MEMORANDUM

To:	Craig Rankine and Joyce Mercuri Washington State Department of Ecology	Date:	November 18, 2011
From:	Madi Novak and Phil Wiescher, PhD	Project:	9003.01.40
RE:	Dioxin Natural Background Sediment Evaluation Port of Ridgefield Lake River Industrial Site Agreed order No. 01TCPSR-3119		

On behalf of the Port of Ridgefield (Port), Maul Foster & Alongi, Inc. (MFA) has prepared this memorandum to provide the results of a literature search conducted to identify chlorinated dibenzo-p-dioxins and dibenzofurans (collectively referred to as dioxins) data in sediment in the region in order to develop a natural background upper tolerance limit (UTL) for dioxins. This evaluation updates the previous dioxin background memorandum prepared and communicated to Ecology on August 24, 2011. In an electronic mail (Mercuri, 2011a), Ecology requested an evaluation of dioxin background concentrations as part of the dioxin cleanup-level development process for Carty Lake and Lake River, adjacent to the Port's LRIS property. In subsequent electronic email (Mercuri, 2011b), Ecology requested revisions to the background calculation method. This memorandum addresses the requested revision. This evaluation is being conducted as part of ongoing remedial investigation and feasibility study activities being performed at the Lake River Industrial Site (LRIS) in Ridgefield, Washington, under an Agreed Order between the Port and the Washington State Department of Ecology (Ecology).

Background

The current Ecology definition of natural background under MTCA regulations (WAC 173-340-200) is as follows: "The concentration of hazardous substance consistently present in the environment that has not been influenced by localized human activities. For example, low concentrations of some particularly persistent organic compounds such as polychlorinated biphenyls (PCBs) can be found in surficial soils and sediment throughout an area due to global distribution of these hazardous substances. These low concentrations would be considered natural background."

Review of Natural Sediment Data

MFA consulted multiple sources in seeking sediment dioxin data that may be suitable for generating a natural dioxin background level, including Ecology, the Oregon Department of Environmental Quality, the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS), and the Lower Columbia River Estuary Partnership. Table 1 summarizes the studies MFA reviewed and provides comments as to the suitability of the data for evaluating natural background concentrations of dioxins in sediment. For this assessment data from samples collected along the Lower Columbia River and tributaries were assembled; samples collected in the Willamette River and the Columbia River estuary were not incorporated into the natural background data analysis for Lake River and Carty Lake.

Only sediment samples collected from the surface of the river bottom were included in the analysis. Surface samples are generally considered to include sediment collected from zero to 30 centimeters below the mudline. However, in an effort to assemble as many data points as possible, five samples were included that were collected from zero to approximately 40 or 50 centimeters below the mudline.

The attached figure shows the approximate locations of the samples included in the natural background data analysis and Table 2 summarizes the dioxin data used. Grain size and total organic carbon (TOC) results are also listed in Table 2 when available. Table 3 summarizes the statistics calculated using the background data set. Dioxin data were all reported on a dry weight basis.

Not all data listed in Table 2 are considered ideal for natural background concentration development for comparison with dioxin concentrations in Carty Lake and Lake River. It is generally preferable to include in the background data set samples that are collected in a similar manner, from a similar fluvial environment, with similar TOC and grain size, and analyzed using the same method. However, sample results appear to be generally similar (average and median concentrations are within the same order of magnitude), indicating that the sampling and analytical methodology and physical characteristics of the sample sediment may not cause undue influence on this analysis. Therefore, all data shown in Table 2 are used in the dioxin background evaluation.

TEQs were calculated as described below using the following data rules to handle non-detect and estimated results.

- For congeners not detected and assigned a "U" qualifier, half of the detection limit was used in the TEQ calculation.

- Sample results that were estimated and flagged with "J' were used in TEQ calculations at the reported, estimated value.

- Historical data with "E" or "EMPC" flagged results (i.e., result is the estimated maximum possible concentration because of unresolved interfering compounds) were treated as estimated results (i.e., "J"-flagged results) consistent with validation procedures applied to site data (Anchor QEA and MFA, 2011).

- Historical data with "PR" (chromatograph peak was poorly resolved and concentration was likely overestimated) and "E" (result is estimated; result concentration exceeds the calibration range) qualifiers were treated as estimated results and used in TEQ calculations at face value.

- Historical data with "B" (analyte is detected in the laboratory method blank; concentration could be overestimated) qualifiers were treated as follows: 1) where the sample concentration was less than five times the blank concentration, the results were treated as a non-detect and ½ the value was used in the TEQ calculation, and 2) where the sample concentration was greater than five times the blank concentration the results were treated as detections and the face value was used in the TEQ calculation.

Derivation of Natural Background Sediment Concentrations

Statistics were calculated for the total 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalence (2,3,7,8-TCDD TEQ). The 2,3,7,8-TCDD TEQ concentrations were calculated consistent with WAC 173-340-900 using toxic equivalence factors adopted by the World Health Organization in 2006 for evaluating risk to mammals and humans. Consistent with recent interagency guidance (COE et al., 2009), the dioxin background UTL was calculated based on the 90th upper confidence limit on the 90th percentile using the Kaplan-Meier nonparametric method. This is appropriate when there are greater than ten detections. The USEPA ProUCL software version 4.1.01 was used to calculate the UTL, which is shown in Table 3 to one significant figure. The ProUCL output is provided as an attachment.

