Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

Lower Duwamish Waterway Remedial Investigation

BENTHIC INVERTEBRATE DATA REPORT ADDENDUM: PCB CONGENER DATA AND SIM ANALYSES FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

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Acronyms

Acronym	Definition
ACG	analytical concentration goal
AET	apparent effects threshold
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd.
CAS	Columbia Analytical Services
dw	dry weight
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
LDW	Lower Duwamish Waterway
MS	matrix spike
MSD	matrix spike duplicate
OC	organic carbon
PCB	polychlorinated biphenyl
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SIM	selected ion monitoring
SQS	sediment quality standard
SVOC	semivolatile organic compound
TEF	toxicity equivalence factor
TEQ	toxic equivalents
Windward	Windward Environmental LLC
WHO	World Health Organization
ww	wet weight

1.0 Introduction

This data report is an addendum to the *Lower Duwamish Waterway Final Data Report: Chemical Analyses of Benthic Invertebrate and Clam Tissue Samples and Co-located Sediment Samples* (Windward 2005a). It provides the results of the following additional chemical analyses of archived samples collected as part of the Lower Duwamish Waterway (LDW) Phase 2 Remedial Investigation (RI):

- a subset of benthic invertebrate and clam co-located sediment samples were submitted for additional selected ion monitoring (SIM) analysis of certain semivolatile organic compounds (SVOCs) in order to achieve lower reporting limits (RLs) than were achieved in the original SIM analysis. The shorter analyte list for the SIM reanalysis resulted in more sensitive instrument response and lower reporting limits.
- a subset of the benthic invertebrate and clam tissue samples and their co-located sediments were analyzed for individual polychlorinated biphenyl (PCB) congeners, as specified in the benthic invertebrate quality assurance project plan (QAPP) (QAPP; Windward 2004).

This report is organized into sections addressing sample selection and laboratory analyses, chemical analysis results, and references. The text is supported by the following appendices:

- Appendix A – PCB congener data
- Appendix B – results of SIM reanalysis of sediment samples
- Appendix C – data management
- Appendix D – data validation reports
- Appendix E - laboratory Form 1s
- Appendix F –graphical representations of the PCB congener data

2.0 Sample Selection and Laboratory Analyses

Sediment samples were selected for additional SIM analysis (EPA Method 8270C-SIM) for certain analytes based on the presence of RLs above the Washington State Sediment Quality Standards (SQS) in the original SVOC results (EPA Method 8270C-SIM). The sample selection process and the SIM analyses are discussed in Section 2.1. Selection of sediment and tissue samples for PCB congener analyses was based on the Aroclor concentrations reported for the samples as well as the spatial distribution of the samples in the LDW. The selected samples and the congener analyses are discussed in Section 2.2.

2.1 SIM ANALYSES

Co-located sediment and benthic invertebrate and clam composite tissue samples were collected for the Phase 2 RI as specified in the benthic invertebrate QAPP (Windward 2004). Thirty-four co-located sediment samples were compared to the SQS to assess sediment quality and to identify candidate locations for toxicity testing. In 22 of the 34 sediment samples, the RLs for a subset of SVOCs—such as 2,4-dimethyl phenol and 1,2,4-trichlorobenzene—were above the corresponding SQS. Archived sediments from 15 of these 22 samples were submitted to Analytical Resources, Inc. (ARI) for further analysis by SIM gas chromatography/mass spectroscopy (EPA Method 8270C-SIM) to achieve lower RLs (Table 2-1). Seven of the 22 sample locations were flagged for reoccupation during the surface sediment sampling because, in addition to RL issues, at least one chemical had a detected concentration exceeding the SQS. Because of the known SQS exceedances, grab samples were collected at reoccupied locations and submitted to the laboratories for both chemical analyses and toxicity testing as part of Round 2 sediment sampling. The data characterizing these seven reoccupied locations will be presented in the Surface Sediment Round 2 Data Report. No further chemical analyses were required for the remaining 12 of the original 34 locations because no further chemistry data were needed to make judgments about sediment quality or the need for toxicity testing.

Table 2-1. Sediment samples identified for additional SIM analysis, location reoccupation, or no further action

SIM ANALYSIS	REOCCUPY	NO FURTHER ACTION
LDW-B1a-S	LDW-B4a-S	LDW-B5a-S
LDW-B2a-S	LDW-B6a-S	LDW-B8a-S
LDW-B3a-S	LDW-B7a-S	LDW-B3b-S
LDW-B10a-S	LDW-B9a-S	LDW-B4b-S
LDW-B1b-S	LDW-B2b-S	LDW-B6b-S
LDW-B8b-S	LDW-B5b-S	LDW-B7b-S
LDW-B9b-S	LDW-C1-S	LDW-C2-S1
LDW-B10b-S		LDW-C7-S1
LDW-C2-S2		LDW-C7-S2
LDW-C3-S1		LDW-C8-S
LDW-C3-S2		LDW-C10-S1
LDW-C4-S		LDW-C10-S2
LDW-C5-S		
LDW-C6-S		
LDW-C9-S		

Each of the samples reanalyzed by SIM was analyzed for all compounds listed in Table 2-2, despite the fact that generally only a few compounds had RLs above the SQS based on the initial SIM SVOC analysis conducted by Columbia Analytical Services (CAS). The target analytes for the SIM analysis conducted by ARI and the sample RLs are presented in Table 2-2.

The SIM target analytes were identified in the surface sediment QAPP (Windward 2005b) based on a review of historical data to identify analytes that had been reported with either detection limits or RLs above the SQS. The initial analysis of the sediment samples resulted in RLs above the SQS for 10 chemicals (Table 2-2). Phenol was reported as undetected in one sample (LDW-B10a) with an RL above the SQS. This analyte was not a SIM target analyte so an additional qualitative evaluation was performed to assess the presence of phenol in this sample (Section 3.1).

