) and smaller than the entire site (as used for the other fish species). For these two species, special methods for describing exposure areas were developed to estimate chemical concentrations in sediment for BSAR and FWM development. These approaches are described in Section 3.3.2.

### **3.3 GENERAL APPROACH FOR BSARS FOR SPECIES WITH HOME RANGES SMALLER THAN THE SITE**

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The FWM and BSARs were developed for preliminary COCs (see Table 1) for those species with exposure areas smaller than the site. This includes benthic invertebrates (lab clams, lab worms, field clams, and crayfish), sculpin, and smallmouth bass.

For organic chemicals, sediment chemical concentrations were normalized based on organic carbon (OC) content, and tissue chemical concentrations were normalized based on lipid content before BSAR regressions were performed. For non-organics, regressions were performed using total sediment chemical concentration and total tissue concentrations (unadjusted).

The selection of a final BSAR for each receptor-preliminary COC pair was a two-step process informed by Burkhard (2006), which involved first screening several possible linear tissue-sediment models and then selecting the best-fitting model from those models that passed the screening step (see Section 3.3.3 for details). Only linear models (i.e., untransformed linear, log-linear, and log-log linear models) were considered in this BSAR development process inasmuch as data were rarely adequate to consider more complex models.

In the screening step of the BSAR process, any model that passed predetermined significance and fit statistics criteria was screened in as a potential BSAR. This screening step is discussed in detail in Section 3.3.3. In the second step of the BSAR process, described in Section 3.3.4, the fits of all models that passed the screen were evaluated based on visual inspection of graphical displays of the tissue-sediment relationships and distributions of model residuals. From the models that passed the screen, the simplest model that was linear and had homogeneous variance of residuals across the full range of concentrations was selected. If no model passed, the initial screen for a receptor-preliminary COC pair, no BSAR was selected.

#### **3.3.1 BSAR Data Preparation for Benthic Invertebrates**

The co-located surface sediment and biota tissue data within the study area from the baseline ecological risk assessment (BERA) dataset<sup>9</sup> (for the receptor-preliminary COC pairs presented in Table 1) were used in the development of BSARs. Empirical sediment chemical concentrations (expressed as dry weight and OC-normalized concentrations) and co-located tissue concentrations (expressed as wet weight and lipid normalized concentrations) were used for developing BSARs. Up to 40 and 28 co-located sediment and tissue data pairs were evaluated for field clams and crayfish, respectively. Up to 35 co-located sediment and tissue data pairs were evaluated for lab clams and lab worms. As directed by EPA for the BERA (EPA 2008), concentrations of neutral organic COCs (i.e., butyltins, PCBs, phthalates, and pesticides) measured in lab clam and lab worm tissue were adjusted to estimate steady-state concentrations using the process described in the US Army Corps of Engineers *Inland*

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<sup>9</sup> The BERA dataset is defined in Section 4 of Appendix H of the remedial investigation report.

*Testing Manual* (EPA and USACE 1998) based on McFarland (1995). These tissue concentrations were adjusted because field and steady-state conditions may not be represented in tissue concentrations measured in laboratory-exposed organisms within the 28-day exposure period.

Any co-located data pairs with non-detected tissue or sediment concentrations were removed from the BSAR analysis, so that only pairs of detected sediment and detected tissue concentrations were used in BSAR development. As discussed in Section 3.3, for organic chemicals, sediment chemical concentrations were normalized based on OC content, and tissue chemical concentrations were normalized based on lipid content. No adjustments were made to sediment and tissue chemical concentrations for non-organics.

### 3.3.2 BSAR Data Preparation for Smallmouth Bass and Sculpin

There were 39 and 32 composite tissue samples analyzed for whole-body sculpin and whole-body smallmouth bass, respectively. Special approaches for describing exposure areas were developed to characterize exposure areas for sculpin and bass, which are expected to be of intermediate size (i.e., larger than a single point but smaller than site-wide). These areas were intended to describe the foraging areas of the target species and the prey of those species.

For sculpin, a circular area with a radius of one-tenth (0.1) of a mile centered on the centroid of the locations for the sculpin included in each composite sample was selected. Foraging ranges reported in the literature support small home ranges for sculpin. Sculpin movements of over 200 feet have been reported in the literature (Hill and Grossman 1987; Natsumeda 1998, 1999, 2001; Petty and Grossman 2004; Cunjak et al. 2005). An exposure radius of approximately 0.1 miles (500 ft) was assumed to be representative of the home range of the sculpin and their prey. This exposure scale was assumed to be roughly equivalent to the scale over which composite samples were collected. The SWAC for that circular area from a natural neighbors interpolation<sup>10</sup> (de Smith et al. 2008) of sediment data for the BERA was assigned to each composite sculpin sample.

For smallmouth bass, the exposure reach for each composite sample was assumed to be a 1-mile length of the river. Foraging ranges and movements reported in the literature and in region-specific studies have supported small home ranges for smallmouth bass that are smaller than the entire length of the study area. Pribyl et al. (2005) conducted a study from 2000 to 2003, in which the movement of predatory resident fish (including smallmouth bass) was tracked using radio-tagged fish in the Lower Willamette River. Radio-tagged smallmouth bass tended to stay near release points, and the median of the maximum distance traveled by smallmouth bass was 2.3 km (1.4 miles) from the release site over the tracking period; however, most smallmouth bass traveled only 0.4 km (0.25 mile) within 1 month after the release. In addition, all of the radio-tagged smallmouth bass collected from the

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<sup>10</sup> Natural neighbors interpolation calculates the value for each cell by adding the cell location to the original set of locations and recalculating the set of Thiessen polygons (de Smith et al. 2008); each cell's value is proportional to the average of the area of the original Thiessen polygon set covered by that cell's Thiessen polygon.

lower portion of the Willamette River (from River Mile [RM] 0.0 to RM 22.5) were located within 20% of the width of the river from either shore, suggesting a preference for nearshore habitat. An exposure area of approximately 1 mile was assumed to be representative of the foraging range of the smallmouth bass.

Because it was unknown whether the smallmouth bass might forage upstream or downstream from where they were collected, 1 RM exposure areas at one-tenth of a mile increments were evaluated ranging from 1 mile upstream to 1 mile downstream of the collection location of each smallmouth bass in a given composite.<sup>11</sup> Thus there were up to 10 exposure estimates (each being a SWAC covering 1 RM) for each fish. The SWACs for all the fish within a composite were then averaged. Due to the scatter or closeness of the individual fish collected for each composite tissue sample and the upstream and downstream boundaries of the site (exposure was not estimated for areas beyond study boundaries), the number of 1-mile exposure areas averaged for each composite varied. The 1-mile exposure areas had boundaries perpendicular to the river course, and SWACs for these areas were calculated from natural neighbors interpolations. Again the sediment chemistry data for the natural neighbor interpolation came from the BERA dataset.

The sediment data used to generate SWACs were based on the BERA dataset, which included a subset of data from the site characterization and risk assessment (SCRA) database. Only those data included in the SCRA database of acceptable data quality for risk evaluation (Category 1/QA2) have been included in the BERA dataset, as agreed to between the Lower Willamette Group (LWG), US Environmental Protection Agency (EPA), and EPA's partners in the programmatic work plan (Integral et al. 2004). Surface sediment in the ERA dataset included all data collected within the top 30.5 cm of the sediment horizon and located within the study area (RM 1.9 to RM 11.8), excluding Round 1 human health beach sediment. Sediment natural attenuation cores collected by LWG for nature and extent were not included in the ERA dataset because multiple depth intervals in small increments (as small as 4 cm) were collected within the 0-to-30.5-cm surface sediment depth horizon, and these cores were collected to support the nature and extent evaluation.

For GIS mapping, surface sediment results qualified as non-detected were treated as one-half the reporting limit (RL) value. Only those stations with reported results were included in the set of points for generating natural neighbors for the SWAC calculation.

### 3.3.3 Model Development and Screening

In the first step of the BSAR development, several possible linear tissue sediment models were developed and screened. Several potential BSARs were calculated for each receptor-preliminary COC dataset with a minimum of three co-located empirical data values. Only linear models were considered in this BSAR development process because data were rarely adequate to consider more complex models. The following linear regressions were considered for each receptor-preliminary COC dataset:

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<sup>11</sup> The study area (RM 1.9 to 11.8) was stratified by 0.1 mile increments, and a SWAC based on natural neighbor interpolation was calculated for each RM.

1. Untransformed tissue concentrations vs. sediment concentrations
2. Untransformed tissue concentrations vs. log-transformed sediment concentrations
3. Log-transformed tissue concentrations vs. log-transformed sediment concentrations
4. The strength of the tissue-sediment relationship was rated as one of the following categories based on the coefficient of determination ( $r^2$ ):
  - No relationship: where  $0.0 \leq r^2 < 0.3$
  - Weak relationship: where  $0.3 \leq r^2 < 0.5$
  - Moderate relationship: where  $0.5 \leq r^2 < 0.7$
  - Strong relationship: where  $0.7 \leq r^2 < 1.0$

A regression model passed the screen if the slope was significantly different from zero ( $p < 0.05$ ) and the coefficient of determination ( $r^2$ ) was greater than 0.30 (i.e., at the minimum, a weak relationship was established).

All BSAR calculations, statistical analyses (significance levels, outlier diagnostics, and goodness-of-fit statistics), and graphical summaries were conducted in the software program R. Statistical summaries were downloaded to a Microsoft Excel<sup>®</sup> workbook, where screening steps were performed through a series of “if-then” statements. Graphical summaries and outlier diagnostic statistics were considered in the second step of the BSAR development process, the model selection step.

### 3.3.4 Model Selection

In the second step of BSAR development, the best-fit model was selected from those models that passed the screening step for each receptor-preliminary COC dataset. If more than one model passed the screen for a receptor-preliminary COC dataset, a visual and quantitative analysis was conducted to select the best model. Visual analysis involved comparison of scatter plots of tissue concentrations (Y axis) vs. sediment concentrations (X axis) and plots of model residual distributions<sup>12</sup> for each of the three model types. In addition, outlier statistics, including Leverage and Cook’s Distance, were calculated for each data value, and the number of potential “outliers” was identified for each model. Graphical analyses and outlier statistics were used in combination to evaluate the extent to which linearity of the tissue-sediment relationship and the variance of residuals were consistent across the range of sampled sediment concentrations and to compare the distributions of residuals around the model for each of the models that passed the initial screen (Section 3.3.3).

Final BSARs were selected from the available models based on the following considerations:

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<sup>12</sup> Plots of model residual distributions included plots of ordered residual values, q-q plots of residuals, and scatterplots of residuals vs. predicted values and residuals vs. leverage values.

- Consistency of linear relationship across the range of sediment concentrations
- Logical consistency of predictions of bioaccumulation (significant intercept greater than zero indicating background concentration from water or metabolism)
- Distribution (homogeneity of variance and normality) of residuals around model predictions
- Outlier and influence diagnostics such as Studentized residuals; Leverage; slope, intercept, fit influence measures; Cook's distance
- The number and spatial distribution of influential data values (potential outliers)
- Possibility that influential or non-fitting data points indicate existence of separate or subpopulations
- Consistency of model type selected within a chemical class (e.g., selected all log-log models for PAHs because overwhelming majority of best performing models for PAHs were log-log models)

Tables 2 through 6 present the best fit models chosen from the available models from the BSAR screen for all benthic invertebrate and fish preliminary COCs. If no model fit a dataset across its entire range of concentrations, indicating that tissue residues were unrelated to sediment chemical concentrations, no BSAR model was selected. In general, the lack of a relationship between sediment and tissue concentrations indicates that the organisms are bioregulating their tissue residues or metabolizing the chemical, that a medium other than sediment (e.g., surface water) is the source of the tissue residue, or that the exposure area or relative use of the exposure area by organisms have not been described with sufficient precision to define a relationship.

Table 2. Selected BSARs for Field Clams

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
<b>Metals</b>				
Arsenic	No relationship <sup>c</sup>	NA	NA	NA
Cadmium	No relationship <sup>c</sup>	NA	NA	NA
Copper	No relationship <sup>c</sup>	NA	NA	NA
Zinc	No relationship <sup>c</sup>	NA	NA	NA
<b>PAHs</b>				
Benzo(a)anthracene	$\ln(C_{tiss}) = 0.588 \times \ln(C_{sed}) + \ln(CF) - 0.97$	log-log	1.70	0.40
Benzo(a)pyrene	$\ln(C_{tiss}) = 0.60 \times \ln(C_{sed}) + \ln(CF) - 2.47$	log-log	2.31	0.36
Benzo(b)fluoranthene	No relationship <sup>c</sup>	NA	NA	NA
Benzo(k)fluoranthene	$\ln(C_{tiss}) = 0.707 \times \ln(C_{sed}) + \ln(CF) - 2.55$	log-log	2.13	0.43
Chrysene	$\ln(C_{tiss}) = 0.486 \times \ln(C_{sed}) + \ln(CF) - 0.66$	log-log	1.57	0.34

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Table 2. Selected BSARs for Field Clams

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
Dibenzo(a,h)anthracene	No relationship <sup>c</sup>	NA	NA	NA
Indeno(1,2,3-cd)pyrene	No relationship <sup>c</sup>	NA	NA	NA
Total cPAHs	Surrogate = benzo(a)pyrene	NA	NA	NA
<b>Phthalates</b>				
BEHP	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Dibutyl phthalate	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
<b>Butyltins</b>				
Tributyltin	No relationship <sup>c</sup>	NA	NA	NA
<b>SVOCs</b>				
Hexachlorobenzene	No relationship <sup>c</sup>	NA	NA	NA

<sup>a</sup> All BSARs based on lipid normalized tissue and OC-normalized sediment data, with the exception of metals where BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>b</sup> Correction factors were used only for log-log BSAR models. The use of the correction factor in calculating PRGs is explained in Section 4.0.

<sup>c</sup> No appropriate BSAR could be developed because the linear and log linear models had either an  $r^2 < 0.30$  or an insignificant slope.

<sup>d</sup> Not enough detect-detect tissue-sediment data pairs.

BEHP – bis(2-ethylhexyl) phthalate

NA – not applicable

BSAR – biota-sediment accumulation regression

HCH – hexachlorocyclohexane

CF – correction factor

PAH – polycyclic aromatic hydrocarbon

C<sub>sed</sub> – sediment concentrations

SVOC – semivolatile organic compound

C<sub>tiss</sub> – tissue concentration

Table 3. Selected BSARs for Crayfish

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
<b>Metals</b>				
Arsenic	No relationship <sup>c</sup>	NA	NA	NA
Copper	No relationship <sup>c</sup>	NA	NA	NA
<b>PAHs</b>				
Benzo(a)anthracene	Insufficient data to determine BSAR	NA	NA	NA
Benzo(a)pyrene	$\ln(C_{tiss}) = 0.983 \times \ln(C_{sed}) + \ln(CF) - 5.54$	log-log	1.09	0.92
Benzo(b)fluoranthene	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Benzo(k)fluoranthene	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Chrysene	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Dibenzo(a,h)anthracene	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Indeno(1,2,3-cd)pyrene	Insufficient data to determine BSAR <sup>d</sup>	NA	NA	NA
Total cPAHs	Surrogate = benzo(a)pyrene	NA	NA	NA
<b>Butyltins</b>				
Tributyltin	No relationship <sup>c</sup>	NA	NA	NA
<b>SVOCs</b>				

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Table 3. Selected BSARs for Crayfish

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
Hexachlorobenzene	No relationship <sup>c</sup>	NA	NA	NA
Pentachlorophenol	Insufficient data to determine BSAR	NA	NA	NA

<sup>a</sup> All BSARs based on lipid normalized tissue and OC-normalized sediment data, with the exception of metals where BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>b</sup> Correction factors were used only for log-log BSAR models. The use of the correction factor in calculating PRGs is explained in Section 4.0.

<sup>c</sup> No appropriate BSAR could be developed because the linear and log linear models had either an  $r^2 < 0.30$  or an insignificant slope.

<sup>d</sup> Not enough detect-detect tissue sediment data pairs.

CF – correction factor	C <sub>sed</sub> – sediment concentrations
C <sub>sed</sub> – sediment concentrations	C <sub>tiss</sub> – tissue concentration
C <sub>tiss</sub> – tissue concentration	HCH – hexachlorocyclohexane
BEHP – bis(2-ethylhexyl) phthalate	NA – not applicable
BSAR – biota-sediment accumulation regression	PAH – polycyclic aromatic hydrocarbon
CF – correction factor	SVOC – semivolatile organic compound

Table 4. Selected BSARs for Lab Worms

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
<b>Metals</b>				
Arsenic	No relationship <sup>c</sup>	NA	NA	NA
Cadmium	No relationship <sup>c</sup>	NA	NA	NA
Copper	No relationship <sup>c</sup>	NA	NA	NA
Zinc	No relationship <sup>c</sup>	NA	NA	NA
<b>PAHs</b>				
Benzo(a)pyrene	$\ln(C_{tiss}) = 0.618 \times \ln(C_{sed}) + \ln(CF) - 0.48$	log-log	1.83	0.393
<b>Butyltins</b>				
Tributyltin	$\ln(C_{tiss}) = 0.968 \times \ln(C_{sed}) + \ln(CF) - 1.67$	log-log	1.52	0.66

<sup>a</sup> All BSARs based on lipid normalized tissue and OC-normalized sediment data, with the exception of metals where BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>b</sup> Correction factors were used only for log-log BSAR models. The use of the correction factor in calculating PRGs is explained in Section 4.0.

