Appendix Q

Dioxin, Furan, and PCB Congener Data

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TABLE Q.1

TYPICAL CHEMICAL/PHYSIOCHEMICAL PROPERTIES OF DIOXINS/FURANS
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Congener Group	Vapor Pressure (mmHg@ 25C)	Log Kow	Solubility (mg/L@ 25C)	Henry's Constant
TCDD	8.10E-07	6.4	3.50E-04	1.35E-03
PeCDD	7.30E-10	6.6	1.20E-04	1.07E-04
HxCDD	5.90E-11	7.3	4.40E-06	1.83E-03
HpCDD	3.20E-11	8	2.40E-06	5.14E-04
OCDD	8.30E-13	8.2	7.40E-08	2.76E-04
TCDF	2.50E-08	6.2	4.20E-04	6.06E-04
PeCDF	2.70E-09	6.4	2.40E-04	2.04E-04
HxCDF	2.80E-10	7	1.30E-05	5.87E-04
HpCDF	9.90E-11	7.9	1.40E+00	5.76E-04
OCDF	3.80E-12	8.8	1.40E-06	4.04E-05

Reference McKay, 2001.

Molecular Weight (g/mol)	322
Water solubility (ng/L)	19.3
Specific Gravity	1.827
Average Log Kow	5.77
Koc	1.15E3 - 3.8E7

Reference: Watts, Richard.1997 Hazardous Waste: Sources, Pathways, Receptors.

Congener Group Octanol/Water Partition Coefficient

TCDD	5.91 to 8.84
PeCDD	6.2 to 9.69
HxCDD	6.85 to 10.55
HpCDD	8.2 to 11.54
OCDD	7.46 to 8.6
TCDF	5.6 to 6.73
PeCDF	6.19 to 6.92
HcCDF	NA
HpCDF	7.92
OCDF	7.05 to 13.35

Reference: http://www.cqs.com/epa/exposure/v2chap2.htm

Notes:

mmHg	Millimeters of Mercury.
mg/L	Milligram per liter.
g/mol	Grams per mole.
ng/L	Nanogram per liter.
Kow	Octanol-water partition coefficient.
Koc	Organic carbon-water partition coefficient.

TABLE Q.2

CHEMICAL AND PHYSICAL PROPERTIES OF PCBS
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	Chemical and Physical Properties					Half life			
	Solubility	Log Kow	Koc	Vapor Pressure	Henry's Constant	Water	Soil	Sediment	Air
	mg/L		L/kg	mmHg	atm-m3/mol at 25C				
Aroclor 1016	0.57	5.4		7.00E-04	4.23E-04				
Aroclor 1248			436516						
Aroclor 1254	0.01	6.2	172492	9.00E-05	3.79E-03				
Aroclor 1260			822422						
PCBs						2-6 yrs.	2-6 yrs.	2-6 yrs.	1 wk. - 6 yrs.

Reference: USEPA 2000. http://www.epa.gov/greatlakes/lakemich/lmlamp2000/LM%20appendix%20b.pdf

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	GROUNDWATER (pg/L)								
	Monitoring Wells								
Sample Location:	**3-25**	**4-25R**	**14-25R**	**14-50R**	**14-50R**	**21-25R**	**53-50**	**53C-25**	**65-25**
Sample ID:	**WG-082812-JN-3-25-001**	***GW-011706-TS-4-25R***	***GW-122005-14-25R-001***	***GW-122005-14-50R-002***	***GW-122005-14-50R-003***	***GW-011706-TS-21-25R***	***GW-011706-TS-53-50***	***WG-072412-AK-53C-25-091***	***WG-081212-ALK-65-25-108***
Sample Depth (ft BGS/BML):	**25**	***25***	***25***	***50***	***50***	***25***	***50***	***25***	***25***
PCB Congeners									
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	82.77				459.18	U	U	108
(PCB 31) 2,4',5-Trichlorobiphenyl	U	113.44				528.29	U	U	118
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	U				U	U	U	41.4
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	60.41				1763.01	U	U	161
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U				U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	8.18	36.68				451.51	U	U	22.2
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl									
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	6.51	24.90	U	49.10	16.94	371.65	U	U	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	57.80	U	U	U	1336.70	U	U	26.5
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	U	109.96				1271.77	30.59	U	25.1
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	5.22	U				U	U	3.1	6.13
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	U				U	U	U	2.34
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	2.89	U	U	30.55	14.94	U	U	U	2.55
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	4.93	84.17	682.05	742.77	567.51	5114.91	U	U	U
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	U	U	5515.42	2705.51	2661.24	2739.83	U	U	U
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	5.31	106.16				U	U	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	7.36	U				U	U	4.44	U
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	8.42	3617.02	U	U	U
Sum of Congeners	**40.40**	**676.29**	**6197.47**	**3527.92**	**3269.05**	**17653.87**	**30.59**	**7.54**	**513.22**

Ratio Method to Estimate Total PCBs based on 1260									
Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**138.976**	**2326.4376**	**21319.2796**	**12136.0448**	**11245.5148**	**60729.3128**	**105.2296**	**25.9376**	**1765.4768**
Aroclor 1260 Factor	**3.44**								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Sample Location:	69-25	70-25	83C-25	90C-25	95-15	95C-25	709-MW6-15	709-MW9-15
Sample ID:	*WG-072712-AMK-69-25-114*	*WG-082612-AMK-70-25-115*	*WG-072512-AK-83C-25-141*	*WG-072312-AK-90C-25-183*	*WG-082512-PR-95-15-215*	*WG-071912-DJT-95C-25-216*	*WG-080912-LP-709-MW6-15-229*	*WG-081412-AMK-709-MW9-15-234*
Sample Depth (ft BGS/BML):	*25*	*25*	*25*	*25*	*15*	*25*	*15*	*15*
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	32.4	U	U	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	37.8	U	U	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	U	U	10.9	U	U	U	2.1
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	U	U	132	U	U	U	24.1
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	10.3	U	U	U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	U	2.28	1.78	39.6	U	1.29	U	39.8
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	U	2.74	3.02	31.8	U	1.62	U	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	U	U	48.5	U	U	U	45.2
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	47	U	U	61.2	U	U	U	93.1
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	13.3	U	U	16.5	U	U	U	40.6
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	8.27	U	U	11.5	U	U	U	10.7
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	2.97	U	U	15.6	U	U	U	7.32
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U	3.81
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	16.4	2.3	U	20.3	U	U	U	10.7
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	49.8	U	U	56.5	U	U	U	U
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	16.4	U	U	68.7	U	U	U	5.46
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	34.5	2.29	1.31	32.1	2.97	U	6.2	6.05
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	U	U	U
Sum of Congeners	**175.34**	**9.61**	**6.11**	**625.70**	**2.97**	**2.91**	**6.20**	**288.94**
Ratio Method to Estimate Total PCBs based on 1260								
Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**603.1696**	**33.0584**	**21.0184**	**2152.408**	**10.2168**	**10.0104**	**21.328**	**993.9536**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

				709/721 Alexander Avenue			
Sample Location:	**709-MW15-15**	**709-MW20-15**	**709-MW20-25**	**721-MW7-15**	**721-MW9-15**	**721-MW9-25**	**721-MW10-15**
Sample ID:	***WG-081512-TS-709MW15-15-238***	***WG-082112-JN-709-MW20-15-223***	***WG-082312-JN-709-MW20-25-224***	***WG-080912-TRH-721-MW7-15-261***	***WG-072212-DJT-721-MW9-15-262***	***WG-072212-DJT-721-MW9-25-263***	***WG-080812-TRH-721-MW10-15-265***
Sample Depth (ft BGS/BML):	***15***	***15***	***25***	***15***	***15***	***25***	***15***
PCB Congeners							
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	U	21.7	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	U	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	U	U	U	4.61	U	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	U	U	U	142	U	U
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	2.03	5.19	U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	4.85	U	2.82	U	22.4	U	4.21
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl							
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	2.77	U	3.67	U	U	U	6.26
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	24.8	U	U
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	U	U	U	U	U	U	U
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	6.08	4.16	U	3.93	4.09	U	2.18
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	U	U	U	U	U	U	2.13
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	3.15	2.23	2.25	2.89	U	U	2.53
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	U	U
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	2.03	U	1.71	U	U	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	4.32	5.54	2.38	3.93	1.58	2.42	3.31
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	U	U
Sum of Congeners	**23.20**	**11.93**	**12.83**	**12.78**	**226.37**	**2.42**	**20.62**
Ratio Method to Estimate Total PCBs based on 1260							
Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**79.808**	**41.0392**	**44.1352**	**43.9632**	**778.7128**	**8.3248**	**70.9328**
Aroclor 1260 Factor							

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

				Extraction Well Branches	
Sample Location:	**721-MW10-25**	**721-MW12-15**	**721-MW13-15**	**EWB-A**	**EWB-A**
Sample ID:	***WG-080712-TRH-721-MW10-25-266***	***WG-073012-ALK-721-MW12-15-273***	***WG-073112-AK-721-MW13-15-276***	***GW-013007-MM-EWB-A-001***	***GW-013007-MM-EWB-A-002***
Sample Depth (ft BGS/BML):	***25***	***15***	***15***	***NA***	***NA***
PCB Congeners					
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	U	U	20.37	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	U	U	U	U
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl					
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1.63	U	1.77	U	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	U	U	U	U	U
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	U	U	U	U	U
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	U	U	U	U	U
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	U	U	U	65.84	80.90
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	U	U	U	688.19	730.72
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	U	U	U	U	96.21
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	U	1.94	U	U	U
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U
Sum of Congeners	**1.63**	**1.94**	**1.77**	**774.40**	**907.83**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**5.6072**	**6.6736**	**6.0888**	**2663.936**	**3122.9352**
Aroclor 1260 Factor					

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	GROUNDWATER (pg/L) (Cont.)					
	Extraction Well Branches (Cont.)					
Sample Location:	**EWB-B**	**EWB-B**	**EWB-C**	**EWB-C**	**EWB-D**	**EWB-D**
Sample ID:	***GW-013007-MM-EWB-B-001***	***GW-013007-MM-EWB-B-002***	***GW-013007-MM-EWB-C-001***	***GW-013007-MM-EWB-C-002***	***GW-013007-MM-EWB-D-001***	***GW-013007-MM-EWB-D-002***
Sample Depth (ft BGS/BML):	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***
PCB Congeners						
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	U	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	23.76	U	U	U	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	U	U	U	U	U
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	U	U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl						
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	99.41	203.12	165.70	181.68	U	363.83
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	766.15	1726.80	1263.34	1083.01	320.98	3218.11
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	100.37	196.29	163.85	93.11	43.69	387.78
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	U	U	U	U	U	U
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	U
Sum of Congeners	**965.93**	**2149.97**	**1592.89**	**1357.80**	**364.67**	**3969.72**
Ratio Method to Estimate Total PCBs based on 1260						
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**3322.7992**	**7395.8968**	**5479.5416**	**4670.832**	**1254.4648**	**13655.8368**
Aroclor 1260 Factor						

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

GROUNDWATER (pg/L) (Cont.)									
			Hylebos Waterway					Navy-Todd Dump	Embankment Seep
Sample Location:	**HW-1**	**HW-1**	**HW-2**	**HW-3**	**HW-4**	**WW-A1R**		**NTD-2**	**P-A18**
Sample ID:	***GW-012407-BS-HW-1-001***	***GW-012407-BS-HW-1-002***	***GW-012507-BS-HW-2-001***	***GW-012207-BS-HW-3-001***	***GW-012307-BS-HW-4-001***	***GW-082112-MD-WWA1R-003***		***GW-121406-ILM-NTD2-010***	***P-013007-MM-A18-001***
Sample Depth (ft BGS/BML):	***0.5 to 2.5***	***0.5 to 2.5***	***2.5 TO 4.5***	***9 to 11***	***9 to 11***	***11***		***73 to 75***	***NA***
PCB Congeners									
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	202.72	U	U	U	44		U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	U	34.7		U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	U	66.23	U	15.88	U	8.08		U	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	292.44	435.56	U	U	U	52.4		U	U
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	U	U	U		U	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U		U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	96.93	113.70	7.54	16.09	8.35	8.45		3551.52	19.11
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl									
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	110.39	128.24	U	U	U	5.17		3991.25	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U		U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	160.43	192.42	U	U	U	U		7095.47	U
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U		U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	8.65	U		U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	618.38	266.77	U	205.80	272.25	U		26092.13	U
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	189.32	137.11	18.24	U	40.68	4.05		U	U
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	80.05	53.85	5.29	U	16.05	2.16		U	168.84
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	45.55	39.49	U	U	U	U		1408.21	4.4
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	22.19	U	U	U	U		972.58	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	74.70	U	U	U	44.43	U		U	7.06
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	1054.11	U	130.97	859.61	705.47	2.65		U	172.47
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	8618.98	U	1342.28	6806.16	6113.21	U		110317.56	1174.11
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	287.01	U	201.83	883.14	391.30	2.29		20614.42	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	11254.09	U	1683.51	5719.62	8163.68	7.43		182779.73	U
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	12.72	U	U	U	U	U		401.64	U
Sum of Congeners	**22895.10**	**1658.28**	**3389.66**	**14506.30**	**15764.07**	**171.38**		**357224.51**	**1545.99**
Ratio Method to Estimate Total PCBs based on 1260									
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**78759.144**	**5704.4832**	**11660.4304**	**49901.672**	**54228.4008**	**589.5472**		**1228852.314**	**5318.2056**
Aroclor 1260 Factor									

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

GROUNDWATER (pg/L) (Cont.)								
	Area 5106							
Sample Location:	**PT-13A**	**PT-13A**	**PT-15A**	**PT-15A**	**PT-15A**	**PT-15A**	**PT-15B**	**PT-15B**
Sample ID:	***GW-110905-PT-13A-001***	***GW-110905-PT-13A-002***	***GW-110905-PT-15A-001***	***GW-110905-FD-001***	***GW-110905-PT-15A-002***	***GW-111005-PT-15A-003***	***GW-122006-PT-15B-DR-001***	***GW-122006-PT-15B-DR-002***
Sample Depth (ft BGS/BML):	***11.8 to 14.8***	***21.8 to 24.8***	***56 to 57***	***56 to 57***	***66 to 67***	***66 to 67***	***13 to 15***	***18 to 20***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl							U	U
(PCB 31) 2,4',5-Trichlorobiphenyl							U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl							27.03	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl							219.18	276.83
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	27.25	U	944.06	716.19	817.79	U	8.61	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl							U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl							52.96	65.15
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	136.67	35.60	8597.28	5013.91	4712.36	739.80	41.69	67.91
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	249.41	62.87	16127.42	12253.23	9503.57	1509.87	118.43	155.17
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	18.48	U	796.15	463.92	208.46	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl							343.24	363.75
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl							108.63	109.91
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl							27.55	39.74
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	34.59	U	4112.09	4217.24	1539.76	359.36	18.98	28.31
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	2137.58	2178.95	820.91	174.37	7.21	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	340.57	U	25871.18	3229.54	2916.09	178.33	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	1410.24	363.20	93122.11	66904.34	17010.21	5061.65	228.29	164.37
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	13024.10	2290.44	407989.53	294404.31	85142.52	29053.82	1162.63	U
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl							U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl							2056.23	1465.27
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	1893.02	1232.52	311.30	U	U	U
Sum of Congeners	**15241.31**	**2752.09**	**561590.42**	**390614.13**	**122982.97**	**37077.18**	**4420.66**	**2736.41**
Ratio Method to Estimate Total PCBs based on 1260								
Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**52430.09952**	**9467.20336**	**1931871.028**	**1343712.618**	**423061.3996**	**127545.4958**	**15207.0704**	**9413.2504**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	GROUNDWATER (pg/L) (Cont.)				SEDIMENT/SOIL (ng/kg)			
	Area 5106 (Cont.)				Hylebos Waterway			
Sample Location:	**PT-15B**	**PT-15B**	**PT-17A**	**PT-17A**	**HW-1**	**HW-1**	**HW-1**	**HW-2**
Sample ID:	***GW-122106-PT-15B-DR-003***	***GW-122106-BI-PT-15B-004***	***GW-020107-ILM-PT-17A-001***	***GW-020207-ILM-PT-17A-002***	***SE-012407-BS-HW-1-001***	***SE-012407-BS-HW-1-002***	***SE-012407-BS-HW-1-003***	***SE-012507-BS-HW-2-001***
Sample Depth (ft BGS/BML):	***28 to 30***	***38 to 40***	***0.5 to 2.5***	***10 to 12***	***0 to 0.33***	***0.5 to 2.5***	***0.5 to 2.5***	***0 to 0.33***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	29981.11	77263.96	373368.84	10283.45	4298.03	371	356.29	268.3
(PCB 31) 2,4',5-Trichlorobiphenyl	44276.99	110187.00	413794.57	12082.93	4433.36	454.19	410.45	265.27
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	10805.92	24096.75	83859.42	3167.29	886.12	70.68	71.91	49.77
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	123936.55	336107.68	1134876.42	50367.25	14148.87	840.86	1028.24	804.13
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	4568.76	9429.49	51350.13	2131.32	557.92	41.96	35.53	41.85
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	214.54	476.09	966.49	U	3.63	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	23366.15	56140.56	158237.76	7657.80	4509.24	123.64	135.16	215.71
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	34417.59	78247.45	204626.05	10511.23	4409.43	215.39	228.9	268.75
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	1684.40	3814.15	9831.58	562.07	163.34	U	10.25	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	70140.35	204021.92	281215.92	16184.05	9856.02	486.3	498.81	664.89
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	4824.97	8388.51	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	1879.00	5382.47	2865.77	240.55	140.56	U	9.39	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	182837.88	617339.09	253036.88	14253.25	19540.37	737.77	910.17	706.53
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	74634.31	193191.65	90888.99	5068.75	6978.82	332.97	322.64	347.23
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	24221.77	72868.28	28903.96	1469.79	25640.94	87.53	1061.95	92.16
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	13660.07	47000.46	32512.04	1673.47	2018.11	70.17	63.16	98.79
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	5249.71	18395.54	14779.63	701.12	945.61	29.26	25.17	37.29
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	6503.11	15848.49	5495.88	198.54	403.18	17.98	23.46	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	130969.37	386622.20	123981.73	7910.12	11492.43	319.06	481.68	227.85
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	575114.36	1677124.35	596311.92	38943.92	41699.82	1585.87	2781.62	1039.31
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	55336.69	174081.13	13580.10	1778.04	U	U	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	827413.67	2331318.57	U	46126.17	63651.12	2091.92	4020.18	1698.26
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	4297.33	9735.29	4077.79	201.62	400.59	U	11.99	U
Sum of Congeners	**2250334.60**	**6457081.08**	**3878561.87**	**231512.73**	**216177.51**	**7876.55**	**12486.95**	**6826.09**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**7741151.024**	**22212358.92**	**13342252.83**	**796403.7912**	**743650.6344**	**27095.332**	**42955.108**	**23481.7496**
Aroclor 1260 Factor								