Table 2-2. SIM target analytes and range of RLs

ANALYTE	RANGE OF SAMPLE REPORTING LIMITS (µg/kg dw)
1,2-Dichlorobenzene [a]	6.3 – 17
1,4-Dichlorobenzene [a]	6.3 – 17
1,2,4-Trichlorobenzene [a]	6.3 – 8.7
Hexachlorobenzene	6.3 – 17
Hexachlorobutadiene [a]	6.3 – 17
Benzoic acid [a]	63 – 170
Dimethyl phthalate	6.3 – 17
Diethyl phthalate	6.3 – 17
Butyl benzyl phthalate [a]	6.3 – 17
2-Methyl phenol [a]	6.3 – 17
2,4-Dimethyl phenol [a]	6.3 – 17
N-nitrosodiphenylamine	6.3 – 17
N-nitroso-di-n-propylamine	32 – 86
N-nitrosodimethylamine	32 – 86
Benzyl alcohol [a]	32 – 86
Pentachlorophenol [a]	32 – 86
Benzo(a)anthracene	6.3 – 17
Benzo(b)fluoranthene	6.3 – 17
Benzo(a)pyrene	6.3 – 17
Indeno(1,2,3-cd)pyrene	6.3 – 17

[a] Chemical never detected; RL exceeded the SQS in a subset of the initial SIM analyses

2.2 PCB CONGENER ANALYSES

In consultation with the US Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology), tissue and sediment samples from eight benthic invertebrate locations and eight clam locations were selected for PCB congener analysis:

- Benthic invertebrate locations B1b, B2a, B3b, B4b, B5a, B8a, B9b, and B10a
- Clam locations C1, C2-2, C4, C6, C7-1, C8, C9, and C10-1

These locations were selected to cover a range of total PCB concentrations based on the Aroclor sums and to provide spatial coverage of the LDW (Figure 1).

The archived tissue and sediment samples associated with these locations, a total of 32 samples (16 tissue and 16 sediment), were submitted to Axys Analytical Services, Ltd. (Axys) for PCB congener analysis (EPA Method 1668). Following the PCB congener analytical method described in the QAPP (Windward 2004), the tissue samples were analyzed for all 209 PCB congeners. The sediment samples were analyzed for the coplanar congeners (PCB-077, PCB-081, PCB-105, PCB-114, PCB-118, PCB-123, PCB-126, PCB-156, PCB-157, PCB-167, PCB-169, and PCB-189) and six selected principal PCB congeners (PCB-066, PCB-101, PCB-110, PCB-138, PCB-153, PCB-180).

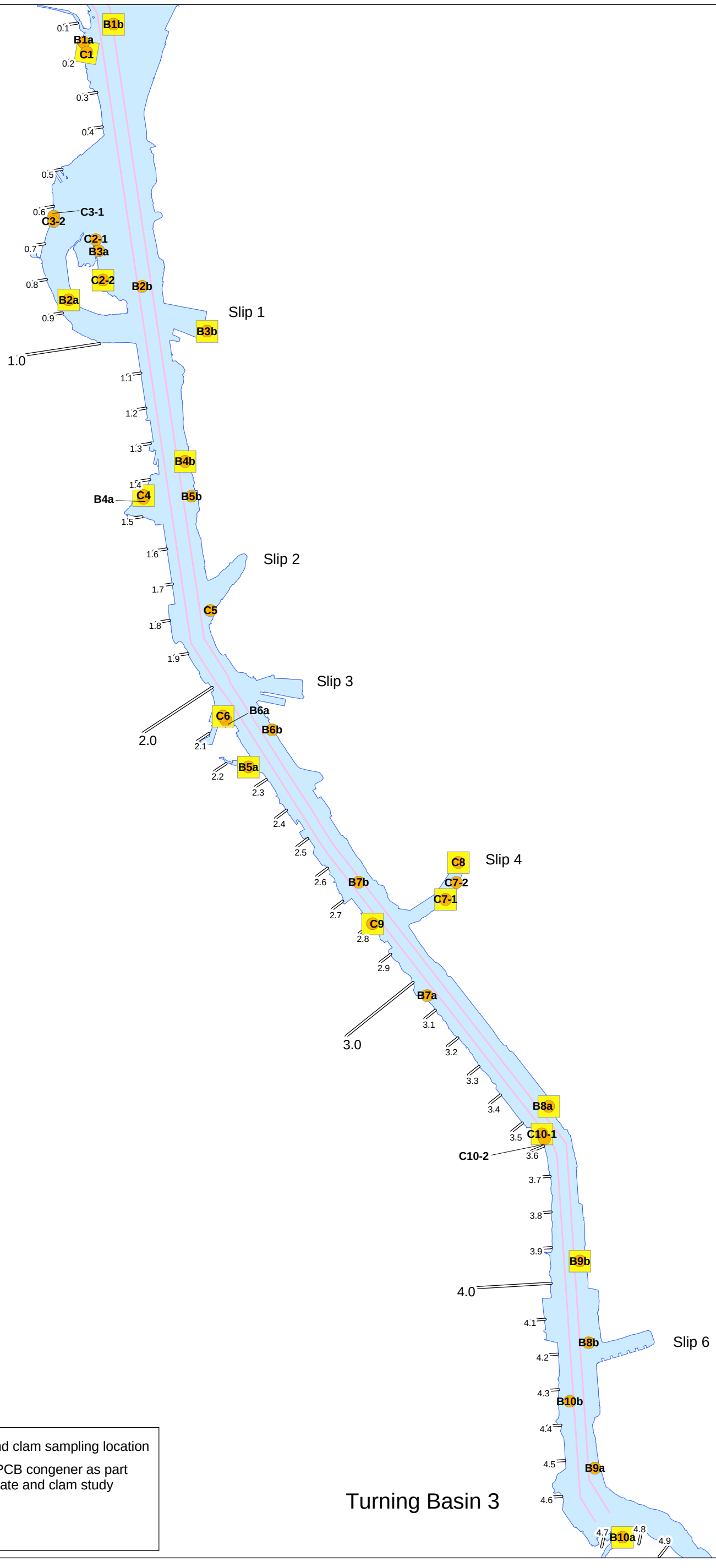

Figure 1: Benthic invertebrate and clam sampling locations analyzed for PCB congeners

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Prepared by STS 05/06/05 Map 1816

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3.0 Results of Chemical Analyses

The results of the SIM reanalyses for the subset of sediment samples and the results of the PCB congener analyses on a subset of benthic invertebrate and clam tissue samples and co-located sediment samples are presented in Sections 3.1 and 3.2, respectively.

3.1 SIM Reanalysis Results

The complete results of the SIM reanalyses of selected sediment samples are presented in Appendix B. Tables 3-1 and 3-2 present the concentrations of each SIM target analyte selected for use in the Phase 2 RI. Thus, for the concentrations of individual analytes in each of these samples, these tables report either the result from the original CAS SIM analysis or the result from the ARI SIM reanalysis.