<sup>c</sup> No appropriate BSAR could be developed because the linear and log linear models had either an  $r^2 < 0.30$  or an insignificant slope.

CF – correction factor	C <sub>sed</sub> – sediment concentrations
C <sub>sed</sub> – sediment concentrations	C <sub>tiss</sub> – tissue concentration
C <sub>tiss</sub> – tissue concentration	NA – not applicable
BSAR – biota-sediment accumulation regression	PAH – polycyclic aromatic hydrocarbon
CF – correction factor	

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Table 5. Selected BSARs for Sculpin

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
<b>Metals</b>				
Cadmium	No relationship <sup>c</sup>	NA	NA	NA
Copper	No relationship <sup>c</sup>	NA	NA	
Lead	$\ln(C_{\text{tiss}}) = 0.610 \times \ln(C_{\text{sed}}) + \ln(\text{CF}) - 0.486$	log-log	1.29	0.486
<b>Butyltins</b>				
Tributyltin	No relationship <sup>c</sup>	NA	NA	NA

<sup>a</sup> All BSARs based on lipid normalized tissue and OC-normalized sediment data, with the exception of metals where BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>b</sup> Correction factors were used only for log-log BSAR models. The use of the correction factor in calculating PRGs is explained in Section 4.0.

<sup>c</sup> No appropriate BSAR could be developed because the linear and log linear models had either an  $r^2 < 0.30$  or an insignificant slope.

CF – correction factor

CF – correction factor

C<sub>sed</sub> – sediment concentrations

C<sub>sed</sub> – sediment concentrations

C<sub>tiss</sub> – tissue concentration

C<sub>tiss</sub> – tissue concentration

BSAR – biota-sediment accumulation regression

NA – not applicable

Table 6. Selected BSARs for Smallmouth Bass

Chemical	Selected BSAR <sup>a</sup>	Model Type	Correction Factor <sup>b</sup>	R <sup>2</sup>
<b>Metals</b>				
Antimony	No relationship <sup>c</sup>	NA	NA	NA
Arsenic	No relationship <sup>c</sup>	NA	NA	NA
Lead	No relationship <sup>c</sup>	NA	NA	NA
Mercury	No relationship <sup>c</sup>	NA	NA	NA
Selenium	No relationship <sup>c</sup>	NA	NA	NA
Zinc	No relationship <sup>c</sup>	NA	NA	NA
<b>PAHs</b>				
Benzo(a)anthracene	No relationship <sup>c</sup>	NA	NA	NA
Benzo(a)pyrene	No relationship <sup>c</sup>	NA	NA	NA
Dibenzo(a,h)anthracene	No relationship <sup>c</sup>	NA	NA	NA
Total cPAHs	Surrogate = benzo(a)pyrene	NA	NA	NA
<b>Phthalates</b>				
BEHP	No relationship <sup>c</sup>	NA	NA	NA
<b>SVOCs</b>				
Hexachlorobenzene	No relationship <sup>c</sup>	NA	NA	NA

<sup>a</sup> All BSARs based on lipid normalized tissue and OC-normalized sediment data, with the exception of metals where BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>b</sup> Correction factors were used only for log-log BSAR models. The use of the correction factor in calculating PRGs is explained in Section 4.0.

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<sup>c</sup> No appropriate BSAR could be developed because the linear and log linear models had either an  $r^2 < 0.30$  or an insignificant slope.

BEHP – bis(2-ethylhexyl) phthalate

BSAR – biota-sediment accumulation regression

CF – correction factor

$C_{sed}$  – sediment concentrations

$C_{tiss}$  – tissue concentration

HCH – hexachlorocyclohexane

NA – not applicable

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

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### 3.4 LARGE-HOME-RANGE SPECIES BSAFs

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As previously discussed (Section 3.0 introduction), BSAFs were developed for black crappie, carp, and brown bullhead based on a ratio of tissue to sediment chemical concentration. BSAFs were also developed for largescale sucker, northern pikeminnow, and peamouth,<sup>13</sup> for one chemical (lead), using the same approach. The tissue concentration was the average of available composite samples for each species, and the sediment concentration was the SWAC based on a natural neighbor interpolation for the study area.<sup>14</sup> If at least one BSAR for a smaller-home-range species (Section 3.3.4) could be identified for a given chemical, then a BSAF was developed for that chemical (see Tables 2 through 6). However, if no BSARs were identified for a chemical (due to a lack of data or inability to reasonably describe a tissue sediment relationship, see Tables 2 through 6), then no BSAFs for large-home-range species were calculated for that chemical. This step was necessary to prevent the calculation of BSAFs where no relationship between sediment and tissue could be established.

BSAFs express the assumed steady-state relationship between the measured concentration of a bioaccumulating chemical in sediment and that in tissue.

BSAFs for organic preliminary COCs were derived using Equation 1:

$$\text{BSAF} = \frac{(C_{\text{tiss,LN}})}{(C_{\text{sed,OC}})} \quad \text{Equation 1}$$

Where:

BSAF = site-specific fish BSAF  
 $C_{\text{tiss,LN}}$  = fish tissue concentration, LN (mg/kg lipid dry weight [dw])  
 $C_{\text{sed,OC}}$  = surface sediment concentration, OC-normalized (mg/kg OC dw)

BSAFs for metals were derived using Equation 2:

$$\text{BSAF} = \frac{(C_{\text{tiss,dw}})}{(C_{\text{sed,dw}})} \quad \text{Equation 2}$$

Where:

BSAF = site-specific fish BSAF  
 $C_{\text{tiss,dw}}$  = fish tissue concentration (mg/kg ww)  
 $C_{\text{sed,dw}}$  = surface sediment concentration (mg/kg dw)

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<sup>13</sup> These species were also part of the dietary LOE for birds.

<sup>14</sup> It is worth noting that natural neighbor interpolation and the Thiessen polygon method yield identical study area SWACs (de Smith et al. 2008). Thiessen polygons were used previously to derive SWACs used in the *Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report* (Integral et al. 2007).

BSAFs were derived using surface sediment and fish tissue data. Tissue data consisted of all Round 1, Round 2, and Round 3 whole-body fish tissue collected by LWG included in the LWG ERA dataset. SWACs based on natural neighbor interpolations were calculated to represent surface sediment concentrations to estimate fish BSAFs (see Section 3.3.1 for more detailed description of the sediment dataset). Table 7 presents the BSAFs for black crappie, brown bullhead, and carp.

Table 7. BSAFs for Large-Home-Range Species

Chemical	BSAF Use <sup>a</sup>	BSAF Equation <sup>b</sup>		
		Black Crappie	Brown Bullhead	Carp
<b>Metals</b>				
Antimony	Yes	$C_{tiss} = 0.000802 \times C_{sed}$	$C_{tiss} = 0.000802 \times C_{sed}$	$C_{tiss} = 0.00353 \times C_{sed}$
Arsenic	No	NA	NA	NA
Copper	No	NA	NA	NA
Lead <sup>c</sup>	Yes	$C_{tiss} = 0.000269 \times C_{sed}$	$C_{tiss} = 0.00102 \times C_{sed}$	$C_{tiss} = 0.00817 \times C_{sed}$
Mercury	No	NA	NA	NA
Selenium	No	NA	NA	NA
Zinc	No	NA	NA	NA
<b>PAHs</b>				
Benzo(a)anthracene	Yes	No tissue data	$C_{tiss} = 0.0139 \times C_{sed}$	$C_{tiss} = 0.00168 \times C_{sed}$
Benzo(a)pyrene	Yes	No tissue data	$C_{tiss} = 0.0109 \times C_{sed}$	$C_{tiss} = 0.00132 \times C_{sed}$
Dibenzo(a,h)anthracene	Yes	No tissue data	$C_{tiss} = 0.107 \times C_{sed}$	$C_{tiss} = 0.0129 \times C_{sed}$
Total cPAHs	Yes	Surrogate = benzo(a)pyrene	Surrogate = benzo(a)pyrene	Surrogate = benzo(a)pyrene
<b>Phthalates</b>				
BEHP	No	NA	NA	NA
<b>SVOCs</b>				
Hexachlorobenzene	Yes	$C_{tiss} = 0.295 \times C_{sed}$	$C_{tiss} = 2.02 \times C_{sed}$	$C_{tiss} = 0.244 \times C_{sed}$

<sup>a</sup> BSAFs were not used if no BSAR could be developed for any small home range species (lab clams, field clams, lab worms, and crayfish) or medium home range species (sculpin and smallmouth bass).

<sup>b</sup> All BSAFs based on lipid-normalized tissue and OC-normalized sediment data, with the exception of metals for which BSAFs are based on wet weight tissue and dry weight sediment data.

<sup>c</sup> BSAFs were developed for lead for peamouth ( $C_{tiss} = 0.110 \times C_{sed}$ ), largescale sucker ( $C_{tiss} = 0.00490 \times C_{sed}$ ), and northern pikeminnow ( $C_{tiss} = 0.000359 \times C_{sed}$ )

BEHP – bis(2-ethylhexyl) phthalate

BSAF – biota-sediment accumulation factor

NA – not applicable

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

### 3.5 SUMMARY OF BSAR/F AVAILABILITY FOR DIFFERENT SPECIES

Table 8 presents a summary of the chemical species combinations for which BSAFs or BSARs were developed. Small mouth bass were not included on the table because no BSARs

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could be developed for this species (see Table 6). The BSAFs or BSARs were used for the calculation of early PRGs. BSARs could not be developed for some preliminary COCs because of insufficient data (i.e., too many non-detect tissue concentration values) or because none of the models appeared to fit the dataset across the range of sample concentrations. As noted in Section 3.4, if a BSAR for at least one species for a given chemical could not be developed, then no BSAFs for that chemical were developed.

Table 8. Summary of BSAF and BSAR Availability

Chemical	Small- and Medium-Home-Range Species <sup>a</sup>			Large-Home-Range Species <sup>b</sup>		
	Field Clam	Crayfish	Lab Worm	Black Crappie	Brown Bullhead	Carp
<b>Metals</b>						
Antimony				Y	Y	Y
Arsenic	N – NM	N – NM	N – NM	N – NA	N – NA	N – NA
Cadmium	N – NM		N – NM			
Copper	N – NM	N – NM	N – NM			
Lead				Y	Y	Y
Mercury				N – NA	N – NA	N – NA
Selenium				N – NA	N – NA	N – NA
Zinc	N – NM		N – NM	N – NA	N – NA	N – NA
<b>PAHs</b>						
Benzo(a)anthracene	Y	N – ISD		N – NTD	Y	Y
Benzo(a)pyrene	Y	Y	Y	N – NTD	Y	Y
Benzo(b)fluoranthene	N – NM	N – ISD				
Benzo(k)fluoranthene	Y	N – ISD				
Chrysene	Y	N – ISD				
Dibenzo(a,h)anthracene	N – NM	N – ISD		N – NTD	Y	Y
Indeno(1,2,3-cd)pyrene	N – NM	N – ISD				
Total cPAHs (surrogate=benzo[a]pyrene)						
<b>Phthalates</b>						
BEHP	N – ISD			N – NA	N – NA	N – NA
Dibutyl phthalate	N – ISD					
<b>SVOCs</b>						
Hexachlorobenzene	N – NM	N – NM		Y	Y	Y
Pentachlorophenol		N – ISD				
<b>Butyltins</b>						
Tributyltin	N – NM		Y			

<sup>a</sup> Smallmouth bass were not included in this table inasmuch as no BSAR models could be developed for this species because no relationship was found (see Table 6). Sculpin were also not included because only one BSAR was

developed for this species (lead). No relationship was found when sculpin models were attempted for cadmium, copper, and tributyltin (see Table 5). Reasons for unavailable BSAR models for small- and medium-home-range species: ISD - insufficient data (i.e., not enough detect-detect tissue sediment data pairs); NM – no BSAR model passed screening requirements (significant slope and  $R^2 > 0.3$ ).

- <sup>b</sup> BSAFs were also developed for peamouth, largescale sucker, and northern pikeminnow for lead. Reasons for unavailable BSAF models for large-home-range species:
  - NTD – tissue not analyzed for this chemical, and thus no BSAF could be developed
  - NA – BSAF not applicable because BSAR models could not be developed for small- or medium-home-range species
  - NC – model for TEQ conversion did not pass screening requirements (significant slope and  $R^2 > 0.3$ )

BEHP – bis(2-ethylhexyl) phthalate

BSAF – biota-sediment accumulation factor

BSAR – biota-sediment accumulation regression

HCH – hexachlorocyclohexane

N – model not available

Y – model available

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

## 4.0 CALCULATION OF EARLY PRGS

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The calculation of early PRGs involved several steps. Some of these were specific to PRG developed using the FWM, and some were specific to PRGs developed using BSAR/Fs. For TEQs (which were modeled using the FWM), a conversion step was first performed for target tissue concentrations (for human health) or TRVs (for ecological receptors. This step is not necessary for non-TEQ-based target tissue concentrations or TRVs. The process for developing PRGs based on the selected TEQ component chemicals was as follows:

1. Convert ecological or human health target tissue concentrations from PCB TEQ, or dioxin TEQ to the selected surrogate chemical using a regression equation (as described in Attachment 1).
2. Use the FWM for the component chemical to determine the sediment concentration (i.e., PRG) associated with the target tissue level.

The PRG was developed for the surrogate chemical (rather than directly for PCB or dioxin TEQ). This selection of surrogate chemicals is described briefly in Section 3.1 and in detail in Attachment 1. The equations for converting TEQs or total cPAHs to surrogate chemical concentrations are presented in Attachment 1 in more detail.

For chemicals evaluated using the FWM (see Table 1), early PRGs were calculated assuming that water concentrations were equal to background water concentrations (methods for the estimation of background water concentrations will be provided in the RI). This approach was requested by EPA. This assumption is likely not conservative unless chemical concentrations in sediment at the site are assumed to be lower than in background areas. The FWM was also used to calculate early PRGs assuming water concentrations were equal to zero, per EPA request. This assumes that concentrations of chemicals in water within the study area would not be impacted by concentrations of chemicals in sediments within the study area or upstream of the study area and that all background sources of chemicals would be removed from the watershed. When using the FWM to predict early PRGs for people consuming multiple species, one sediment PRG could be estimated, because the FWM predicts chemical concentrations in all species at once. For ecological receptors that consume multiple species, a range of early PRGs was developed assuming consumption of each dietary component exclusively. This is because the ecological diets were considered highly uncertain.

For chemicals evaluated using BSAR/Fs, the target tissue concentration or TRV was paired with its respective BSAF or BSAR to calculate the early PRGs. This required the rearrangement of the BSAR or BSAF equation to solve for a sediment concentration based on specified tissue concentration. Because all BSARs were based on log-log regressions, a correction factor was applied using the “smearing estimator” of Duan (1983), as described in Chapter 9 of Helsel and Hirsh (2002).<sup>15</sup> The correction factors for regressions are provided in

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<sup>15</sup> For log-log BSARs: sediment PRG = EXP((ln(target tissue concentration)-ln(correction) -a)/b) where a= intercept and b=slope of the BSAR.

Tables 2 through 6. In cases where target tissue concentrations were based on the consumption of multiple species (i.e., human health multi-species diets or ecological receptors with multiple prey items), a range of the early PRGs for each of the species consumed was calculated. This approach may be refined in the future to generate PRGs that better account for multi-species diets.

Early PRGs were calculated whenever possible for all COCs for all species, all exposure scenarios that resulted in risks above target levels, and for all risk levels provided by the human health and ecological risk assessors and will be provided in the baseline HHRA and BERA. Note that early PRGs could not be calculated in some cases because no BSAR or BSAF was identified for the particular chemical species combination.

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# **EARLY PRG DEVELOPMENT METHODS**

## **Attachment 1** **TEQ Surrogates for PRG Development**

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## SELECTION OF CHEMICALS FOR TEQ MODELING

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Toxic equivalents (TEQs) were used for totaling certain groups of chemicals, specifically dioxin/furan TEQ and polychlorinated biphenyl (PCB) TEQs. Toxic equivalency factors (TEFs) relate the toxicity of the co-planar PCB congeners and certain dioxin and furan congeners to the toxicity of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). TEFs for dioxin and furans and PCB congeners were determined during a conference of the World Health Organization (Van den Berg et al. 2006). PCB TEQ and dioxin/furan TEQ were calculated for each sample by summing the products of the concentrations of each individual congener or compound and its specific TEF for each group (PCB TEQ or dioxin/furan TEQ, respectively).