Lake River total organic carbon (TOC) concentrations tend to be approximately 1 percent (the Lake River surface sediment TOC range is 0.34 to 3.2 percent, with an average and median of 1.3 percent and 1.2 percent, respectively) while the background data set TOC is generally about half that of Lake River (the background data set TOC range is 0.045 to 1.4 percent, with an average and median of 0.53 percent and 0.49 percent, respectively). TOC content effects the bioavailability of dioxins; as TOC increases, bioavailability decreases. Thus the bioavailability of dioxins in the Lower Columbia River where background samples were collected is higher than in Lake River. If the background UTL is corrected for bioavailability, the UTL is effectively raised by a factor of two for comparison with Lake River dioxin concentrations.

Attachments: Tables 1 through 3
Figure
Attachment

REFERENCES

Anchor QEA and MFA. 2011. Memorandum (re: Sediment remedial investigation, lake river industrial site). Prepared by Anchor QEA, LLC and Maul Foster & Alongi for Port of Ridgefield and Union Pacific Railroad Company. February.

COE, USEPA, Ecology, DNR, DEQ, IDEQ, NMFS, and USFWS. 2009. Sediment evaluation framework for the Pacific Northwest. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, Washington State Department of Ecology, Washington State Department of Natural Resources, Oregon Department of Environmental Quality, Idaho Department of Environmental Quality, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. May.

Mercuri, J. 2011a. Electronic mail (re Lake River industrial site—Ecology comments on sediment remedial investigation) to A. Hughes, Maul Foster & Alongi, Inc., from J. Mercuri, Washington State Department of Ecology. May 26.

Mercuri, J. 2011b. Electronic mail (re Pacific Wood Treating site-Background dioxin calculations)to M. Novak, Maul Foster & Alongi, from J. Mercuri, Washington State Department of Ecology. November 11.

TABLES

Table 1
Background Dioxins in Sediment Literature Review Summary
Lower Columbia Rriver
Oregon and Washington

Study	Prepared By	Prepared For	Study Year	Purpose	Project Area	Results Used in Regional Background Evaluation	Notes
Longview Fibre Co.—Class 2 Inspection	NA; data reviewed via EIM	NA; data reviewed via EIM	1990	This survey originally entered in 1997. Catalogue Number SY-24.	Longview	No	Results all non-detect. Data not usable because of elevated detection limits.
Oregon Dioxin Sediment Study	COE	USEPA	1990	Study performed to correlate organochlorines and dioxins in sediments.	Columbia, Chetco, and Willamette rivers and Yaquina Bay	Yes	Method reporting limits acceptable. Sediment data collected 21 years ago and may not be representative of current background conditions. Information on potential sources of dioxins at sample locations in 1990 is not available. Surface sediment data (up to 46 cm) included in regional background evaluation.
Dioxin/Furans Study	Bi-State Water Quality Program	Bi-State Water Quality Program	1991	Dioxin/furan evaluation.	Wallace Island	No	Dioxins analyzed in fish tissue only, not in sediment.
Lower Columbia Backwater Reconnaissance Survey	NA; data reviewed via EIM	NA; data reviewed via EIM	1993	Bioaccumulation study.	Three locations near Columbia River from Washougal to Longview, including Bachelor Slough and Burke Slough	No	Results all non-detect. Data not usable because of elevated detection limits.
Hammond Boat Basin Sediment Evaluation	COE	COE	1994	Characterization for dredging action.	Hammond Boat Basin, located 8.7 miles from mouth of Columbia River on Oregon side	No	Method reporting limits acceptable. QA/QC sample results were not provided by COE with data, although discussion of QA results deemed QA/QC acceptable. Sediment data collected 17 years ago at a boat basin. Given age of data (17 years), potential sources of dioxin to boat basin, and location in Columbia River Estuary, sediment data are not considered suitable for use in regional background determination.
Westport Slough Sediment Evaluation	COE	COE	1998	Characterization for dredging action.	Westport Slough entrance at Columbia River RM 43.5.	Yes	Dioxin analysis conducted by screening method P-450 RGA. Method reporting limits acceptable. COE did not provide QA/QC sample results with data, although discussion of QA results deemed QA/QC acceptable. Sediments were found to be suitable for open, in-water, unconfined placement. Sediment sample was a composite from two different locations (one 21-inch core and one 44-inch core). Sediment data included in regional background evaluation.
Polychlorinated Dibenzo-p-dioxin and Polychlorinated Dibenzofuran Congener Profiles in Fish, Crayfish, and Sediment Collected Near a Wood Treating Facility and a Bleached Kraft Pulp Mill	Foster et al.	Bulletin of Environmental Contamination and Toxicology	1999	Dioxin/furan evaluation.	Lake River	No	Sediment data presented as averages that include locations both upstream and downstream of effluent discharges. Sediment data are not considered suitable for use in regional background determination.