The goal of the SIM reanalysis was to achieve RLs below the corresponding SQS for each of the analytes in order to reduce uncertainty associated with undetected results with RLs above SQS. For each sample, the results of the SIM reanalysis were compared to the results of original SIM analysis, and one result was selected for each analyte using rules presented in Appendix C. The selected result was then compared to the SQS. All detected chemical concentrations and RLs for 13 samples were below their corresponding SQS. For two of the samples (LDW-B1b-S and LDW-C5-S), total organic carbon concentrations were equal to or less than 0.5%; in such cases, comparisons with the SQS for non-polar organic compounds are not generally conducted. Instead, results of chemical analyses for these two samples were compared to the lowest dry weight (dw) apparent effects threshold (AET) values, which are functionally equivalent to the organic carbon-normalized SQS. All RLs were less than the analytical concentration goals (ACGs) established for sediment samples co-located with clam tissue samples (Appendix D of the QAPP).

The phenol RL reported for LDW-B10a (1,100 µg/kg) was above the corresponding SQS of 420 µg/kg dw. However, phenol was not included in the target analyte list for SIM analysis. Instead, the laboratory reviewed the SIM data to establish whether phenol was present in the sample. Only a trace amount of the phenol parent ion (i.e., m/z 94) was noted in the mass spectra by the laboratory analyst. The instrument was not calibrated to quantify phenol; however, data for the surrogate compound, phenol-d5 (a deuterated analog of phenol) were available. In order to determine an approximate concentration for the suspected presence of phenol, a response factor for the phenol-d5 surrogate compound was calculated. This response factor was then used as an internal standard to calculate an approximate concentration of phenol based on the response of the m/z 94 ion. Using this procedure, the laboratory estimated that phenol may be present at a concentration less than 13 µg/kg. This evaluation is qualitative, so the original phenol result (undetected with RL of 1,100 µg/kg dw) remains in the database.

Table 3-1. Concentrations of SIM target analytes in sediment samples (co-located with benthic invertebrate tissue samples) submitted for SIM reanalysis and selected for use in the Phase 2 RI

ANALYTE	UNIT	SQS	LDW-B1a-S	LDW-B2a-S	LDW-B3a-S	LDW-B8b-S	LDW-B9b-S	LDW-B10a-S	LDW-B10b-S	Lowest AET (µg/kg dw)	LDW-B1b-S
Chlorobenzenes											
1,2,4-Trichlorobenzene	mg/kg OC	0.81	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.37 U**	**0.59 U**	31[a]	**6.3 U[b]**
1,2-Dichlorobenzene	mg/kg OC	2.3	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.37 U**	**0.59 U**	35[a]	**6.3 U[b]**
1,4-Dichlorobenzene	mg/kg OC	3.1	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.37 U**	**0.59 U**	110[a]	**6.3 U[b]**
Hexachlorobenzene	mg/kg OC	0.38	0.059 U	0.051 U	0.074 U	0.042 U	0.057 U	0.075 U	0.092 U	22[a]	1.0 U[b]
PAHs											
Benzo(a)anthracene	mg/kg OC	110	3.0	**10**	**2.0**	2.0	3.0	3.0	**1.0**	1,300[a]	31[b]
Benzo(a)pyrene	mg/kg OC	99	3.0	**10**	**1.0**	2.0	3.6	4.0	1.0	1,600[a]	38[b]
Benzo(b)fluoranthene	µg/kg dw	na	46	280	**27**	71	75	77	21	na	41
Indeno(1,2,3-cd)pyrene	mg/kg OC	34	2.0	10	1.0	2.0	3.0	4.0	1.0	600[a]	27[b]
Total HPAH (calc'd)	mg/kg OC	370	40	**120**	**20 J**	30	40 J	40	**32 J**	12,000[a]	570 J[b]
Phthalates											
Butyl benzyl phthalate	mg/kg OC	4.9	**0.38 U**	1.0	**0.49 U**	0.39 J	1.0	0.42 J	0.42 J	63[a]	**6.3 U[b]**
Diethyl phthalate	mg/kg OC	61	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.55 U**	**0.59 U**	48[a]	**6.3 U[b]**
Dimethyl phthalate	mg/kg OC	53	**0.38 U**	**0.34 U**	**0.49 U**	0.20 J	1.0	**0.37 U**	**0.59 U**	71[a]	**6.3 U[b]**
Other SVOCs											
Hexachlorobutadiene	mg/kg OC	3.9	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.37 U**	**0.6 U**	11[a]	**6.3 U[b]**
2,4-Dimethylphenol	µg/kg dw	29	**6.5 U**	**6.6 U**	**6.6 U**	**6.5 U**	**6.6 UJ**	**6.4 U**	**6.4 U**	29	**6.3 U**
2-Methylphenol	µg/kg dw	63	**6.5 U**	**6.6 U**	**6.6 U**	**6.5 U**	**6.6 UJ**	**6.4 U**	**6.4 U**	63	**6.3 U**
Pentachlorophenol	µg/kg dw	360	**33 U**	**33 U**	**33 U**	**33 U**	**33 UJ**	**32 U**	**32 U**	360	**32 U**
Benzoic acid	µg/kg dw	650	**500**	**69**	**220**	**110**	**120 J**	**160**	**300**	650	**72**
Benzyl alcohol	µg/kg dw	57	10 U	10 U	20 U	11 UJ	10 U	20 U	10 UJ	57	10 U
N-Nitrosodimethylamine	µg/kg dw	na	**33 U**	**33 U**	**33 U**	**33 U**	**33 UJ**	**32 U**	**32 U**	na	**32 U**
N-Nitroso-di-n-propylamine	µg/kg dw	na	10 U	10 U	20 U	11 UJ	10 U	20 U	10 UJ	na	10 U
N-Nitrosodiphenylamine	mg/kg OC	11	**0.38 U**	**0.34 U**	**0.49 U**	**0.28 U**	**0.38 UJ**	**0.37 U**	**0.59 U**	28[a]	**6.3 U[b]**

[a] Dry weight AET for comparison to LDW-B1b-S

[b] Sample TOC was 0.5%; therefore, all results are presented on a dry weight basis and compared to the lowest dry-weight AETs