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)								
	Hylebos Waterway (Cont.)								
Sample Location:	**HW-2**	**HW-2**	**HW-3**	**HW-3**	**HW-3**	**HW-4**	**HW-4**	**HW-4**	**WW-A1R**
Sample ID:	***SE-012507-BS-HW-2-002***	***SE-012507-BS-HW-2-003***	***SE-012207-BS-HW-3-001***	***SE-012207-BS-HW-3-002***	***SE-012207-BS-HW-3-003***	***SE-012307-BS-HW-4-001***	***SE-012307-BS-HW-4-002***	***SE-012307-BS-HW-4-003***	***S-082112-MD-WW-AIR-001***
Sample Depth (ft BGS/BML):	***0.5 to 2.5***	***2.5 to 4.5***	***0 to 0.33***	***0 to 2***	***8 to 10***	***0 to 0.33***	***0 to 2***	***8 to 10***	***0 to 2***
PCB Congeners									
(PCB 20) 2,3,3'-Trichlorobiphenyl	1344.49	133.11	1549.26	489.58	60.67	2299.21	720.78	63.87	1480
(PCB 31) 2,4',5-Trichlorobiphenyl	1466.58	145.64	1333.12	542.62	61.15	2943.86	812.58	62.53	1230
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	225.97	23.18	63.02	83.59	U	477.9	143.92	9.59	209
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	3618.33	415.08	1784.64	1398.73	137.61	8826.08	4012.05	168.84	3710
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	188.54	23.06	U	U	U	371.11	118.1	5.54	158
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	U	U	6.35
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	983	80.34	363.59	462.68	40	1203.3	1967.63	53.42	2200
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl									
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1175.81	67.19	400.66	377.21	24.83	4134.86	2310.15	63.7	1370
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	53.15	U	U	U	U	204.11	132.87	U	54.2
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	2923.95	268.96	1194.32	1249.69	105.85	10336.63	6434.16	170.57	3360
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	91.39	U	U	U	U	41.5
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	32.69	U	U	U	U	91.32	50.68	U	11.5
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	2612.58	282.41	1078.86	1302.36	159.31	10786.87	6091.64	183.19	5060
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	1084.98	160.72	469.67	486.63	71.26	4428	3310.22	95.06	1750
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	332.98	43.95	112.26	154.66	20.45	1381.01	637.45	27.44	1100
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	408.95	38.24	132.07	144.04	14.12	1499.71	924.23	20.73	532
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	159.34	13.24	60.97	57.51	6.33	583.96	274.91	7.83	199
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	214.76	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	821.62	59.82	237.91	311.19	51.08	2704.89	768.55	37.36	1370
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	3733.74	322.89	997.14	1364.48	292.36	9710.14	2623.14	158.85	4930
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	U	U	353.52	145.05	95.92	U	U	U	1600
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	5618.94	506.89	1756.04	2160.14	437.86	17734.78	4079.79	257.69	3690
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	100.91	37.12	U	57.6
Sum of Congeners	**26785.64**	**2584.72**	**11887.05**	**10821.55**	**1578.8**	**80033.41**	**35449.97**	**1386.21**	**34119.15**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**92142.6016**	**8891.4368**	**40891.452**	**37226.132**	**5431.072**	**275314.9304**	**121947.8968**	**4768.5624**	**117369.876**
Aroclor 1260 Factor									

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

			N Landfill
Sample Location:	**WW-A1R**	**WW-A1R**	**NL-2A**
Sample ID:	***S-082112-MD-WW-AIR-002***	***S-082112-MD-WW-AIR-003***	***S-122106-BI-NL2A-001***
Sample Depth (ft BGS/BML):	***4 to 6***	***8***	***2 to 4***
PCB Congeners			
(PCB 20) 2,3,3'-Trichlorobiphenyl	1200	4.52	167.92
(PCB 31) 2,4',5-Trichlorobiphenyl	960	3.92	140.13
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	175	0.552	24.10
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	3900	10.7	202.59
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	192	0.465	32.72
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	5.09	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	1760	9.48	46.54
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl			
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	892	3.33	40.02
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	33.8	U	7.91
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	2480	7.91	79.83
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	32.2	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	11.9	U	15.12
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	3070	11.3	102.86
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	1010	3.66	29.43
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	986	2.42	14.41
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	281	1.01	32.67
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	110	0.407	27.69
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	1110	2.76	120.90
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	5310	9.26	524.37
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	1330	2.63	70.19
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	3810	6.86	633.75
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	44.7	U	U
Sum of Congeners	**28703.69**	**81.184**	**2313.15**
Ratio Method to Estimate Total PCBs based on 1260			
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**98740.6936**	**279.27296**	**7957.236**
Aroclor 1260 Factor			

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)								
	N Landfill (Cont.)								
Sample Location:	**NL-2A**	**NL-18**	**NL-24**	**NL-24**	**NL-25**	**NL-25**	**NL-25**	**NL-26**	**NL-26**
Sample ID:	***S-020807-ILM-NL-2A-002***	***S-080106-LH-NL18-003***	***SE-011207-BS-NL-24-001***	***SE-011507-BS-NL-24-003***	***SE-011807-ILM-NL-25-001***	***SE-011807-ILM-NL-25-002***	***SE-011807-ILM-NL-25-003***	***SE-011707-BS-NL-26-001***	***SE-011707-ILM-NL-26-003***
Sample Depth (ft BGS/BML):	***6 to 8***	***8 to 10***	***0 to 3***	***10 to 13***	***0 to 3***	***5 to 8***	***5 to 8***	***0 to 3***	***10 to 13***
PCB Congeners									
(PCB 20) 2,3,3'-Trichlorobiphenyl	420.91	454.23	766.26	56.9	486.18	604	113	1915.96	141
(PCB 31) 2,4',5-Trichlorobiphenyl	348.74	418.53	810.19	U	531.89	589	94.4	2135.57	129
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	94.98	276.15	122.05	5.82	73.16	62.9	13.5	306.26	12.4
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	769.72	2588.59	3142.27	105	2739.56	1160	303	5502.94	368
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	78.49	167.85	131.96	U	53.67	44.1	18.2	189.1	22.4
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	286.88	2560.19	321.22		2515.26			1704.83	
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl									
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	278.82	2125.55	2025.74	58.1	3682.08	613	211	2261.33	186
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	59.17	U	U	3.37	283.19	28.6	8.19	136.84	8.59
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	708.42	6499.27	4055.61	146	7197.65	1430	493	4396.53	444
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	2.16	U	17.4	8.36	U	17.4
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	53.51	95.64	U	U	55.53	U	2.58	30.64	13.3
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	808.23	11043.68	3774.26	217	8057.21	1480	669	3823.4	504
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	231.37	5431.64	1484.13	56.5	3601.87	405	168	1429.89	122
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	1003.63	380.56	21.5	630.78	143	76.8	393.11	92.2
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	357.48	780.53	439.59	23.2	2338.64	200	75.8	521.22	64.6
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	248.35	364.86	135.21	8.62	321.72	64.8	30.2	185.88	44.5
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	74.55	10.82	9.46	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	1021.37	1401.84	1161.14	65.1	1024.13	399	225	1293.79	174
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	2333.63	2961.50	3675.86	176	2061.73	1040	684	4442.01	538
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	59.32	466.01	717.42	23.1	414.71	110	73	642.52	58
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	2893.42	3546.77	6382.8	78.2	3040.27	422	283	6371.35	228
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	225.27	61.75	48.09	U	44.71	U	U	U	U
Sum of Congeners	**11352.63**	**42259.03**	**29583.82**	**1046.57**	**39153.94**	**8812.8**	**3550.03**	**37683.17**	**3167.39**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**39053.0472**	**145371.0632**	**101768.3408**	**3600.2008**	**134689.5536**	**30316.032**	**12212.1032**	**129630.1048**	**10895.8216**
Aroclor 1260 Factor									

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	N Landfill (Cont.)							
Sample Location:	**NL-26**	**NL-27**	**NL-27**	**NL-28**	**NL-28**	**NL-28**	**NL-29**	**NL-29**
Sample ID:	***SE-011807-ILM-NL-26-006***	***SE-011907-BS-NL-27-001***	***SE-011907-BS-NL-27-002***	***SE-011707-BS-NL-28-002***	***SE-011707-BS-NL-28-003***	***SE-011707-BS-NL-28-004***	***SE-011807-BS-NL-29-001***	***SE-011807-BS-NL-29-002***
Sample Depth (ft BGS/BML):	***20 to 23***	***0 to 2***	***6 to 8***	***5 to 8***	***10 to 13***	***15 to 18***	***0 to 3***	***5 to 8***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	1190	3390.24	4110.3	28658.16	2380	425	1590	3499.18
(PCB 31) 2,4',5-Trichlorobiphenyl	1180	2956.18	3308.85	28510.51	2090	340	1110	3646.91
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	149	828.55	709.81	6912.19	389	63.2	308	662.29
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	3070	14677.82	14042.28	81836.77	6810	927	5870	11116.16
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	187	750.43	858.25	3988.63	381	61.8	233	393.29
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	6.89	405.96	U	230.73	11	2.62	U	14.61
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl		5578.87	6179.51	31774.75				5441.31
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1450	5105.03	6198.01	31717.48	2230	302	4310	6042.2
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	72.8	138.48	U	3105.94	104	15.4	224	492.36
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	26.5	13008.93	18645.82	66384.83	4400	629	10500	14295.31
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	70.4	U	1829.77	1352.89	112	14.4	163	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	28.2	U	U	500.27	35.9	6.55	U	66.78
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	3650	9977.94	13927.88	81624.84	4000	796	15200	14948.87
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	863	4450.85	6698.11	31777.89	1020	194	U	5700.62
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	515	1259.6	1509.62	8535.12	603	119	1560	U
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	460	1931.3	2094.08	9450.07	508	79.7	1850	5072.04
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	194	1627.74	1425.56	2968.32	223	38.2	618	709.27
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	9.42	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	1360	4688.42	2298.36	24969.37	1530	441	6420	3882.07
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	4300	11011.58	7723.56	70936.91	4850	1380	14800	10001.95
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	404	2284.26	2480.09	U	541	158	1100	1691.1
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	1870	12405.66	10396.51	138406.48	2260	636	5840	13591.76
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	867.41	U	1839.81	53.4	U	248	222.04
Sum of Congeners	**21046.79**	**97345.25**	**104436.37**	**655481.96**	**34540.72**	**6628.87**	**71944**	**101490.12**

Ratio Method to Estimate Total PCBs based on 1260								
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**72400.9576**	**334867.66**	**359261.1128**	**2254857.942**	**118820.0768**	**22803.3128**	**247487.36**	**349126.0128**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)								
	N Landfill (Cont.)								Navy-Todd Dump
Sample Location:	**NL-29**	**NL-30**	**17C**	**17C**	**17C**	**NTD-1**	**NTD-1**	**NTD-1**	**NTD-2**
Sample ID:	***SE-011807-BS-NL-29-003***	***SE-011907-BS-NL-30-001***	***S-071312-KB-17C-001***	***S-071312-KB-17C-002***	***S-071412-KB-17C-004***	***S-112906-ILM-NTD1-001***	***S-011007-TS-NTD1-001***	***S-011007-TS-NTD1-002***	***S-112906-ILM-NTD2-001***
Sample Depth (ft BGS/BML):	***10 to 13***	***0 to 3***	***5***	***15.2***	***25.5***	***3 to 4***	***3 to 5***	***13 to 15***	***3 to 4.5***
PCB Congeners									
(PCB 20) 2,3,3'-Trichlorobiphenyl	999	272.26	12200	65100	3.91	896.00	3594.27	2699.87	2240.00
(PCB 31) 2,4',5-Trichlorobiphenyl	922	297.21	4840	51400	2.81	600.00	3347.89	5811.65	1400.00
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	134	56.17	11300	13000	1.64	3820.00	9854.88	7274.55	3590.00
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	1600	659.78	68100	219000	12.9	3960.00	10376.90	141045.46	12200.00
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	216	33.25	6430	10100	0.762	1260.00	956.25	3669.10	534.00
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	8.94	U	216	528	U	108.00	U	U	37.60
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl		250.51	23800	36400	3.03		10980.13	188182.56	
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl						5160.00			15700.00
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	628	183.97	13400	22800	2.24	5220.00	5003.37	121604.19	9550.00
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	47.3	U	648	1670	U	172.00	336.37	U	421.00
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	1720	396.78	25500	37300	4.36	7580.00	11829.03	251020.00	24000.00
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	147	U	841	1150	U	226.00	273.91	3026.55	477.00
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	2940	U	199	114	U	400.00	282.43	U	178.00
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	2010	409.33	36600	15300	3.99	89900.00	49573.40	868659.11	113000.00
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	487	122.13	12100	5010	1.24	26100.00	14660.89	194873.42	22900.00
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	1110	96.76	U	1600	1.19	12200.00	7671.84	U	14600.00
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	283	50.02	3090	1720	U	3480.00	2818.23	63687.30	5710.00
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	403	27.03	1190	518	U	2570.00	1784.41	31375.06	2540.00
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	56.6	U	U	U	U	593.00	43.34	U	507.00
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	791	115.63	14100	1740	1.06	116000.00	39506.43	641923.99	137000.00
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	2920	473.5	37400	5340	3	385000.00	177510.96	3116303.98	387000.00
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	707	74.82	13000	1490	0.843	104000.00	43785.31	U	147000.00
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	1390	1116.76	21300	4230	2.2	67700.00	348422.37	178495.02	237000.00
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	75.5	U	695	73.1	U	2680.00	968.88	20387.82	2180.00
Sum of Congeners	**19595.34**	**4635.91**	**306949**	**495583.1**	**45.175**	**839625.00**	**743581.49**	**5840039.63**	**1139764.60**
Ratio Method to Estimate Total PCBs based on 1260									
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**67407.9696**	**15947.5304**	**1055904.56**	**1704805.864**	**155.402**	**2888310**	**2557920.326**	**20089736.33**	**3920790.224**
Aroclor 1260 Factor									

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Sample Location:	NTD-2	NTD-2	NTD-2
Sample ID:	*S-112906-ILM-NTD2-002*	*S-112906-ILM-NTD2-003*	*S-121306-ILM-NTD2-006*
Sample Depth (ft BGS/BML):	*13 to 14.5*	*22.5 to 25*	*43 to 45*
PCB Congeners			
(PCB 20) 2,3,3'-Trichlorobiphenyl	1029.86	311.00	133.00
(PCB 31) 2,4',5-Trichlorobiphenyl	1946.62	317.00	144.00
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	1028.01	172.00	71.00
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	23010.20	2090.00	854.00
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	330.22	63.30	35.60
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	7.14	1.79
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	17696.21		
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl		2070.00	812.00
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	14074.56	1730.00	764.00
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	370.99	94.50	42.40
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	32871.23	3950.00	1860.00
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	2187.00	55.70	27.10
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	33.20	11.40
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	103725.13	11500.00	6020.00
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	21815.62	2390.00	94.10
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	10812.98	3810.00	1060.00
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	5389.84	718.00	353.00
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	1318.03	315.00	138.00
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	34.10	19.60
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	95996.52	11800.00	5770.00
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	688962.02	74400.00	29200.00
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	133530.05	19000.00	6200.00
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	1401388.21	47200.00	16600.00
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	1223.75	176.00	84.80
Sum of Congeners	**2558707.05**	**182236.94**	**70295.79**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**8801952.252**	**626895.0736**	**241817.5176**
Aroclor 1260 Factor			

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	Navy-Todd Dump				Pier 25A			
Sample Location:	**NTD-2**	**NTD-2**	**NTD-2**	**NTD-2**	**Pier 25A**	**Pier 25A**	**Pier 25A**	**Pier 25B**
Sample ID:	***S-121306-ILM-NTD2-007***	***S-121306-ILM-NTD2-008***	***S-121306-ILM-NTD2-009***	***S-121406-ILM-NTD2-010***	***SE-013007-BI-PIER25A-001***	***SE-013007-BI-PIER25A-002***	***SE-013007-BI-PIER25A-003***	***SE-013007-BI-PIER25B-001***
Sample Depth (ft BGS/BML):	***43 to 45***	***53 to 55***	***63 to 65***	***73 to 75***	***0 to 0.33***	***0 to 3***	***3.3 to 5***	***0 to 0.33***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	160.00	181.00	1120.00	U	3597.74	9250.43	7426.32	7682.25
(PCB 31) 2,4',5-Trichlorobiphenyl	194.00	206.00	1240.00	116.01	2386.97	8126.91	5557.08	5730.22
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	77.30	99.00	347.00	53.87	3286.21	5254.21	2824.3	2834.59
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	1370.00	1710.00	24600.00	1340.50	17211.53	35560.65	15326.58	41775.52
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	33.90	50.10	78.80	24.65	1336.17	2362.39	1410.06	2344.82
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	1.97	3.00	U	U	JU	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl				949.64	36723.13	53321.47	12421.85	18193.95
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl	U	1500.00	21500.00					
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1020.00	1550.00	24100.00	733.39	21388.68	48277.99	14272.32	20107.36
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	57.50	90.60	1230.00	56.53	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	2380.00	3700.00	56700.00	1993.17	72404.37	133858.08	44205.67	57557.88
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	42.20	58.50	665.00	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	12.00	17.30	U	U	1669	2109.75	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	8120.00	11700.00	375000.00	4790.14	287465.29	362104.26	128035.68	131139.48
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	1550.00	2400.00	64400.00	1432.39	105684.46	121935.85	48103.14	57390.53
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	1230.00	2030.00	41200.00	643.85	22613.45	24310.56	8945.74	13844.66
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	471.00	739.00	15500.00	332.03	19937.79	35631.18	10304.95	13851.68
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	174.00	275.00	4380.00	79.64	10981.61	17047.03	5455.24	5313.18
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	32.50	42.70	4720.00	U	1183.28	1653.39	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	9340.00	12900.00	610000.00	6422.14	149113.28	157800.82	60385.1	U
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	49200.00	64000.00	3290000.00	34464.83	372872.51	380788	156670.7	143103.11
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	9690.00	13000.00	438000.00	6254.31	67310.98	71424.38	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	26500.00	34700.00	1660000.00	60721.24	476555.71	437016.49	163549.89	185808.7
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	116.00	171.00	6090.00	79.38	4251.41	6800.19	2607.54	2618.13
Sum of Congeners	**111772.37**	**151123.20**	**6640870.80**	**120487.71**	**1677973.57**	**1914634.03**	**687502.16**	**709296.06**
Ratio Method to Estimate Total PCBs based on 1260								
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**384496.9528**	**519863.808**	**22844595.55**	**414477.7224**	**5772229.081**	**6586341.063**	**2365007.43**	**2439978.446**
Aroclor 1260 Factor								