Preliminary remediation goals (PRGs) for TEQ sums were represented by a PRG for an individual chemical (that is a component of the TEQ sum). TEQ PRGs were not directly calculated because they are toxicity-weighted sums of individual chemical concentrations rather than true concentrations.

Unlike concentrations of chemical mixtures such as total PCBs or total DDTs, which are simple sums of the mass of their chemical constituents, TEQ sums reflect both the concentration and toxicity of their constituents. Thus, a chemical with a relatively small mass contribution may dominate the TEQ. Bioaccumulative properties may also vary greatly across chemicals. For these reasons, a single chemical surrogate was selected to represent each type of TEQ for PRG development.

Potential surrogate chemicals were selected based both on toxicity to birds and to mammals and the strength of a linear relationship between the chemical and its associated PCB or dioxin TEQ. The 12 PCB congeners that make up the PCB TEQ and the 17 chemicals that make up the dioxin TEQ were evaluated as candidates for use as surrogate chemicals by considering the following:

- Detection frequencies of component chemicals in sediment, water, and species tissue<sup>16</sup> (Tables 1 and 2)
- Average percent contribution to the four TEQs (mammal PCB TEQ, bird PCB TEQ, mammal dioxin/furan TEQ and bird dioxin/furan TEQ)<sup>17</sup> in tissue, sediment, and water (Tables 3 through 6)
- Regression relationship between individual chemicals and the TEQ (Figures 1 through 9)

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<sup>16</sup> Species included clams, crayfish, sculpin, carp, and smallmouth bass. Largescale sucker and northern pikeminnow were not analyzed for PCB congeners or dioxins/furans, and thus are not included in this analysis.

<sup>17</sup> For calculating the average percent contribution to the TEQ, the TEF-weighted concentration of each individual concentration (detected concentration or one-half of the DL) was used.

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Chemicals with both high detection frequencies and high average percent contribution to the TEQ were selected as potential surrogates for PCB and dioxin TEQ for use in PRG development. These included:

- PCB TEQ (birds): PCB-077 or PCB-126
- PCB TEQ (mammals): PCB-118 or PCB-126
- Dioxin TEQ (birds): 2,3,4,7,8-pentaCDF or 2,3,7,8-tetraCDF
- Dioxin TEQ (mammals): 1,2,3,7,8-pentaCDD, 2,3,4,7,8-pentaCDF, or 2,3,7,8-tetraCDD

For each of these chemicals, scatter plots of the relationship between the empirical concentration of the individual component chemical and the TEQ sum for each tissue sample were used to visually assess the shape of the relationship and variability in the data and to determine if transformations of either variable would help to linearize the relationship or homogenize variance. Linear regression of each relationship was calculated and the  $R^2$  and p-values for the regressions were evaluated to determine the goodness of fit and the significance of the regression. All fish and invertebrate species for which data were available were modeled separately. Based on the regressions shown in Figures 1 through 9 and the corresponding statistics, the following chemicals were selected as surrogates for PCB TEQ and dioxin TEQs:

- PCB TEQ (birds): PCB-077
- PCB TEQ (mammals): PCB-126
- Dioxin TEQ (birds): 2,3,4,7,8-pentaCDF
- Dioxin TEQ (mammals): 2,3,4,7,8-pentaCDF

Table 7 presents the regression relationships for the selected chemicals. Log-log transformations were chosen in all cases because these regressions provided the best fit for the data (i.e., most homogeneously distributed residuals and most linear relationship). For a few species-chemical combinations the relationship was not considered strong enough to use the surrogate chemical to represent the TEQ (i.e.,  $p > 0.05$ ). The species-chemical combinations with regression relationships that did not meet the  $p > 0.05$  criteria are indicated in Table 7. PCB-118 may also be modeled as a surrogate for PCB TEQ (mammals) because it has a strong relationship with total PCB concentrations (by mass).

The regression equations presented in Table 7 will be used to calculate PRGs for PCB TEQ and dioxin TEQ. The process for developing PRGs based on the selected TEQ component chemicals will be as follows

1. Convert ecological or human health target tissue concentrations from PCB TEQ or dioxin TEQ to the selected component chemical using the equations presented in Table 7.
2. Use the FWM for the component chemical to determine the sediment concentration (i.e., PRG) associated with the target tissue level.

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Because the surrogate relationships were all based on log transformations, a correction factor was applied in Step 1 using the “smearing estimator” of Duan (1983) as described in Chapter 9 of Helsel and Hirsh (2002).<sup>18</sup> The correction factors for each regression are provided in Table 7. Thus the PRG for each TEQ will be estimated in terms of its surrogate chemical (e.g., the PRG for PCB TEQ [bird] will be provided as a concentration of PCB 77).

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<sup>18</sup> Surrogate target tissue concentration=  $\exp(a+b*\ln(\text{TEQ target tissue concentration}))$ \*correction, where a=intercept and b-slope of regression equation

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## TABLES

Table 1. Detection Frequencies for Chemical Components of PCB TEQ

TEQ Component	Detection Frequency Ratio						Smallmouth Bass
	Sediment	Water	Clam	Crayfish	Sculpin	Carp	
PCB-77	254/266	92/114	38/38	15/15	21/21	14/15	32/32
PCB-81	223/266	7/114	23/38	15/15	9/21	14/15	18/32
PCB-105	264/266	114/114	38/38	15/15	21/21	15/15	32/32
PCB-114	254/266	68/114	37/38	15/15	21/21	15/15	31/32
PCB-106 and 118 <sup>a</sup>	255/255	NA	NA	NA	NA	NA	NA
PCB-118 <sup>a</sup>	40/96	114/114	38/38	15/15	21/21	15/15	32/32
PCB-123	252/266	58/114	38/38	15/15	21/21	15/15	32/32
PCB-126	251/266	18/114	36/38	15/15	9/21	9/15	25/32
PCB-156 <sup>b</sup>	265/266	NA	NA	10/10	9/9	6/6	14/14
PCB-156 and 157 <sup>b</sup>	NA	83/114	38/38	5/5	12/12	9/9	18/18
PCB-157 <sup>b</sup>	259/266	NA	NA	10/10	9/9	6/6	14/14
PCB-167	264/266	86/114	38/38	15/15	21/21	15/15	32/32
PCB-169	49/266	1/114	1/38	3/15	9/21	6/15	14/32
PCB-189	257/266	47/114	38/38	15/15	21/21	15/15	32/32

<sup>a</sup> PCB 106 and 118 co-elute in most sediment samples, and thus PCB-118 is shown as a co-elution and individually.

<sup>b</sup> PCB 156 and 157 co-elute in some samples, and thus they are shown both individually and together.

NA – not applicable (no data)

PCB – polychlorinated biphenyl

TEQ – toxic equivalent

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Table 2. Detection Frequencies for Chemical Components of Dioxin TEQ

TEQ Component	Detection Frequency Ratio						Smallmouth Bass
	Sediment	Water	Clam	Crayfish	Sculpin	Carp	
1,2,3,4,6,7,8-HeptaCDF	207/219	34/72	21/36	14/15	21/21	15/15	19/32
1,2,3,4,6,7,8-HeptaCDD	215/219	70/72	36/36	15/15	21/21	15/15	29/32
1,2,3,4,7,8,9-HeptaCDF	167/219	37/72	10/36	13/15	18/21	15/15	17/32
1,2,3,4,7,8-HexaCDF	197/219	68/72	31/36	14/15	21/21	15/15	32/32
1,2,3,4,7,8-HexaCDD	132/219	28/72	25/36	12/15	20/21	15/15	31/32
1,2,3,6,7,8-HexaCDF	191/219	14/72	10/36	11/15	21/21	15/15	32/32
1,2,3,6,7,8-HexaCDD	200/219	9/72	33/36	15/15	21/21	15/15	32/32
1,2,3,7,8,9-HexaCDF	60/219	27/72	0/36	3/15	4/21	13/15	12/32
1,2,3,7,8,9-HexaCDD	189/219	34/72	28/36	13/15	21/21	15/15	30/32
1,2,3,7,8-PentaCDF	167/219	10/72	27/36	15/15	21/21	15/15	32/32
1,2,3,7,8-PentaCDD	128/219	35/72	19/36	15/15	21/21	15/15	32/32
2,3,4,6,7,8-HexaCDF	177/219	18/72	7/36	13/15	20/21	15/15	32/32
2,3,4,7,8-PentaCDF	173/219	12/72	24/36	15/15	21/21	15/15	32/32
2,3,7,8-TetraCDF	145/219	21/72	32/36	15/15	21/21	15/15	32/32
2,3,7,8-TetraCDD	41/219	16/723	4/36	15/15	21/21	15/15	32/32
OctaCDF	208/219	27/72	29/36	12/15	21/21	15/15	10/32
OctaCDD	215/219	1/72	36/36	15/15	21/21	15/15	10/32

CDD – chlorodibenzo-*p*-dioxin  
CDF – chlorodibenzofuran  
TEQ – toxic equivalent

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Table 3. Percent Contribution to PCB TEQ (Birds)

TEQ Component	TEF	Average Percent Contribution to PCB TEQ (Birds) <sup>a</sup>						Smallmouth Bass
		Sediment	Water	Clam	Crayfish	Sculpin	Carp	
PCB-77	0.05	<b>67%</b>	<b>64%</b>	<b>80%</b>	<b>74%</b>	<b>64%</b>	<b>65%</b>	<b>66%</b>
PCB-81	0.1	<b>10%</b>	<b>23%</b>	5.3%	6.9%	6.8%	7.8%	5.9%
PCB-105	0.0001	1.0%	0.6%	1.5%	1.2%	4.4%	2.9%	3.5%
PCB-114	0.0001	0.1%	0.03%	0.1%	0.2%	0.3%	0.2%	0.3%
PCB-118	0.00001	0.0%	0.2%	0.7%	0.8%	1.3%	1.0%	1.1%
PCB-123	0.00001	0.0%	0.003%	0.0%	0.0%	0.0%	0.0%	0.0%
PCB-126	0.1	<b>21%</b>	<b>11%</b>	<b>12%</b>	<b>13%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>
PCB-156 <sup>b</sup>	0.0001	0.6%	NA	0.0%	0.6%	1.3%	1.2%	1.3%
PCB-156 & 157 <sup>b</sup>	0.0001	NA	0.2%	0.9%	2.4%	2.0%	1.9%	1.8%
PCB-157 <sup>b</sup>	0.0001	0.1%	NA	0.0%	0.1%	0.1%	0.1%	0.1%
PCB-167	0.00001	0.0%	0.01%	0.1%	0.1%	0.1%	0.1%	0.1%
PCB-169	0.001	0.0%	0.4%	0.1%	0.1%	0.1%	0.2%	0.1%
PCB-189	0.00001	0.0%	1.7%	0.0%	0.1%	0.1%	0.1%	0.1%

<sup>a</sup> Average percent contributions greater than or equal to 10% are shown in **bold** text.

<sup>b</sup> PCB 156 and 157 co-elute in some samples, and thus they are shown both individually and together.

NA – not applicable (no data)

PCB – polychlorinated biphenyl

TEF – toxic equivalency factor

TEQ – toxic equivalent

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Table 4. Percent Contribution to PCB TEQ (Mammals)

PCB Congener	TEF	Average Percent Contribution to PCB TEQ (Mammals) <sup>a</sup>						
		Sediment	Water	Clam	Crayfish	Sculpin	Carp	Smallmouth Bass
PCB077	0.0001	0.9%	1.1%	1.2%	1.2%	0.6%	0.6%	0.6%
PCB081	0.0003	0.2%	0.5%	0.1%	0.2%	0.1%	0.1%	0.1%
PCB105	0.00003	1.4%	1.4%	2.9%	1.7%	4.9%	3.4%	4.4%
PCB114	0.00003	0.1%	0.1%	0.2%	0.3%	0.4%	0.2%	0.3%
PCB118	0.00003	0.3%	4.1%	<b>12%</b>	<b>11%</b>	<b>14%</b>	<b>11%</b>	<b>13%</b>
PCB123	0.00003	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.2%
PCB126	0.1	<b>88%</b>	<b>65%</b>	<b>72%</b>	<b>75%</b>	<b>66%</b>	<b>65%</b>	<b>69%</b>
PCB-156 <sup>b</sup>	0.00003	0.6%	NA	NA	1.2%	1.0%	1.0%	1.1%
PCB-156 & 157 <sup>b</sup>	0.00003	NA	0.4%	1.2%	1.8%	1.8%	1.8%	1.8%
PCB-157 <sup>b</sup>	0.00003	0.1%	NA	NA	0.2%	0.1%	0.1%	0.1%
PCB167	0.00003	0.3%	0.2%	1.3%	1.6%	1.0%	1.4%	1.2%
PCB169	0.03	3.9%	<b>27%</b>	8.7%	5.6%	9.0%	<b>14%</b>	7.0%
PCB189	0.00003	0.1%	0.03%	0.1%	0.5%	0.4%	0.5%	0.4%

<sup>a</sup> Average percent contributions greater than or equal to 10% are shown in **bold** text.

<sup>b</sup> PCB 156 and 157 co-elute in some samples, and thus they are shown both individually and together.

NA – not applicable (no data)

PCB – polychlorinated biphenyl

TEF – toxic equivalency factor

TEQ – toxic equivalent

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Table 5. Percent Contribution to Dioxin TEQ (Bird)

TEQ Component	TEF	Average Percent Contribution to Dioxin TEQ (Birds) <sup>a</sup>						Smallmouth Bass
		Sediment	Water	Clam	Crayfish	Sculpin	Carp	
1,2,3,4,6,7,8-HeptaCDF	0.01	4.1%	0.9%	0.3%	0.3%	0.1%	0.2%	0.02%
1,2,3,4,6,7,8-HeptaCDD	0.001	2.6%	1.8%	0.2%	0.2%	0.1%	0.1%	0.01%
1,2,3,4,7,8,9-HeptaCDF	0.01	0.3%	0.4%	0.05%	0.02%	0.01%	0.02%	0.003%
1,2,3,4,7,8-HexaCDF	0.1	8%	3.3%	1.1%	1.6%	1.4%	1.9%	0.6%
1,2,3,4,7,8-HexaCDD	0.05	0.7%	1.3%	0.3%	0.2%	0.2%	0.8%	0.1%
1,2,3,6,7,8-HexaCDF	0.1	3.4%	2.7%	0.4%	0.6%	0.4%	0.7%	0.2%
1,2,3,6,7,8-HexaCDD	0.01	1.0%	0.8%	0.3%	0.2%	0.3%	0.6%	0.2%
1,2,3,7,8,9-HexaCDF	0.1	0.5%	2.0%	0.4%	0.1%	0.03%	0.03%	0.01%
1,2,3,7,8,9-HexaCDD	0.1	5.1%	4.9%	1.0%	0.7%	0.4%	0.7%	0.2%
1,2,3,7,8-PentaCDF	0.1	3.0%	2.3%	1.0%	1.9%	1.7%	1.3%	1.1%
1,2,3,7,8-PentaCDD	1	9.2%	<b>18%</b>	8.8%	<b>12%</b>	<b>13%</b>	<b>20%</b>	<b>19%</b>
2,3,4,6,7,8-HexaCDF	0.1	2.6%	2.0%	0.4%	0.3%	0.3%	0.4%	0.1%
2,3,4,7,8-PentaCDF	1	<b>22%</b>	<b>18%</b>	<b>17%</b>	<b>21%</b>	<b>17%</b>	<b>25%</b>	<b>27%</b>
2,3,7,8-TetraCDF	1	<b>30%</b>	<b>28%</b>	<b>60%</b>	<b>52%</b>	<b>58%</b>	<b>37%</b>	<b>41%</b>
2,3,7,8-TetraCDD	1	3.6%	13%	8.5%	8.6%	6.9%	<b>10%</b>	<b>11%</b>
OctaCDF	NA	NA	NA	NA	NA	NA	NA	NA
OctaCDD	0.0001	2.3%	0.9%	0.1%	0.1%	0.02%	0.03%	0.001%

<sup>a</sup> Average percent contributions greater than or equal to 10% are shown in **bold** text.