Note: ARI SIM reanalysis results selected as the preferred result for the Phase 2 RI are shown in **bold**; all other results are from the original CAS SIM analysis

dw – dry weight
na – not available or not applicable
OC – organic carbon-normalized

Data qualifiers:
U - not detected at reporting limit shown; J - estimated concentration; UJ - not detected at estimated reporting limit shown; BU – Qualified as not detected because of the presence of analyte in method blank

Table 3-2. Concentrations of SIM target analytes in sediment samples (co-located with clam tissue samples) submitted for SIM reanalysis and selected for use in the Phase 2 RI

ANALYTE	UNIT	SQS	LDW-C2-S2	LDW-C3-S1	LDW-C3-S2	LDW-C4-S	LDW-C6-S	LDW-C9-S	Lowest AET (µg/kg dw)	LDW-C5-S
Chlorobenzenes										
1,2,4-Trichlorobenzene	mg/kg OC	0.81	**0.61 U**	**0.70 U**	**0.66 UJ**	**0.47 U**	**0.53 U**	**0.59 J**	31[a]	**6.4 U**[b]
1,2-Dichlorobenzene	mg/kg OC	2.3	**0.6 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	35[a]	**6.4 U**[b]
1,4-Dichlorobenzene	mg/kg OC	3.1	**0.61 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	110[a]	**6.4 U**[b]
Hexachlorobenzene	mg/kg OC	0.38	0.092 U	0.1 U	0.076 U	0.31	0.080 U	0.14 J	22[a]	0.98 U[b]
PAHs										
Benzo(a)anthracene	mg/kg OC	110	**2.0**	**10**	4.0	10	3.0	8.0	1,300[a]	**410**[b]
Benzo(a)pyrene	mg/kg OC	99	**2.0**	**11**	6.0	10	3.0	7.0	1,600[a]	**390**[b]
Benzo(b)fluoranthene	µg/kg dw	na	**20**	**85**	79	140	58	67	na	**390**
Indeno(1,2,3-cd)pyrene	mg/kg OC	34	**2.0**	**7.0**	5.0	10	3.0	6.0	600[a]	**200**[b]
Total HPAH (calc'd)	mg/kg OC	370	**15 J**	**80**	60	110	42	90	12,000[a]	**2,830**[a]
Phthalates										
Butyl benzyl phthalate	mg/kg OC	4.9	**0.61 U**	**0.70 U**	**1.0 U**	**0.47 U**	0.56 J	**1.1 U**	63[a]	**39**[b]
Diethyl phthalate	mg/kg OC	61	**0.61 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	48[a]	**6.4 U**[b]
Dimethyl phthalate	mg/kg OC	53	**0.61 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	71[a]	**6.4 U**[b]
Other SVOCs										
Hexachlorobutadiene	mg/kg OC	3.9	**0.6 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	11[a]	**6.4 U**[b]
2,4-Dimethylphenol	µg/kg dw	29	**6.5 U**	**6.5 U**	**1.0 U**	**6.6 U**	**6.6 U**	**6.4 U**	29	**6.4 U**
2-Methylphenol	µg/kg dw	63	**6.5 U**	**6.5 U**	**17 U**	**6.6 U**	**6.6 U**	**6.4 U**	63	**6.4 U**
Pentachlorophenol	µg/kg dw	360	**32 U**	**33 U**	**86 U**	**130**	**33 U**	**32 U**	360	**44**
Benzoic acid	µg/kg dw	650	79	**66**	**170 U**	**100**	**89**	**270**	650	**600**
Benzyl alcohol	µg/kg dw	57	20 U	20 U	50 U	**33 U**	23	20 U	57	20 U
N-Nitrosodimethylamine	µg/kg dw	na	**32 U**	**33 U**	**86 U**	**33 U**	**33 U**	**32 U**	na	**32 U**
N-Nitroso-di-n-propylamine	µg/kg dw	na	20 U	20 U	50 U	**33 U**	20 U	20 U	na	20 U
N-Nitrosodiphenylamine	mg/kg OC	11	**0.61 U**	**0.70 U**	**1.0 U**	**0.47 U**	**0.53 U**	**1.1 U**	28[a]	**6.4 U**[b]

[a] Dry weight AET for comparison to LDW-C5-S

[b] Sample TOC was 0.32%; therefore, all results are presented on a dry weight basis and compared to the lowest dry-weight AETs

Note: ARI SIM reanalysis results selected as the preferred result for the Phase 2 RI are shown in **bold**; all other results are from the original CAS SIM analysis

dw – dry weight
na – not available or not applicable
OC – organic carbon-normalized

Data qualifiers:
U - not detected at reporting limit shown; J - estimated concentration; UJ - not detected at estimated reporting limit shown; BU – Qualified as not detected because of the presence of analyte in method blank

3.2 PCB CONGENER RESULTS

This section presents the results of the coplanar PCB congener analyses for benthic invertebrate and clam tissue samples and for their co-located sediment samples. The coplanar PCB congeners are those congeners for which World Health Organization (WHO) toxic equivalency factors (TEFs) are available (Van den Berg et al. 1998). Coplanar PCB congeners include PCB-077, PCB-081, PCB-105, PCB-114, PCB-118, PCB-123, PCB-126, PCB-156, PCB-157, PCB-167, PCB-169, and PCB-189. In addition, total PCBs based on PCB congener sums are presented for the tissue samples, which were analyzed for all 209 PCB congeners. Sediment samples were analyzed for coplanar congeners and six principal congeners (PCB-066, PCB-101, PCB-110, PCB-138, PCB-153, and PCB-180). As specified in Phase 2 Work Plan/and the Benthic Invertebrate QAPP (Windward 2004). The complete PCB congener datasets for both tissue and sediment samples are presented in Appendix A. There are cases in which two or more congeners cannot be separated analytically. In these cases, the congeners are said to be coeluting and the concentration of the combined congeners is reported as one value. The laboratory responsible for the PCB congener analyses (Axys) has the convention of assigning the concentration of the coelution to the coeluting congener with the lowest IUPAC number. For example, PCB-156 and PCB-157 coelute and the concentration is reported as PCB-156. PCB-157 is reported as C156 to indicate that it is a component of a coelution. This convention has been followed in presenting PCB congener data throughout this addendum.

3.2.1 Benthic invertebrate and clam tissue results

All of the coplanar PCB congeners were detected in all of the benthic invertebrate and clam tissue samples, except PCB-169, which was not detected in any of the tissue samples (Table 3-3). All RLs for PCB-169 were less than the ACG for PCB-169 established for clam tissue samples (Appendix C of the QAPP). ACGs were not developed for PCB congeners in benthic invertebrate tissue.