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	Pier 25A (Cont.)							
Sample Location:	**Pier 25B**	**Pier 25B**	**Pier 25C**	**Pier 25C**	**Pier 25C**	**Pier 25D**	**Pier 25D**	**Pier 25D**
Sample ID:	***SE-013007-BI-PIER25B-002***	***SE-013007-BI-PIER25B-003***	***SE-013107-BI-PIER25C-001***	***SE-013107-BI-PIER25C-002***	***SE-013107-BI-PIER25C-003***	***SE-013107-BI-PIER25D-001***	***SE-013107-BI-PIER25D-002***	***SE-013107-BI-PIER25D-003***
Sample Depth (ft BGS/BML):	***2 to 3.5***	***2 to 3.5***	***0 to 0.33***	***0 to 2***	***2 to 3.5***	***0 to 0.33***	***0.5 to 2***	***2- 3.5***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	638.96	771.32	443.09	1569.06	1137.88	95441.1	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	626.13	732.31	457.33	1674.93	876.72	85725.72	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	102.42	131.41	213.21	417.71	607.65	24338.37	59.34	28.18
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	1803.79	1870.73	920.78	1855.64	3151.3	184566.59	522.33	107.25
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	50.74	79.88	150.48	233.86	364.46	13560.61	119.58	22.75
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	652.27	1335.03	1818.53	1977.99	4753.07	35597.69	808.17	188.19
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1194.26	1507.89	1081.9	1330.24	3022.89	33606.18	862.86	88.44
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	51.97	U	U	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	3271.61	4024.27	4390.19	5130.63	14283.41	146168.51	6865.05	784.4
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	212.4	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	35.78	60.54	295.44	217.62	U	11228.88	311.37	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	7575.05	9040.42	70078.82	32052.92	140477.94	1420471.52	72419.05	9667.16
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	3598.6	4155.78	24760.48	12527.79	51024.12	650793.96	32070.42	3919.35
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	739.51	816.29	5574.65	2617.2	12340.03	142489.39	7437.23	880.33
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	687.01	843.72	3776.61	1696.3	8556.39	92656.13	4653.64	492.27
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	227.07	312.73	2534.6	1212.44	4651.14	48404.21	2358.1	308.77
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	14.66	235.48	153.39	424.88	10362.72	159.07	33.11
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	2575.44	3015.23	45134.26	16522.01	77037.81	782777.45	29854.03	4822.79
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	6178.35	7224.97	95521.66	35654.87	162874.48	1524977.22	59559.31	10516.04
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	1036.82	1494.02	13180.44	5157.28	28078.12	355428.72	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	8562.11	9028.24	102739.87	44690.73	197888.42	1860581.92	85295.37	13210.76
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	87.35	104	1640.75	531.4	2641.31	34644.87	1186.77	168.37
Sum of Congeners	**39907.64**	**46563.44**	**374948.57**	**167224.01**	**714192.02**	**7553821.76**	**304541.69**	**45238.16**
Ratio Method to Estimate Total PCBs based on 1260								
Total PCBs (estimated using ratio of 209 congener/ 24 selected congener)	**137282.2816**	**160178.2336**	**1289823.081**	**575250.5944**	**2456820.549**	**25985146.85**	**1047623.414**	**155619.2704**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	Area 5106							
Sample Location:	**PT-13A**	**PT-13A**	**PT-15A**	**PT-15A**	**PT-15A**	**PT-15B**	**PT-15B**	**PT-15B**
Sample ID:	***SE-110905-PT-13A-001***	***SE-110905-PT-13A-002***	***SE-110905-FD-001***	***SE-110905-NR-PT-15A-001***	***SE-110905-NR-PT-15A-002***	***S-122006-PT-15B-DR-001***	***S-122006-PT-15B-DR-002***	***S-122006-PT-15B-DR-003***
Sample Depth (ft BGS/BML):	***11.8 to 13.8***	***21.8 to 23.8***	***56 to 57***	***56 to 57***	***66 to 67***	***13 to 15***	***18 to 20***	***28 to 30***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl						21617.51	4502.96	5490.37
(PCB 31) 2,4',5-Trichlorobiphenyl						31482.29	5557.48	7214.36
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl						7024.99	999.53	1265.82
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl						105526.97	15713.43	17008.31
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	486.177	26.587	2279.984	512.819	840.365	3804.77	485.32	556.56
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl						U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl						20345.17	2858.59	3060.07
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	1558.917	71.932	12422.335	3491.695	4375.754	23927.04	3608.06	3919.29
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	98.084	U	605.924	163.072	174.229	1022.15	186.81	159.44
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	2901.399	129.436	25564.858	7897.087	9165.601	43924.07	7451.73	9443.05
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	133.68	U	293.401	155.866	134.783	717.11	147.74	131.62
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl						33851.62	13201.61	20397.76
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl						22123.18	6030.56	7757.89
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl						7308.85	2101.91	2742.40
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	1616.579	29.226	5273.162	1655.325	1841.931	6898.85	1474.45	1684.43
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	457.957	8.392	2636.413	811.451	937.819	3096.10	641.41	897.27
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	1152.907	370.3	497.843	3308.64	484.13	552.52
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	3928.823	154.781	57297.949	17116.507	102559.455	51368.76	11353.83	10186.86
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	25026.49	805.067	96606312.34	80463.228	84761.315	236106.79	54863.20	50657.02
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl						33882.43	6164.43	5541.55
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl						305998.21	71799.23	54198.73
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	1627.636	395.754	412.644	1369.62	295.90	418.08
Sum of Congeners	**36208.11**	**1225.42**	**96715466.91**	**113033.10**	**205701.74**	**964705.12**	**209922.31**	**203283.40**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**124555.8846**	**4215.44824**	**332701206.2**	**388833.8778**	**707613.9822**	**3318585.613**	**722132.7464**	**699294.896**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	Area 5106 (Cont.)				Waste Management Unit A			
Sample Location:	**PT-15B**	**PT-17A**	**PT-17A**	**PT-17A**	**WMUA-11**	**WMUA-14**	**WMUA-15**	**WMUA-20**
Sample ID:	***S-122106-PT-15B-DR-004***	***SE-020107-ILM-PT-17A-001***	***SE-020107-ILM-PT-17A-002***	***SE-020107-ILM-PT-17A-003***	***S-080206-LH-WMUA11-001***	***S-080806-LH-WMUA14-001***	***S-080706-LH-WMUA15-001***	***S-071706-LH-WMUA20-003***
Sample Depth (ft BGS/BML):	***38 to 40***	***0.5 to 2.5***	***10 to 12***	***10 to 12***	***17 to 19***	***18 to 20***	***14 to 16***	***15 to 17***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	6146.00	1725421.59	55167.95	17588.27	U	U	U	U
(PCB 31) 2,4',5-Trichlorobiphenyl	8307.11	1312509.25	73280.33	20603.53	U	U	U	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	1860.55	249865.19	8196.71	4473.94	U	U	U	U
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	24207.02	2113443.42	113244.42	43673.98	U	38.98	U	U
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	796.93	116877.28	5227.01	1068.2	U	U	20.93	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	11630.01	445.95	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	3814.21	218671.75	11325.75	4337.18	U	U	U	U
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	5452.04	351987.16	21648.81	7252.45	U	U	U	U
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	314.58	29422.36	1267.16	430.68	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	12522.74	548140.28	36796.89	13815.33	U	24.83	U	U
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	61917.09	U	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	260.19	3343.66	229.88	101.18	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	21303.78	547634.15	34929.59	12767.97	U	53.34	U	U
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	10588.46	149637.39	8143.26	3426.51	U	27.88	U	U
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	3469.95	46561.81	3015.48	1035.04	U	U	U	U
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	2469.05	54592.32	3164.52	1072.48	U	U	55.09	U
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	1314.39	23888.67	1280.36	428.33	U	U	U	U
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	849.05	47804.65	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	15282.67	174452.84	12390.62	3985.24	U	U	U	U
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	72270.29	833300.99	55911.08	18522.66	U	54.94	U	U
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	7387.51	53147.7	3828.37	U	U	U	U	U
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	107086.73	1213209.73	63790.42	22786.18	U	77.54	U	U
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	561.68	5840.57	354.14	159.18	U	U	U	U
Sum of Congeners	**306264.93**	**9893299.86**	**513638.70**	**177528.33**	**0.00**	**277.51**	**76.02**	**0.00**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**1053551.359**	**34032951.52**	**1766917.128**	**610697.4552**	**0**	**954.6344**	**261.5088**	**0**
Aroclor 1260 Factor								

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

	SEDIMENT/SOIL (ng/kg) (Cont.)							
	Waste Management Unit A (Cont.)							
Sample Location:	**WMUA-26**	**WMUA-26**	**WMUA-31**	**WMUA-31**	**WMUA-32**	**WMUA-32**	**709-BH04**	**709-BH04**
Sample ID:	***S-071306-DR-WMUA26-005***	***S-071306-DR-WMUA26-008***	***S-081506-BG-WMUA31-059***	***S-081506-BG-WMUA31-063***	***S-020107-ILM-WMUA32-101***	***S-081706-BG-WMUA32-104***	***S-051612-NE-709BH04-001***	***S-051612-NE-709BH04-002***
Sample Depth (ft BGS/BML):	***23 to 25***	***51 to 53***	***25 to 27***	***55 to 57***	***17 to 20***	***55 to 57***	***1.5 to 2.5***	***6.5 to 7.5***
PCB Congeners								
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	U	232.58	U	53.6	U
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	228.96	U	69.3	U
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	1.96	U	1.53	U	35.43	U	159	3.25
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	U	U	U	475.97	U	4650	35.1
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	U	U	U	45.11	U	323	U
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U	U	35	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	U	U	U	U	54.56	U	23000	53.6
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl								
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	U	U	U	U	81.86	U	7040	18.8
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	274	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	149.91	U	20000	42.3
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	1060	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U	U	309	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	U	U	U	U	77.80	U	122000	74.6
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	U	U	U	U	50.59	U	55000	29.7
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	U	U	U	U	27.62	U	16900	10.5
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	U	U	U	U	58.09	U	9490	7.42
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U	U	5620	3.26
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	4.07	U	U	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	U	U	U	U	43.53	U	13900	21.2
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	125.50	U	19800	62.1
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	U	U	3.14	3.26	133.32	5.19	6490	23.7
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	U	U	U	U	54.72	U	8560	41.3
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	U	U	U	U	U	654	U
Sum of Congeners	**6.03**	**0.00**	**4.67**	**3.26**	**1875.55**	**5.19**	**315386.90**	**426.83**
Ratio Method to Estimate Total PCBs based on 1260 Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**20.7432**	**0**	**16.0648**	**11.2144**	**6451.892**	**17.8536**	**1084930.936**	**1468.2952**
Aroclor 1260 Factor								

TABLE Q.3

CALCULATION OF TOTAL PCBS FROM CONGENER DATA
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Sample Location:	709-BH05	721-BH13	721-BH14	721-BH14	721-BH16
Sample ID:	*S-051712-NE-709BH05-001*	*S-052112-NE-721BH13-001*	*S-052012-NE-721BH14-001*	*FD-052012-NE-721BH14-001*	*S-052012-NE-721BH16-001*
Sample Depth (ft BGS/BML):	*4 to 5*	*4 to 5*	*2 to 3*	*2 to 3*	*0.25 to 1.25*
PCB Congeners					
(PCB 20) 2,3,3'-Trichlorobiphenyl	U	U	U	U	4.71
(PCB 31) 2,4',5-Trichlorobiphenyl	U	U	U	U	3.64
(PCB 50) 2,2',4,6-Tetrachlorobiphenyl	1.94	2.58	U	U	0.717
(PCB 70) 2,3',4',5-Tetrachlorobiphenyl	U	61.6	U	U	14.7
(PCB 77) 3,3',4,4'-Tetrachlorobiphenyl	U	6.97	U	U	2.68
(PCB 81) 3,4,4',5-Tetrachlorobiphenyl	U	U	U	U	U
(PCB 83) 2,2',3,3',5-Pentachlorobiphenyl	18.8	102	U	U	8.84
(PCB 99) 2,2',4,4',5-Pentachlorobiphenyl					
(PCB 105) 2,3,3',4,4'-Pentachlorobiphenyl	5.26	39.1	U	U	10.3
(PCB 114) 2,3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 118) 2,3',4,4',5-Pentachlorobiphenyl	U	97.9	U	U	21.9
(PCB 123) 2',3,4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 126) 3,3',4,4',5-Pentachlorobiphenyl	U	U	U	U	U
(PCB 129) 2,2',3,3',4,5-Hexachlorobiphenyl	25.6	400	U	U	68.6
(PCB 132) 2,2',3,3',4,6'-Hexachlorobiphenyl	10.7	205	U	U	40.5
(PCB 146) 2,2',3,4',5,5'-Hexachlorobiphenyl	4.62	89.3	U	U	10.4
(PCB 156) 2,3,3',4,4',5-Hexachlorobiphenyl	3.01	27	U	U	4.98
(PCB 167) 2,3',4,4',5,5'-Hexachlorobiphenyl	U	22.2	U	U	2.62
(PCB 169) 3,3',4,4',5,5'-Hexachlorobiphenyl	U	U	U	U	U
(PCB 170) 2,2',3,3',4,4',5-Heptachlorobiphenyl	5.05	112	U	U	34.9
(PCB 180) 2,2',3,4,4',5,5'-Heptachlorobiphenyl	10.8	452	U	U	83.8
(PCB 183) 2,2',3,4,4',5',6-Heptachlorobiphenyl	5.41	183	U	U	31.9
(PCB 187) 2,2',3,4',5,5',6-Heptachlorobiphenyl	8.59	381	U	U	67.2
(PCB 189) 2,3,3',4,4',5,5'-Heptachlorobiphenyl	U	4.88	U	U	1.75
Sum of Congeners	**99.78**	**2186.53**	**0.00**	**0.00**	**414.14**
Ratio Method to Estimate Total PCBs based on 1260					
Total PCBs (estimated using ratio of 209 congener/24 selected congener)	**343.2432**	**7521.6632**	**0**	**0**	**1424.63128**
Aroclor 1260 Factor					