CDD – chlorodibenzo-*p*-dioxin

CDF – chlorodibenzofuran

NA – not applicable (no data)

TEF – toxic equivalency factor

TEQ – toxic equivalent

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Table 6. Percent Contribution to Dioxin TEQ (Mammals)

TEQ Component	TEF	Average Percent Contribution to Dioxin TEQ (Mammals) <sup>a</sup>						
		Sediment	Water	Clam	Crayfish	Sculpin	Carp	Smallmouth Bass
1,2,3,4,6,7,8-HeptaCDF	0.01	4.0%	1.0%	0.7%	0.6%	0.2%	0.3%	0.0%
1,2,3,4,6,7,8-HeptaCDD	0.01	<b>23%</b>	<b>19%</b>	4.6%	3.5%	1.4%	2.5%	0.2%
1,2,3,4,7,8,9-HeptaCDF	0.01	0.3%	0.5%	0.1%	0.1%	0.0%	0.0%	0.0%
1,2,3,4,7,8-HexaCDF	0.1	<b>12%</b>	4%	3.2%	4.5%	4.1%	3.7%	1.6%
1,2,3,4,7,8-HexaCDD	0.1	1.4%	2.9%	1.5%	0.7%	0.8%	2.7%	0.6%
1,2,3,6,7,8-HexaCDF	0.1	4.5%	3.3%	0.9%	1.4%	1.2%	1.4%	0.5%
1,2,3,6,7,8-HexaCDD	0.1	9.0%	8.4%	7.4%	4.2%	6.7%	<b>11%</b>	3.9%
1,2,3,7,8,9-HexaCDF	0.1	0.6%	2.4%	1.0%	0.1%	0.1%	0.1%	0.0%
1,2,3,7,8,9-HexaCDD	0.1	4.8%	5.1%	2.4%	1.5%	1.0%	1.3%	0.3%
1,2,3,7,8-PentaCDF	0.03	1.6%	1.0%	1.0%	1.9%	1.7%	0.8%	0.9%
1,2,3,7,8-PentaCDD	1	9.5%	<b>20%</b>	<b>21%</b>	<b>27%</b>	<b>31%</b>	<b>35%</b>	<b>38%</b>
2,3,4,6,7,8-HexaCDF	0.1	2.8%	2.3%	1.0%	0.7%	0.6%	0.7%	0.3%
2,3,4,7,8-PentaCDF	0.3	<b>10%</b>	7.1%	<b>14%</b>	<b>17%</b>	<b>14%</b>	<b>15%</b>	<b>20%</b>
2,3,7,8-TetraCDF	0.1	5.4%	4.5%	<b>19%</b>	<b>17%</b>	<b>18%</b>	7.2%	<b>11%</b>
2,3,7,8-TetraCDD	1	4.0%	<b>15%</b>	<b>21%</b>	<b>19%</b>	<b>18%</b>	<b>18%</b>	<b>23%</b>
OctaCDF	0.0003	0.4%	0.05%	0.0%	0.0%	0.0%	0.0%	0.0%
OctaCDD	0.0003	0.0%	2.8%	0.9%	0.9%	0.2%	0.1%	0.0%

<sup>a</sup> Average percent contributions greater than or equal to 10% are shown in **bold** text.

CDD – chlorodibenzo-*p*-dioxin

CDF – chlorodibenzofuran

TEF – toxic equivalency factor

TEQ – toxic equivalent

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Table 7. Selected Regression Relationships for TEQs

TEQ Component/Species	Count	FWM Species	R <sup>2</sup>	p-value	Correction Factor	Linear Regression Equation (pg/g) (for ln-transformed data)
<b>PCB TEQ (Bird): PCB-077</b>						
Black crappie	4	No	1.00	0.0003	1.0001	$\ln(\text{PCB077}) = 2.525 + 1.077 * \ln(\text{PCB TEQ-bird})$
Brown bullhead	6	No	0.49	0.1		NA
Carp	15	Yes	0.33	0.02	1.0083	$\ln(\text{PCB077}) = 4.019 + 0.499 * \ln(\text{PCB TEQ-bird})$
Chinook	9	No	0.09	$8 \times 10^{-5}$	1.0072	$\ln(\text{PCB077}) = 2.504 + 1.033 * \ln(\text{PCB TEQ-bird})$
Field clam	38	Yes	0.98	$1 \times 10^{-31}$	1.0050	$\ln(\text{PCB077}) = 2.713 + 1.022 * \ln(\text{PCB TEQ-bird})$
Lab clam	35	No	1.00	$4 \times 10^{-44}$	1.0008	$\ln(\text{PCB077}) = 2.714 + 1.042 * \ln(\text{PCB TEQ-bird})$
Lab clam SS	35	No	0.99	$2 \times 10^{-37}$	1.0021	$\ln(\text{PCB077}) = 2.676 + 1.038 * \ln(\text{PCB TEQ-bird})$
Crayfish	15	Yes	0.97	$2 \times 10^{-11}$	1.0144	$\ln(\text{PCB077}) = 2.609 + 1.047 * \ln(\text{PCB TEQ-bird})$
Lab worm	35	No	0.99	$2 \times 10^{-37}$	1.0055	$\ln(\text{PCB077}) = 2.669 + 1.028 * \ln(\text{PCB TEQ-bird})$
Lab worm SS	35	No	0.99	$1 \times 10^{-35}$	1.0071	$\ln(\text{PCB077}) = 2.628 + 1.027 * \ln(\text{PCB TEQ-bird})$
Lamprey	6	No	1.00	$2 \times 10^{-8}$	1.0001	$\ln(\text{PCB077}) = 2.692 + 1.043 * \ln(\text{PCB TEQ-bird})$
Largescale sucker	0	Yes	ND	ND		ND
Multiplates	7	No	0.97	$4 \times 10^{-5}$	1.0035	$\ln(\text{PCB077}) = 2.499 + 1.244 * \ln(\text{PCB TEQ-bird})$
Mussels	7	No	1.00	$8 \times 10^{-10}$	1.0002	$\ln(\text{PCB077}) = 2.774 + 1.010 * \ln(\text{PCB TEQ-bird})$
Northern pikeminnow	0	Yes	ND	ND		ND
Peamouth	0	No	ND	ND		ND
Sculpin	21	Yes	0.94	$4 \times 10^{-13}$	1.0244	$\ln(\text{PCB077}) = 2.462 + 1.022 * \ln(\text{PCB TEQ-bird})$
Smallmouth bass	32	Yes	0.87	$1 \times 10^{-14}$	1.0310	$\ln(\text{PCB077}) = 2.535 + 1.004 * \ln(\text{PCB TEQ-bird})$
Sturgeon	15	No	0.93	$1 \times 10^{-8}$	1.0069	$\ln(\text{PCB077}) = 2.498 + 1.203 * \ln(\text{PCB TEQ-bird})$

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Table 7. Selected Regression Relationships for TEQs

TEQ Component/Species	Count	FWM Species	R <sup>2</sup>	p-value	Correction Factor	Linear Regression Equation (pg/g) (for ln-transformed data)
<b>PCB TEQ (Mammals): PCB-126</b>						
Black crappie	4	No	0.98	0.009	1.0006	$\ln(\text{PCB126}) = 2.122 + 0.961 * \ln(\text{PCB TEQ-mammal})$
Brown bullhead	6	No	0.99	$3 \times 10^{-5}$	1.0007	$\ln(\text{PCB126}) = 2.218 + 0.877 * \ln(\text{PCB TEQ-mammal})$
Carp	15	Yes	0.94	$1 \times 10^{-9}$	1.0109	$\ln(\text{PCB126}) = 2.096 + 1.019 * \ln(\text{PCB TEQ-mammal})$
Chinook	9	No	0.93	$3 \times 10^{-5}$	1.0015	$\ln(\text{PCB126}) = 2.015 + 1.086 * \ln(\text{PCB TEQ-mammal})$
Field clam	38	Yes	0.94	$1 \times 10^{-23}$	1.0022	$\ln(\text{PCB126}) = 1.991 + 1.012 * \ln(\text{PCB TEQ-mammal})$
Lab clam	35	No	0.98	$2 \times 10^{-29}$	1.0135	$\ln(\text{PCB126}) = 1.963 + 0.852 * \ln(\text{PCB TEQ-mammal})$
Lab clam SS	35	No	0.96	$1 \times 10^{-24}$	1.0006	$\ln(\text{PCB126}) = 2.028 + 1.053 * \ln(\text{PCB TEQ-mammal})$
Crayfish	15	Yes	0.96	$1 \times 10^{-10}$	1.0134	$\ln(\text{PCB126}) = 1.988 + 0.961 * \ln(\text{PCB TEQ-mammal})$
Lab worm	35	No	0.98	$1 \times 10^{-31}$	1.0119	$\ln(\text{PCB126}) = 2.111 + 0.937 * \ln(\text{PCB TEQ-mammal})$
Lab worm SS	35	No	0.98	$1 \times 10^{-29}$	1.0026	$\ln(\text{PCB126}) = 2.167 + 0.965 * \ln(\text{PCB TEQ-mammal})$
Lamprey	6	No	1.00	$1 \times 10^{-6}$	1.0002	$\ln(\text{PCB126}) = 2.113 + 0.976 * \ln(\text{PCB TEQ-mammal})$
Largescale sucker	0	Yes	ND	ND		ND
Multiplates	7	No	0.61	0.04	1.0166	$\ln(\text{PCB126}) = 1.980 + 0.809 * \ln(\text{PCB TEQ-mammal})$
Mussels	7	No	0.99	$1 \times 10^{-6}$	1.0093	$\ln(\text{PCB126}) = 1.901 + 0.892 * \ln(\text{PCB TEQ-mammal})$
Northern pikeminnow	0	Yes	ND	ND		ND
Peamouth	0	No	ND	ND		ND
Sculpin	21	Yes	0.96	$2 \times 10^{-14}$	1.0071	$\ln(\text{PCB126}) = 2.539 + 0.779 * \ln(\text{PCB TEQ-mammal})$
Smallmouth bass	32	Yes	0.94	$3 \times 10^{-20}$	1.0199	$\ln(\text{PCB126}) = 1.996 + 1.042 * \ln(\text{PCB TEQ-mammal})$
Sturgeon	15	No	0.72	$7 \times 10^{-5}$	1.0200	$\ln(\text{PCB126}) = 1.313 + 0.906 * \ln(\text{PCB TEQ-mammal})$

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Table 7. Selected Regression Relationships for TEQs

TEQ Component/Species	Count	FWM Species	R <sup>2</sup>	p-value	Correction Factor	Linear Regression Equation (pg/g) (for ln-transformed data)
<b>Dioxin TEQ (Birds): 2,3,4,7,8-PentaCDF</b>						
Black crappie	4	No	0.002	0.95	NA	
Brown bullhead	6	No	0.91	0.003	1.0046	$\ln(2,3,4,7,8\text{-PCDF}) = -2.161 + 2.082 \cdot \ln(\text{Dioxin TEQ-birds})$
Carp	15	Yes	0.91	$4 \times 10^{-8}$	1.0304	$\ln(2,3,4,7,8\text{-PCDF}) = -2.375 + 1.480 \cdot \ln(\text{Dioxin TEQ-birds})$
Chinook	9	No	0.93	$3 \times 10^{-5}$	1.0178	$\ln(2,3,4,7,8\text{-PCDF}) = -1.754 + 1.010 \cdot \ln(\text{Dioxin TEQ-birds})$
Field clam	36	Yes	0.83	$2 \times 10^{-14}$	1.095	$\ln(2,3,4,7,8\text{-PCDF}) = -1.691 + 1.035 \cdot \ln(\text{Dioxin TEQ-birds})$
Lab clam	35	No	0.89	$2 \times 10^{-17}$	1.07	$\ln(2,3,4,7,8\text{-PCDF}) = -1.430 + 0.862 \cdot \ln(\text{Dioxin TEQ-birds})$
Lab clam SS	35	No	0.78	$2 \times 10^{-12}$	1.185	$\ln(2,3,4,7,8\text{-PCDF}) = -1.445 + 0.870 \cdot \ln(\text{Dioxin TEQ-birds})$
Crayfish	15	Yes	0.95	$9 \times 10^{-10}$	1.046	$\ln(2,3,4,7,8\text{-PCDF}) = -1.586 + 0.988 \cdot \ln(\text{Dioxin TEQ-birds})$
Lab worm	35	No	0.92	$5 \times 10^{-20}$	1.075	$\ln(2,3,4,7,8\text{-PCDF}) = -1.455 + 0.993 \cdot \ln(\text{Dioxin TEQ-birds})$
Lab worm SS	35	No	0.91	$4 \times 10^{-19}$	1.079	$\ln(2,3,4,7,8\text{-PCDF}) = -1.390 + 1.010 \cdot \ln(\text{Dioxin TEQ-birds})$
Lamprey	6	No	0.93	0.002	1.0019	$\ln(2,3,4,7,8\text{-PCDF}) = -1.574 + 0.909 \cdot \ln(\text{Dioxin TEQ-birds})$
Largescale sucker	0	Yes	ND	ND	ND	
Multiplates	7	No	0.94	$3 \times 10^{-4}$	1.023	$\ln(2,3,4,7,8\text{-PCDF}) = -1.324 + 0.842 \cdot \ln(\text{Dioxin TEQ-birds})$
Mussels	7	No	0.60	0.04	1.022	$\ln(2,3,4,7,8\text{-PCDF}) = -1.387 + 0.584 \cdot \ln(\text{Dioxin TEQ-birds})$
Northern pikeminnow	0	Yes	ND	ND	ND	
Peamouth	0	No	ND	ND	ND	
Sculpin	21	Yes	0.91	$2 \times 10^{-11}$	1.078	$\ln(2,3,4,7,8\text{-PCDF}) = -1.945 + 1.076 \cdot \ln(\text{Dioxin TEQ-birds})$
Smallmouth bass	32	Yes	0.87	$5 \times 10^{-15}$	1.076	$\ln(2,3,4,7,8\text{-PCDF}) = -1.691 + 1.164 \cdot \ln(\text{Dioxin TEQ-birds})$
Sturgeon	15	No	0.55	0.002	1.019	$\ln(2,3,4,7,8\text{-PCDF}) = -2.583 + 0.833 \cdot \ln(\text{Dioxin TEQ-birds})$

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Table 7. Selected Regression Relationships for TEQs

TEQ Component/Species	Count	FWM Species	R <sup>2</sup>	p-value	Correction Factor	Linear Regression Equation (pg/g) (for ln-transformed data)
<b>Dioxin TEQ (Mammals): 2,3,4,7,8-PentaCDF</b>						
Black crappie	4	No	0.06	0.7	NA	
Brown bullhead	6	No	0.67	0.05	1.017	$\ln(2,3,4,7,8\text{-PCDF}) = -0.961 + 1.584 \cdot \ln(\text{Dioxin TEQ-mammals})$
Carp	15	Yes	0.87	$3 \times 10^{-7}$	1.042	$\ln(2,3,4,7,8\text{-PCDF}) = -1.948 + 1.832 \cdot \ln(\text{Dioxin TEQ-mammals})$
Chinook	9	No	0.72	0.004	1.077	$\ln(2,3,4,7,8\text{-PCDF}) = -1.672 + 1.587 \cdot \ln(\text{Dioxin TEQ-mammals})$
Field clam	36	Yes	0.90	$4 \times 10^{-15}$	1.075	$\ln(2,3,4,7,8\text{-PCDF}) = -0.595 + 1.274 \cdot \ln(\text{Dioxin TEQ-mammals})$
Lab clam	35	No	0.86	$1 \times 10^{-15}$	1.086	$\ln(2,3,4,7,8\text{-PCDF}) = -0.717 + 0.901 \cdot \ln(\text{Dioxin TEQ-mammals})$
Lab clam SS	35	No	0.76	$10 \times 10^{-12}$	1.209	$\ln(2,3,4,7,8\text{-PCDF}) = -0.696 + 0.901 \cdot \ln(\text{Dioxin TEQ-mammals})$
Crayfish	15	Yes	0.95	$1 \times 10^{-9}$	1.043	$\ln(2,3,4,7,8\text{-PCDF}) = -0.567 + 1.222 \cdot \ln(\text{Dioxin TEQ-mammals})$
Lab worm	35	No	0.85	$2 \times 10^{-15}$	1.13	$\ln(2,3,4,7,8\text{-PCDF}) = -0.766 + 1.042 \cdot \ln(\text{Dioxin TEQ-mammals})$
Lab worm SS	35	No	0.84	$1 \times 10^{-14}$	1.143	$\ln(2,3,4,7,8\text{-PCDF}) = -0.641 + 1.029 \cdot \ln(\text{Dioxin TEQ-mammals})$
Lamprey	6	No	0.62	0.06	NA	
Largescale sucker	0	Yes	ND	ND	ND	
Multiplates	7	No	0.84	0.004	1.059	$\ln(2,3,4,7,8\text{-PCDF}) = -0.823 + 1.181 \cdot \ln(\text{Dioxin TEQ-mammals})$
Mussels	7	No	0.60	0.04	1.022	$\ln(2,3,4,7,8\text{-PCDF}) = -1.100 + 0.595 \cdot \ln(\text{Dioxin TEQ-mammals})$
Northern pikeminnow	0	Yes	ND	ND	ND	
Peamouth	0	No	ND	ND	ND	
Sculpin	21	Yes	0.94	$2 \times 10^{-13}$	1.036	$\ln(2,3,4,7,8\text{-PCDF}) = -0.930 + 1.263 \cdot \ln(\text{Dioxin TEQ-mammals})$
Smallmouth bass	32	Yes	0.77	$4 \times 10^{-11}$	1.121	$\ln(2,3,4,7,8\text{-PCDF}) = -0.794 + 1.240 \cdot \ln(\text{Dioxin TEQ-mammals})$
Sturgeon	15	No	0.75	$3 \times 10^{-5}$	1.01	$\ln(2,3,4,7,8\text{-PCDF}) = -1.109 + 0.867 \cdot \ln(\text{Dioxin TEQ-mammals})$