Table 3-3. Coplanar PCB congener detection frequencies, minimum and maximum detected concentrations, and minimum and maximum reporting limits for benthic invertebrate and clam tissue samples

Chemical	Unit	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit
Benthic invertebrate tissue						
PCB-077	ng/kg ww	8/8	33.3	1,440	na	na
PCB-081	ng/kg ww	8/8	2.24 J	67.6	na	na
PCB-105	ng/kg ww	8/8	434	8,210	na	na
PCB-114	ng/kg ww	8/8	25.5	526	na	na
PCB-118	ng/kg ww	8/8	1,340	28,000	na	na
PCB-123	ng/kg ww	8/8	24.5	433	na	na
PCB-126	ng/kg ww	8/8	2.60	52.5	na	na
PCB-156	ng/kg ww	8/8	195 C	6,100 C	na	na
PCB-157	ng/kg ww	8/8	C156	C156	na	na
PCB-167	ng/kg ww	8/8	79.0	2,550	na	na
PCB-169	ng/kg ww	0/8	nd	nd	3.22	200
PCB-189	ng/kg ww	8/8	14.7	1,170	na	na
Clam tissue						
PCB-077	ng/kg ww	8/8	71.5	454	na	na
PCB-081	ng/kg ww	8/8	3.04	26.7 J	na	na
PCB-114	ng/kg ww	8/8	29.8	359	na	na
PCB-118	ng/kg ww	8/8	1,290	33,100	na	na
PCB-123	ng/kg ww	8/8	32.6	453	na	na
PCB-126	ng/kg ww	8/8	3.31	41.0	na	na
PCB-156	ng/kg ww	8/8	163 C	2,980 C	na	na
PCB-157	ng/kg ww	8/8	C156	C156	na	na
PCB-167	ng/kg ww	8/8	85.8	1,310	na	na
PCB-169	ng/kg ww	0/8	nd	nd	1.21	20
PCB-189	ng/kg ww	8/8	7.52	160	na	na

na – not applicable

nd – not detected

C156 - PCB-156 and PCB-157 co-elute; the combined concentration is presented as the concentration of PCB-156

Data qualifiers: C – concentration represents a coelution, J - estimated concentration

The concentrations of the individual coplanar PCB congener and total PCB concentrations (i.e., the sum of the concentrations of all 209 congeners) for all tissue samples are presented in Table 3-4. Total PCB concentrations ranged from 32.1 to 1,350 µg/kg wet weight (ww) in the benthic invertebrate tissue samples. Total PCB concentrations ranged from 41 to 930 µg/kg ww in the clam tissue samples. The highest total PCB tissue concentrations were reported for LDW-B8a-T (1,350 µg/kg ww) and LDW-C8-T (930 µg/kg ww) (Table 3-4). Total PCB concentrations calculated as the sum of the concentrations of detected congeners are plotted against total PCB concentrations calculated as the sum of the concentrations of detected Aroclors for both clam and benthic tissue samples in Appendix F. In addition, PCB congener patterns for both benthic invertebrate and clam tissue are presented in Appendix F.

Table 3-4. Coplanar PCB congener and total PCB concentrations in benthic invertebrate and clam tissue samples

Sample ID	PCB-077 ng/kg ww	PCB-081 ng/kg ww	PCB-105 ng/kg ww	PCB-114 ng/kg ww	PCB-118 ng/kg ww	PCB-123 ng/kg ww	PCB-126 ng/kg ww	PCB-156 ng/kg ww	PCB-157 ng/kg ww	PCB-167 ng/kg ww	PCB-169 ng/kg ww	PCB-189 ng/kg ww	Sum of PCB Congeners[a] µg/kg ww
Benthic invertebrate tissue													
LDW-B1b-T	310	22.1 J	3,340	185	8,940	206	17.5	1,300 C	C156	607	20 U	132	212.9 J
LDW-B2a-T	247	12.1	2,180	112	8,420	122	17.8	917 C	C156	382	10 U	71.7	154.2 J
LDW-B3b-T	594	39.3	6,370	343	19,400	315	32.9	2,100 C	C156	954	20 U	111	347.3 J
LDW-B4b-T	427	29.4	4,330	256	12,000	199	19.8	1,660 C	C156	658	30 U	118	259.7 J
LDW-B5a-T	1,440	67.6	8,210	526	28,000	433	52.5	2,530 C	C156	1,040	60 U	228	732.3 J
LDW-B8a-T	345	26.1 J	5,960	298	25,400	302	43.2	6,100 C	C156	2,550	200 U	1,170	1,346 J
LDW-B9b-T	49.5	5.78 J	853	49.2	2,920	52.2	4.43	394 C	C156	146	10 U	22.6	63.84 J
LDW-B10a-T	33.3	2.24 J	434	25.5	1,340	24.5	2.60	195 C	C156	79.0	3.22 U	14.7	32.13 J
Clam tissue													
LDW-C1-T	71.5	3.04	478	29.8	1,290	32.6	3.51	163 C	C156	85.8	1.21 U	7.52	41.05 J
LDW-C2-T2	82.6	4.03	613	37.7	1,650	40.3	3.76	204 C	C156	114	1.7 U	10.1	51.45 J
LDW-C4-T	91.9	4.55	573	36.3	1,620	35.7	3.31	201 C	C156	94.8	1.46 U	8.93	46.49 J
LDW-C6-T	87.4	4.18 J	643	40.2	1,780	44.0	4.15	224 C	C156	109	2.08 U	11.6	52.08 J
LDW-C7-T1	194	11.1 J	2,750	149	11,400	211	15.0	1,160 C	C156	561	10 U	32.5	308.5 J
LDW-C8-T	454	26.7 J	6,680	359	33,100	453	41.0	2,980 C	C156	1,310	10 U	87.5	930 J
LDW-C9-T	110	5.35 J	917	56.9	2,990	59.1	5.22	313 C	C156	157	3.15 U	13.6	79.01 J
LDW-C10-T1	76.9	4.27 J	983	52.4	3,380	51.9	8.64	969 C	C156	572	20 U	159	264.8 J

[a] Total PCB concentration calculated as the sum of all 209 congeners following summation rules in Appendix C

C156 - PCB-156 and PCB-157 co-elute; the combined concentration is presented as the concentration of PCB-156

ww – wet weight

Data qualifiers: U - not detected at reporting limit shown; J - estimated concentration; C – concentration represents a coelution

Toxic equivalents (TEQs) were calculated using the WHO mammalian TEF values for each tissue sample (Van den Berg et al. 1998). For each sample, three different TEQs were calculated using either zero, half RL, or full RL as the selected value for undetected congeners (Table 3-5). The magnitude of the differences among the TEQ values calculated for each sample based on the different RLs was small, because the only coplanar congener that was reported as undetected in the tissue samples was PCB-169. The coelution between PCB-156 and PCB-157 does not affect the TEQ calculation because both congeners have a TEF of 0.0005. Plots of benthic invertebrate and clam tissue TEQ versus total PCB concentrations are presented in Appendix F.