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***4-25R***
Sample ID:	***GW-011706-TS-4-25R***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7***
Sample Elevation (feet NGVD):	***-13.3***
Sample Date:	***1/17/2006***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.504	U	-	0.252
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.564	U	-	0.282
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.939	U	-	0.047
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.969	U	-	0.048
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.966	U	-	0.048
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.048	U	-	0.005
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	1.583	U	-	0.000
			TEC Dioxins			**0.000**	0.683 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.672	U	-	0.034
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.536	U	-	0.008
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.513	U	-	0.077
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.522	U	-	0.026
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.614	U	-	0.031
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.695	U	-	0.035
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.59	U	-	0.030
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.82	U	-	0.004
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.121	U	-	0.006
Octachlorodibenzofuran	pg/l	NV	0.0003	1.373	U	-	0.000
			TEC Furans			**0.000**	0.250 **pg/l**
			Total TEC Dioxin/Furan			0.000	0.933 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***14-25R***
Sample ID:	***GW-122005-14-25R-001***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7***
Sample Elevation (feet NGVD):	***-13.3***
Sample Date:	***12/20/2005***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.22	U	-	0.110	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.399	U	-	0.200	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.364	U	-	0.018	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.395	U	-	0.020	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.381	U	-	0.019	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.254	U	-	0.001	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	0.654	U	-	0.000	
			TEC Dioxins			**0.000**	0.368	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.31	U	-	0.016	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.227	U	-	0.003	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.253	U	-	0.038	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.244	U	-	0.012	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.251	U	-	0.013	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.283	U	-	0.014	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.247	U	-	0.012	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.272	U	-	0.001	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.376	U	-	0.002	
Octachlorodibenzofuran	pg/l	NV	0.0003	0.561	U	-	0.000	
			TEC Furans			**0.000**	0.111	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.479	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Upland Monitoring Wells***									
Sample Location:				***14-50R***									
Sample ID:				***GW-122005-14-50R-002***		***GW-122005-14-50R-003***							
Nominal Sample Depth (feet BGS):				***50***		***50***		***50***					
Sample Depth (feet BML):				***NA***		***NA***		***NA***					
Sample Elevation (feet MLLW):				***-32***		***-32***		***-32***					
Sample Elevation (feet NGVD):				***-38.32***		***-38.32***		***-38.32***					
Sample Date:				***12/20/2005***		***12/20/2005 duplicate***		***average***					
		Cleanup Level	***TEF*** [1]							***TEC***			
										ND = 0 [2]		***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)													
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.131	U	0.134	U	0.133	U	-		0.066	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.337	U	0.458	U	0.398	U	-		0.199	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.472	U	0.422	U	0.447	U	-		0.022	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.493	U	0.433	U	0.463	U	-		0.023	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.482	U	0.429	U	0.456	U	-		0.023	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.214	U	4.55	U	2.382	U	-		0.012	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	31.3	J	37.9	J	34.600	J	0.010		0.010	
			TEC Dioxins							**0.010**		0.355	**pg/l**
Furans (Field Filtered)													
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.18	U	0.313	U	0.247	U	-		0.012	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.165	U	0.211	U	0.188	U	-		0.003	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.17	U	0.216	U	0.193	U	-		0.029	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.196	U	0.218	U	0.207	U	-		0.010	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.215	U	0.23	U	0.223	U	-		0.011	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.273	U	0.299	U	0.286	U	-		0.014	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.216	U	0.227	U	0.222	U	-		0.011	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.327	J	1.301	J	1.314	J	0.010		0.010	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.315	U	0.33	U	0.323	U	-		0.002	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.122	J	2.395	J	2.259	J	0.001		0.001	
			TEC Furans							**0.011**		0.104	**pg/l**
			Total TEC Dioxin/Furan							0.021		0.459	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***21-25R***
Sample ID:	***GW-011706-TS-21-25R***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7***
Sample Elevation (feet NGVD):	***-13.3***
Sample Date:	***1/17/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.59	U	-	0.295	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	6.621	U	-	3.311	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	9.384	U	-	0.469	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	10.094	U	-	0.505	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	9.88	U	-	0.494	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	11.71	U	-	0.059	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	4.969	U	-	0.001	
			TEC Dioxins			**0.000**	5.133	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	13.604	U	-	0.680	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	8.799	J	0.26397	0.264	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	34.613	J	10.3839	10.384	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	30.15	J	3.015	3.015	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	5.091	U	-	0.255	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	6.226	U	-	0.311	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	5.117	U	-	0.256	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	83.237	J	0.83237	0.832	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	14.953	J	0.14953	0.150	
Octachlorodibenzofuran	pg/l	NV	0.0003	1008.536		0.30256	0.303	
			TEC Furans			**14.947**	16.449	**pg/l**
			Total TEC Dioxin/Furan			14.947	21.582	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***53-50***
Sample ID:	***GW-011706-TS-53-50***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32***
Sample Elevation (feet NGVD):	***-38.32***
Sample Date:	***1/17/2006***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.413	U	-	0.207	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.659	U	-	0.330	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.815	U	-	0.041	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.866	U	-	0.043	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.853	U	-	0.043	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.697	U	-	0.003	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	1.918	U	-	0.000	
			TEC Dioxins			**0.000**	0.666	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.626	U	-	0.031	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.573	U	-	0.009	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.546	U	-	0.082	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.53	U	-	0.027	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.629	U	-	0.031	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.748	U	-	0.037	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.622	U	-	0.031	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.931	U	-	0.005	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.353	U	-	0.007	
Octachlorodibenzofuran	pg/l	NV	0.0003	1.244	U	-	0.000	
			TEC Furans			**0.000**	0.260	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.926	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-A***
Sample ID:	***GW-013007-MM-EWB-A-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.462	U	-	0.231	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.423	U	-	0.212	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.002	U	-	0.050	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.153	U	-	0.058	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.094	U	-	0.055	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.299	U	-	0.006	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	3.208	U	-	0.000	
			TEC Dioxins			**0.000**	0.612	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.360	U	-	0.018	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.396	U	-	0.006	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.375	U	-	0.056	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.518	U	-	0.026	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.572	U	-	0.029	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.731	U	-	0.037	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.588	U	-	0.029	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.379	U	-	0.007	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.738	U	-	0.009	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.789	U	-	0.000	
			TEC Furans			**0.000**	0.217	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.829	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-A***
Sample ID:	***GW-013007-MM-EWB-A-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.467	U	-	0.234	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.382	U	-	0.191	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.416	U	-	0.021	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.430	U	-	0.022	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.425	U	-	0.021	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.912		0.019	0.019	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	1.680	U	-	0.000	
			TEC Dioxins			**0.019**	0.507	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.513	U	-	0.026	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.202	U	-	0.003	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.207	U	-	0.031	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.310	U	-	0.016	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.369	U	-	0.018	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.423	U	-	0.021	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.370	U	-	0.019	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.499	U	-	0.002	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.573	U	-	0.003	
Octachlorodibenzofuran	pg/l	NV	0.0003	1.438	U	-	0.000	
			TEC Furans			**0.000**	0.139	**pg/l**
			Total TEC Dioxin/Furan			0.019	0.646	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-B***
Sample ID:	***GW-013007-MM-EWB-B-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.290	U	-	0.145	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.495	U	-	0.248	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.775	U	-	0.039	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.875	U	-	0.044	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.838	U	-	0.042	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.788	U	-	0.004	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	3.515	U	-	0.001	
			TEC Dioxins			**0.000**	0.521	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.454	U	-	0.023	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.304	U	-	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.297	U	-	0.045	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.344	U	-	0.017	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.397	U	-	0.020	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.539	U	-	0.027	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.404	U	-	0.020	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.737	U	-	0.004	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.093	U	-	0.005	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.500	U	-	0.000	
			TEC Furans			**0.000**	0.166	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.687	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-B***
Sample ID:	***GW-013007-MM-EWB-B-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.366	U	-	0.183	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.970	U	-	0.485	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.785	U	-	0.039	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.882	U	-	0.044	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.846	U	-	0.042	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.939	U	-	0.005	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	7.066	U	-	0.001	
			TEC Dioxins			**0.000**	0.799	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.398	U	-	0.020	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.348	U	-	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.338	U	-	0.051	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.461	U	-	0.023	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.532	U	-	0.027	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.748	U	-	0.037	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.554	U	-	0.028	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.498	U	-	0.007	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	2.141	U	-	0.011	
Octachlorodibenzofuran	pg/l	NV	0.0003	3.741	U	-	0.001	
			TEC Furans			**0.000**	0.209	**pg/l**
			Total TEC Dioxin/Furan			0.000	1.009	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-C***
Sample ID:	***GW-013007-MM-EWB-C-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.526	U	-	0.263	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.517	U	-	0.259	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.682	U	-	0.034	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.743	U	-	0.037	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.723	U	-	0.036	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.896	U	-	0.004	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	3.713	U	-	0.001	
			TEC Dioxins			**0.000**	0.634	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.347	U	-	0.017	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.313	U	-	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.305	U	-	0.046	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.432	U	-	0.022	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.500	U	-	0.025	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.749	U	-	0.037	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.532	U	-	0.027	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.944	U	-	0.005	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.485	U	-	0.007	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.774	U	-	0.000	
			TEC Furans			**0.000**	0.191	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.825	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-C***
Sample ID:	***GW-013007-MM-EWB-C-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.439	U	-	0.220	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.534	U	-	0.267	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.767	U	-	0.038	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.861	U	-	0.043	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.827	U	-	0.041	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.705	U	-	0.004	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	2.911	U	-	0.000	
			TEC Dioxins			**0.000**	0.613	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.479	U	-	0.024	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.319	U	-	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.316	U	-	0.047	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.510	U	-	0.026	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.579	U	-	0.029	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.842	U	-	0.042	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.622	U	-	0.031	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.173	U	-	0.006	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.726	U	-	0.009	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.813	U	-	0.000	
			TEC Furans			**0.000**	0.219	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.832	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-D***
Sample ID:	***GW-013007-MM-EWB-D-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.476	U	-	0.238	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.720	U	-	0.360	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.692	U	-	0.035	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.773	U	-	0.039	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.744	U	-	0.037	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.052	U	-	0.005	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	4.362	U	-	0.001	
			TEC Dioxins			**0.000**	0.714	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.465	U	-	0.023	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.435	U	-	0.007	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.420	U	-	0.063	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.428	U	-	0.021	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.485	U	-	0.024	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.647	U	-	0.032	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.521	U	-	0.026	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.113	U	-	0.006	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.572	U	-	0.008	
Octachlorodibenzofuran	pg/l	NV	0.0003	3.421	U	-	0.001	
			TEC Furans			**0.000**	0.211	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.925	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Extraction Well Branches***
Sample Location:	***EWB-D***
Sample ID:	***GW-013007-MM-EWB-D-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.449	U	-	0.225	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.658	U	-	0.329	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.726	U	-	0.036	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.826	U	-	0.041	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.788	U	-	0.039	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.633	U	-	0.003	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	3.513	U	-	0.001	
			TEC Dioxins			**0.000**	0.674	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.306	U	-	0.015	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.196	U	-	0.003	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.187	U	-	0.028	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.387	U	-	0.019	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.440	U	-	0.022	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.666	U	-	0.033	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.460	U	-	0.023	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.997	U	-	0.005	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.576	U	-	0.008	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.806	U	-	0.000	
			TEC Furans			**0.000**	0.157	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.831	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Hylebos Waterway***						
Sample Location:				***HW-1***						
Sample ID:				***GW-012407-BS-HW-1-001***		***GW-012407-BS-HW-1-002***				
Nominal Sample Depth (feet BGS):				***NA***		***NA***		***NA***		
Sample Depth (feet BML):				***0.5 to 2.5***		***0.5 to 2.5***		***0.5 to 2.5***		
Sample Elevation (feet MLLW):				***-42.8 to -44.8***		***-42.8 to -44.8***		***-42.8 to -44.8***		
Sample Elevation (feet NGVD):				***-49.12 to -51.12***		***-49.12 to -51.12***		***-49.12 to -51.12***		
Sample Date:				***1/24/2007***		***1/24/2007 duplicate***		***1/24/2007 average***		
		Cleanup Level	***TEF [1]***						***TEC***	
									ND = 0 [2]	***ND = 0.5xDL [3]***
Dioxins (Field Filtered)										
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	3.532	U	1.869	U	2.7005	U	- 1.350
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	2.997	U	1.857	U	2.427	U	- 1.214
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	2.769	U	1.767	U	2.268	U	- 0.113
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.284	U	2.06	U	2.672	U	- 0.134
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.04	U	1.922	U	2.481	U	- 0.124
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	3.051	U	4.606	U	3.8285	U	- 0.019
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	5.424	U	3.431	U	4.4275	U	- 0.001
			TEC Dioxins						**0.000**	2.955 **pg/l**
Furans (Field Filtered)										
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	3.351	U	1.636	U	2.4935	U	- 0.125
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	2.136	U	1.008	U	1.572	U	- 0.024
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	2.186	U	1.041	U	1.6135	U	- 0.242
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	1.843	U	1.812	J	1.36675	J	0.137 0.137
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	2.212	U	1.529	J	1.3175	J	0.132 0.132
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	2.277	U	1.001	U	1.639	U	- 0.082
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	2.238	U	0.926	U	1.582	U	- 0.079
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	4.005	J	4.745	J	4.375	J	0.044 0.044
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	2.275	U	1.422	U	1.8485	U	- 0.009
Octachlorodibenzofuran	pg/l	NV	0.0003	23.16	J	26.381	J	24.7705	J	0.007 0.007
			TEC Furans						**0.320**	0.880 **pg/l**
			Total TEC Dioxin/Furan						0.320	3.835 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-2***
Sample ID:	***GW-012507-BS-HW-2-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***2.5 to 4.5***
Sample Elevation (feet MLLW):	***-44.4 to -46.4***
Sample Elevation (feet NGVD):	***-50.72 to -52.72***
Sample Date:	***1/25/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	1.14	U	-	0.570	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	1.049	U	-	0.525	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.091	U	-	0.055	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.265	U	-	0.063	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.184	U	-	0.059	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.15	U	-	0.006	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	2.424	U	-	0.000	
			TEC Dioxins			**0.000**	1.278	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	1.134	U	-	0.057	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.797	U	-	0.012	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.809	U	-	0.121	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.625	U	-	0.031	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.756	U	-	0.038	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.757	U	-	0.038	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.732	U	-	0.037	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.796	U	-	0.004	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.955	U	-	0.005	
Octachlorodibenzofuran	pg/l	NV	0.0003	2.189	U	-	0.000	
			TEC Furans			**0.000**	0.343	**pg/l**
			Total TEC Dioxin/Furan			0.000	1.620	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-3***
Sample ID:	***GW-012207-BS-HW-3-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***9 to 11***
Sample Elevation (feet MLLW):	***-45.8 to -47.8***
Sample Elevation (feet NGVD):	***-52.12 to -54.12***
Sample Date:	***1/22/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.302	U	-	0.151	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.456	U	-	0.228	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.009	U	-	0.050	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.106	U	-	0.055	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.073	U	-	0.054	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	1.027	U	-	0.005	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	1.763	U	-	0.000	
			TEC Dioxins			**0.000**	0.544	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.361	U	-	0.018	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.333	U	-	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.352	U	-	0.053	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.326	U	-	0.016	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.384	U	-	0.019	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.504	U	-	0.025	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.419	U	-	0.021	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	0.894	U	-	0.004	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.401	U	-	0.007	
Octachlorodibenzofuran	pg/l	NV	0.0003	1.307	U	-	0.000	
			TEC Furans			**0.000**	0.169	**pg/l**
			Total TEC Dioxin/Furan			0.000	0.713	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-4***
Sample ID:	***GW-012307-BS-HW-4-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***9 to 11***
Sample Elevation (feet MLLW):	***-45 to -47***
Sample Elevation (feet NGVD):	***-51.32 to -53.32***
Sample Date:	***1/23/2007***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	204.08	U	-	102.040
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	204.08	U	-	102.040
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	204.08	U	-	10.204
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	102.04	U	-	5.102
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	102.04	U	-	5.102
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	102.04	U	-	0.510
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	204.08	U	-	0.031
			TEC Dioxins			**0.000**	225.029 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	20.408	U	-	1.020
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	102.04	U	-	1.531
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	102.04	U	-	15.306
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	4.36	J	0.436	0.436
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	102.04	U	-	5.102
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	102.04	U	-	5.102
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	102.04	U	-	5.102
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	6.64	J	0.066	0.066
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	102.04	U	-	0.510
Octachlorodibenzofuran	pg/l	NV	0.0003	17.89	J	0.005	0.005
			TEC Furans			**0.508**	34.181 **pg/l**
			Total TEC Dioxin/Furan			0.508	259.210 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***GW-121406-ILM-NTD2-010***
Nominal Sample Depth (feet BGS):	***73 to 75***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-55 to -57***
Sample Elevation (feet NGVD):	***-61.3 to -63.3***
Sample Date:	***12/14/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.878	U	-	0.439	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	2.017	U	-	1.009	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.574	U	-	0.079	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.672	U	-	0.084	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	1.646	U	-	0.082	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	27.324	J	0.273	0.273	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	214.755	J	0.064	0.064	
			TEC Dioxins			**0.338**	2.030	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	16.478	U	-	0.824	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	5.508	J	0.165	0.165	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	12.906	J	3.872	3.872	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	8.862	J	0.886	0.886	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	4.339	J	0.434	0.434	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	1.576	U	-	0.079	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	7.143	J	0.714	0.714	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	12.785	J	0.128	0.128	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.808	U	-	0.009	
Octachlorodibenzofuran	pg/l	NV	0.0003	20.75	J	0.006	0.006	
			TEC Furans			**6.206**	7.117	**pg/l**
			Total TEC Dioxin/Furan			6.543	9.147	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***P-A018***
Sample Location:	***P-A18***
Sample ID:	***P-013007-MM-A18-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***NA***
Sample Elevation (feet NGVD):	***NA***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	18.518	U	-	9.259	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	92.592	U	-	46.296	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	92.592	U	-	0.463	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	185.18	U	-	0.028	
			TEC Dioxins			**0.000**	69.935	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	18.518	U	-	0.926	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	92.592	U	-	1.389	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	92.592	U	-	13.889	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	92.592	U	-	4.630	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	92.592	U	-	4.630	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	92.592	U	-	0.463	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	92.592	U	-	0.463	
Octachlorodibenzofuran	pg/l	NV	0.0003	185.18	U	-	0.028	
			TEC Furans			**0.000**	35.676	**pg/l**
			Total TEC Dioxin/Furan			0.000	105.610	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-13A***
Sample ID:	***GW-110905-PT-13A-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***11.8 to 14.8***
Sample Elevation (feet MLLW):	***-31.9 to -34.9***
Sample Elevation (feet NGVD):	***-38.22 to -41.22***
Sample Date:	***11/9/2005***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	20	U	-	10.000	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	20	U	-	10.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	20	U	-	1.000	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	-	5.000	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	20	U	-	1.000	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	20	U	-	0.100	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	200	U	-	0.030	
			TEC Dioxins			**0.000**	27.130	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	20	U	-	1.000	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	100	U	-	1.500	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	100	U	-	15.000	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	-	5.000	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	-	5.000	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	-	5.000	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	-	5.000	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	100	U	-	0.500	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	100	U	-	0.500	
Octachlorodibenzofuran	pg/l	NV	0.0003	200	U	-	0.030	
			TEC Furans			**0.000**	38.530	**pg/l**
			Total TEC Dioxin/Furan			0.000	65.660	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-13A***
Sample ID:	***GW-110905-PT-13A-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***21.8 to 24.8***
Sample Elevation (feet MLLW):	***-41.9 to -44.9***
Sample Elevation (feet NGVD):	***-48.22 to -51.22***
Sample Date:	***11/9/2005***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	9.389	U	-	4.695	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	46.948	U	-	23.474	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	46.948	U	-	2.347	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	46.948	U	-	2.347	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	46.948	U	-	2.347	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	46.948	U	-	0.235	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	93.896	U	-	0.014	
			TEC Dioxins			**0.000**	35.460	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	9.389	U	-	0.469	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	46.896	U	-	0.703	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	46.896	U	-	7.034	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	46.896	U	-	2.345	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	46.896	U	-	2.345	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	46.896	U	-	2.345	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	46.896	U	-	2.345	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	46.896	U	-	0.234	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	46.896	U	-	0.234	
Octachlorodibenzofuran	pg/l	NV	0.0003	93.896	U	-	0.014	
			TEC Furans			**0.000**	18.070	**pg/l**
			Total TEC Dioxin/Furan			0.000	53.529	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