Table 1
Background Dioxins in Sediment Literature Review Summary
Lower Columbia Rriver
Oregon and Washington

Study	Prepared By	Prepared For	Study Year	Purpose	Project Area	Results Used in Regional Background Evaluation	Notes
Investigation of the Distribution of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in the Lower Columbia River Using Semipermeable Membrane Devices	U.S. Dept. of the Interior, USGS; Kathleen McCarthy, Robert Gale	USFWS	1999	Evaluation of potential impacts to fish and wildlife throughout Columbia River Basin.	Lower Columbia River Region	No	Some congeners detected and quantified and others detected but not quantified. Data set not complete and not usable.
Columbia River Mile 29-24, Brookfield Mound and Skamakawa Turn Sediment Evaluation	COE	COE	2000	Characterization for dredging action.	Columbia River RM 29-24, Brookfield Mound and Skamakawa Turn	Yes	Dioxin analysis conducted by screening method P-450 RGA. Method reporting limits acceptable. Sediments were found to be suitable for open, in-water, unconfined placement. Sediment data included in regional background evaluation.
Oregon Slough Entrance Channel Sediment Evaluation	COE	COE	2001	Study performed for dredging action.	Oregon Slough entrance near Columbia River RM 108	No	Most results non-detect. Method reporting limits acceptable. COE did not provide QA/QC sample results with data, although discussion of QA results deemed QA/QC acceptable. Vibracore sediment samples collected; depths of samples not provided in report, but sedqual results indicate that sample depth was between 0 and 177 to 304 centimeters, depending on the sample. Sediments were found to be suitable for open, in-water, unconfined placement. Given that sediment samples likely do not represent surface sediment conditions, sediment not used for regional background determinations.
Portland Harbor Public Health Assessment	ATSDR	City of Portland	2002	Evaluation of public health significance as mandated by Congress.	Portland Harbor	No	Provides ranges of dioxin concentrations for 20 samples collected in and around Portland Harbor. Not considered representative of background.
Bachelor Slough Study , Dredged Material Evaluation	COE	COE and USFWS	2003	Study performed for dredging action proposed by USFWS, and Ridgefield NWR, to dredge Bachelor Slough to enhance in-stream salmonid habitat. Study to determine suitability of the material in Bachelor Slough for upland disposal sites on Bachelor Island.	Bachelor Slough	Yes	Method reporting limits acceptable. COE did not provide QA/QC sample results with data. Surface sediment samples collected; maximum depth of sediment samples was 22.86 cm. No known sources of dioxins to Bachelor Slough. Sediment evaluation determined sediment suitable for unconfined, in-water or upland placement without further characterization. Sediment data included in regional background evaluation.
Environmental Contaminants in Aquatic Resources from the Columbia River	Jeremy Buck, Environmental Specialist, USFWS	State and federal agencies	2004	Determine if persistent, bioaccumulative compounds are present at concentrations hazardous to fish and wildlife inhabiting NWRs and other locations in the Columbia River.	Lower Columbia River (between mouth and Camas Slough; in middle river region near McNary Dam; Willamette River near Portland)	Yes	A single composite consisting of three sediment grab samples collected from each sample area. Collected from shallow, depositional areas. Qualifiers indicate that results may be overestimated. Samples collected from Julia Butler Hansen NWR, Longview, Ridgefield, and Camas Slough selected as potentially most representative of regional dioxin concentrations. Lewis and Clark NWR samples were anomalously elevated and Baker and Cathlamet Bay samples were collected in the Columbia River Estuary. Sediment data included in regional background evaluation.

Table 1
Background Dioxins in Sediment Literature Review Summary
Lower Columbia Rriver
Oregon and Washington

Study	Prepared By	Prepared For	Study Year	Purpose	Project Area	Results Used in Regional Background Evaluation	Notes
City of Ridgefield Sediment Sampling	MFA	City of Ridgefield	2007	Evaluate sediment in areas of proposed WWTP outfall and piping.	Lake River	Yes	Single composite consisting of three sediment grab samples collected; one grab sample collected just downstream of LRIS in area of contamination. Because of proximity of one sample location to known source of dioxins, data not suitable for regional background evaluation.
Vancouver Lake PCBs, Chlorinated Pesticides, and Dioxins in Fish Tissue and Sediment	Ecology	Ecology	2007	Evaluate fish tissue and sediment in Vancouver Lake and Lake River.	Lake River	No	Dioxins analyzed in fish tissue only, not in sediment.
Boise St. Helens Pulp and Paper Mill Remedial Investigation	URS Corporation	OfficeMax, Inc.	2010	Background assessment for remedial investigation.	Multnomah Channel	Yes	Three incremental sample composites. Method reporting limits acceptable; QA/QC sample results appear acceptable. Data included in regional background evaluation.
Davy Crockett Ship Dismantling Area Investigation, Camas, Washington	Laboratory Reports from Apex Laboratories	Ecology	2011	Characterization of ship dismantling area.	Lower Columbia River	No	Laboratory results initially provided by Ecology for use in regional background evaluation. Not included in analysis due to elevated dioxin reporting limits relative to other studies included in evaluation.
Lake River Industrial Site Remedial Investigation	Anchor QEA and MFA	Port of Ridgefield	2011	Background assessment for remedial investigation.	Lake River and Bachelor Slough	Yes	Method reporting limits acceptable. QA/QC sample results acceptable. Sediment data included in regional background evaluation.