CDF – chlorodibenzofuran

FWM – food web model

NA – not applicable (no surrogate regression selected because relationship not significant [p > 0.05])

ND – no data

PCB – polychlorinated biphenyl

SS – steady state

TEQ – toxic equivalent

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## FIGURES

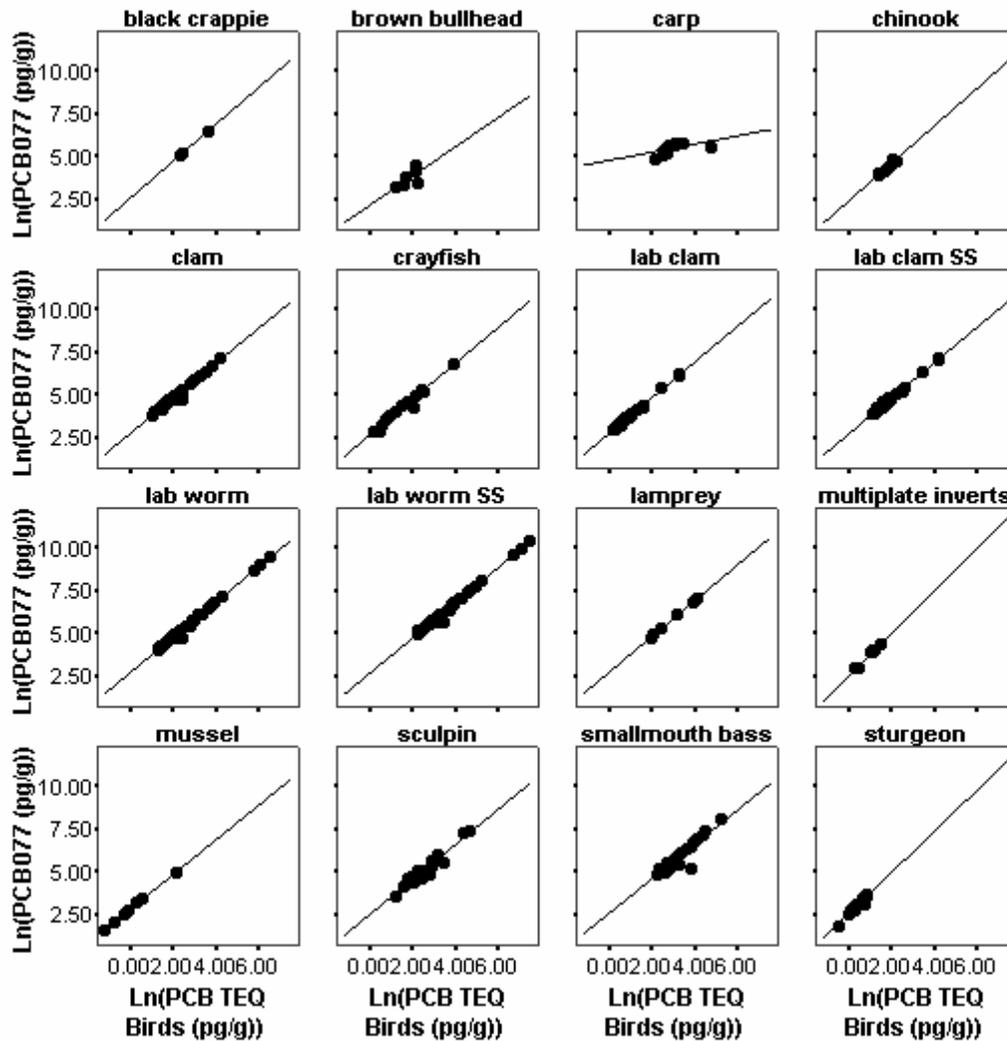


Figure 1. Ln(PCB-77) vs. Ln(PCB TEQ [Birds])

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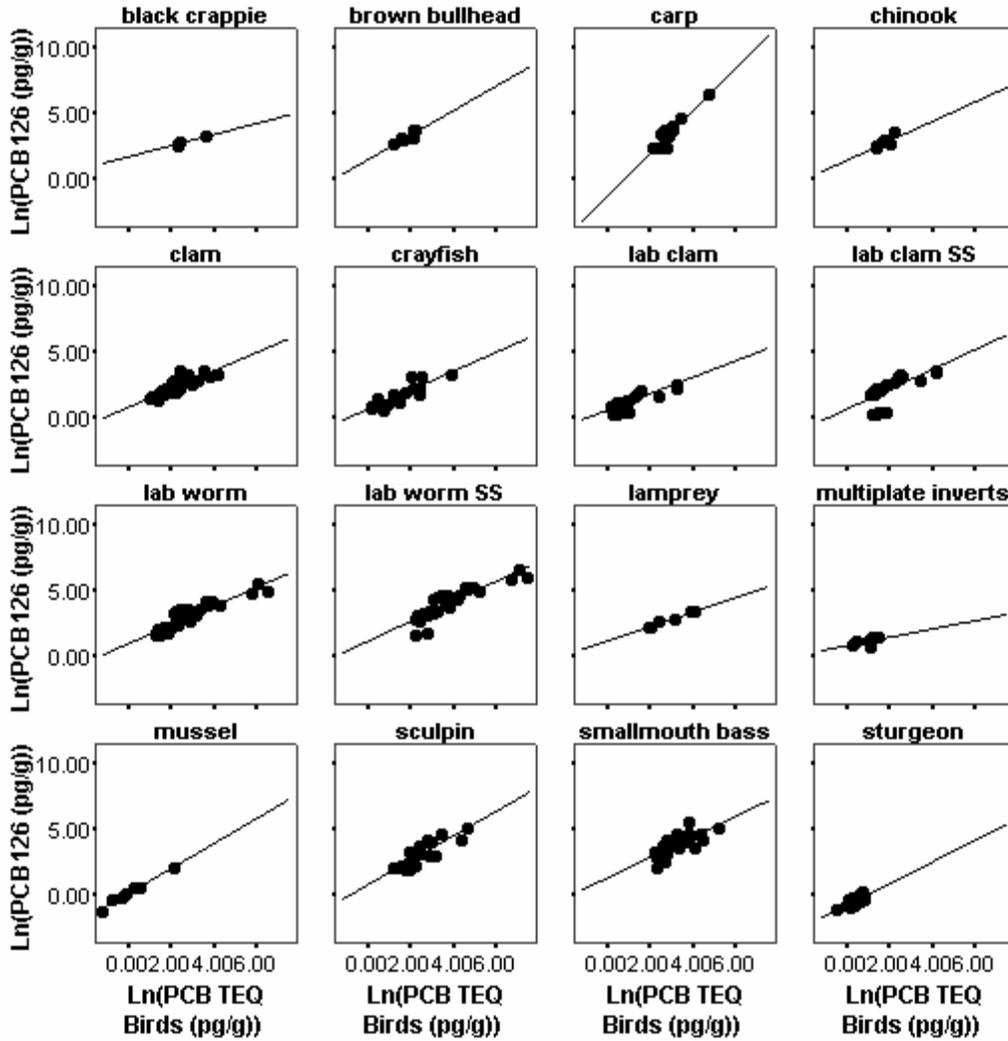


Figure 2. Ln(PCB-126) vs. Ln(PCB TEQ [Birds])

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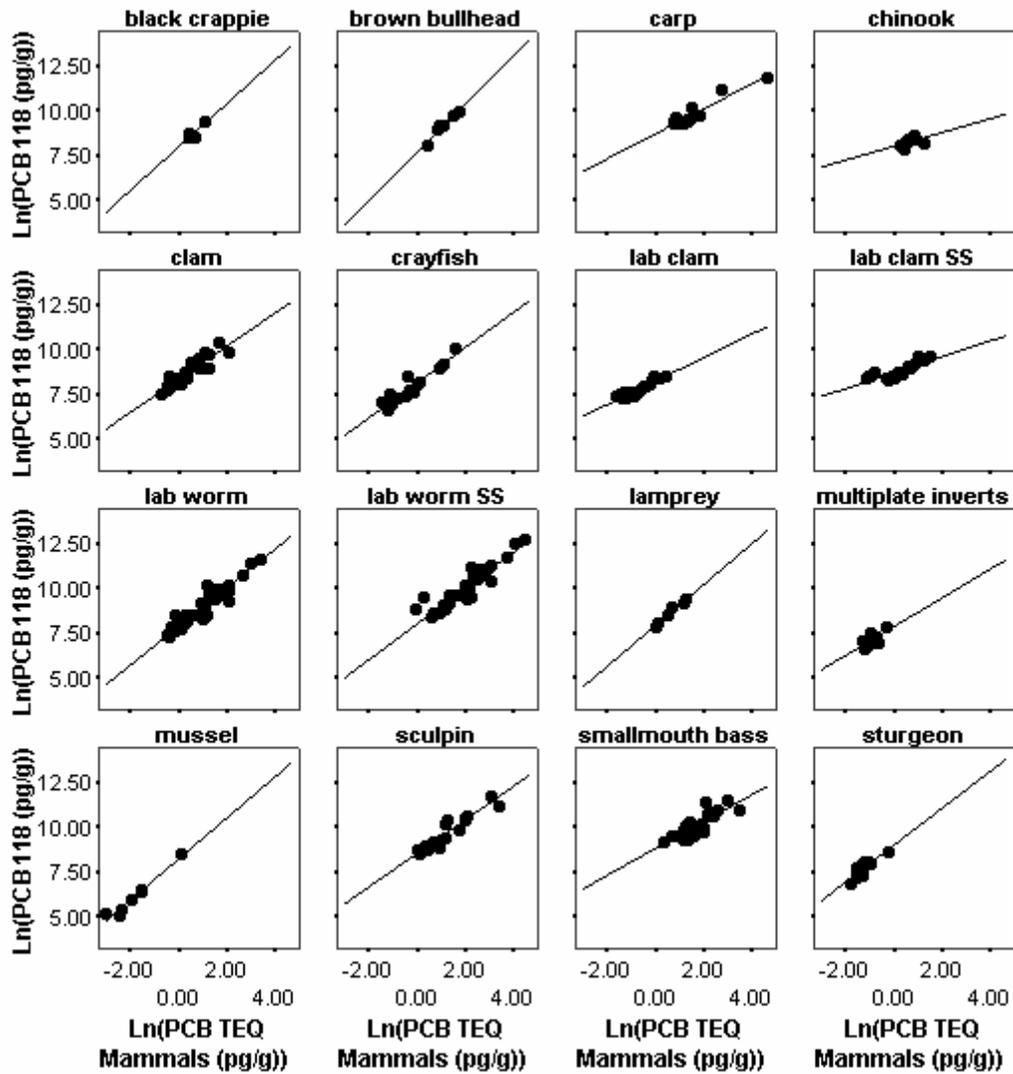


Figure 3. Ln(PCB-118) vs. Ln(PCB TEQ [Mammals])

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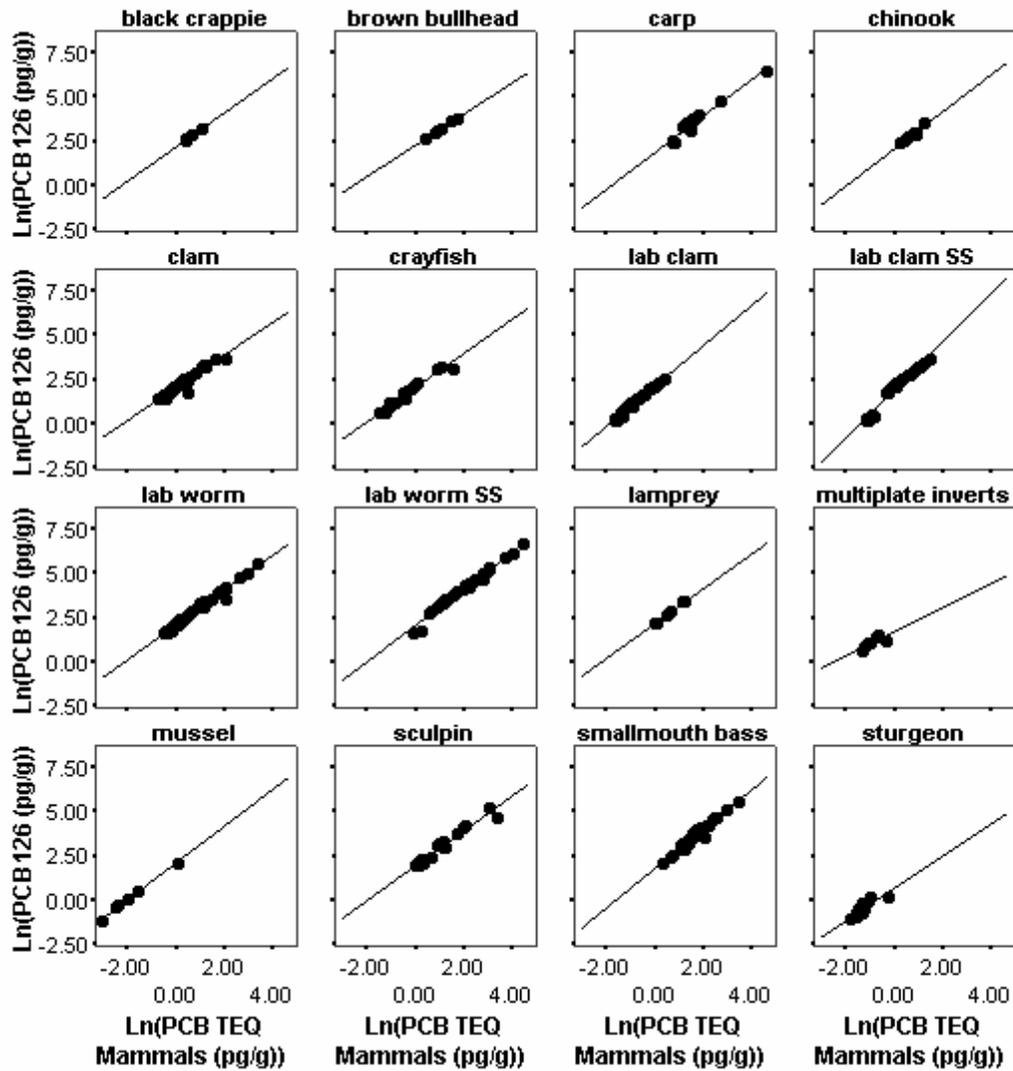


Figure 4. Ln(PCB-126) vs. Ln(PCB TEQ [Mammals])