											TEC	
											ND = 0 [2]	ND = 0.5xDL [3]
Investigative Area:				***Area 5106***								
Sample Location:				***PT-15A***								
Sample ID:				***GW-110905-PT-15A-001***		***GW-110905-FD-001***						
Nominal Sample Depth (feet BGS):				***NA***		***NA***		***NA***				
Sample Depth (feet BML):				***56 to 57***		***56 to 57***		***56 to 57***				
Sample Elevation (feet MLLW):				***-94 to -95***		***-94 to -95***		***-94 to -95***				
Sample Elevation (feet NGVD):				***-100.32 to -101.32***		***-100.32 to -101.32***		***-100.32 to -101.32***				
Sample Date:				***11/9/2005***		***11/9/2005 duplicate***		***11/9/2005 average***				
		Cleanup Level	***TEF [1]***									
Dioxins (Field Filtered)												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	20	U	20	U	20.000	U		-	10.000
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	100	U	100	U	100.000	U		-	50.000
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U		-	5.000
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U		-	5.000
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U		-	5.000
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	7.3	J	100	U	28.650	J		0.287	0.287
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	108	J	88.2	J	98.1	J		0.029	0.029
			TEC Dioxins								**0.316**	75.316 **pg/l**
Furans (Field Filtered)												
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	61.8		112		86.9			8.690	8.690
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	106	J	168	J	137			4.110	4.110
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	31.2	J	49.5	J	40.35	J		12.105	12.105
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	314		414		364			36.400	36.400
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	47.6	J	61.8	J	54.7	J		5.470	5.470
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	6.38	J	7.25	J	6.815	J		0.682	0.682
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	20.3	J	25.7	J	23.00	J		2.300	2.300
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	182		223		202.5			2.025	2.025
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	150		190		170			1.700	1.700
Octachlorodibenzofuran	pg/l	NV	0.0003	1392		1725		1558.5			0.468	0.468
			TEC Furans								**73.949**	73.949 **pg/l**
			Total TEC Dioxin/Furan								74.265	149.265 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

			Investigative Area:	*Area 5106*								
			Sample Location:	*PT-15A*								
			Sample ID:	*GW-110905-PT-15A-002*		*GW-111005-PT-15A-003*						
			Nominal Sample Depth (feet BGS):	*NA*		*NA*		*NA*				
			Sample Depth (feet BML):	*66 to 67*		*66 to 67*		*66 to 67*				
			Sample Elevation (feet MLLW):	*-104 to -105*		*-104 to -105*		*-104 to -105*				
			Sample Elevation (feet NGVD):	*-110.32 to -111.32*		*-110.32 to -111.32*		*-110.32 to -111.32*				
			Sample Date:	*11/9/2005*		*11/10/2005 duplicate*		*11/9/2005 average*				
		Cleanup Level	*TEF* [1]							*TEC*		
										ND = 0 [2]	*ND = 0.5xDL* [3]	
Dioxins (Field Filtered)												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	20	U	20	U	20.000	U	-	10.000	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	100	U	100	U	100.000	U	-	50.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U	-	5.000	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U	-	5.000	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	100	U	100	U	100.000	U	-	5.000	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	100	U	100.000	U	100.000	U	-	0.500	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	30.1	J	56.6	J	43.350	J	0.013	0.013	
			TEC Dioxins							**0.013**	75.513	**pg/l**
Furans (Field Filtered)												
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	40.279		30.791		35.54		3.554	3.554	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	25.9	J	27.4	J	26.65	J	0.800	0.800	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	10.3	J	13.6	J	11.95	J	3.585	3.585	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	37.7	J	51.4	J	44.550	J	4.455	4.455	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	7.35	J	11.3	J	9.325	J	0.933	0.933	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	100	U	100.000	U	-	5.000	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	100	U	100	U	100.000	U	-	5.000	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	18.3	J	32.5	J	25.4	J	0.254	0.254	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	12.9	J	19.4	J	16.15	J	0.162	0.162	
Octachlorodibenzofuran	pg/l	NV	0.0003	113	J	215	J	164	J	0.049	0.049	
			TEC Furans							**13.790**	23.790	**pg/l**
			Total TEC Dioxin/Furan							13.803	99.303	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***GW-122006-PT-15B-DR-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***13 to 15***
Sample Elevation (feet MLLW):	***-27 to -30***
Sample Elevation (feet NGVD):	***-33.3 to -36.3***
Sample Date:	***12/20/2006***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.2	U	-	0.100
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.194	U	-	0.097
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.257	U	-	0.013
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.321	U	-	0.016
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.292	U	-	0.015
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.662	U	-	0.003
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	0.865	U	-	0.000
			TEC Dioxins			**0.000**	0.244 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.283	U	-	0.014
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.121	U	-	0.002
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.117	U	-	0.018
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	1.262	J	0.126	0.126
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.199	U	-	0.010
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.216	U	-	0.011
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.185	U	-	0.009
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.462	J	0.015	0.015
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.436	U	-	0.002
Octachlorodibenzofuran	pg/l	NV	0.0003	0.655	U	-	0.000
			TEC Furans			**0.141**	0.207 **pg/l**
			Total TEC Dioxin/Furan			0.141	0.451 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***GW-122006-PT-15B-DR-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***18 to 20***
Sample Elevation (feet MLLW):	***-32 to -34***
Sample Elevation (feet NGVD):	***-38.3 to -40.3***
Sample Date:	***12/20/2006***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.261	U	-	0.131	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.225	U	-	0.113	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.353	U	-	0.018	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.435	U	-	0.022	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	0.4	U	-	0.020	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	0.572	U	-	0.003	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	1.149	U	-	0.000	
			TEC Dioxins			**0.000**	0.305	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	0.298	U	-	0.015	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	0.169	U	-	0.003	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	0.162	U	-	0.024	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.974	J	0.097	0.097	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.225	U	-	0.011	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	0.265	U	-	0.013	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.226	U	-	0.011	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	1.359	J	0.014	0.014	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	0.415	U	-	0.002	
Octachlorodibenzofuran	pg/l	NV	0.0003	0.612	U	-	0.000	
			TEC Furans			**0.111**	0.191	**pg/l**
			Total TEC Dioxin/Furan			0.111	0.496	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***GW-122106-PT-15B-DR-003***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***28 to 30***
Sample Elevation (feet MLLW):	***-52 to -54***
Sample Elevation (feet NGVD):	***-48.3 to -50.3***
Sample Date:	***12/21/2006***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.475	U	-	0.238	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	0.991	U	-	0.496	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	2.787	U	-	0.139	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.287	U	-	0.164	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.084	U	-	0.154	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	35.962	J	0.360	0.360	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	267.1		0.080	0.080	
			TEC Dioxins			**0.440**	1.631	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	162		16.200	16.200	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	302		9.060	9.060	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	93		27.900	27.900	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	667		66.700	66.700	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	128		12.800	12.800	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	15	J	1.500	1.500	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	28.5	J	2.850	2.850	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	348		3.480	3.480	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	292		2.920	2.920	
Octachlorodibenzofuran	pg/l	NV	0.0003	2912		0.874	0.874	
			TEC Furans			**144.284**	144.284	**pg/l**
			Total TEC Dioxin/Furan			144.723	145.915	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***GW-122106-BI-PT-15B-004***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***38 to 40***
Sample Elevation (feet MLLW):	***-42 to -44***
Sample Elevation (feet NGVD):	***-58.3 to -60.3***
Sample Date:	***12/21/2006***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.82	U	-	0.410	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	1.723	U	-	0.862	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	4.637	U	-	0.232	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	5.583	U	-	0.279	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	5.185	U	-	0.259	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	55.787		0.558	0.558	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	474.227		0.142	0.142	
			TEC Dioxins			**0.700**	2.742	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	193		19.300	19.300	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	449		13.470	13.470	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	137		41.100	41.100	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	1071		107.100	107.100	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	184		18.400	18.400	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.70	J	2.470	2.470	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	32.78	J	3.278	3.278	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	529		5.290	5.290	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	492		4.920	4.920	
Octachlorodibenzofuran	pg/l	NV	0.0003	4600		1.380	1.380	
			TEC Furans			**216.708**	216.708	**pg/l**
			Total TEC Dioxin/Furan			217.408	219.450	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-17A***
Sample ID:	***GW-020107-ILM-PT-17A-001***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***0.5 to 2.5***
Sample Elevation (feet MLLW):	***-21.5 to -23.5***
Sample Elevation (feet NGVD):	***-27.82 to -29.82***
Sample Date:	***2/1/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	1.37	U	-	0.685	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	5.84	U	-	2.920	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	20.4	U	-	1.020	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.9	U	-	1.195	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	22.5	U	-	1.125	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	46.3	J	0.463	0.463	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	678		0.203	0.203	
			TEC Dioxins			**0.666**	7.611	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	2592		259.200	259.200	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	589		17.670	17.670	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	498		149.400	149.400	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	857		85.700	85.700	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	134		13.400	13.400	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	10.6	J	1.060	1.060	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	291		29.100	29.100	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	845		8.450	8.450	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	152		1.520	1.520	
Octachlorodibenzofuran	pg/l	NV	0.0003	2703		0.811	0.811	
			TEC Furans			**566.311**	566.311	**pg/l**
			Total TEC Dioxin/Furan			566.977	573.922	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-17A***
Sample ID:	***GW-020107-ILM-PT-17A-002***
Nominal Sample Depth (feet BGS):	***NA***
Sample Depth (feet BML):	***10 to 12***
Sample Elevation (feet MLLW):	***-31 to -33***
Sample Elevation (feet NGVD):	***-37.32 to -39.32***
Sample Date:	***2/2/2007***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	0.992	U	-	0.496	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	1.42	U	-	0.710	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	2.87	U	-	0.144	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.35	U	-	0.168	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	3.16	U	-	0.158	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	19.4	J	0.194	0.194	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	180	J	0.054	0.054	
			TEC Dioxins			**0.248**	1.923	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	152		15.200	15.200	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	45.9	J	1.377	1.377	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.1	J	7.230	7.230	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	62.1	J	6.210	6.210	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	10.6	J	1.060	1.060	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	1.59	U	-	0.080	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	12.6	J	1.260	1.260	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	48.2	J	0.482	0.482	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	10.6	J	0.106	0.106	
Octachlorodibenzofuran	pg/l	NV	0.0003	151	J	0.045	0.045	
			TEC Furans			**32.970**	33.050	**pg/l**
			Total TEC Dioxin/Furan			33.218	34.973	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***11-25***
Sample ID:	***WG-080612-JN-11-25-018***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-6.38***
Sample Elevation (feet NGVD):	***-12.7***
Sample Date:	***8/6/2012***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***14-25R***
Sample ID:	***WG-081312-TS-14-25R-029***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.32***
Sample Elevation (feet NGVD):	***-13.7***
Sample Date:	***8/13/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	5	U	-	2.500	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	25	U	-	12.500	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	50.9	J	0.509	0.509	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	374	J	0.112	0.112	
			TEC Dioxins			**0.621**	19.371	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	5	U	-	0.250	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	25	U	-	0.375	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	25	U	-	3.750	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	4.37	J	0.437	0.437	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	25	U	-	0.125	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	25	U	-	0.125	
Octachlorodibenzofuran	pg/l	NV	0.0003	51.7	J	0.016	0.016	
			TEC Furans			**0.4525**	8.828	**pg/l**
			Total TEC Dioxin/Furan			1.074	28.199	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***14-50R***
Sample ID:	***WG-081312-TS-14-50R-030***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.28***
Sample Elevation (feet NGVD):	***-38.6***
Sample Date:	***8/13/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	43.9		0.439	0.439	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	369	J	0.111	0.111	
			TEC Dioxins			**0.550**	18.925	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.550	28.365	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***15-120***
Sample ID:	***WG-081512-TS-15-120-032***
Nominal Sample Depth (feet BGS):	***120***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-102.48***
Sample Elevation (feet NGVD):	***-108.8***
Sample Date:	***8/15/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	5.1	U	-	2.550	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	25.5	U	-	12.750	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	25.5	U	-	0.128	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	124	J	0.037	0.037	
			TEC Dioxins			**0.037**	19.290	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	8.84	U	-	0.442	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	25.5	U	-	0.383	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	25.5	U	-	3.825	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	25.5	U	-	0.128	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	25.5	U	-	0.128	
Octachlorodibenzofuran	pg/l	NV	0.0003	51	U	-	0.008	
			TEC Furans			**0.0000**	10.012	**pg/l**
			Total TEC Dioxin/Furan			0.037	29.302	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***15-50R***
Sample ID:	***WG-081312-PR-15-50R-31***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.78***
Sample Elevation (feet NGVD):	***-39.1***
Sample Date:	***8/13/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	32.2		0.322	0.322
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	325		0.098	0.098
			TEC Dioxins			**0.420**	18.425 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	1.65	J	0.017	0.017
Octachlorodibenzofuran	pg/l	NV	0.0003	45.5	J	0.014	0.014
			TEC Furans			**0.0302**	9.151 **pg/l**
			Total TEC Dioxin/Furan			0.450	27.575 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Upland Monitoring Wells***								
Sample Location:				***17C-25***				***17C-25 (Dupe)***				
Sample ID:				***WG-080612-AMK-17C-25-033***				***WG-080612-AMK-FD02-299***				
Nominal Sample Depth (feet BGS):				***25***				***25***				
Sample Depth (feet BML):				***NA***				***NA***				
Sample Elevation (feet MLLW):				***-6.98***				***-6.98***				
Sample Elevation (feet NGVD):				***-13.3***				***-13.3***				
Sample Date:				***8/6/2012***				***8/6/2012***				
						TEC				***TEC***		
		Cleanup Level	***TEF [1]***			***ND = 0 [2]***	***ND = 0.5xDL [3]***			***ND = 0 [2]***	***ND = 0.5xDL [3]***	
Dioxins (Field Filtered)												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.000	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	7	J	0.002	0.002	49	U	-	0.007	
			TEC Dioxins			**0.002**	18.007 **pg/l**			**0.000**	18.505 **pg/l**	
Furans (Field Filtered)												
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	49	U	-	0.007	
			TEC Furans			**0.0000**	9.248 **pg/l**			**0.0000**	9.440 **pg/l**	
			Total TEC Dioxin/Furan			0.002	27.255 **pg/l**			0.000	27.945 **pg/l**	

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***17C-50***
Sample ID:	***WG-080612-ALK-17C-50-034***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-31.98***
Sample Elevation (feet NGVD):	***-38.3***
Sample Date:	***8/6/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	30.7	J	0.009	0.009
			TEC Dioxins			**0.009**	18.507 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007
			TEC Furans			**0.0000**	9.440 **pg/l**
			Total TEC Dioxin/Furan			0.009	27.947 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***41C-25***
Sample ID:	***WG-071612-BW-41C-25-067***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-8.38***
Sample Elevation (feet NGVD):	***-14.7***
Sample Date:	***7/16/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***41C-50***
Sample ID:	***WG-071612-BW-41C-50-068***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-33.38***
Sample Elevation (feet NGVD):	***-39.7***
Sample Date:	***7/16/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	5.1	U	-	2.550
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	25.5	U	-	12.750
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	25.5	U	-	0.128
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	51	U	-	0.008
			TEC Dioxins			**0.000**	19.260 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	5.1	U	-	0.255
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	25.5	U	-	0.383
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	25.5	U	-	3.825
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25.5	U	-	1.275
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	25.5	U	-	0.128
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	25.5	U	-	0.128
Octachlorodibenzofuran	pg/l	NV	0.0003	51	U	-	0.008
			TEC Furans			**0.0000**	9.825 **pg/l**
			Total TEC Dioxin/Furan			0.000	29.085 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***53C-25***
Sample ID:	***WG-072412-AK-53C-25-091***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-6.48***
Sample Elevation (feet NGVD):	***-12.8***
Sample Date:	***7/24/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.9	J	0.015	0.007	
			TEC Dioxins			**0.015**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.015	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***60-50***
Sample ID:	***WG-081512-TS-60-50-099***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.58***
Sample Elevation (feet NGVD):	***-38.9***
Sample Date:	***8/15/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	75	J	0.023	0.011	
			TEC Dioxins			**0.023**	18.136	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.023	27.384	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***65-25***
Sample ID:	***WG-081212-ALK-65-25-108***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.28***
Sample Elevation (feet NGVD):	***-13.6***
Sample Date:	***8/12/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***65-50***
Sample ID:	***WG-081212-ALK-65-50-109***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.18***
Sample Elevation (feet NGVD):	***-38.5***
Sample Date:	***8/12/2012***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***67-25***
Sample ID:	***WG-072612-AMK-67-25-112***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.38***
Sample Elevation (feet NGVD):	***-13.7***
Sample Date:	***7/26/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Upland Monitoring Wells***								
Sample Location:				***67-50***				***67-50 (Dupe)***				
Sample ID:				***WG-072612-AMK-67-50-113***				***WG-072612-AMK-FD08-305***				
Nominal Sample Depth (feet BGS):				***50***				***50***				
Sample Depth (feet BML):				***NA***				***NA***				
Sample Elevation (feet MLLW):				***-32.28***				***-32.28***				
Sample Elevation (feet NGVD):				***-38.6***				***-38.6***				
Sample Date:				***7/26/2012***				***7/26/2012***				
		Cleanup Level	***TEF [1]***			***TEC***				***TEC***		
						ND = 0 [2]	***ND = 0.5xDL [3]***			***ND = 0 [2]***	***ND = 0.5xDL [3]***	
Dioxins (Field Filtered)												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.505 **pg/l**			**0.000**	18.132 **pg/l**	
Furans (Field Filtered)												
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	0.918	J	0.092	0.092	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.440 **pg/l**			**0.0918**	8.140 **pg/l**	
			Total TEC Dioxin/Furan			0.000	27.945 **pg/l**			0.092	26.272 **pg/l**	