NOTES:
ATSDR = Agency for Toxic Substances and Disease Registry.
cm = centimeter(s).
COE = U.S. Army Corps of Engineers.
Ecology = Washington State Department of Ecology.
EIM = Environmental Information Management system.
LRIS = Lake River Industrial Site.
MFA = Maul Foster & Alongi, Inc.
NA = not available.
NWR = national wildlife refuge.
PCB = polychlorinated biphenyl.
QA = quality assurance.
QC = quality control.
RM = river mile.
USEPA = U.S. Environmental Protection Agency.
USFWS = U.S. Fish and Wildlife Service.
USGS = U.S. Geological Survey.
WWTP = wastewater treatment plant.

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Lake River Industrial Site Remedial Investigation			USFWS Columbia River Study			
Location	LRIS-BKG-01	LRIS-BKG-02	LRIS-BKG-03	Julia Butler Hansen (RM 64-72)	Longview (RM 64-72) (collected along shoreline in Longview)	Ridgefield (RM 87-102) (Lake River at Ridgefield NWR)	Camas Slough (RM 87 - 102) (in Camas Slough)
Sample ID	LRIS-BKG-01-SS	LRIS-BKG-02-SS	LRIS-BKG-03-SS	CRJSD120	CRLSD171	CRRSD117	CRCSD151
Date Collected	04/20/2010	04/20/2010	04/20/2010	8/1991 - 11/1991	8/1991 - 11/1991	8/1991 - 11/1991	8/1991 - 11/1991
Sample Type	Discrete	Discrete	Discrete	Composite	Composite	Composite	Composite
Sample Depth (below mudline)	0-10 cm	0-10 cm	0-10 cm	0 to 30 cm	0 to 30 cm	0 to 30 cm	0 to 30 cm
Analyte							
Total Organic Carbon (percent)	1.20000	0.21000	1.40000	NA	NA	NA	NA
Grain Size (percent)							
Gravel	0	0	0	No grain size analysis, although visual inspection indicated primarily fine-grained.	No grain size analysis, although visual inspection indicated primarily fine-grained.	No grain size analysis, although visual inspection indicated primarily fine-grained.	No grain size analysis, although visual inspection indicated primarily fine grained.
Coarse Sand	0	0.2	0				
Medium Sand	1.1	20	0.6 J				
Fine Sand	80.9	76.2	46 J				
Silt	14	2.6	47				
Clay	3.2	1.3	6.5 J				
Dioxins/Furans (pg/g)							
2,3,7,8-TCDD	0.054 U	0.053 U	0.065 U	0.3 U	0.2 U	0.1 U	0.1 U
1,2,3,7,8-PeCDD	0.18 U	0.038 U	0.12 U	0.3	0.4 U	0.2 U	0.2 U
1,2,3,4,7,8-HxCDD	0.26 U	0.05 U	0.24 U	0.4 U	0.3 U	0.2 U	0.2 U
1,2,3,6,7,8-HxCDD	0.93 J	0.12 U	1.3 J	0.5	0.5	0.5 U	0.8
1,2,3,7,8,9-HxCDD	0.59 J	0.15 U	0.69 J		0.2	0.4 U	0.2 U
1,2,3,4,6,7,8-HpCDD	23	2.9	27	9.1 B	13 B	8.3 B	7.8 B
OCDD	190	22	230	78 B	122 B	105 B	70 B
2,3,7,8-TCDF	0.52 J	0.2 J	0.63 J	0.9 E	0.9 U	0.6 E	0.2 U
1,2,3,7,8-PeCDF	0.62 U	0.31 U	0.27 U	0.3 U	0.3 U	0.2 U	0.1 U
2,3,4,7,8-PeCDF	0.25 J	0.066 U	0.21 U	0.2 U	0.2 U	0.1 U	0.2
1,2,3,4,7,8-HxCDF	1 U	0.58 U	0.81 U	0.3 U	0.3	0.2	0.1 U
1,2,3,6,7,8-HxCDF	0.3 U	0.14 U	0.31 U	0.2 U	0.2 U	0.1 U	0.1 U
1,2,3,7,8,9-HxCDF	0.18 U	0.11 U	0.085 U	0.3 U	0.3 U	0.1 U	0.1 U
2,3,4,6,7,8-HxCDF	0.19 U	0.048 U	0.18 U	0.4	0.4 B	0.3 U	0.4
1,2,3,4,6,7,8-HpCDF	3.6	0.68 U	4.6	0.7	1 U	2 U	0.8
1,2,3,4,7,8,9-HpCDF	0.67 U	0.62 U	0.76 U	0.4 U	0.4 U	0.2 U	0.2 U
OCDF	9.6	1.4 U	14	2 U	5.7	2.4	2.3