Table 3-5. Mammalian TEQs for tissue samples calculated with zero RL, half RL, and full RL

Sample ID	Mammalian TEQ–Zero RL (ng/kg ww)		Mammalian TEQ–Half RL (ng/kg ww)		Mammalian TEQ–Full RL (ng/kg ww)	
Benthic invertebrate tissue						
LDW-B1b-T	3.79	J	3.89	J	3.99	J
LDW-B2a-T	3.40		3.45		3.50	
LDW-B3b-T	7.20		7.30		7.40	
LDW-B4b-T	4.65		4.80		4.95	
LDW-B5a-T	10.6		10.9		11.2	
LDW-B8a-T	10.9	J	12.0	J	13.0	J
LDW-B9b-T	1.06	J	1.11	J	1.16	J
LDW-B10a-T	0.556	J	0.572	J	0.588	J
Clam tissue						
LDW-C1-T	0.637		0.643		0.649	
LDW-C2-T2	0.738		0.746		0.755	
LDW-C4-T	0.684		0.691		0.699	
LDW-C6-T	0.805	J	0.816	J	0.826	J
LDW-C7-T1	3.62	J	3.67	J	3.72	J
LDW-C8-T	9.86	J	9.91	J	9.96	J
LDW-C9-T	1.12	J	1.13	J	1.15	J
LDW-C10-T1	1.85	J	1.90	J	2.00	J

ww – wet weight

Data qualifiers: J - estimated concentration

3.2.2 Sediment results

All of the coplanar and principal PCB congeners were detected in all of the co-located sediment samples, except PCB-169, which was not detected in any of the sediment samples (Table 3-6). ACGs were not established for PCB congeners in sediment samples. It should be noted that the PCB congener pairs 90/101, 129/138, and 156/157 coeluted, and thus PCB-101, PCB-138, and PCB-157 do not have values shown in Table 3-6.

Table 3-6. Coplanar PCB congener detection frequencies, minimum and maximum detected concentrations, and minimum and maximum reporting limits for sediment samples co-located with benthic invertebrate and clam tissue samples

Chemical	Unit	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit
Sediment samples co-located with benthic invertebrate tissue samples						
Coplanar congeners						
PCB-077	ng/kg dw	8/8	49.5	2,050	na	na
PCB-081	ng/kg dw	8/8	2.44 CJ	88.1 CJ	na	na
PCB-105	ng/kg dw	8/8	438	16,800	na	na
PCB-114	ng/kg dw	8/8	21.5	918	na	na
PCB-118	ng/kg dw	8/8	1,060	53,100	na	na
PCB-123	ng/kg dw	8/8	17.4	928	na	na
PCB-126	ng/kg dw	8/8	2.60	178	na	na
PCB-156	ng/kg dw	8/8	204 CJ	15,600 C	na	na
PCB-157	ng/kg dw	8/8	C156	C156	na	na
PCB-167	ng/kg dw	8/8	70.3 J	6,300	na	na
PCB-169	ng/kg dw	0/8	nd	nd	1.09	165
PCB-189	ng/kg dw	8/8	15.7	3,890	na	na
Principal congeners						
PCB-066	ng/kg dw	8/8	488	23,600	na	na
PCB-090	ng/kg dw	8/8	1,440 C	103,000 C	na	na
PCB-101	ng/kg dw	8/8	C90	C90	na	na
PCB-110	ng/kg dw	8/8	1,420 C	84,900 C	na	na
PCB-129	ng/kg dw	8/8	2,250 CJ	273,000 C	na	na
PCB-138	ng/kg dw	8/8	C129	C129	na	na
PCB-153	ng/kg dw	8/8	1,780 C	308,000 C	na	na
PCB-180	ng/kg dw	8/8	838 C	307,000 C	na	na
Sediment samples co-located with clam tissue samples						
Coplanar congeners						
PCB-077	ng/kg dw	8/8	10.4	5,740	na	na
PCB-081	ng/kg dw	8/8	0.396 CJ	215 CJ	na	na
PCB-105	ng/kg dw	8/8	61.4	87,600	na	na
PCB-114	ng/kg dw	8/8	2.75	4,030	na	na
PCB-118	ng/kg dw	8/8	154	275,000	na	na
PCB-123	ng/kg dw	8/8	2.79	4,080	na	na
PCB-126	ng/kg dw	8/8	0.758 J	725	na	na
PCB-156	ng/kg dw	8/8	27.5 C	41,700 C	na	na
PCB-157	ng/kg dw	8/8	C156	C156	na	na
PCB-167	ng/kg dw	8/8	10.6	20,200	na	na
PCB-169	ng/kg dw	0/8	nd	nd	0.399	1,410
PCB-189	ng/kg dw	8/8	3.06 C	14,100 C	na	na

Chemical		Unit	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Minimum Reporting Limit	Maximum Reporting Limit
Principal congeners							
	PCB-066	ng/kg dw	8/8	73.6	90,700	na	na
	PCB-090	ng/kg dw	8/8	180 C	368,000 C	na	na
	PCB-101	ng/kg dw	8/8	C90	C90	na	na
	PCB-110	ng/kg dw	8/8	230 C	467,000 C	na	na
	PCB-129	ng/kg dw	8/8	320 C	1,200,000 C	na	na
	PCB-138	ng/kg dw	8/8	C129	C129	na	na
	PCB-153	ng/kg dw	8/8	258 C	1,440,000 C	na	na
	PCB-180	ng/kg dw	8/8	155 C	1,120,000 C	na	na

na – not applicable

nd – not detected

C90 – PCB-090 and PCB-101 coelute; the combined concentration is presented as the concentration of PCB-090

C129– PCB-129 and PCB-138 coelute; the combined concentration is presented as the concentration of PCB-129

C156 - PCB-156 and PCB-157 co-elute; the combined concentration is presented as the concentration of PCB-156

Data qualifiers: C – concentration represents a coelution; J - estimated concentration

The coplanar PCB congener concentrations reported in sediment samples are presented in Table 3-7. The highest coplanar PCB congener concentrations were reported for sediment samples LDW-B8a-S and LDW-C8-S co-located with benthic invertebrate and clam tissue samples, respectively. The principal PCB congener concentrations reported in the sediment samples are presented in Table 3-8. The highest principal PCB congener concentrations were reported for sediment samples LDW-B8a-S and LDW-C10-S1 co-located with benthic invertebrate and clam tissue samples, respectively.