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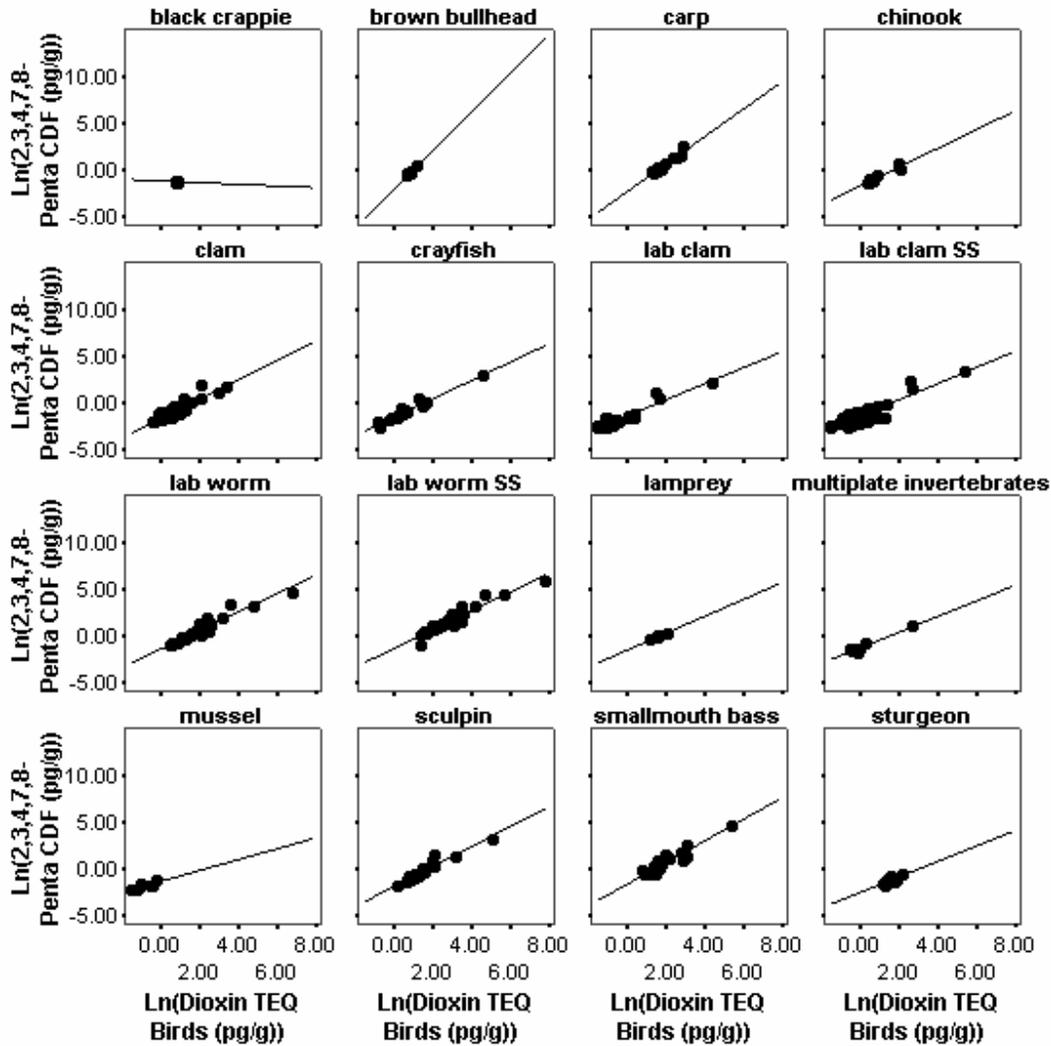


Figure 5. Ln(2,3,4,7,8-PentaCDF) vs. Ln(Dioxin TEQ [Birds])

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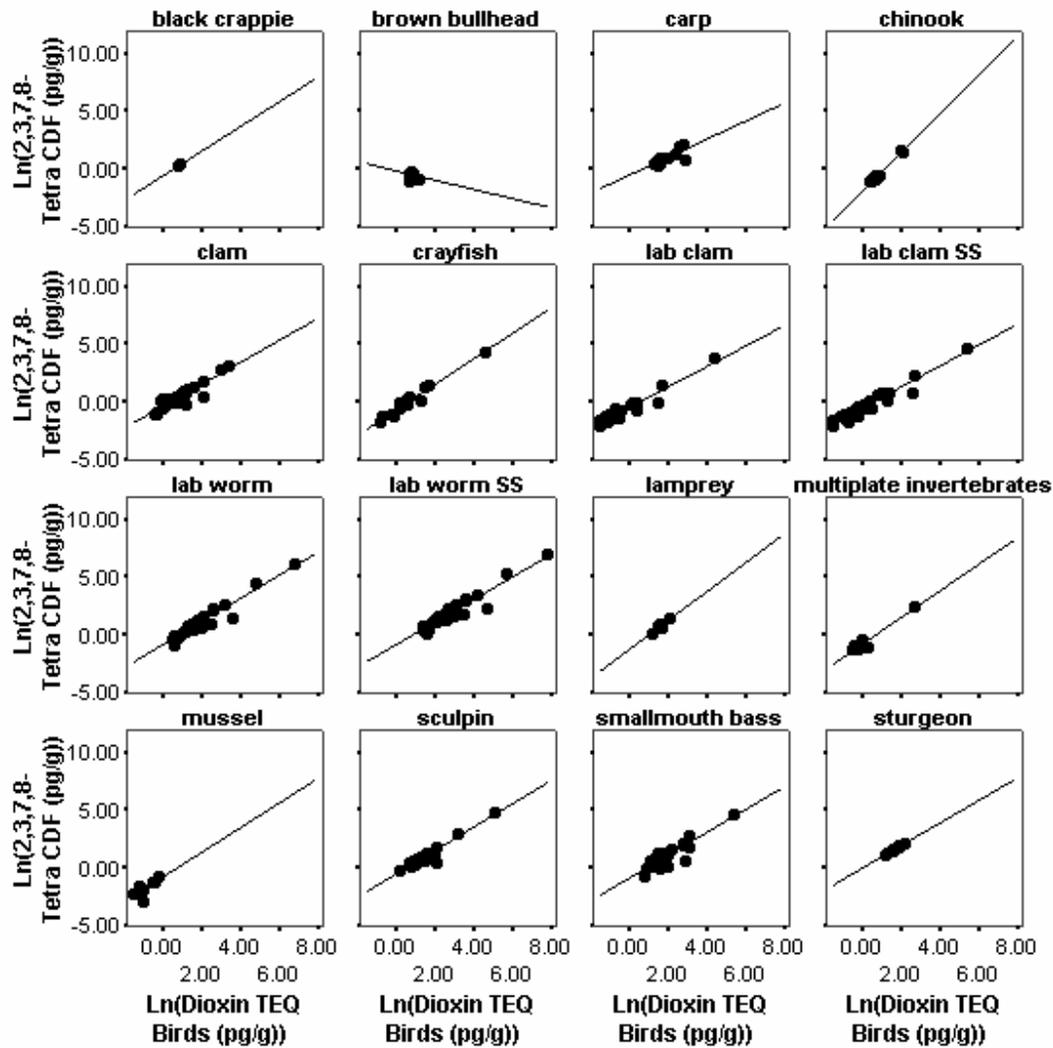


Figure 6. Ln(2,3,7,8-TetraCDF) vs. Ln(Dioxin TEQ [Birds])

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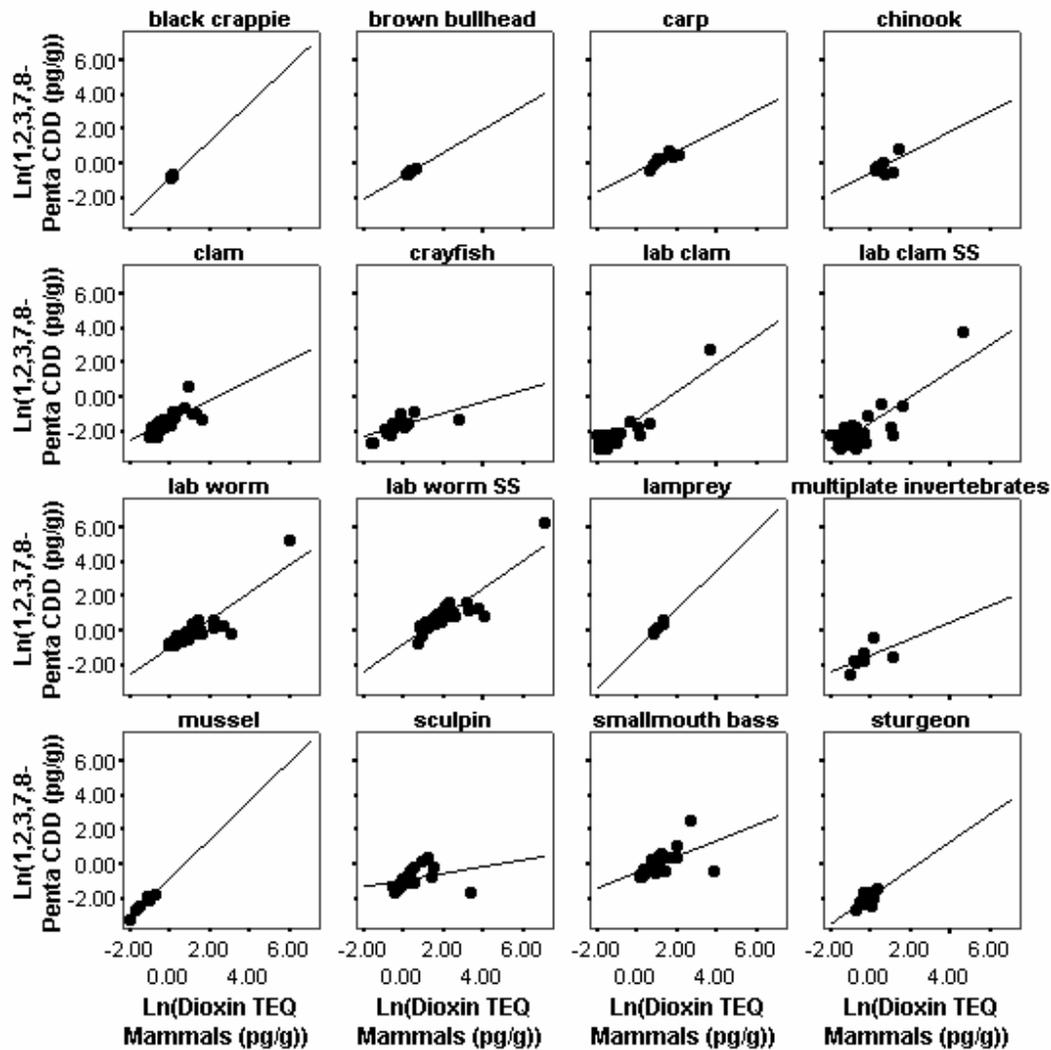


Figure 7. Ln(1,2,3,7,8-PentaCDD) vs. Ln(Dioxin TEQ [Mammals])

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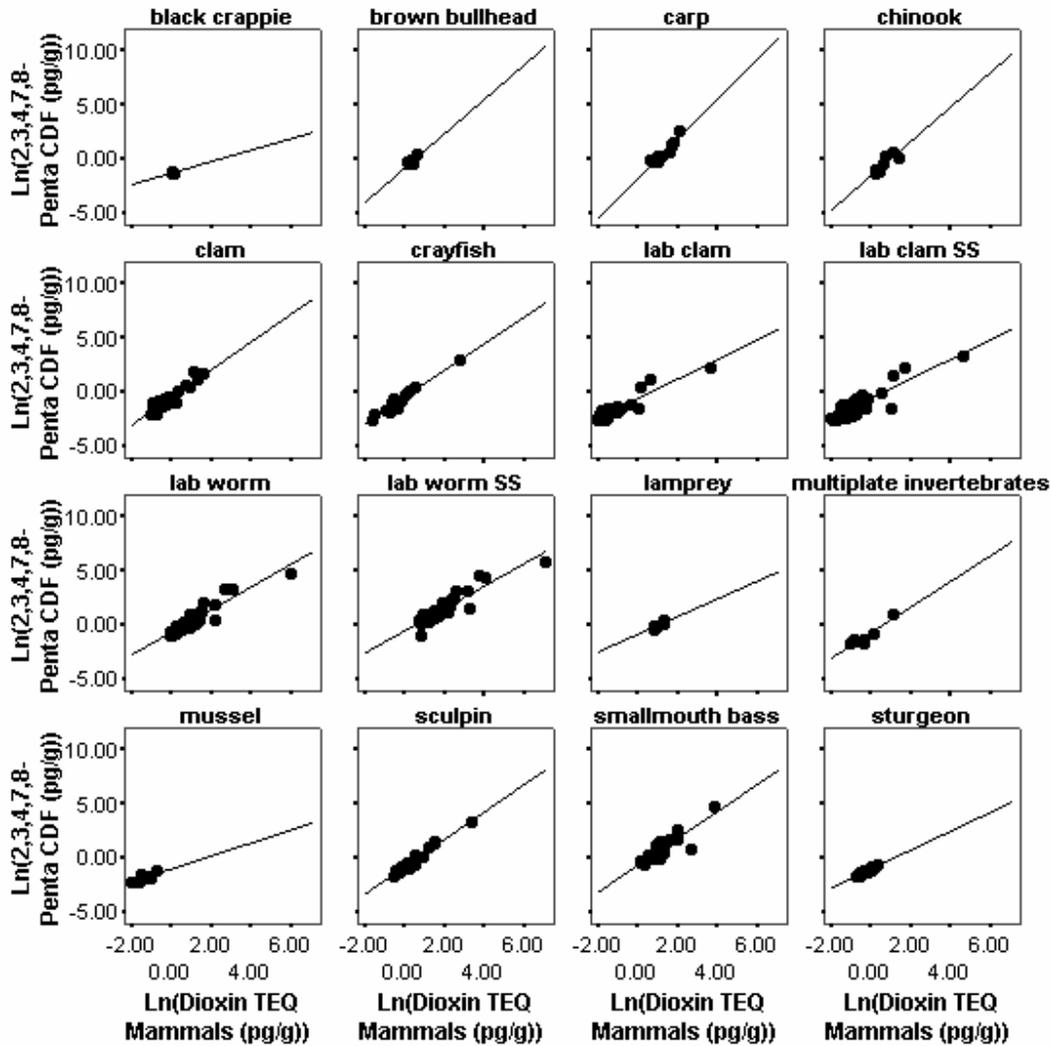


Figure 8. Ln(2,3,4,7,8-PentaCDF) vs. Ln(Dioxin TEQ [Mammals])

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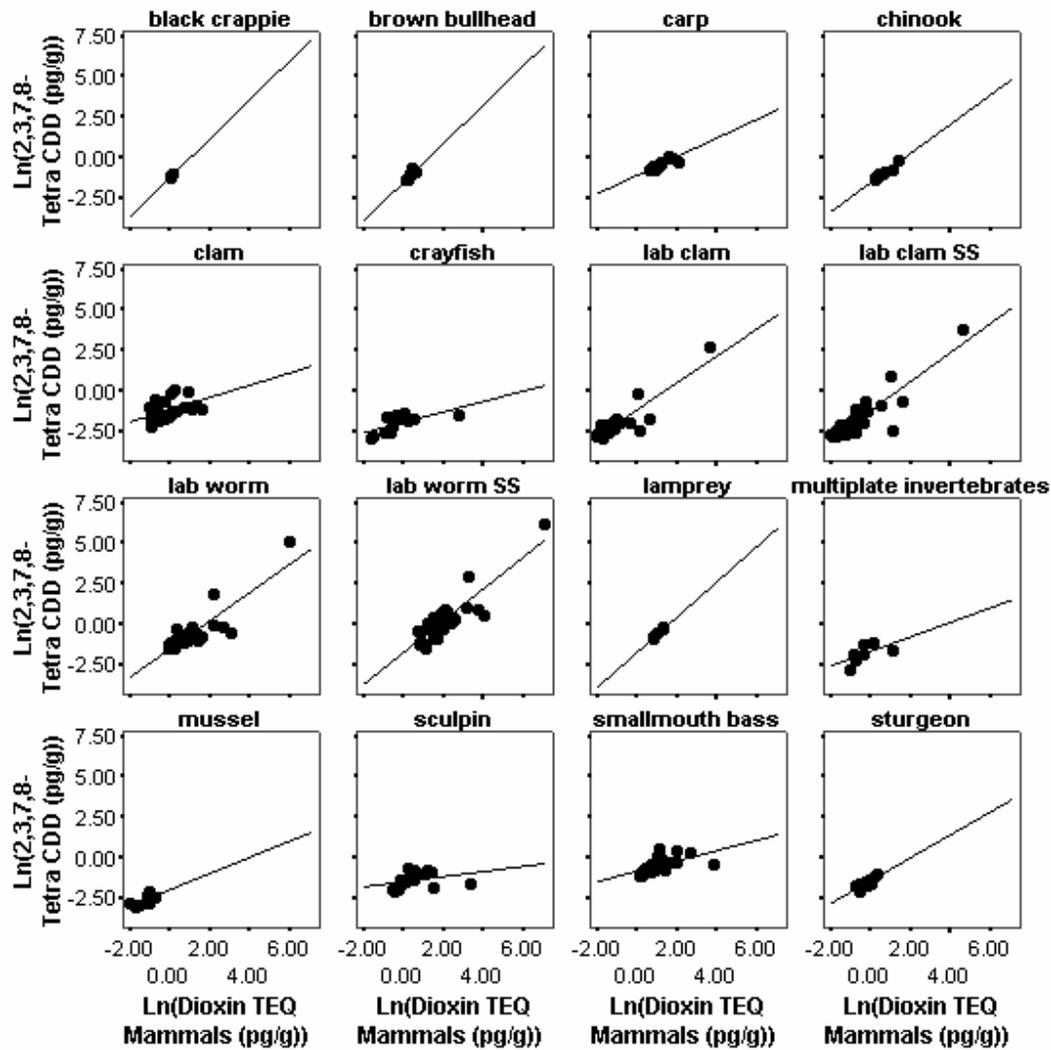


Figure 9. Ln(2,3,7,8-TetraCDD) vs. Ln(Dioxin TEQ [Mammals])

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# **APPENDIX B**

## **POTENTIAL AND PRIMARY OUTLIERS FOR BACKGROUND SUPPLIERS**

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Table BG-1. Potential and Primary Outliers in Upriver Sediments, Dry Weight Concentrations.