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Lake River Industrial Site Remedial Investigation			USFWS Columbia River Study			
Location	LRIS-BKG-01	LRIS-BKG-02	LRIS-BKG-03	Julia Butler Hansen (RM 64-72)	Longview (RM 64-72) (collected along shoreline in Longview)	Ridgefield (RM 87-102) (Lake River at Ridgefield NWR)	Camas Slough (RM 87 - 102) (in Camas Slough)
Sample ID	LRIS-BKG-01-SS	LRIS-BKG-02-SS	LRIS-BKG-03-SS	CRJSD120	CRLSD171	CRRSD117	CRCSD151
Date Collected	04/20/2010	04/20/2010	04/20/2010	8/1991 - 11/1991	8/1991 - 11/1991	8/1991 - 11/1991	8/1991 - 11/1991
Sample Type	Discrete	Discrete	Discrete	Composite	Composite	Composite	Composite
Sample Depth (below mudline)	0-10 cm	0-10 cm	0-10 cm	0 to 30 cm	0 to 30 cm	0 to 30 cm	0 to 30 cm
Analyte							
Total HpCDD	74	6.1 U	53	NA	NA	NA	NA
Total HpCDF	12	2.6 U	16	NA	NA	NA	NA
Total HxCDD	7.4	1.4 U	8.3	NA	NA	NA	NA
Total HxCDF	8.1 U	2.6 U	9.5	NA	NA	NA	NA
Total PeCDD	0.76	0.046	0.91	NA	NA	NA	NA
Total PeCDF	2.5	0.85	3.1	NA	NA	NA	NA
Total TCDD	0.47	0.16	0.77	NA	NA	NA	NA
Total TCDF	1.9	0.57	2.5	NA	NA	NA	NA

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Boise St. Helens Pulp and Paper Mill Remedial Investigation			Bachelor Slough Study, Dredge Material Evaluation				
Location	Columbia Slough	Columbia Slough	Columbia Slough	BACH-02	BACH-04	BACH-07	BACH-08	BACH-09
Sample ID	B-1-A	B-1-B	B-1-C	BACH-BC-02	BACH-BC-04	BACH-BC-07	BACH-BC-08	BACH-BC-09
Date Collected	9/2009 - 10/2009	9/2009 - 10/2009	9/2009 - 10/2009	06/03/2003	06/03/2003	06/03/2003	06/03/2003	06/03/2003
Sample Type	IS Composite	IS Composite	IS Composite	Discrete	Discrete	Discrete	Discrete	Discrete
Sample Depth (below mudline)	10 to 30 cm	10 to 30 cm	10 to 30 cm	0 to 15 cm	0 to 10 cm	0 to 20 cm	0 to 10 cm	0 to 20 cm
Analyte								
Total Organic Carbon (percent)	0.80000	0.68000	0.71800	0.38900	0.16900	0.58200	0.31300	0.75200
Grain Size (percent)								
Gravel	0	0	0	0.01	0.01	0.01	0.01	0.01
Coarse Sand	0.9	0.6	3.6	88.4	92.4	77.7	88.9	80.7
Medium Sand	7.1	4.6	8.6					
Fine Sand	53.6	50.4	48.4					
Silt	22.5	25.0	22.4	11.6	7.6	22.3	11.1	19.3
Clay	15.9	19.4	17.0					
Dioxins/Furans (pg/g)								
2,3,7,8-TCDD	0.11 EMPC	0.107	0.105 EMPC	0.34 U	0.25 U	0.25 U	0.15 U	0.25 U
1,2,3,7,8-PeCDD	0.17	0.15	0.194	0.18 U	0.18 U	0.19 U	0.13 U	0.32 U
1,2,3,4,7,8-HxCDD	0.298	0.27	0.311	0.29 U	0.25 U	0.22 U	0.22 U	0.23 U
1,2,3,6,7,8-HxCDD	1.05	1.01	1.36	0.43 U	0.39 U	0.55 U	0.73 U	0.78 U
1,2,3,7,8,9-HxCDD	0.787	0.76	0.852	0.44 U	0.39 U	0.49 U	0.45 U	0.86 U
1,2,3,4,6,7,8-HpCDD	17.4	18.5	22.7	5 J	6.1 J	8.1 J	16	13
OCDD	160	158	199	44 B	48 B	79 B	120 B	110 B
2,3,7,8-TCDF	0.407	0.404	0.465	0.4 U	0.24 U	0.55 U	0.42 U	0.6 U
1,2,3,7,8-PeCDF	0.28	0.301	0.546	0.32 U	0.22 U	0.24 U	0.18 U	0.38 U
2,3,4,7,8-PeCDF	0.22	0.2	0.261	0.29 U	0.22 U	0.19 U	0.25 U	0.34 U
1,2,3,4,7,8-HxCDF	0.627	0.66	14.8	0.15 U	0.3 U	0.39 U	0.53 U	0.51 U
1,2,3,6,7,8-HxCDF	0.259	0.259 EMPC	0.912	0.2 U	0.19 U	0.22 U	0.24 U	0.31 U
1,2,3,7,8,9-HxCDF	0.0469 U	0.0485 U	0.075 EMPC	0.12 U	0.12 U	0.15 U	0.11 U	0.25 U
2,3,4,6,7,8-HxCDF	0.162	0.163	0.182	0.23 U	0.1 U	0.13 U	0.22 U	0.14 U
1,2,3,4,6,7,8-HpCDF	3.5	4.24	12.3	1.3 U	1.9 U	1.9 U	2 U	2.4 U
1,2,3,4,7,8,9-HpCDF	0.26	0.355	3.42	0.32 U	0.18 U	0.28 U	0.18 U	0.28 U
OCDF	10.1	11.5	53.6	2.3 U	3.6 U	2.8 U	2.2 U	3.5 U