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***69-25***
Sample ID:	***WG-072712-AMK-69-25-114***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-8.28***
Sample Elevation (feet NGVD):	***-14.6***
Sample Date:	***7/27/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***70-25***
Sample ID:	***WG-082612-AMK-70-25-115***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-8.18***
Sample Elevation (feet NGVD):	***-14.5***
Sample Date:	***8/26/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.63	U	-	2.315	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	23.1	U	-	11.550	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	23.1	U	-	0.116	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	46.3	U	-	0.007	
			TEC Dioxins			**0.000**	17.452	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.63	U	-	0.232	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	23.1	U	-	0.347	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	23.1	U	-	3.465	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	23.1	U	-	1.155	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.1	U	-	1.155	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	23.1	U	-	0.116	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	23.1	U	-	0.116	
Octachlorodibenzofuran	pg/l	NV	0.0003	46.3	U	-	0.007	
			TEC Furans			**0.0000**	8.901	**pg/l**
			Total TEC Dioxin/Furan			0.000	26.353	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***71-25***
Sample ID:	***WG-072712-AMK-71-25-116***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.88***
Sample Elevation (feet NGVD):	***-14.2***
Sample Date:	***7/27/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.63	U	-	0.232	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	0.63	J	0.063	0.063	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0630**	8.264	**pg/l**
			Total TEC Dioxin/Furan			0.063	26.769	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***71-50***
Sample ID:	***WG-072712-AMK-71-50-117***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.98***
Sample Elevation (feet NGVD):	***-39.3***
Sample Date:	***7/27/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	71.4	J	0.021	0.021
			TEC Dioxins			**0.021**	18.146 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007
			TEC Furans			**0.0000**	9.248 **pg/l**
			Total TEC Dioxin/Furan			0.021	27.394 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***80-25***
Sample ID:	***WG-072712-AMK-80-25-138***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.38***
Sample Elevation (feet NGVD):	***-13.7***
Sample Date:	***7/27/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***82-100***
Sample ID:	***WG-072912-PR-82-100-140***
Nominal Sample Depth (feet BGS):	***100***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-83.48***
Sample Elevation (feet NGVD):	***-89.8***
Sample Date:	***7/29/2012***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***83C-25***
Sample ID:	***WG-072512-AK-83C-25-141***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.18***
Sample Elevation (feet NGVD):	***-13.5***
Sample Date:	***7/25/2012***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	5	U	-	2.500	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	25	U	-	12.500	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	25	U	-	0.125	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	50	U	-	0.008	
			TEC Dioxins			**0.000**	18.883	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	5	U	-	0.250	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	25	U	-	0.375	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	25	U	-	3.750	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	25	U	-	1.250	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	25	U	-	0.125	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	25	U	-	0.125	
Octachlorodibenzofuran	pg/l	NV	0.0003	50	U	-	0.008	
			TEC Furans			**0.0000**	9.633	**pg/l**
			Total TEC Dioxin/Furan			0.000	28.515	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***83C-50***
Sample ID:	***WG-072512-AK-83C-50-142***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.18***
Sample Elevation (feet NGVD):	***-38.5***
Sample Date:	***7/25/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***90C-25***
Sample ID:	***WG-072312-AK-90C-25-183***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.08***
Sample Elevation (feet NGVD):	***-13.4***
Sample Date:	***7/23/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Upland Monitoring Wells***								
Sample Location:				***90C-50***					***90C-50 (Dupe)***			
Sample ID:				***WG-072312-AK-90C-50-184***					***WG-072312-AK-FD15-312***			
Nominal Sample Depth (feet BGS):				***50***					***50***			
Sample Depth (feet BML):				***NA***					***NA***			
Sample Elevation (feet MLLW):				***-32.08***					***-32.08***			
Sample Elevation (feet NGVD):				***-38.4***					***-38.4***			
Sample Date:				***7/23/2012***					***7/23/2012***			
						TEC					***TEC***	
		Cleanup Level	***TEF*** [1]			***ND = 0*** [2]	***ND = 0.5xDL*** [3]				***ND = 0*** [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450		4.9	U	-	2.450
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250		24.5	U	-	12.250
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123		24.5	U	-	0.123
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007		49	U	-	0.007
			TEC Dioxins			**0.000**	18.505	**pg/l**			**0.000**	18.505 **pg/l**
Furans (Field Filtered)												
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245		4.9	U	-	0.245
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368		24.5	U	-	0.368
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675		24.5	U	-	3.675
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225		24.5	U	-	1.225
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123		24.5	U	-	0.123
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123		24.5	U	-	0.123
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007		49	U	-	0.007
			TEC Furans			**0.0000**	9.440	**pg/l**			**0.0000**	9.440 **pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**			0.000	27.945 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***90C-75***
Sample ID:	***WG-072312-PR-90C-75-185***
Nominal Sample Depth (feet BGS):	***75***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-57.08***
Sample Elevation (feet NGVD):	***-63.4***
Sample Date:	***7/23/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***90C-100***
Sample ID:	***WG-072312-AK-90C-100-186***
Nominal Sample Depth (feet BGS):	***100***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-82.08***
Sample Elevation (feet NGVD):	***-88.4***
Sample Date:	***7/23/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Dioxins			**0.000**	18.132	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.380	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***PZ-SHI-2-75***
Sample ID:	***WG-082512-AMK-PZ-SHI-2-75-291***
Nominal Sample Depth (feet BGS):	***75***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-72.88***
Sample Elevation (feet NGVD):	***-79.2***
Sample Date:	***8/25/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.67	U	-	2.335
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	23.4	U	-	11.700
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	63.9	J	0.639	0.639
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	607	J	0.182	0.182
			TEC Dioxins			**0.821**	18.366 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.67	U	-	0.234
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	23.4	U	-	0.351
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	23.4	U	-	3.510
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	23.4	U	-	1.170
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.4	U	-	1.170
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	27.4	J	0.274	0.137
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	23.4	U	-	0.117
Octachlorodibenzofuran	pg/l	NV	0.0003	118	J	0.035	0.018
			TEC Furans			**0.3094**	9.046 **pg/l**
			Total TEC Dioxin/Furan			1.131	27.412 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***PZ-SHI-2-100***
Sample ID:	***WG-082512-LP-PZ-SHI-2-100-292***
Nominal Sample Depth (feet BGS):	***100***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-99.58***
Sample Elevation (feet NGVD):	***-105.9***
Sample Date:	***8/25/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	94.7	J	0.028	0.028	
			TEC Dioxins			**0.028**	18.153	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	22.5	J	2.250	2.250	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	59.7	J	0.597	0.597	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**2.8470**	10.775	**pg/l**
			Total TEC Dioxin/Furan			2.875	28.928	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***PZ-SHI-3-75***
Sample ID:	***WG-082512-AMK-PZ-SHI-3-75-293***
Nominal Sample Depth (feet BGS):	***75***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-81.98***
Sample Elevation (feet NGVD):	***-88.3***
Sample Date:	***8/25/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.72	U	-	2.360	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	23.6	U	-	11.800	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	23.6	U	-	0.118	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	25.8	J	0.008	0.008	
			TEC Dioxins			**0.008**	17.826	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.72	U	-	0.236	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	23.6	U	-	0.354	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	23.6	U	-	3.540	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	23.6	U	-	1.180	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.6	U	-	1.180	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	23.6	U	-	0.118	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	23.6	U	-	0.118	
Octachlorodibenzofuran	pg/l	NV	0.0003	47.2	U	-	0.007	
			TEC Furans			**0.0000**	9.093	**pg/l**
			Total TEC Dioxin/Furan			0.008	26.919	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***T3-50***
Sample ID:	***WG-072912-PR-T3-50-294***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.98***
Sample Elevation (feet NGVD):	***-39.3***
Sample Date:	***7/29/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.76	U	-	2.380
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	23.8	U	-	11.900
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	23.8	U	-	0.119
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	47.6	U	-	0.007
			TEC Dioxins			**0.000**	17.976 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.76	U	-	0.238
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	23.8	U	-	0.357
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	23.8	U	-	3.570
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	23.8	U	-	1.190
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	23.8	U	-	1.190
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	23.8	U	-	0.119
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	23.8	U	-	0.119
Octachlorodibenzofuran	pg/l	NV	0.0003	47.6	U	-	0.007
			TEC Furans			**0.0000**	9.170 **pg/l**
			Total TEC Dioxin/Furan			0.000	27.146 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***T6-60***
Sample ID:	***WG-082412-LP-T6-60-296***
Nominal Sample Depth (feet BGS):	***60***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-42.88***
Sample Elevation (feet NGVD):	***-49.2***
Sample Date:	***8/24/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	157	J	0.047	0.047	
			TEC Dioxins			**0.047**	18.172	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120	
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007	
			TEC Furans			**0.0000**	9.248	**pg/l**
			Total TEC Dioxin/Furan			0.047	27.420	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***709-MW20-25***
Sample ID:	***WG-082312-JN-709-MW20-25-224***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-5.18***
Sample Elevation (feet NGVD):	***-11.5***
Sample Date:	***8/23/2012***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	60.9	J	0.018	0.018	
			TEC Dioxins			**0.018**	18.516	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.018	27.956	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***709-MW20-50***
Sample ID:	***WG-082112-JN-709-MW20-50-225***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-30.48***
Sample Elevation (feet NGVD):	***-36.8***
Sample Date:	***8/21/2012***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins (Field Filtered)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.81	U	-	2.405
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24	U	-	12.000
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24	U	-	0.120
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	170	J	0.051	0.051
			TEC Dioxins			**0.051**	18.176 **pg/l**
Furans (Field Filtered)							
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.81	U	-	0.241
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24	U	-	0.360
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24	U	-	3.600
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24	U	-	1.200
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24	U	-	0.120
Octachlorodibenzofuran	pg/l	NV	0.0003	48.1	U	-	0.007
			TEC Furans			**0.0000**	9.248 **pg/l**
			Total TEC Dioxin/Furan			0.051	27.424 **pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***721-MW9-25***
Sample ID:	***WG-072212-DJT-721-MW9-25-263***
Nominal Sample Depth (feet BGS):	***25***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-7.28***
Sample Elevation (feet NGVD):	***-13.6***
Sample Date:	***8/21/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	50.6	J	0.015	0.015	
			TEC Dioxins			**0.015**	18.513	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.015	27.953	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Upland Monitoring Wells***
Sample Location:	***721-MW9-50***
Sample ID:	***WG-072212-DJT-721-MW9-50-264***
Nominal Sample Depth (feet BGS):	***50***
Sample Depth (feet BML):	***NA***
Sample Elevation (feet MLLW):	***-32.28***
Sample Elevation (feet NGVD):	***-38.6***
Sample Date:	***7/22/2012***

		Cleanup Level	***TEF*** [1]			***TEC*** ***ND = 0*** [2]	***TEC*** ***ND = 0.5xDL*** [3]	
Dioxins (Field Filtered)								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/l	0.014	1	4.9	U	-	2.450	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/l	NV	1	24.5	U	-	12.250	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzo-p-dioxin	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Dioxins			**0.000**	18.505	**pg/l**
Furans (Field Filtered)								
2,3,7,8-Tetrachlorodibenzofuran	pg/l	NV	0.1	4.9	U	-	0.245	
1,2,3,7,8-Pentachlorodibenzofuran	pg/l	NV	0.03	24.5	U	-	0.368	
2,3,4,7,8-Pentachlorodibenzofuran	pg/l	NV	0.3	24.5	U	-	3.675	
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/l	NV	0.1	24.5	U	-	1.225	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/l	NV	0.01	24.5	U	-	0.123	
Octachlorodibenzofuran	pg/l	NV	0.0003	49	U	-	0.007	
			TEC Furans			**0.0000**	9.440	**pg/l**
			Total TEC Dioxin/Furan			0.000	27.945	**pg/l**

TABLE Q.4

TEC CALCULATIONS - DIOXIN AND FURAN GROUNDWATER SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Notes:

(1)	World Health Organization, September 2006.
(2)	TEC calculated using only detected concentrations.
(3)	TEC calculated using detected concentrations plus 0.5 times the detection limit for non-detected concentrations.
++	Congener co-elutes with 2,3,3',4,4',5-HxCB (156). Result is the sum of both congeners.
BGS	Below ground surface.
BML	Below mudline.
MLLW	Mean lower low water.
NGVD	National geodetic vertical datum.
J	Estimated.
TEC	Toxicity Equivalency Concentration.
TEF	Toxicity Equivalency Factor.
U	Non-detect at associated value.