PCB congener patterns for co-located sediment samples are presented in Appendix F.

Table 3-7. Coplanar PCB congener concentrations in sediment samples

SAMPLE ID	PCB-077 ng/kg dw	PCB-081 ng/kg dw	PCB-105 ng/kg dw	PCB-114 ng/kg dw	PCB-118 ng/kg dw	PCB-123 ng/kg dw	PCB-126 ng/kg dw	PCB-156 ng/kg dw	PCB-157 ng/kg dw	PCB-167 ng/kg dw	PCB-169 ng/kg dw	PCB-189 ng/kg dw
LDW-B1b-S	64.4	2.98 J	438	21.5	1,060	17.4	2.6	204 CJ	C156	70.3 J	1.14 U	23.3 J
LDW-B2a-S	268	8.18 J	1,450	64.8	4,180	66.6	13.9 J	591 C	C156	217	3.37 U	54.4
LDW-B3b-S	678	27.7 J	5,270	229	13,700	234	41.2	2,100 C	C156	772	8.31 U	169
LDW-B4b-S	586	26.8 J	4,740	226	12,100	174	23.6	1,780 C	C156	609	10.9 U	166
LDW-B5a-S1	173	5.89 J	733	35.2	1,730	32	7.49	297 C	C156	108	3.98 U	41.8
LDW-B8a-S	2,050	88.1 J	16,800	918	53,100	928	178	15,600 C	C156	6,300	165 U	3,890
LDW-B9b-S	267	10.9 J	3,020	152	9,100	153	23.6	1,420 C	C156	470	7.66 U	126
LDW-B10a-S	49.5	2.44 J	790	40.7	1,940	29.5	3.79	252 C	C156	86	1.09 U	15.7
LDW-C1-S	10.4	0.396 J	61.4	2.75	154	2.79	0.758 J	27.5 C	C156	10.6	0.399 U	3.06
LDW-C2-S2	169	5.57 J	1,290	58.6	3,590	53.4	8.3	497 C	C156	171	6.17 U	40.2
LDW-C4-S	120	4.7 J	1,190	54.3	3,640	62.6	4.97	544 C	C156	189	1.25 U	33.2
LDW-C6-S	104	3.71 J	697	33.5	1,820	33.5	5.27	294 C	C156	110	1.26 U	30.2
LDW-C7-S1	1,250	43.2 J	33,300	1,400	108,000	1,570	218	16,000 C	C156	6,190	48.1 U	1,010
LDW-C8-S	5,740	215 J	87,600	4,030	275,000	4,080	725	39,300 C	C156	13,700	229 U	1,640
LDW-C9-S	56.4	3.49 J	434	17.8	1,110	24.7	3.7	190 C	C156	86.5	3.91 U	24.5
LDW-C10-S1	478	70.3 J	8,240	177	56,000	533	332	41,700 C	C156	20,200	1,410 U	14,100

C156 - PCB-156 and PCB-157 co-elute; the combined concentration is presented as the concentration of PCB-156

Data qualifiers: U - not detected at reporting limit shown; J - estimated concentration

Table 3-8. Principal PCB congener concentrations in sediment samples

SAMPLE ID	PCB-066 ng/kg dw	PCB-090 ng/kg dw	PCB-101 ng/kg dw	PCB-110 ng/kg dw	PCB-129 ng/kg dw	PCB-138 ng/kg dw	PCB-153 ng/kg dw	PCB-180 ng/kg dw
LDW-B1b-S	682	1,440 C	C90	1,420	2,250 CJ	C129	2,190 J	1,770 J
LDW-B2a-S	2,540	4,550 C	C90	5,160	6,180 C	C129	4,950	2,860
LDW-B3b-S	6,200	13,900 C	C90	18,900	20,400 C	C129	16,300	8,400
LDW-B4b-S	6,510	13,000 C	C90	14,800	18,100 C	C129	15,000	9,130
LDW-B5a-S1	1,600	2,630 C	C90	2,750	3,490 C	C129	3,220	2,830
LDW-B8a-S	23,600	103,000 C	C90	84,900	273,000 C	C129	308,000	307,000
LDW-B9b-S	3,290	9,670 C	C90	12,800	14,100 C	C129	10,600	7,840
LDW-B10a-S	488	1,860 C	C90	2,430	2,330 C	C129	1,780	838
LDW-C1-S	73.6	180 C	C90	230	320 C	C129	258	155
LDW-C2-S2	1,640	3,950 C	C90	4,410	4,830 C	C129	5,340	13,300
LDW-C4-S	1,180	5,170 C	C90	6,150	5,340 C	C129	4,060	1,620
LDW-C6-S	956	2,190 C	C90	2,750	3,170 C	C129	2,630	1,680
LDW-C7-S1	23,200	178,000 C	C90	231,000	198,000 C	C129	146,000	59,600
LDW-C8-S	90,700	366,000 C	C90	467,000	412,000 C	C129	292,000	65,100
LDW-C9-S	476	1,450 C	C90	2,120	2,550 C	C129	2,110	1,740
LDW-C10-S1	2,880	368,000 C	C90	171,000	1,200,000C	C129	1,440,000	1,120,000

C90- PCB-090 and PCB-101 co-elute; the combined concentration is presented as the concentration of PCB-090

C129 – PCB-129 and PCB-138 co-elute; the combined concentration is presented as the concentration of PCB-129

Data qualifier: C – concentration represents a coelution; J - estimated concentration

TEQs were calculated for each of the sediment samples using the WHO mammalian TEF values (Van den Berg et al. 1998; see Appendix C). For each sample, three different TEQs were calculated using either zero, half RL, or full RL as the selected value for undetected congeners (Table 3-9). The magnitudes of the differences among the TEQ values based on the different RLs for each sample were small because the only coplanar congener that was reported as undetected in the sediment samples was PCB-169. The coelution between PCB-156 and PCB-157 does not affect the TEQ calculation because both congeners have a TEF of 0.0005. Plots of sediment TEQ versus total PCB concentrations are presented in Appendix F.