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Boise St. Helens Pulp and Paper Mill Remedial Investigation			Bachelor Slough Study, Dredge Material Evaluation				
Location	Columbia Slough	Columbia Slough	Columbia Slough	BACH-02	BACH-04	BACH-07	BACH-08	BACH-09
Sample ID	B-1-A	B-1-B	B-1-C	BACH-BC-02	BACH-BC-04	BACH-BC-07	BACH-BC-08	BACH-BC-09
Date Collected	9/2009 - 10/2009	9/2009 - 10/2009	9/2009 - 10/2009	06/03/2003	06/03/2003	06/03/2003	06/03/2003	06/03/2003
Sample Type	IS Composite	IS Composite	IS Composite	Discrete	Discrete	Discrete	Discrete	Discrete
Sample Depth (below mudline)	10 to 30 cm	10 to 30 cm	10 to 30 cm	0 to 15 cm	0 to 10 cm	0 to 20 cm	0 to 10 cm	0 to 20 cm
Analyte								
Total HpCDD	37.2	39	44.1	13	12	16	30	27
Total HpCDF	9.73	11	25.9	1.3 U	2.7 U	1.9 U	2 U	3.1 U
Total HxCDD	8.53	8.39	8.97	0.83 U	0.79 U	1.3 U	1.6 U	1.6 U
Total HxCDF	5.57	5.38	22.5	0.44 U	0.86 U	0.76 U	0.91 U	1.1 U
Total PeCDD	1.37	1.04	1.36	0.18 U	0.18 U	0.19 U	0.13 U	0.32 U
Total PeCDF	3.06	3.04	3.27	0.29 U	0.22 U	0.3 U	0.32 U	0.43 U
Total TCDD	2	1.78	1.81	0.34 U	0.25 U	0.49 U	0.24 U	0.43 U
Total TCDF	3.44	3.1	3.17	0.4 U	0.27 U	0.55 U	0.42 U	0.6 U

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Oregon Dioxin Sediment Study					Columbia River Mile 29-34, Brookfield Mound and Skamakawa Turn Sediment Evaluation			Westport Slough Sediment Evaluation
Location	CR17/18	CR23/24	CR25/26	CR-GC-16	CR-GC-4	CRM-BC1	CRM-BC3	CRM-BC5	WP-GC-13
Sample ID	CR17/18	CR23/24	CR25/26	CR-GC-16	CR-GC-4	CRM-BC1	CRM-BC3	CRM-BC5	WP-GC-13
Date Collected	05/10/1990	05/10/1990	05/10/1990	05/10/1990	05/09/1990	08/09/2000	08/09/2000	08/09/2000	06/04/1998
Sample Type	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Composite
Sample Depth (below mudline)	0 to 46 cm	0 to 38 cm	0 to 23 cm	0 to 46 cm	0 to 40 cm	0 to 20 cm	0 to 20 cm	0 to 20 cm	0 to 53 cm
Analyte									
Total Organic Carbon (percent)	NA	NA	NA	NA	NA	0.05700	0.05000	0.04500	NA
Grain Size (percent)									
Gravel	NA	NA	NA	NA	NA	0	0	0	NA
Coarse Sand	NA	NA	NA	NA	NA	99.08	99.52	99.96	NA
Medium Sand	NA	NA	NA	NA	NA				
Fine Sand	NA	NA	NA	NA	NA				
Silt	NA	NA	NA	NA	NA	0.92	0.48	0.04	NA
Clay	NA	NA	NA	NA	NA				
Dioxins/Furans (pg/g)									
2,3,7,8-TCDD	0.74 U	0.46 U	0.45 U	0.98 U	0.38 U	0.13 U	0.14 U	0.12 U	0.2 U
1,2,3,7,8-PeCDD	1.2 U	0.25 U	0.054 U	0.24 U	0.17 U	0.2 U	0.22 U	0.23 U	0.19 U
1,2,3,4,7,8-HxCDD	0.8 U	0.43 U	0.25 U	0.88 U	0.11 U	0.17 U	0.16 U	0.14 U	0.14 U
1,2,3,6,7,8-HxCDD	1 U	0.29 U	0.22 U	0.99 U	0.28	0.16 U	0.15 U	0.13 U	0.8 U
1,2,3,7,8,9-HxCDD	0.85 U	0.25 U	0.36 U	1.9 U	0.27 U	0.15 U	0.14 U	0.12 U	0.51 U
1,2,3,4,6,7,8-HpCDD	4.1	1.5	2.8	3.5	2.9	0.39 U	0.6 U	0.76 U	15
OCDD	53	8.6	45	30	25	2.8 U	3.4 U	3.6 U	170
2,3,7,8-TCDF	1.1	0.57 U	0.43	0.58	0.8	0.11 U	0.1 U	0.1 U	0.94 J
1,2,3,7,8-PeCDF	0.83 U	0.057 U	0.085 U	0.59 U	0.2 U	0.11 U	0.14 U	0.11 U	0.26 U
2,3,4,7,8-PeCDF	0.68 U	0.18 U	0.1 U	0.39 U	0.16 U	0.11 U	0.13 U	0.11 U	0.26 U
1,2,3,4,7,8-HxCDF	0.47 U	0.23 U	0.13 U	0.8 U	0.2 U	0.12 U	0.11 U	0.12 U	0.33 U
1,2,3,6,7,8-HxCDF	0.61 U	0.18 U	0.074 U	0.75 U	0.22 U	0.1 U	0.096 U	0.083 U	0.13 U
1,2,3,7,8,9-HxCDF	0.49	0.28 U	0.22	1.4 U	0.27	0.13 U	0.12 U	0.1 U	0.092 U
2,3,4,6,7,8-HxCDF	0.69 U	0.27 U	0.096 U	1.5 U	0.08 U	0.13 U	0.12 U	0.1 U	0.085 U
1,2,3,4,6,7,8-HpCDF	0.47	0.27 U	0.62 U	0.74 U	0.48	0.15 U	0.17 U	0.2 U	1.9 U
1,2,3,4,7,8,9-HpCDF	0.25 U	0.21 U	0.13 U	3.3 U	0.12 U	0.11 U	0.12 U	0.15 U	0.16 U
OCDF	1.6	0.41 U	0.97	0.73	0.66	0.22 U	0.26 U	0.27 U	5.3 J