Analyte	Units	Mean Concentration	Number of Potential Outliers (Graphical)	Number of Primary Outliers	Outlier Sample ID	Outlier Concentration	Potential Outlier	Primary Outlier	Outlier:Mean Concentration Ratio
Aluminum	mg/kg	20581	0	0	--	--	--	--	--
Arsenic	mg/kg	2.869	3	0	LW2-U6TOC-2	5.29	√	--	1.84
Arsenic					WLFLH07WR08SD	5.2	√	--	1.81
Arsenic					LW2-U6TOC-3	4.85	√	--	1.69
Chromium	mg/kg	22.57	0	0	--	--	--	--	--
Copper	mg/kg	24.32	0	0	--	--	--	--	--
Mercury	mg/kg	0.0313	0	0	--	--	--	--	--
Nickel	mg/kg	20.7	0	0	--	--	--	--	--
Zinc	mg/kg	74.68	1	0	LW2-U2C-2	165	√	--	2.21
Tributyltin ion	ug/kg	0.636	0	0	--	--	--	--	--
Total cPAH	ug/kg	10.52	3	1	LW3-UG04B	76.988	√	√	7.32
Total cPAH					LW3-UG12C	40.085	√	--	3.81
Total cPAH					WLCMBJ99D09942D09942	39.742	√	--	3.78
Naphthalene	ug/kg	3.536	1	0	LW3-UG03B	9.9	√	--	2.80
Benzo(a)pyrene	ug/kg	6.718	6	1	LW3-UG04B	53	√	√	7.89
Benzo(a)pyrene					WLCMBJ99D09942D09942	28	√	--	4.17
Benzo(a)pyrene					LW3-UG12C	27	√	--	4.02
Benzo(a)pyrene					WLFLH07BH04SD	21	√	--	3.13
Benzo(a)pyrene					WLFLH07CR01SD	19	√	--	2.83
Benzo(a)pyrene					LW2-U2C-2	18	√	--	2.68
Benzo(a)anthracene	ug/kg	6.607	5	1	LW3-UG04B	51	√	√	7.72
Benzo(a)anthracene					LW3-UG12C	32	√	--	4.84
Benzo(a)anthracene					WLCDRD05PGR01Ref01	28	√	--	4.24
Benzo(a)anthracene					WLFLH07WR09SD	24	√	--	3.63
Benzo(a)anthracene					LW2-U2C-2	20	√	--	3.03
Benzo(b)fluoranthene	ug/kg	9.005	5	1	LW3-UG04B	72	√	√	8.00
Benzo(b)fluoranthene					LW3-UG12C	40	√	--	4.44
Benzo(b)fluoranthene					WLCMBJ99D09942D09942	32	√	--	3.55
Benzo(b)fluoranthene					WLFLH07WR09SD	30	√	--	3.33
Benzo(b)fluoranthene					LW2-U2C-2	25	√	--	2.78
Benzo(k)fluoranthene	ug/kg	4.37	7	1	LW3-UG04B	23	√	√	5.26
Benzo(k)fluoranthene					WLFLH07WR09SD	22	√	--	5.03
Benzo(k)fluoranthene					WLFLH07CR01SD	17	√	--	3.89
Benzo(k)fluoranthene					WLCDRD05PGR01Ref01	15	√	--	3.43
Benzo(k)fluoranthene					LW3-UG12C	14	√	--	3.20
Benzo(k)fluoranthene					WLCMBJ99D09942D09942	11	√	--	2.52
Benzo(k)fluoranthene					WLFLH07WL01SD	11	√	--	2.52
Dibenzo(a,h)anthracene	ug/kg	2.41	2	2	WLFLH07WR04SD	22	√	√	9.13
Dibenzo(a,h)anthracene					LW3-UG04B	8	√	√	3.32
Indeno(1,2,3-cd)pyrene	ug/kg	5.386	3	1	LW3-UG04B	34	√	√	6.31
Indeno(1,2,3-cd)pyrene					WLFLH07WR09SD	23	√	--	4.27
Indeno(1,2,3-cd)pyrene					LW3-UG12C	16	√	--	2.97
Bis(2-ethylhexyl) phthalate	ug/kg	73.89	4	1	LW2-U1C-3	2100	√	√	28.42
Bis(2-ethylhexyl) phthalate					LW3-UG11C	240	√	--	3.25
Bis(2-ethylhexyl) phthalate					LW3-UG03B	200	√	--	2.71
Bis(2-ethylhexyl) phthalate					LW3-UG03C	180	√	--	2.44
Hexachlorobenzene	ug/kg	8.35	0	0	--	--	--	--	--
PCB077	pg/g	10.13	3	1	WLFLH07WR08SD	80.4	√	√	7.94
PCB077					LW2-U2C-2	56.8	√	--	5.61
PCB077					WLFLH07TR01SD	26.9	√	--	2.66
PCB126	pg/g	2.137	3	1	LW2-U2C-2	6.61	√	--	3.09

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Table BG-1. Potential and Primary Outliers in Upriver Sediments, Dry Weight Concentrations.

Analyte	Units	Mean Concentration	Number of Potential Outliers (Graphical)	Number of Primary Outliers	Outlier Sample ID	Outlier Concentration	Potential Outlier	Primary Outlier	Outlier:Mean Concentration Ratio
PCB126					WLFLH07WR08SD	6.59	√	√	3.08
PCB126					LW3-UG03A-1	6.47 J	√		3.03
Total PCBs <sup>a</sup>	ug/kg	6.385	8	1	WLFLH07WR08SD	47.98	√	√	7.51
Total PCBs <sup>a</sup>					LW3-UG03C	37.35 J	√		5.85
Total PCBs <sup>a</sup>					LW2-U2C-2	31.01 J	√		4.86
Total PCBs <sup>a</sup>					WLFLH07WR04SD	24.85	√		3.89
Total PCBs <sup>a</sup>					WLFLH07TR01SD	18.67	√		2.92
Total PCBs <sup>a</sup>					LW2-U6TOC-3	16.175 J	√		2.53
Total PCBs <sup>a</sup>					WLCDRI03CREFO2CREFO2	13.7 J	√		2.15
Total PCBs <sup>a</sup>					LW3-UG02B	13.5 J	√		2.11
PCB TEQ - Mammals 2006	pg/g	0.196	3	1	WLFLH07WR11SD	1.27	√		6.48
PCB TEQ - Mammals 2006					LW2-U2C-2	0.72 J	√		3.67
PCB TEQ - Mammals 2006					WLFLH07WR08SD	0.72	√	√	3.67
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	0.414	0	3	WLFLH07WR10SD	1.06 U		√	2.56
2,3,4,7,8-Pentachlorodibenzofuran					WLFLH07WR08SD	1.06		√	2.56
2,3,4,7,8-Pentachlorodibenzofuran					WLFLH07WR09SD	1.04 U		√	2.51
TCDD TEQ - Mammals 2006	pg/g	1.159	2	3	WLFLH07WR08SD	19.11	√	√	16.49
TCDD TEQ - Mammals 2006					WLFLH07WR04SD	3.79	√		3.27
TCDD TEQ - Mammals 2006					WLFLH07WR10SD	3.1859		√	2.75
TCDD TEQ - Mammals 2006					WLFLH07WR09SD	2.72802		√	2.35
Sum DDT	ug/kg	0.591	1	0	LW3-UG12A	2.97 J	√		5.03
Sum DDE	ug/kg	0.976	3	0	LW2-U6TOC-2	2.45	√		2.51
Sum DDE					LW3-G786	2.35 J	√		2.41
Sum DDE					LW3-UG12A	2.24 J	√		2.30
Sum DDD	ug/kg	0.753	0	0	--	--	--	--	--
Total DDX	ug/kg	1.713	2	0	LW3-UG12A	6.7 J	√	EPA case only	3.91
Total DDX					LW2-U6TOC-2	5 J	√	EPA case only	2.92
Total Chlordane	ug/kg	0.408	1	0	LW2-U6TOC-2	1.18 J	√		2.89
Aldrin	ug/kg	0.242	0	0	--	--	--	--	--
Dieldrin	ug/kg	0.119	0	0	--	--	--	--	--
alpha-Hexachlorocyclohexane	ug/kg	0.302	1	1	LW2-U5Q-1	5.03 NJ	√	√	16.66
beta-Hexachlorocyclohexane	ug/kg	0.47	4	0	LW2-U2C-1	2.01 J	√		4.28
beta-Hexachlorocyclohexane					LW2-U1C-1	1.87 J	√		3.98
beta-Hexachlorocyclohexane					LW2-U6TOC-2	1.52 NJ	√		3.23
beta-Hexachlorocyclohexane					LW2-U2C-3	1.47 J	√		3.13
gamma-Hexachlorocyclohexane	ug/kg	0.117	0	0	--	--	--	--	--
Heptachlor	ug/kg	0.175	0	0	--	--	--	--	--
Heptachlor epoxide	ug/kg	0.26	0	0	--	--	--	--	--

**Notes:**

<sup>a</sup> Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

N/A - not available

ND - non-detect

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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Table BG-2. Potential and Primary Outliers in Upriver Sediments, OC-normalized Concentrations

Analyte	Units	Mean Concentration	Number of Potential Outliers (Graphical)	Number of Primary Outliers	Outlier Sample ID	Outlier Concentration	Potential Outlier	Primary Outlier	Outlier:Mean Concentration Ratio
Tributyltin ion	ug/kg	69.22	0	0	--	--	--	--	--
Total cPAH	ug/kg	1480	5	1	WFLH07WR04SD	12442	√		8.4
Total cPAH					WFLH07BH04SD	11788	√		8.0
Total cPAH					LW3-UG04B	7623	√	√	5.2
Total cPAH					WFLH07CR01SD	7482	√		5.1
Total cPAH					WLCMBJ99D09942D09942	4289	√		2.9
Naphthalene	ug/kg	491	0	0	--	--	--	--	--
Benzo(a)pyrene	ug/kg	867.2	6	2	WFLH07BH04SD	10500	√	√	12.1
Benzo(a)pyrene					LW3-UG04B	5248	√	√	6.1
Benzo(a)pyrene					WFLH07CR01SD	5135	√		5.9
Benzo(a)pyrene					WLCMBJ99D09942D09942	3022	√		3.5
Benzo(a)pyrene					LW3-UG12C	2389	√		2.8
Benzo(a)pyrene					WLCDRD05PGR01Ref01	1806	√		2.1
Benzo(a)anthracene	ug/kg	767.4	8	1	LW3-UG04B	5050	√	√	6.6
Benzo(a)anthracene					WLCDRD05PGR01Ref01	3889	√		5.1
Benzo(a)anthracene					WFLH07CR01SD	3514	√		4.6
Benzo(a)anthracene					WFLH07BH03SD	3067	√		4.0
Benzo(a)anthracene					LW3-UG12C	2832	√		3.7
Benzo(a)anthracene					WFLH07WR06SD	2200	√		2.9
Benzo(a)anthracene					WLCMBJ99D09942D09942	2159	√		2.8
Benzo(a)anthracene					LW2-U2C-2	1695	√		2.2
Benzo(b)fluoranthene	ug/kg	1014	7	1	LW3-UG04B	7129	√	√	7.0
Benzo(b)fluoranthene					WFLH07CR01SD	5135	√		5.1
Benzo(b)fluoranthene					WFLH07BH03SD	4400	√		4.3
Benzo(b)fluoranthene					WFLH07WR06SD	3700	√		3.6
Benzo(b)fluoranthene					LW3-UG12C	3540	√		3.5
Benzo(b)fluoranthene					WLCMBJ99D09942D09942	3454	√		3.4
Benzo(b)fluoranthene					LW2-U2C-2	2119	√		2.1
Benzo(k)fluoranthene	ug/kg	599.1	6	1	WFLH07CR01SD	4595	√		7.7
Benzo(k)fluoranthene					WFLH07BH03SD	4000	√		6.7
Benzo(k)fluoranthene					WFLH07WR06SD	2900	√		4.8
Benzo(k)fluoranthene					LW3-UG04B	2277	√	√	3.8
Benzo(k)fluoranthene					WFLH07WR07SD	2200	√		3.7
Benzo(k)fluoranthene					WLCDRD05PGR01Ref01	2083	√		3.5
Dibenzo(a,h)anthracene	ug/kg	454.2	10	2	WFLH07WR04SD	11000	√	√	24.2
Dibenzo(a,h)anthracene					WFLH07WR02SD	1200	√		2.6
Dibenzo(a,h)anthracene					WFLH07WR03SD	1200	√		2.6
Dibenzo(a,h)anthracene					WFLH07WR06SD	1150	√		2.5
Dibenzo(a,h)anthracene					WFLH07CR01SD	1135	√		2.5
Dibenzo(a,h)anthracene					WFLH07BH01SD	1084	√		2.4
Dibenzo(a,h)anthracene					WFLH07BH04SD	1050	√		2.3
Dibenzo(a,h)anthracene					WFLH07BH03SD	1022	√		2.3
Dibenzo(a,h)anthracene					WFLH07WR07SD	920	√		2.0
Dibenzo(a,h)anthracene					LW3-UG04B	792	√	√	1.7
Indeno(1,2,3-cd)pyrene	ug/kg	636.3	3	1	WFLH07WR06SD	4500	√		7.1
Indeno(1,2,3-cd)pyrene					LW3-UG04B	3366	√	√	5.3
Indeno(1,2,3-cd)pyrene					WFLH07CR01SD	2973	√		4.7
Bis(2-ethylhexyl) phthalate	ug/kg	15813	2	1	LW2-UIC-3	750000	√	√	47.4
Bis(2-ethylhexyl) phthalate					LW3-UG11C	23301	√		1.5
Hexachlorobenzene	ug/kg	1903	10	0	WFLH07WR02SD	12000	√		6.3
Hexachlorobenzene					WFLH07WR03SD	12000	√		6.3
Hexachlorobenzene					WFLH07WR06SD	11500	√		6.0

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Table BG-2. Potential and Primary Outliers in Upriver Sediments, OC-normalized Concentrations

Analyte	Units	Mean Concentration	Number of Potential Outliers (Graphical)	Number of Primary Outliers	Outlier Sample ID	Outlier Concentration	Potential Outlier	Primary Outlier	Outlier:Mean Concentration Ratio
Hexachlorobenzene					WFLH07WR04SD	11000	√		5.8
Hexachlorobenzene					WFLH07BH01SD	10837	√		5.7
Hexachlorobenzene					WFLH07BH04SD	10500	√		5.5
Hexachlorobenzene					WFLH07BH03SD	10222	√		5.4
Hexachlorobenzene					WFLH07WR07SD	9200	√		4.8
Hexachlorobenzene					WFLH07WR05SD	7767	√		4.1
Hexachlorobenzene					WFLH07CR01SD	6486	√		3.4
PCB077	pg/g	924.9	3	1	LW2-U2C-2	4814	√		5.2
PCB077					WFLH07WR08SD	2707	√	√	2.9
PCB077					WFLH07BH03SD	2298	√		2.5
PCB126	pg/g	182.4	1	1	LW2-U2C-2	560	√		3.1
PCB126					WFLH07WR08SD	222		√	1.2
PCB156	pg/g	4524	5	2	WFLH07WR04SD	54000	√	√	11.9
PCB156					WFLH07WR06SD	26550 U	√		5.9
PCB156					LW2-U2C-2	11186	√		2.5
PCB156					WFLH07BH03SD	6089	√		1.3
PCB156					WFLH07WR08SD	5623	√	√	1.2
PCB157	pg/g	3983	4	2	WFLH07WR04SD	54000	√	√	13.6
PCB157					WFLH07WR06SD	26550 U	√		6.7
PCB157					WFLH07BH03SD	6089	√		1.5
PCB157					WFLH07WR08SD	5623	√	√	1.4
PCB169	pg/g	1244	0	1	WFLH07WR08SD	63 U		√	0.1
Total PCBs <sup>a</sup>	ug/kg	815.4	3	2	WFLH07WR04SD	12423	√	√	15.2
Total PCBs <sup>a</sup>					LW2-U2C-2	2628 J	√		3.2
Total PCBs <sup>a</sup>					WFLH07BH03SD	2621	√		3.2
Total PCBs <sup>a</sup>					WFLH07WR08SD	1615		√	2.0
PCB TEQ - Mammals 2006	pg/g	28.21	1	2	WFLH07WR11SD	217	√	√	7.7
PCB TEQ - Mammals 2006					WFLH07WR08SD	24		√	0.9
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	110.4	8	4	WFLH07WR04SD	915	√	√	8.3
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR03SD	525 U	√		4.8
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07BH04SD	520 U	√		4.7
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR02SD	520 U	√		4.7
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR06SD	520 U	√		4.7
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07BH01SD	479 U	√		4.3
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07BH03SD	440 U	√		4.0
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR07SD	416 U	√		3.8
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR10SD	76 U		√	0.7
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR09SD	61 U		√	0.6
2,3,4,7,8-Pentachlorodibenzofuran					WFLH07WR08SD	36		√	0.3
TCDD TEQ - Mammals 2006	pg/g	193.7	8	4	WFLH07WR04SD	1895	√	√	9.8
TCDD TEQ - Mammals 2006					WFLH07BH03SD	909	√		4.7
TCDD TEQ - Mammals 2007					WFLH07WR03SD	681	√		3.5
TCDD TEQ - Mammals 2008					WFLH07BH04SD	673	√		3.5
TCDD TEQ - Mammals 2009					WFLH07WR02SD	645	√		3.3
TCDD TEQ - Mammals 2010					WFLH07WR08SD	643	√	√	3.3
TCDD TEQ - Mammals 2011					WFLH07WR06SD	628	√		3.2
TCDD TEQ - Mammals 2012					WFLH07BH01SD	624	√		3.2
TCDD TEQ - Mammals 2013					WFLH07WR10SD	228		√	1.2
TCDD TEQ - Mammals 2014					WFLH07WR09SD	160		√	0.8
4,4'-DDD	ug/kg	45.05	0	0	--	--	--	--	--
4,4'-DDT	ug/kg	41.38	1	0	LW3-UG12A	166	√		4.0