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-1***
Sample ID:	***SE-012407-BS-HW-1-001***
Sample Depth (feet BML):	***0 to 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-42.3 to -42.63***
Sample Elevation (feet NGVD):	***-48.62 to-48.95***
Sample Date:	***1/24/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.034	U	-	0.017	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.055	U	-	0.028	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.146	U	-	0.007	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.408	J	0.041	0.041	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.169	U	-	0.008	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	7.482	J	0.075	0.075	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	72.25		0.022	0.022	
			TEC Dioxins			**0.137**	0.198	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	2.304		0.230	0.230	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	2.102	J	0.063	0.063	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.132	J	0.340	0.340	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.703	J	0.370	0.370	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.864	J	0.086	0.086	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.159	U	-	0.008	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.462	J	0.046	0.046	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.879	J	0.039	0.039	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.554	J	0.016	0.016	
Octachlorodibenzofuran	ng/kg	NV	0.0003	22.047		0.007	0.007	
			TEC Furans			**1.197**	1.205	**ng/kg**
			Total TEC Dioxin/Furan			1.334	1.403	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Hylebos Waterway***								
Sample Location:				***HW-1***								
Sample ID:				***SE-012407-BS-HW-1-002***		***SE-012407-BS-HW-1-003***						
Sample Depth (feet BML):				***0.5 to 2.5***		***0.5 to 2.5***		***0.5 to 2.5***				
Sample Depth (feet BGS):				***NA***		***NA***		***NA***				
Sample Elevation (feet MLLW):				***-42.8 to -44.8***		***-42.8 to -44.8***		***-42.8 to -44.8***				
Sample Elevation (feet NGVD):				***-49.12 to -51.12***		***-49.12 to -51.12***		***-49.12 to -51.12***				
Sample Date:				***1/24/2007***		***1/24/2007 duplicate***		***######## average***				
		Cleanup Level	***TEF [1]***							***TEC***		
										ND = 0 [2]	***ND = 0.5xDL [3]***	
Dioxins												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.097	U	0.014	U	0.0555	U	-	0.028	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.092	U	0.025	U	0.0585	U	-	0.029	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.262	U	0.042	U	0.152	U	-	0.008	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.302	U	0.054	U	0.178	U	-	0.009	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.283	U	0.049	U	0.166	U	-	0.008	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	2.827	J	0.066	U	1.4465	J	0.014	0.014	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	28.039		2.962	J	15.50	J	0.005	0.005	
			TEC Dioxins							**0.019**	0.101	**ng/kg**
Furans												
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.683		0.701	U	1.683		0.168	0.168	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.206	J	0.135	J	0.6705	J	0.020	0.020	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.635	J	0.109	J	0.372	J	0.112	0.112	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.497	J	0.248	J	1.3725	J	0.137	0.137	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.591	J	0.109	J	0.35	J	0.035	0.035	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.115	U	0.041	U	0.078	U	-	0.004	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.112	U	0.038	U	0.075	U	-	0.004	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.457	J	0.53	U	1.4935	J	0.015	0.015	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.065	J	0.116	J	0.5905	J	0.006	0.006	
Octachlorodibenzofuran	ng/kg	NV	0.0003	18.551		1.684	J	10.12	J	0.003	0.003	
			TEC Furans							**0.496**	0.504	**ng/kg**
			Total TEC Dioxin/Furan							0.515	0.605	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-2***
Sample ID:	***SE-012507-BS-HW-2-001***
Sample Depth (feet BML):	***0 to 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-41.9 to -42.23***
Sample Elevation (feet NGVD):	***-48.22 to -48.55***
Sample Date:	***1/25/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.043 U	-	0.022	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.122 U	-	0.061	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.279 U	-	0.014	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.307 U	-	0.015	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.298 U	-	0.015	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	19.6	0.196	0.196	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	175	0.053	0.053	
			TEC Dioxins		**0.249**	0.375	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	2.886	0.289	0.289	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	2.886 J	0.087	0.087	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.732 J	0.520	0.520	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	6.082 J	0.608	0.608	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.598 J	0.160	0.160	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.334 U	-	0.017	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.76 J	0.076	0.076	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.741 J	0.087	0.087	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.501 J	0.025	0.025	
Octachlorodibenzofuran	ng/kg	NV	0.0003	45.4	0.014	0.014	
			TEC Furans		**1.865**	1.882	**ng/kg**
			Total TEC Dioxin/Furan		2.113	2.257	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-2***
Sample ID:	***SE-012507-BS-HW-2-002***
Sample Depth (feet BML):	***0.5 to 2.5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-42.4 to -44.4***
Sample Elevation (feet NGVD):	***-48.72 to -50.72***
Sample Date:	***1/25/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.205	J	0.205	0.205	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.482	U	-	0.241	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.683	U	-	0.034	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.974	J	0.397	0.397	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.727	U	-	0.036	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	66.4		0.664	0.664	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	621		0.186	0.186	
			TEC Dioxins			**1.453**	1.764	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	21.5		2.150	2.150	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	17.4		0.522	0.522	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	11.7		3.510	3.510	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	33.1		3.310	3.310	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.54	J	0.754	0.754	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.46	J	0.046	0.046	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.46	J	0.446	0.446	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	43.8		0.438	0.438	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	13.2		0.132	0.132	
Octachlorodibenzofuran	ng/kg	NV	0.0003	290		0.087	0.087	
			TEC Furans			**11.395**	11.395	**ng/kg**
			Total TEC Dioxin/Furan			12.848	13.159	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-2***
Sample ID:	***SE-012507-BS-HW-2-003***
Sample Depth (feet BML):	***2.5 to 4.5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-44.4 to -46.4***
Sample Elevation (feet NGVD):	***-50.72 to -52.72***
Sample Date:	***1/25/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.03	U	-	0.015	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.094	U	-	0.047	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.276	U	-	0.014	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.293	U	-	0.015	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.289	U	-	0.014	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	4.434	J	0.044	0.044	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	41.5		0.012	0.012	
			TEC Dioxins			**0.057**	0.162	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.693		0.169	0.169	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.139	J	0.034	0.034	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.941	J	0.282	0.282	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.661	J	0.266	0.266	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.664	J	0.066	0.066	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.111	U	-	0.006	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.326	J	0.033	0.033	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	4.76	J	0.048	0.048	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.206	J	0.012	0.012	
Octachlorodibenzofuran	ng/kg	NV	0.0003	29.8		0.009	0.009	
			TEC Furans			**0.919**	0.925	**ng/kg**
			Total TEC Dioxin/Furan			0.976	1.087	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-3***
Sample ID:	***SE-012207-BS-HW3-001***
Sample Depth (feet BML):	***0 to 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-36.8 to -37.13***
Sample Elevation (feet NGVD):	***-43.12 to 43.45***
Sample Date:	***1/22/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.085	J	0.085	0.085	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.119	U	-	0.060	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.476	U	-	0.024	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.697	J	0.170	0.170	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.509	U	-	0.025	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	33.947		0.339	0.339	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	326.857		0.098	0.098	
			TEC Dioxins			**0.692**	0.801	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	5.566		0.557	0.557	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	5.955	J	0.179	0.179	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	3.207	J	0.962	0.962	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	17.258		1.726	1.726	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.961	J	0.496	0.496	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.544	U	-	0.027	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.658	J	0.166	0.166	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	20.587		0.206	0.206	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.353	J	0.054	0.054	
Octachlorodibenzofuran	ng/kg	NV	0.0003	75.899		0.023	0.023	
			TEC Furans			**4.367**	4.394	**ng/kg**
			Total TEC Dioxin/Furan			5.059	5.195	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-3***
Sample ID:	***SE-012207-BS-HW3-002***
Sample Depth (feet BML):	***0 to 2.0***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-36.8 to -38.8***
Sample Elevation (feet NGVD):	***-43.12 to -45.12***
Sample Date:	***1/22/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.088	U	-	0.044	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.324	J	0.324	0.324	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.211	U	-	0.011	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.288	J	0.229	0.229	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.967	J	0.097	0.097	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	33.664		0.337	0.337	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	316.784		0.095	0.095	
			TEC Dioxins			**1.081**	1.137	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	7.528		0.753	0.753	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	7.542		0.226	0.226	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	5.696	J	1.709	1.709	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	17.097		1.710	1.710	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.679	J	0.468	0.468	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.307	J	0.031	0.031	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.014	J	0.201	0.201	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	30.309		0.303	0.303	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.766		0.088	0.088	
Octachlorodibenzofuran	ng/kg	NV	0.0003	215.926		0.065	0.065	
			TEC Furans			**5.553**	5.553	**ng/kg**
			Total TEC Dioxin/Furan			6.634	6.690	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-3***
Sample ID:	***SE-012207-BS-HW3-003***
Sample Depth (feet BML):	***8 to 10***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-44.85 to -46.85***
Sample Elevation (feet NGVD):	***-51.17 to -53.17***
Sample Date:	***1/22/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.127	U	-	0.064	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.083	U	-	0.042	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.075	U	-	0.004	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.228	J	0.023	0.023	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.082	U	-	0.004	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	2.989	J	0.030	0.030	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	24.231		0.007	0.007	
			TEC Dioxins			**0.060**	0.173	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.772	U	-	0.039	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.498	J	0.015	0.015	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.348	J	0.104	0.104	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.989	J	0.099	0.099	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.263	J	0.026	0.026	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.077	U	-	0.004	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.074	U	-	0.004	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.77	J	0.018	0.018	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.52	J	0.005	0.005	
Octachlorodibenzofuran	ng/kg	NV	0.0003	10.352	J	0.003	0.003	
			TEC Furans			**0.271**	0.317	**ng/kg**
			Total TEC Dioxin/Furan			0.331	0.490	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-4***
Sample ID:	***SE-012307-BS-HW-4-001***
Sample Depth (feet BML):	***0 to 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-36 to -36.33***
Sample Elevation (feet NGVD):	***-42.32 to -42.65***
Sample Date:	***1/23/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.735 J	0.735	0.735	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.352 J	2.352	2.352	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.829 J	0.383	0.383	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	17.65 J	1.765	1.765	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	11.03 J	1.103	1.103	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	288	2.880	2.880	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2556	0.767	0.767	
			TEC Dioxins		**9.985**	9.985	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	83.42	8.342	8.342	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	95.98	2.879	2.879	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	48.94	14.682	14.682	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	180	18.000	18.000	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	51.5	5.150	5.150	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.763 J	0.276	0.276	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	12.12 J	1.212	1.212	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	187	1.870	1.870	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	61.13	0.611	0.611	
Octachlorodibenzofuran	ng/kg	NV	0.0003	1002	0.301	0.301	
			TEC Furans		**53.324**	53.324	**ng/kg**
			Total TEC Dioxin/Furan		63.308	63.308	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-4***
Sample ID:	***SE-012307-BS-HW-4-002***
Sample Depth (feet BML):	***0 to 2***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-36 to -38***
Sample Elevation (feet NGVD):	***-42.32 to -44.32***
Sample Date:	***1/23/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.72 U	-	0.860	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.579 J	0.579	0.579	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.604 U	-	0.430	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.918 J	0.292	0.292	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.966 J	0.197	0.197	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	42.18	0.422	0.422	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	383	0.115	0.115	
			TEC Dioxins		**1.604**	2.894	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	17.44	1.744	1.744	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	23.8	0.714	0.714	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	11.6	3.480	3.480	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	40.17	4.017	4.017	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	11.11	1.111	1.111	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.89 J	0.089	0.089	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.363 J	0.436	0.436	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	39.97	0.400	0.400	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	13.1	0.131	0.131	
Octachlorodibenzofuran	ng/kg	NV	0.0003	196	0.059	0.059	
			TEC Furans		**12.181**	12.181	**ng/kg**
			Total TEC Dioxin/Furan		13.785	15.075	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***HW-4***
Sample ID:	***SE-012307-BS-HW-4-003***
Sample Depth (feet BML):	***8 to10***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-44 to -46***
Sample Elevation (feet NGVD):	***-50.32 to -52.32***
Sample Date:	***1/23/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.649	U	-	0.825	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	8.249	U	-	4.125	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.249	U	-	0.412	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.264	J	0.026	0.026	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.249	U	-	0.412	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	2.522	J	0.025	0.025	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	22.36		0.007	0.007	
			TEC Dioxins			**0.058**	5.832	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.329	J	0.133	0.133	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.864	J	0.026	0.026	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.515	J	0.155	0.155	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.567	J	0.157	0.157	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.388	J	0.039	0.039	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	8.249	U	-	0.412	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	8.249	U	-	0.412	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.043	J	0.020	0.020	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.673	J	0.007	0.007	
Octachlorodibenzofuran	ng/kg	NV	0.0003	9.877	J	0.003	0.003	
			TEC Furans			**0.539**	1.364	**ng/kg**
			Total TEC Dioxin/Furan			0.597	7.196	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-2A***
Sample ID:	***S-122106-BI-NL2A-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***2 to 4***
Sample Elevation (feet MLLW):	***16 to 14***
Sample Elevation (feet NGVD):	***9.7 to 7.7***
Sample Date:	***12/21/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	2.34		2.340	2.340	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.164	J	3.164	3.164	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.879	J	0.288	0.288	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.044	J	0.504	0.504	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	6.03	J	0.603	0.603	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	44.681		0.447	0.447	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	145.647		0.044	0.044	
			TEC Dioxins			**7.390**	7.390	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	51.63		5.163	5.163	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	41.112		1.233	1.233	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	21.26		6.378	6.378	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	94.376		9.438	9.438	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	28.17		2.817	2.817	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.45	J	0.145	0.145	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.795	J	0.580	0.580	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	114.213		1.142	1.142	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	67.083		0.671	0.671	
Octachlorodibenzofuran	ng/kg	NV	0.0003	322.763		0.097	0.097	
			TEC Furans			**27.663**	27.663	**ng/kg**
			Total TEC Dioxin/Furan			35.053	35.053	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-2A***
Sample ID:	***S-020807-ILM-NL2A-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***6 to 8***
Sample Elevation (feet MLLW):	***12 to 10***
Sample Elevation (feet NGVD):	***5.7 to 3.7***
Sample Date:	***2/8/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	3.59	3.590	3.590	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.61 U	-	1.305	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.49 U	-	0.225	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.42 U	-	0.271	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.02 U	-	0.251	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	18.6 J	0.186	0.186	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	94.4	0.028	0.028	
			TEC Dioxins		**3.804**	5.856	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	304	30.400	30.400	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	581 J	17.430	17.430	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	211	63.300	63.300	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1695	169.500	169.500	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	430 J	43.000	43.000	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	22.4 U	-	1.120	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	201	20.100	20.100	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	2307 J	23.070	23.070	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	585	5.850	5.850	
Octachlorodibenzofuran	ng/kg	NV	0.0003	9085	2.726	2.726	
			TEC Furans		**375.376**	376.496	**ng/kg**
			Total TEC Dioxin/Furan		379.180	382.351	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-18***
Sample ID:	***S-080106-LH-NL18-003***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***8 to 10***
Sample Elevation (feet MLLW):	***10 to 8***
Sample Elevation (feet NGVD):	***3.7 to 1.7***
Sample Date:	***8/1/2006***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.821	J	0.821	0.821	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.767	J	2.767	2.767	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.235	J	0.224	0.224	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.008	J	0.501	0.501	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.481	J	0.448	0.448	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	41.487		0.415	0.415	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	172.478		0.052	0.052	
			TEC Dioxins			**5.227**	5.227	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	30.371		3.037	3.037	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	19.811		0.594	0.594	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	20.724		6.217	6.217	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	47.855		4.786	4.786	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	19.866		1.987	1.987	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.758	J	0.076	0.076	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	15.906		1.591	1.591	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	75.444		0.754	0.754	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	12.246		0.122	0.122	
Octachlorodibenzofuran	ng/kg	NV	0.0003	108.978		0.033	0.033	
			TEC Furans			**19.197**	19.197	**ng/kg**
			Total TEC Dioxin/Furan			24.424	24.424	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-24***
Sample ID:	***SE-011207-BS-NL-24-001***
Sample Depth (feet BML):	***0 to 3***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-24.39 to -27.39***
Sample Elevation (feet NGVD):	***-30.71 to -33.71***
Sample Date:	***1/12/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.255	U	-	0.128	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.538	J	0.538	0.538	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.315	U	-	0.016	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.7	J	0.370	0.370	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.20	J	0.120	0.120	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	87.98		0.880	0.880	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	891.6		0.267	0.267	
			TEC Dioxins			**2.175**	2.319	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	34.47		3.447	3.447	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	34.93		1.048	1.048	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	14.6	J	4.380	4.380	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	74.06		7.406	7.406	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	18.05		1.805	1.805	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.54	J	0.154	0.154	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.36	J	0.936	0.936	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	97.69		0.977	0.977	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	26.87		0.269	0.269	
Octachlorodibenzofuran	ng/kg	NV	0.0003	393.328		0.118	0.118	
			TEC Furans			**20.539**	20.539	**ng/kg**
			Total TEC Dioxin/Furan			22.715	22.858	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-24***
Sample ID:	***SE-011507-BS-NL-24-003***
Sample Depth (feet BML):	***10 to 13***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-34.39 to -37.39***
Sample Elevation (feet NGVD):	***-40.7 to -43.7***
Sample Date:	***1/15/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.083	U	-	0.042	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.103	U	-	0.052	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.139	U	-	0.007	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.183	J	0.018	0.018	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.143	U	-	0.007	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	2.29	J	0.023	0.023	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	22.7		0.007	0.007	
			TEC Dioxins			**0.048**	0.155	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.23	J	0.123	0.123	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.917	J	0.028	0.028	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.815	J	0.245	0.245	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.59	J	0.259	0.259	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.667	J	0.067	0.067	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.162	U	-	0.008	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.507	J	0.051	0.051	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.55	J	0.026	0.026	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.862	J	0.009	0.009	
Octachlorodibenzofuran	ng/kg	NV	0.0003	8.12	J	0.002	0.002	
			TEC Furans			**0.808**	0.816	**ng/kg**
			Total TEC Dioxin/Furan			0.856	0.971	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***N Landfill***				
Sample Location:				***NL-25***				
Sample ID:				***SE-011807-ILM-NL-25-001***				***SE-01***
Sample Depth (feet BML):				***0 to 3***				
Sample Depth (feet BGS):				***NA***				
Sample Elevation (feet MLLW):				***-27.5 to -30.5***				
Sample Elevation (feet NGVD):				***-33.82 to 36.82***				
Sample Date:				***1/18/2007***				
		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.122	U	-	0.061	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.176	U	-	0.088	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.294	U	-	0.015	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.712	J	0.071	0.071	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.323	U	-	0.016	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	21.798		0.218	0.218	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	202.106		0.061	0.061	
			TEC Dioxins			**0.350**	0.530	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	10.666		1.067	1.067	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	8.905	J	0.267	0.267	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	4.451	J	1.335	1.335	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	20.527		2.053	2.053	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	6.242	J	0.624	0.624	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.122	U	-	0.056	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.885	J	0.189	0.189	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	40.73		0.407	0.407	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	11.765		0.118	0.118	
Octachlorodibenzofuran	ng/kg	NV	0.0003	237.445		0.071	0.071	
			TEC Furans			**6.131**	6.187	**ng/kg**
			Total TEC Dioxin/Furan			6.480	6.716	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***N Landfill***					
Sample Location:				***NL-25***					
Sample ID:				***807-ILM-NL-25-003***		***807-ILM-NL-25-003***			
Sample Depth (feet BML):				***5 to 8***		***5 to 8***		***5 to 8***	
Sample Depth (feet BGS):				***NA***		***NA***		***NA***	
Sample Elevation (feet MLLW):				***-32.5 to -35.5***		***-32.5 to -35.5***		***-32.5 to -35.5***	
Sample Elevation (feet NGVD):				***-38.8 to -41.8***		***-38.8 to -41.8***		***-38.8 to -41.8***	
Sample Date:				***#######***		***######### duplicate***		***1/18/2007 average***	
		Cleanup Level	***TEF [1]***					***TEC***	
								ND = 0 [2]	***ND = 0.5xDL [3]***
Dioxins									
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.2	U	0.094	U	0.14715 U	- 0.074
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.29	U	0.161	U	0.227 U	- 0.114
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.2	U	0.243	U	0.2225 U	- 0.011
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.6	J	0.569	J	0.585 J	0.059 0.059
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.21	U	0.252	U	0.229 U	- 0.011
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	8.51		8.04		8.275	0.083 0.083
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	85.4		79.5		82.45	0.025 0.025
			TEC Dioxins						**0.166** 0.376 **ng/kg**
Furans									
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	10.4		4.83		7.615	0.762 0.762
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	11.9		5.9	J	8.9 J	0.267 0.267
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	5.19	J	2.21	J	3.7 J	1.110 1.110
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	18.2		13.6		15.9	1.590 1.590
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.9	J	3.51	J	4.205 J	0.421 0.421
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.66	J	0.487	J	0.5725 J	0.057 0.057
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.98	J	3.59	J	3.785 J	0.379 0.379
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	16.9		13.7		15.3	0.153 0.153
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.61	J	5.57	J	5.59 J	0.056 0.056
Octachlorodibenzofuran	ng/kg	NV	0.0003	95.2		82.8		89.00	0.027 0.027
			TEC Furans						**4.820** 4.820 **ng/kg**
			Total TEC Dioxin/Furan						4.986 5.196 **ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-26***
Sample ID:	***SE-011707-BS-NL-26-001***
Sample Depth (feet BML):	***0 to 3***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-20.4 to -23.4***
Sample Elevation (feet NGVD):	***-26.72 to -29.72***
Sample Date:	***1/17/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.357	J	0.357	0.357	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.783	J	0.783	0.783	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.828	J	0.083	0.083	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.92	J	0.292	0.292	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.526	U	-	0.026	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	30.267		0.303	0.303	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	241.591		0.072	0.072	
			TEC Dioxins			**1.890**	1.916	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	16.973		1.697	1.697	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	16.468		0.494	0.494	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	7.915	J	2.375	2.375	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	49.64		4.964	4.964	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	12.398		1.240	1.240	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.246	J	0.225	0.225	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	24.7		2.470	2.470	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	63.867		0.639	0.639	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	20.889		0.209	0.209	
Octachlorodibenzofuran	ng/kg	NV	0.0003	217.471		0.065	0.065	
			TEC Furans			**14.377**	14.377	**ng/kg**
			Total TEC Dioxin/Furan			16.267	16.293	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-26***
Sample ID:	***SE-011707-ILM-NL-26-003***
Sample Depth (feet BML):	***10 to 13***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-30.4 to -33.4***
Sample Elevation (feet NGVD):	***-36.7 to -39.7***
Sample Date:	***1/17/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.1	U	-	0.051	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.15	J	0.145	0.145	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.24	U	-	0.012	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.72	J	0.072	0.072	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.25	U	-	0.013	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	6.11	J	0.061	0.061	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	53.0		0.016	0.016	
			TEC Dioxins			**0.294**	0.370	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	4.33		0.433	0.433	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.25	J	0.098	0.098	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.95	J	0.585	0.585	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.28	J	0.728	0.728	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.09	J	0.209	0.209	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.56	U	-	0.028	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.47	J	0.147	0.147	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.19	J	0.082	0.082	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.42	J	0.024	0.024	
Octachlorodibenzofuran	ng/kg	NV	0.0003	44.8		0.013	0.013	
			TEC Furans			**2.319**	2.347	**ng/kg**
			Total TEC Dioxin/Furan			2.613	2.717	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-26***
Sample ID:	***SE-01180ILMBS-NL-26-006***
Sample Depth (feet BML):	***20 to 23***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-40.4 to -43.4***
Sample Elevation (feet NGVD):	***-46.7 to -49.7***
Sample Date:	***1/18/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.315	J	0.315	0.315	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.636	J	0.636	0.636	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.019	U	-	0.001	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.47	J	0.447	0.447	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.019	U	-	0.001	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	53.7		0.537	0.537	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	453		0.136	0.136	
			TEC Dioxins			**2.071**	2.073	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	33.1		3.310	3.310	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	28.8		0.864	0.864	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	15.4		4.620	4.620	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	64.1		6.410	6.410	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	15.4		1.540	1.540	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.2	J	0.120	0.120	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.26		0.926	0.926	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	72.5		0.725	0.725	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	21.2		0.212	0.212	
Octachlorodibenzofuran	ng/kg	NV	0.0003	353		0.106	0.106	
			TEC Furans			**18.833**	18.833	**ng/kg**
			Total TEC Dioxin/Furan			20.904	20.906	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-27***
Sample ID:	***SE-011907-BS-NL-27-001***
Sample Depth (feet BML):	***0 to 2***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-5 to -7***
Sample Elevation (feet NGVD):	***-11.32 to -13.32***
Sample Date:	***1/19/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.268	J	1.268	1.268	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.634	U	-	0.317	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.491	U	-	0.075	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.505	J	0.451	0.451	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.258	J	0.426	0.426	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	94.887		0.949	0.949	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	578.544		0.174	0.174	
			TEC Dioxins			**3.267**	3.658	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	128.173		12.817	12.817	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	104.347	J	3.130	3.130	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	33.341		10.002	10.002	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	287.426	J	28.743	28.743	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	83.516	J	8.352	8.352	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.579	U	-	0.129	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	13.524		1.352	1.352	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	635.583		6.356	6.356	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	139.235		1.392	1.392	
Octachlorodibenzofuran	ng/kg	NV	0.0003	2193.655		0.658	0.658	
			TEC Furans			**72.803**	72.932	**ng/kg**
			Total TEC Dioxin/Furan			76.070	76.590	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-27***
Sample ID:	***SE-011907-BS-NL-27-002***
Sample Depth (feet BML):	***6 to 8***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-11 to -13***
Sample Elevation (feet NGVD):	***-17.32 to -19.32***
Sample Date:	***1/19/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.115	U	-	0.058	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.342	U	-	0.171	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.626	U	-	0.031	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.031	J	0.103	0.103	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.658	U	-	0.033	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	13.981		0.140	0.140	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	86.752		0.026	0.026	
			TEC Dioxins			**0.269**	0.562	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	21.494		2.149	2.149	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	24.924		0.748	0.748	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	8.571	J	2.571	2.571	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	83.536		8.354	8.354	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	24.37	J	2.437	2.437	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.808	U	-	0.040	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.87	U	-	0.044	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	142.269	J	1.423	1.423	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	56.163		0.562	0.562	
Octachlorodibenzofuran	ng/kg	NV	0.0003	730.221		0.219	0.219	
			TEC Furans			**18.462**	18.546	**ng/kg**
			Total TEC Dioxin/Furan			18.731	19.108	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-28***
Sample ID:	***SE-011707-BS-NL-28-002***
Sample Depth (feet BML):	***5 to 8***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-8.4 to -11.4***
Sample Elevation (feet NGVD):	***-14.72 to -17.72***
Sample Date:	***1/17/2007***