Table 2
Dioxins in Sediment in the Lower Columbia River
Oregon and Washington

Study	Oregon Dioxin Sediment Study					Columbia River Mile 29-34, Brookfield Mound and Skamakawa Turn Sediment Evaluation			Westport Slough Sediment Evaluation
Location	CR17/18	CR23/24	CR25/26	CR-GC-16	CR-GC-4	CRM-BC1	CRM-BC3	CRM-BC5	WP-GC-13
Sample ID	CR17/18	CR23/24	CR25/26	CR-GC-16	CR-GC-4	CRM-BC1	CRM-BC3	CRM-BC5	WP-GC-13
Date Collected	05/10/1990	05/10/1990	05/10/1990	05/10/1990	05/09/1990	08/09/2000	08/09/2000	08/09/2000	06/04/1998
Sample Type	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Discrete	Composite
Sample Depth (below mudline)	0 to 46 cm	0 to 38 cm	0 to 23 cm	0 to 46 cm	0 to 40 cm	0 to 20 cm	0 to 20 cm	0 to 20 cm	0 to 53 cm
Analyte									
Total HpCDD	11	1.5	5.8	5.1	5	0.42 U	0.6 U	0.76 U	33
Total HpCDF	1.3	0.27 U	0.67	3.3 U	1.3	0.15 U	0.17 U	0.2 U	4.3
Total HxCDD	1 U	0.43 U	0.31	1.9 U	1.6	0.17 U	0.26 U	0.14 U	2.3 U
Total HxCDF	0.49	0.28 U	0.22	1.5 U	0.49	0.13 U	0.12 U	0.12 U	1.2 U
Total PeCDD	1.2 U	0.25 U	0.054 U	0.24 U	0.17 U	0.55 U	0.44 U	0.4 U	0.48 U
Total PeCDF	0.83 U	0.18 U	0.1 U	0.59 U	0.2 U	0.11 U	0.14 U	0.11 U	1.1 U
Total TCDD	3.7	0.46 U	0.45 U	0.63	3.5	0.13 U	0.14 U	0.12 U	0.71 U
Total TCDF	1.1	0.57 U	0.43	1.2	1.1	0.11 U	0.1 U	0.1 U	1.9