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Table BG-2. Potential and Primary Outliers in Upriver Sediments, OC-normalized Concentrations

Analyte	Units	Mean Concentration	Number of Potential Outliers (Graphical)	Number of Primary Outliers	Outlier Sample ID	Outlier Concentration	Potential Outlier	Primary Outlier	Outlier:Mean Concentration Ratio
Sum DDT	ug/kg	42.57	1	0	LW3-UG12A	176 J	√		4.1
Sum DDE	ug/kg	80.14	0	0	--	--	--	--	--
Sum DDD	ug/kg	58.43	0	0	--	--	--	--	--
Total DDx	ug/kg	1.713	2	0	LW3-UG12A	7 J	√	EPA case only	3.91
Total DDx					LW2-U6TOC-2	5 J	√	EPA case only	2.92
Total DDx	ug/kg	162.8	1	0	LW3-UG12A	396 J	√		2.4
Total Chlordane	ug/kg	35	3	0	LW3-UG11B	134 J	√		3.8
Total Chlordane					LW3-UG11C	80 J	√		2.3
Total Chlordane					LW2-U5Q-1	74 J	√		2.1
Aldrin	ug/kg	15.1	0	0	--	--	--	--	--
Dieldrin	ug/kg	13.37	4	0	LW3-UG11B	54	√		4.1
Dieldrin					WFLH07TR01SD	50 U	√		3.7
Dieldrin					WLCDRD05PGR01Ref01	44 U	√		3.3
Dieldrin					LW3-UG11C	38	√		2.8
alpha-Hexachlorocyclohexane	ug/kg	83.22	10	1	LW2-U5Q-1	2515 NJ	√	√	30.2
alpha-Hexachlorocyclohexane					WFLH07WR02SD	240 U	√		2.9
alpha-Hexachlorocyclohexane					WFLH07WR03SD	240 U	√		2.9
alpha-Hexachlorocyclohexane					WFLH07WR06SD	230 U	√		2.8
alpha-Hexachlorocyclohexane					WFLH07WR04SD	220 U	√		2.6
alpha-Hexachlorocyclohexane					WFLH07BH01SD	217 U	√		2.6
alpha-Hexachlorocyclohexane					WFLH07BH04SD	210 U	√		2.5
alpha-Hexachlorocyclohexane					WFLH07BH03SD	204 U	√		2.5
alpha-Hexachlorocyclohexane					WFLH07WR07SD	184 U	√		2.2
alpha-Hexachlorocyclohexane					WFLH07WR05SD	155 U	√		1.9
beta-Hexachlorocyclohexane	ug/kg	70.4	1	0	LW2-U2C-3	288 J	√		4.1
Gamma-Hexachlorocyclohexane	ug/kg	10.37	1	0	LW3-UG12C	28 NJ	√		2.7
Heptachlor	ug/kg	12.57	7	0	LW3-UG12C	44 NJ	√		3.5
Heptachlor					WFLH07WR10SD	44 U	√		3.5
Heptachlor					WFLH07WR09SD	39 U	√		3.1
Heptachlor					LW3-G788	38 U	√		3.0
Heptachlor					WLCDRD05PGR01Ref01	38 U	√		3.0
Heptachlor					WFLH07WR01SD	35 U	√		2.8
Heptachlor					WFLH07WL01SD	35 U	√		2.8
Heptachlor epoxide	ug/kg	47.74	10	0	LW3-UG12C	44 NJ	√		0.9
Heptachlor epoxide					WFLH07WR10SD	44 U	√		0.9
Heptachlor epoxide					WFLH07WR09SD	39 U	√		0.8
Heptachlor epoxide					LW3-G788	38 U	√		0.8
Heptachlor epoxide					WLCDRD05PGR01Ref01	38 U	√		0.8
Heptachlor epoxide					WFLH07WR01SD	35 U	√		0.7
Heptachlor epoxide					WFLH07WL01SD	35 U	√		0.7
Heptachlor epoxide					WFLH07BG01SD	32 U	√		0.7
Heptachlor epoxide					WFLH07WR08SD	31 U	√		0.6
Heptachlor epoxide					WFLH07TR01SD	26 U	√		0.5

Notes:

<sup>a</sup> Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

N/A - not available

ND - non-detect

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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Table BG-3. Upriver Surface Sediment Central Tendency and Upper Threshold Statistics, Dry Weight Concentrations, Primary Outliers Removed.

Analyte	Units	Distribution (ND = ROS)	Kaplan-Meier Statistics		Upper Threshold Statistics		Central Tendency Statistics		Mean (ND = DL)
			KM Mean	KM SD	UPL		UCL		
					Type	UPL	Type	UCL	
Aluminum	mg/kg	Non-parametric	20581	7885	95% KM UPL (t)	33842	95% KM (Chebyshev) UCL	24877	20581
Arsenic	mg/kg	Approx. Gamma	2.869	0.657	95% KM UPL (t)	3.973	95% KM (BCA) UCL	3.007	2.869
Chromium	mg/kg	Normal	22.57	5.689	95% KM UPL (t)	32.13	95% KM (t) UCL	23.75	22.57
Copper	mg/kg	Normal	24.32	7.724	95% KM UPL (t)	37.3	95% KM (t) UCL	25.91	24.32
Mercury	mg/kg	Normal	0.0307	0.0134	95% KM UPL (t)	0.0532	95% KM (t) UCL	0.0337	0.0313
Nickel	mg/kg	Normal	20.7	3.24	95% KM UPL (t)	26.14	95% KM (t) UCL	21.36	20.7
Zinc	mg/kg	Normal	74.68	21.14	95% KM UPL (t)	110.2	95% KM (t) UCL	79.02	74.68
Tributyltin ion	ug/kg	n/a					n/a		0.636
Total cPAH	ug/kg	Approx. Gamma	9.395	8.003	95% KM UPL (t)	22.83	95% KM (BCA) UCL	11.02	9.572
Naphthalene	ug/kg	Approx. Gamma	2.94	1.944	95% KM UPL (t)	6.21	95% KM (t) UCL	3.362	3.536
Benzo(a)pyrene	ug/kg	Lognormal	5.785	5.678	95% KM UPL (t)	15.32	95% KM (BCA) UCL	7.087	6.057
Benzo(a)anthracene	ug/kg	Lognormal	5.638	6.129	95% KM UPL (t)	15.72	95% KM (BCA) UCL	6.936	5.973
Benzo(b)fluoranthene	ug/kg	Gamma	7.606	7.471	95% KM UPL (t)	20.15	95% KM (BCA) UCL	9.323	8.105
Benzo(k)fluoranthene	ug/kg	Non-parametric	3.568	4.099	95% KM UPL (t)	10.45	95% KM (BCA) UCL	4.597	4.103
Dibenzo(a,h)anthracene	ug/kg	Approx. Gamma	1.476	1.024	95% KM UPL (t)	3.196	95% KM (Percentile Bootstrap) UCL	1.697	2.045
Indeno(1,2,3-cd)pyrene	ug/kg	Gamma	4.6	4.02	95% KM UPL (t)	11.35	95% KM (BCA) UCL	5.695	4.977
Bis(2-ethylhexyl) phthalate	ug/kg	Lognormal	42.88	44.9	95% KM UPL (t)	118.4	95% KM (Chebyshev) UCL	67.17	43.19
Hexachlorobenzene	ug/kg	Non-parametric	7.639	12.06	95% KM UPL (t)	27.9	97.5% KM (Chebyshev) UCL	16.95	8.35
PCB077	pg/g	Lognormal	7.671	10.16	95% KM UPL (t)	25.16	95% KM (t) UCL	10.8	7.933
PCB126	pg/g	Lognormal	1.51	1.397	95% KM UPL (t)	3.923	95% KM (t) UCL	2.005	1.988
Total PCBs <sup>a</sup>	ug/kg	Approx. Gamma	5.436	6.873	95% KM UPL (t)	16.99	95% KM (Percentile Bootstrap) UCL	6.847	5.755
PCB TEQ - Mammals 2006	pg/g	Non-parametric	0.179	0.248	95% KM UPL (t)	0.606	95% KM (Chebyshev) UCL	0.376	0.179
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	Non-parametric	0.0644	0.257	95% KM UPL (t)	0.5	95% KM (BCA) UCL	0.148	0.375
TCDD TEQ - Mammals 2006	pg/g	Non-parametric	0.72	0.848	95% KM UPL (t)	2.157	95% KM (Chebyshev) UCL	1.253	0.72
Sum DDT	ug/kg	Approx. Gamma	0.462	0.378	95% KM UPL (t)	1.098	95% KM (t) UCL	0.544	0.591
Sum DDE	ug/kg	Gamma	0.836	0.525	95% KM UPL (t)	1.719	95% KM (Percentile Bootstrap) UCL	0.951	0.976
Sum DDD	ug/kg	Gamma	0.594	0.426	95% KM UPL (t)	1.309	95% KM (t) UCL	0.689	0.753
Total DDx - LWG case	ug/kg	Non-parametric	1.564	1.207	95% KM UPL (t)	3.592	95% KM (BCA) UCL	1.847	1.713
Total DDx - EPA case	ug/kg	Normal	1.433	0.947	95% KM UPL (t)	3.025	95% KM (t) UCL	1.637	1.586
Total Chlordane	ug/kg	Gamma	0.331	0.218	95% KM UPL (t)	0.698	95% KM (t) UCL	0.38	0.408
Aldrin	ug/kg	Normal	0.254	0.0499	95% KM UPL (t)	0.339	95% KM (t) UCL	0.267	0.242
Dieldrin	ug/kg	Normal	0.122	0.0546	95% KM UPL (t)	0.215	95% KM (t) UCL	0.137	0.119
alpha-Hexachlorocyclohexane	ug/kg	n/a			95% KM UPL (t)		n/a		0.228
beta-Hexachlorocyclohexane	ug/kg	Gamma	0.357	0.411	95% KM UPL (t)	1.049	95% KM (t) UCL	0.446	0.47
gamma-Hexachlorocyclohexane	ug/kg	n/a					n/a		0.117
Heptachlor	ug/kg	n/a					n/a		0.175
Heptachlor epoxide	ug/kg	n/a					n/a		0.26

Notes:

<sup>a</sup>Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

N/A - not available

ND - non-detect

PAH - polycyclic aromatic hydrocarbon

PCB - polychlorinated biphenyl

TEQ - toxic equivalent concentration

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Table BG-4. Upriver Surface Sediment Central Tendency and Upper Threshold Statistics, OC-normalized Concentrations, Primary Outliers Removed.

	Units	Distribution (ND = ROS)	Kaplan-Meier Statistics		Upper Threshold Statistics		Central Tendency Statistics		Mean (ND = DL)
			KM Mean	KM SD	UPL		UCL		
					Type	UPL	Type	UCL	
Tributyltin ion	ug/kg	n/a					n/a		69.22
Total cPAH	ug/kg	Non-parametric	1364	2197	95% KM UPL (t)	5053	95% KM (Chebyshev) UCL	2518	1392
Naphthalene	ug/kg	Gamma	354.8	311.9	95% KM UPL (t)	878.4	95% KM (t) UCL	420.6	491
Benzo(a)pyrene	ug/kg	Lognormal	628.1	755.8	95% KM UPL (t)	1898	95% KM (Chebyshev) UCL	1029	664.1
Benzo(a)anthracene	ug/kg	Non-parametric	657.5	795.1	95% KM UPL (t)	1993	95% KM (BCA) UCL	825.3	706.2
Benzo(b)fluoranthene	ug/kg	Lognormal	874.4	996.3	95% KM UPL (t)	2547	95% KM (BCA) UCL	1106	926.3
Benzo(k)fluoranthene	ug/kg	Non-parametric	527.1	837.9	95% KM UPL (t)	1934	95% KM (Chebyshev) UCL	968.7	575.2
Dibenzo(a,h)anthracene	ug/kg	Non-parametric	230.2	336.4	95% KM UPL (t)	795.3	95% KM (Chebyshev) UCL	410.9	296.5
Indeno(1,2,3-cd)pyrene	ug/kg	Non-Parametric	555.1	670.2	95% KM UPL (t)	1680	95% KM (BCA) UCL	709.7	597.2
Bis(2-ethylhexyl) phthalate	ug/kg	Gamma	4656	4071	95% KM UPL (t)	11500	95% KM (Chebyshev) UCL	6859	4689
Hexachlorobenzene	ug/kg	Non-parametric	1817	3631	95% KM UPL (t)	7919	97.5% KM (Chebyshev) UCL	4620	1903
PCB077	pg/g	Non-parametric	748.8	827.7	95% KM UPL (t)	2174	95% KM (t) UCL	1008	869.2
PCB126	pg/g	Non-parametric	127.6	133.7	95% KM UPL (t)	362.8	95% KM (t) UCL	181.1	180.6
Total PCBs <sup>a</sup>	ug/kg	Gamma	557.5	608.9	95% KM UPL (t)	1582	95% KM (Percentile Bootstrap) UCL	694.400	624.6
PCB TEQ - Mammals 2006	pg/g	Non-parametric	22.04	19.36	95% KM UPL (t)	55.49	95% KM (Chebyshev) UCL	37.72	22.04
2,3,4,7,8-Pentachlorodibenzofuran	pg/g	Normal	2.648	3.056	95% KM UPL (t)	7.83	95% KM (t) UCL	3.619	96.96
TCDD TEQ - Mammals 2006	pg/g	Lognormal	148.9	233.6	95% KM UPL (t)	544.8	97.5% KM (Chebyshev) UCL	361.6	148.9
Sum DDT	ug/kg	Gamma	30.47	28.98	95% KM UPL (t)	79.37	95% KM (t) UCL	37.28	42.57
Sum DDE	ug/kg	Gamma	75.59	30.95	95% KM UPL (t)	127.8	95% KM (BCA) UCL	83.01	80.14
Sum DDD	ug/kg	Gamma	52.3	30.78	95% KM UPL (t)	104.2	95% KM (Percentile Bootstrap) UCL	59.81	58.43
Total DDx - LWG case	ug/kg	Gamma	150.6	63.93	95% KM UPL (t)	258.3	95% KM (Percentile Bootstrap) UCL	165	162.8
Total DDT - EPA case	ug/kg	Normal	145.7	56.11	95% KM UPL (t)	240.3	95% KM (t) UCL	158.5	158.3
Total Chlordane	ug/kg	Non-parametric	28.82	19.69	95% KM UPL (t)	62.03	95% KM (t) UCL	33.38	35
Aldrin	ug/kg	Normal	14.87	3.6	95% KM UPL (t)	20.97	95% KM (t) UCL	15.9	15.1
Dieldrin	ug/kg	Normal	9.386	8.133	95% KM UPL (t)	23.17	95% KM (t) UCL	11.55	13.37
alpha-Hexachlorocyclohexane	ug/kg	n/a					n/a		45.22
beta-Hexachlorocyclohexane	ug/kg	Gamma	36	47.32	95% KM UPL (t)	115.6	95% KM (t) UCL	46.68	70.4
gamma-Hexachlorocyclohexane	ug/kg	n/a					n/a		10.37
Heptachlor	ug/kg	n/a					n/a		12.57
Heptachlor epoxide	ug/kg	n/a					n/a		47.74

Notes:

<sup>a</sup>Total PCBs are calculated as the sum of individual congeners, where available. The sum of individual Aroclors was used for samples in which congeners were not analyzed.

cPAH - carcinogenic polycyclic aromatic hydrocarbon

DL - detection limit

N/A - not available

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PAH - polycyclic aromatic hydrocarbon

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