Table 3-9. Mammalian TEQs for sediment samples calculated with zero RL, half RL, and full RL

Sample ID	Mammalian TEQ - Zero RL (ng/kg dw)		Mammalian TEQ - Half RL (ng/kg dw)		Mammalian TEQ - Full RL (ng/kg dw)	
LDW-B1b-S	0.531	J	0.537	J	0.542	J
LDW-B2a-S	2.32	J	2.34	J	2.36	J
LDW-B3b-S	7.30	J	7.34	J	7.38	J
LDW-B4b-S	5.15	J	5.20	J	5.26	J
LDW-B5a-S1	1.19	J	1.21	J	1.23	J
LDW-B8a-S	33.8	J	34.6	J	35.5	J
LDW-B9b-S	4.42	J	4.46	J	4.49	J
LDW-B10a-S	0.809	J	0.814	J	0.820	J
LDW-C1-S	0.114	J	0.116	J	0.118	J
LDW-C2-S2	1.62	J	1.66	J	1.69	J
LDW-C4-S	1.30	J	1.31	J	1.32	J
LDW-C6-S	0.961	J	0.967	J	0.973	J
LDW-C7-S1	45.1	J	45.3	J	45.6	J
LDW-C8-S	132	J	133	J	134	J
LDW-C9-S	0.640	J	0.660	J	0.679	J
LDW-C10-S1	62.3	J	69.3	J	76.4	J

Data qualifiers: J - estimated concentration

3.3 Data Validation Results

Independent data validation of all the data packages was conducted by Laboratory Data Consultants. All results were found to be usable for the Phase 2 RI (i.e., no data were rejected). The complete data validation reports are presented in Appendix D. The following sections summarize the results of the data validation for each analysis.

3.3.1 SIM reanalyses

All of the SIM reanalyses were conducted by ARI in one sample delivery group (SDG), HV45, which contained 15 samples. Results for only one chemical in three samples

were qualified based on the data review. Method blank results were the only source of validation qualifiers; all other quality control (QC) requirements were met. Two compounds were detected in the method blank (diethylphthalate and n-nitrosodiphenylamine). The sample concentrations were compared to the method blank concentrations, and as a result the diethylphthalate concentrations in three samples (LDW-C2-S2, LDW B9b-S, and LDW-B10a-S) were qualified as undetected because of potential blank interference.

3.3.2 PCB congener analyses

PCB congener analyses were conducted in accordance with the QAPP, with the following exception. Matrix spike/matrix spike duplicate (MS/MSD) samples are not required for EPA Method 1668. However, the QAPP listed MS/MSD samples as required quality assurance (QA) samples for this analysis. Consultation among Axys, EPA, and Windward determined that MS/MSD samples would not be required QA samples.

3.3.2.1 Tissue samples

The 16 tissue samples were analyzed for PCB congeners by Axys in one SDG (DPWG15217). Select congeners in 11 samples were qualified based on the data review. Method blank results were the only source of validation qualifiers; all other QC requirements were met. The laboratory qualified data as estimated due to analytical issues. The laboratory qualified some results as "estimated maximum potential concentrations" because the QC limit for the ratio of the responses for the two characteristic ions (i.e., ion abundance ratio) was not met, but all other criteria for qualitative identification were met. This issue resulted in the J qualification of results for PCB-036, PCB-081, PCB-184, and PCB-204.

Eight PCB congeners were detected in one method blank. The PCB congener concentrations were compared to the method blank results and most of the affected PCB congeners were either not detected or they were present at concentrations more than five times the concentrations in the blank. Detected PCB congener results in 11 samples were qualified as undetected (U) with elevated RLs because of the presence of the PCB congeners in the blank. The samples and the qualified PCB congeners are presented in Table 3-10.

Table 3-10. PCB congener concentrations qualified as undetected due to blank contamination

Sample	Congener	Qualified Result (ng/kg ww)
LDW-B2a-T	PCB-002	1.06 U
	PCB-003	1.60 U
LDW-B8a-T	PCB-002	0.895 U
	PCB-003	1.75 U

SAMPLE	CONGENER	QUALIFIED RESULT (ng/kg ww)
LDW-B9b-T	PCB-002	0.259 U
	PCB-003	0.756 U
	PCB-011	4.45 U
LDW-B10a-T	PCB-001	0.382 U
	PCB-002	0.526 U
	PCB-003	0.442 U
LDW-C1-T	PCB-002	0.311 U
	PCB-003	0.819 U
LDW-C2-T2	PCB-001	1.00 U
	PCB-002	0.293 U
	PCB-003	0.715 U
	PCB-204	0.021 U
LDW-C4-T	PCB-001	0.971 U
	PCB-002	0.316 U
	PCB-003	0.711 U
	PCB-204	0.049 U
LDW-C6-T	PCB-002	0.847 U
	PCB-003	1.23 U
LDW-C7-T1	PCB-002	0.665 U
	PCB-003	1.24 U
LDW-C9-T	PCB-002	0.310 U
	PCB-003	0.781 U
LDW-C10-T1	PCB-002	0.853 U

Data qualifiers: U - not detected at reporting limit shown, J – estimated value

3.3.2.2 Sediment samples

The 16 sediment samples were analyzed by Axys as one SDG (DPWG15252). Seven congeners in one sample were qualified based on the data review. Although PCB congeners were detected in the method blank, qualification of the associated data was not required because the affected PCB congeners were either not detected in the samples or they were present at concentrations more than 5 times the concentrations found in the method blank. The duplicate sample analysis of sample LDW-B1b-S resulted in relative percent differences (RPD) for seven congener results (PCB-099, PCB-129, PCB-153, PCB-156, PCB-167, PCB-180, and PCB-189) that were above the RPD limit of 50%. The results for these congeners were J qualified for sample LDW-B1b-S.

4.0 References

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