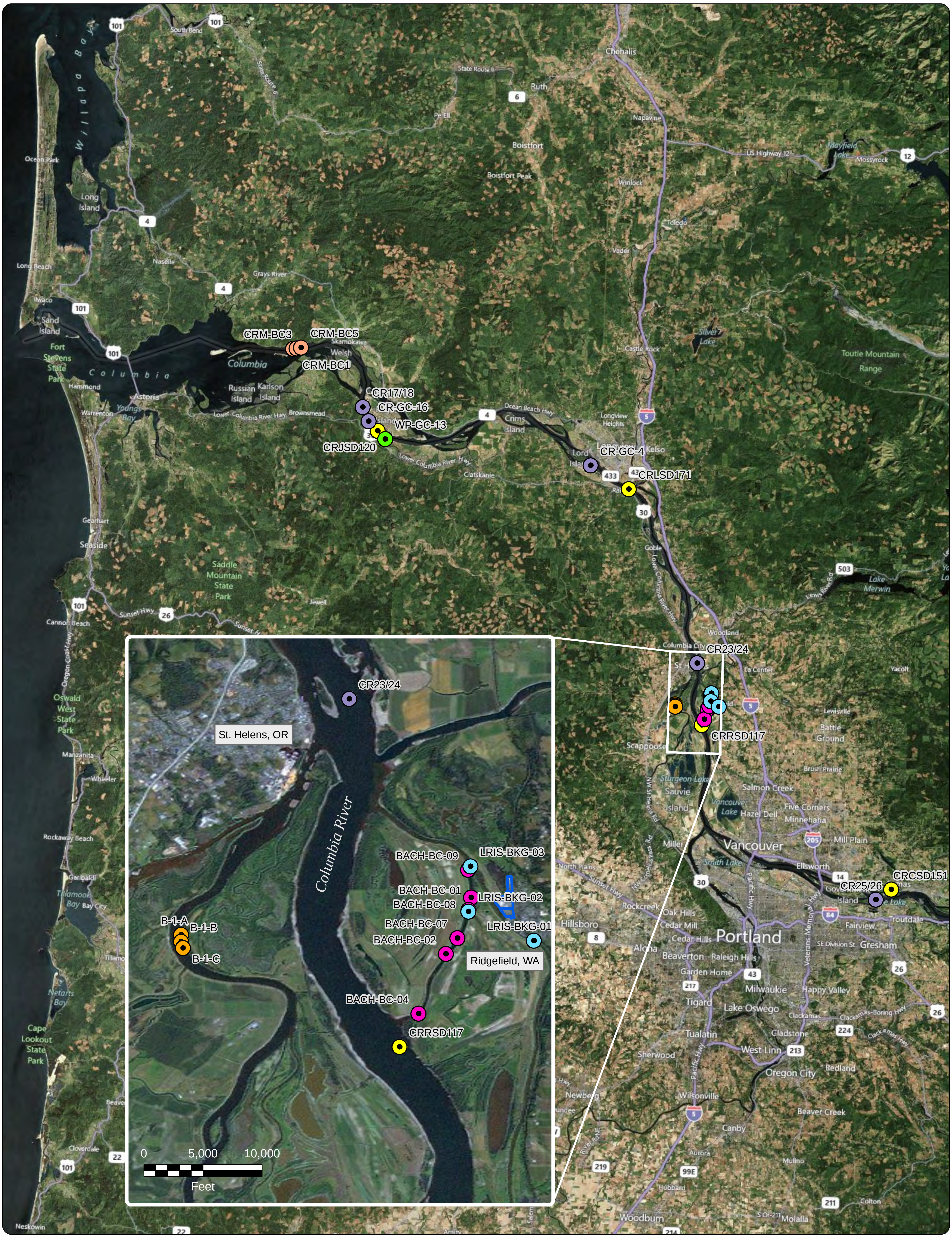
Table 3
Summary Statistics for Dioxins in Sediment
Lower Columbia River
Oregon and Washington

Analyte	Units	Minimum	Maximum	Average	Median	90th UCL on the 90th Percentile	90th Percentile	Upper Tolerance Limit (UTL)
Dioxins/Furans (pg/g)								
Total 2,3,7,8-TCDD Equivalence U=1/2)	pg/g	0.18	2.75	0.73	0.53	1.64	1.41	2.0

NOTE:
pg/g = picograms per gram.
Upper tolerance limit is calculated to one significant figure.

FIGURE

File: X:\9003.01 Port of Ridgefield\40\Projects\05\Fig_Natural Dioxin Background Sediment Sample Locations.mxd



Source: Aerial photograph obtained from ESRI, Inc. ArcGIS Online/Bing Maps

Notes:
1. Boise St. Helens and US Fish & Wildlife sample locations are approximate (based on composite sample locations).
2. Davy Crockett sample locations estimated.

Legend

- Lake River Industrial Site Remedial Investigation (2010)
- Boise St. Helens Pulp and Paper Mill Remedial Investigation (2009)
- Bachelor Slough Study, Dredged Material Evaluation (2003)
- Brookfield Mound and Skamakawa Turn Sediment Evaluation (2000)
- Westport Slough Sediment Evaluation (1998)
- Oregon Dioxin Sediment Study (1990)
- US Fish & Wildlife Columbia River Study (1991)
- POR Cell Boundaries

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Figure
Natural Dioxin Background Sediment Sample Locations

Lower Columbia River
Oregon and Washington

0 20,000 40,000
Feet

Print Date: 11/07/2011
Approved By: M. Novak
Produced By: J. Schane
Project: 9003.01.40

ATTACHMENT

	Nonparametric Background Statistics for Data Sets with Non-Detects	
	User Selected Options	
	From File	WorkSheet.wst
	Full Precision	OFF
	Confidence Coefficient	90%
	Coverage	90%
	Different or Future K Values	1

Total 2,3,7,8-TCDD Equivalence (ND=0.5*EDL)

Total Number of Data	24
Number of Non-Detect Data	3
Number of Detected Data	21
Minimum Detected	0.182
Maximum Detected	2.749
Percent Non-Detects	12.50%
Minimum Non-detect	0.24
Maximum Non-detect	0.256
Mean of Detected Data	0.796
SD of Detected Data	0.543
Mean of Log-Transformed Detected Data	-0.387
SD of Log-Transformed Detected Data	0.557

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Background Statistics

90% UTL with 90% Coverage

Order Statistic	23
Achieved CC	0.92
UTL	1.528
Largest Non-detect at Order	4

90% UPL

90% UPL	1.369

Kaplan-Meier (KM) Method

Mean	0.719
SD	0.535
Standard Error of Mean	0.112
90% UTL 90% Coverage	1.636
90% KM Chebyshev UPL	2.359
90% KM UPL (t)	1.44
90% KM Percentile (z)	1.405
95% KM Percentile (z)	1.6
99% KM Percentile (z)	1.965

Note: UPL (or upper percentile for gamma distributed data)
represents a preferred estimate of BTV. For an Example:
KM-UPL may be used when multiple detection limits are present