		Cleanup Level	TEF [1]			TEC ND = 0 [2]	TEC ND = 0.5xDL [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	20.753		20.753	20.753	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	10.86	J	10.860	10.860	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	13.105	J	1.311	1.311	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	21.764		2.176	2.176	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.885	J	0.489	0.489	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	291.291	J	2.913	2.913	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	1824.813		0.547	0.547	
			TEC Dioxins			**39.049**	39.049	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	11590.11		1159.011	1159.011	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	4912.991		147.390	147.390	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	2365.48		709.644	709.644	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2490.486		249.049	249.049	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	46.801		4.680	4.680	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	97.169		9.717	9.717	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	134.874		13.487	13.487	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	2761.574		27.616	27.616	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	934.937		9.349	9.349	
Octachlorodibenzofuran	ng/kg	NV	0.0003	7740.443		2.322	2.322	
			TEC Furans			**2332.265**	2332.265	**ng/kg**
			Total TEC Dioxin/Furan			2371.314	2371.314	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-28***
Sample ID:	***SE-011707-BS-NL-28-003***
Sample Depth (feet BML):	***10 to 13***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-13.4 to -16.4***
Sample Elevation (feet NGVD):	***-19.7 to -22.7***
Sample Date:	***1/17/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.43	J	0.429	0.429	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.85	J	0.852	0.852	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.98	J	0.098	0.098	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.66	J	0.266	0.266	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.61	J	0.261	0.261	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	28.5		0.285	0.285	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	182		0.055	0.055	
			TEC Dioxins			**2.246**	2.246	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	177		17.700	17.700	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	81.9		2.457	2.457	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	36.2		10.860	10.860	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	121		12.100	12.100	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	26.4		2.640	2.640	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.02	U	-	0.101	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	13.5		1.350	1.350	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	85.2		0.852	0.852	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	28.7		0.287	0.287	
Octachlorodibenzofuran	ng/kg	NV	0.0003	476		0.143	0.143	
			TEC Furans			**48.389**	48.490	**ng/kg**
			Total TEC Dioxin/Furan			50.635	50.736	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-28***
Sample ID:	***SE-011707-BS-NL-28-004***
Sample Depth (feet BML):	***15 to 18***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-18.4 to -21.4***
Sample Elevation (feet NGVD):	***-24.7 to -27.7***
Sample Date:	***1/17/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.09	U	-	0.044	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.16	U	-	0.081	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.12	U	-	0.006	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.4	J	0.040	0.040	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.25	J	0.025	0.025	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	4.44	J	0.044	0.044	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	37.0		0.011	0.011	
			TEC Dioxins			**0.120**	0.251	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	71.5		7.150	7.150	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	33.1		0.993	0.993	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	12.6		3.780	3.780	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	45.9		4.590	4.590	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.15		0.915	0.915	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.86	J	0.086	0.086	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.43	J	0.343	0.343	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	21.9		0.219	0.219	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.49		0.085	0.085	
Octachlorodibenzofuran	ng/kg	NV	0.0003	77.1		0.023	0.023	
			TEC Furans			**18.184**	18.184	**ng/kg**
			Total TEC Dioxin/Furan			18.304	18.434	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-29***
Sample ID:	***SE-011807-BS-NL-29-001***
Sample Depth (feet BML):	***0 to 3***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-4.5 to -7.5***
Sample Elevation (feet NGVD):	***-10.8 to -13.8***
Sample Date:	***1/18/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.65		1.650	1.650	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.752	U	-	0.376	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.65	J	0.365	0.365	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	11.0		1.100	1.100	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	6.27	J	0.627	0.627	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	230		2.300	2.300	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2330		0.699	0.699	
			TEC Dioxins			**6.741**	7.117	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	743		74.300	74.300	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	472		14.160	14.160	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	173		51.900	51.900	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	777		77.700	77.700	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	180		18.000	18.000	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	12.4		1.240	1.240	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	67.2		6.720	6.720	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	474		4.740	4.740	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	253		2.530	2.530	
Octachlorodibenzofuran	ng/kg	NV	0.0003	2070		0.621	0.621	
			TEC Furans			**251.911**	251.911	**ng/kg**
			Total TEC Dioxin/Furan			258.652	259.028	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-29***
Sample ID:	***SE-011807-BS-NL-29-002***
Sample Depth (feet BML):	***5 to 8***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-9.5 to -12.5***
Sample Elevation (feet NGVD):	***-15.82 to -18.82***
Sample Date:	***1/18/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.615	J	0.615	0.615	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.048	J	1.048	1.048	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.107	J	0.111	0.111	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.85	J	0.385	0.385	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.682	J	0.268	0.268	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	97.203		0.972	0.972	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	834.995		0.250	0.250	
			TEC Dioxins			**3.649**	3.649	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	201.78		20.178	20.178	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	143.99		4.320	4.320	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	59.908		17.972	17.972	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	204.725		20.473	20.473	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	46.801		4.680	4.680	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.836	J	0.384	0.384	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	8.328		0.833	0.833	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	154.848		1.548	1.548	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	51.339		0.513	0.513	
Octachlorodibenzofuran	ng/kg	NV	0.0003	700.756		0.210	0.210	
			TEC Furans			**71.111**	71.111	**ng/kg**
			Total TEC Dioxin/Furan			74.761	74.761	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-29***
Sample ID:	***SE-011807-BS-NL-29-003***
Sample Depth (feet BML):	***10 to 13***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-14.5 to -17.5***
Sample Elevation (feet NGVD):	***-20.8 to -23.8***
Sample Date:	***1/18/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.64 J	0.640	0.640	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.38 J	1.380	1.380	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.48 J	0.148	0.148	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.16 J	0.316	0.316	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.02 J	0.302	0.302	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	37.6	0.376	0.376	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	293	0.088	0.088	
			TEC Dioxins		**3.250**	3.250	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	69.2 J	6.920	6.920	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	62.4	1.872	1.872	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	24.7	7.410	7.410	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	127	12.700	12.700	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	43.6	4.360	4.360	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.31 J	0.531	0.531	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	48.1	4.810	4.810	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	212 J	2.120	2.120	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	53.6	0.536	0.536	
Octachlorodibenzofuran	ng/kg	NV	0.0003	1280	0.384	0.384	
			TEC Furans		**41.643**	41.643	**ng/kg**
			Total TEC Dioxin/Furan		44.893	44.893	**ng/kg**

TABLE N.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***NL-30***
Sample ID:	***SE-011907-BS-NL-30-001***
Sample Depth (feet BML):	***0 to 3***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-23.25 to -26.25***
Sample Elevation (feet NGVD):	***-29.57 to -32.57***
Sample Date:	***1/19/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.102	U	-	0.051	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.117	U	-	0.059	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.224	U	-	0.011	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.344	U	-	0.017	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.26	U	-	0.013	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	9.68		0.097	0.097	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	85.58		0.026	0.026	
			TEC Dioxins			**0.122**	0.273	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	24.28		2.428	2.428	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	9.00		0.270	0.270	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	3.98	J	1.194	1.194	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	16.51		1.651	1.651	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.06	J	0.406	0.406	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.64	U	-	0.032	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.25	J	0.325	0.325	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	18.91		0.189	0.189	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.38	J	0.054	0.054	
Octachlorodibenzofuran	ng/kg	NV	0.0003	86.89		0.026	0.026	
			TEC Furans			**6.543**	6.575	**ng/kg**
			Total TEC Dioxin/Furan			6.665	6.848	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-1***
Sample ID:	***S-112906-ILM-NTD1-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***3 to 4***
Sample Elevation (feet MLLW):	***15 to 14***
Sample Elevation (feet NGVD):	***8.7 to 7.7***
Sample Date:	***11/29/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	29.3	J	29.300	29.300	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	115	J	115.000	115.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	73.3	J	7.330	7.330	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	119	J	11.900	11.900	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	592	J	59.200	59.200	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	1350	J	13.500	13.500	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	4720	J	1.416	1.416	
			TEC Dioxins			**237.646**	237.646	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	443	J	44.300	44.300	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	431	J	12.930	12.930	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	833	J	249.900	249.900	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1500	J	150.000	150.000	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	627	J	62.700	62.700	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	10.3	J	1.030	1.030	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	713	J	71.300	71.300	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1500	J	15.000	15.000	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	86.1	J	0.861	0.861	
Octachlorodibenzofuran	ng/kg	NV	0.0003	424	J	0.127	0.127	
			TEC Furans			**608.148**	608.148	**ng/kg**
			Total TEC Dioxin/Furan			845.794	845.794	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-1***
Sample ID:	***S-011007-TS-NTD1-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***3 to 5***
Sample Elevation (feet MLLW):	***15 to 13***
Sample Elevation (feet NGVD):	***8.7 to 6.7***
Sample Date:	***1/10/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.14	J	1.140	1.140	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.837	J	2.837	2.837	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.365	J	0.537	0.537	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	15.129		1.513	1.513	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	12.119		1.212	1.212	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	249.66		2.497	2.497	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2202.108		0.661	0.661	
			TEC Dioxins			**10.396**	10.396	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	27.105		2.711	2.711	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	14.935	J	0.448	0.448	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	20.926		6.278	6.278	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	33.308		3.331	3.331	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	13.882		1.388	1.388	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.711	U	-	0.036	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	13.22		1.322	1.322	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	76.213		0.762	0.762	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	6.788	J	0.068	0.068	
Octachlorodibenzofuran	ng/kg	NV	0.0003	154.891		0.046	0.046	
			TEC Furans			**16.354**	16.389	**ng/kg**
			Total TEC Dioxin/Furan			26.749	26.785	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-1***
Sample ID:	***S-011007-TS-NTD1-002***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***13 to 15***
Sample Elevation (feet MLLW):	***25 to 23***
Sample Elevation (feet NGVD):	***18.7 to 16.7***
Sample Date:	***1/10/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	13.1	13.100	13.100	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	56.0	56.000	56.000	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	27.2	2.720	2.720	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	185	18.500	18.500	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	576	57.600	57.600	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	757	7.570	7.570	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	1960	0.588	0.588	
			TEC Dioxins		**156.078**	156.078	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	232	23.200	23.200	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	190	5.700	5.700	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	464	139.200	139.200	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	616	61.600	61.600	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	243	24.300	24.300	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.03	0.703	0.703	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	408	40.800	40.800	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1250	12.500	12.500	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	80.8	0.808	0.808	
Octachlorodibenzofuran	ng/kg	NV	0.0003	721	0.216	0.216	
			TEC Furans		**309.027**	309.027	**ng/kg**
			Total TEC Dioxin/Furan		465.105	465.105	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-112906-ILM-NTD2-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***3 to 4.5***
Sample Elevation (feet MLLW):	***15.02 to 13.52***
Sample Elevation (feet NGVD):	***8.7 to 7.2***
Sample Date:	***11/29/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	2.06	J	2.060	2.060	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	8.75	J	8.750	8.750	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.93	J	0.893	0.893	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	29.9	J	2.990	2.990	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	28.3	J	2.830	2.830	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	596	J	5.960	5.960	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	5270	J	1.581	1.581	
			TEC Dioxins			**25.064**	25.064	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	55.4	J	5.540	5.540	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	34.1	J	1.023	1.023	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	77.3	J	23.190	23.190	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	109	J	10.900	10.900	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	47.4	J	4.740	4.740	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.87	J	0.187	0.187	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	54.6	J	5.460	5.460	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	298	J	2.980	2.980	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	17.2	J	0.172	0.172	
Octachlorodibenzofuran	ng/kg	NV	0.0003	451	J	0.135	0.135	
			TEC Furans			**54.327**	54.327	**ng/kg**
			Total TEC Dioxin/Furan			79.391	79.391	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-112906-ILM-NTD2-002***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***13 to 14.5***
Sample Elevation (feet MLLW):	***5 to 3.5***
Sample Elevation (feet NGVD):	***-1.3 to -2.8***
Sample Date:	***11/29/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.17	J	1.170	1.170	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.22	J	1.220	1.220	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.26	J	0.326	0.326	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	18.5	J	1.850	1.850	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.8	J	0.880	0.880	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	522		5.220	5.220	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	7000		2.100	2.100	
			TEC Dioxins			**12.766**	12.766	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	14.8		1.480	1.480	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	8.19	J	0.246	0.246	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	16.4	J	4.920	4.920	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	25.7	J	2.570	2.570	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	11.6	J	1.160	1.160	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.74	J	0.074	0.074	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	19.2	J	1.920	1.920	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	210		2.100	2.100	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	9.87	J	0.099	0.099	
Octachlorodibenzofuran	ng/kg	NV	0.0003	670		0.201	0.201	
			TEC Furans			**14.769**	14.769	**ng/kg**
			Total TEC Dioxin/Furan			27.535	27.535	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-112906-ILM-NTD2-003***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***22.5 to 25***
Sample Elevation (feet MLLW):	***-4.48 to -6.98***
Sample Elevation (feet NGVD):	***-10.8 to -13.3***
Sample Date:	***11/29/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.588	J	0.588	0.588	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.88	J	1.880	1.880	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.33	J	0.133	0.133	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.67	J	0.467	0.467	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.39	J	0.539	0.539	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	55.7	J	0.557	0.557	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	436	J	0.131	0.131	
			TEC Dioxins			**4.295**	4.295	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	25.6	J	2.560	2.560	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	7.39	J	0.222	0.222	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	16.1	J	4.830	4.830	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	24.3	J	2.430	2.430	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	8.53	J	0.853	0.853	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.301	J	0.030	0.030	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	12.6	J	1.260	1.260	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	42.3	J	0.423	0.423	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.49	J	0.025	0.025	
Octachlorodibenzofuran	ng/kg	NV	0.0003	44.2	J	0.013	0.013	
			TEC Furans			**12.646**	12.646	**ng/kg**
			Total TEC Dioxin/Furan			16.941	16.941	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Navy-Todd Dump***							
Sample Location:				***NTD-2***							
Sample ID:				***S-121406-ILM-NTD2-006***		***S-121406-ILM-NTD2-007***					
Sample Depth (feet BML):				***43 to 45***		***43 to 45***		***43 to 45***			
Sample Depth (feet BGS):				***NA***		***NA***		***NA***			
Sample Elevation (feet MLLW):				***-24.98 to -26.98***		***-24.98 to -26.98***		***-24.98 to -26.98***			
Sample Elevation (feet NGVD):				***-31.3 to -33.3***		***-31.3 to -33.3***		***-31.3 to -33.3***			
Sample Date:				***12/14/2006***		***12/14/2006 duplicate***		***12/14/2006 average***			
		Cleanup Level	***TEF [1]***							***TEC***	
										ND = 0 [2]	***ND = 0.5xDL [3]***
Dioxins											
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.215	J	0.114	J	0.1645	J	0.165	0.165
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.653	J	0.401	J	0.527	J	0.527	0.527
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.421	J	0.37	J	0.3955	J	0.040	0.040
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.78	J	1.07	J	1.425	J	0.143	0.143
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.67	J	1.05	J	1.36	J	0.136	0.136
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	26.5	J	22	J	24.25	J	0.243	0.243
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	221	J	209	J	215	J	0.065	0.065
			TEC Dioxins							**1.317**	1.317 **ng/kg**
Furans											
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	4.59	J	3.83	J	4.21	J	0.421	0.421
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	2.72	J	2.12	J	2.42	J	0.073	0.073
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	5.43	J	4.67	J	5.05	J	1.515	1.515
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.31	J	6.64	J	6.975	J	0.698	0.698
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.55	J	2.44	J	2.495	J	0.250	0.250
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.123	J	0.147	UJ	0.09825	UJ	-	0.005
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.05	J	3.69	J	0.63	J	0.063	0.063
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	13.6	J	14.1	J	13.85	J	0.139	0.139
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.02	J	0.857	J	0.7	J	0.007	0.007
Octachlorodibenzofuran	ng/kg	NV	0.0003	21.5	J	22.9	J	22.2	J	0.007	0.007
			TEC Furans							**3.171**	3.176 **ng/kg**
			Total TEC Dioxin/Furan							4.487	4.492 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-121406-ILM-NTD2-008***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***53 to 55***
Sample Elevation (feet MLLW):	***-34.98 to -36.98***
Sample Elevation (feet NGVD):	***-41.3 to -43.3***
Sample Date:	***12/14/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.24	J	0.240	0.240	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.02	J	1.020	1.020	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.891	J	0.089	0.089	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.52	J	0.252	0.252	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.96	J	0.296	0.296	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	51.3	J	0.513	0.513	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	331	J	0.099	0.099	
			TEC Dioxins			**2.509**	2.509	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	6.44	J	0.644	0.644	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.45	J	0.104	0.104	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	9.24	J	2.772	2.772	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	13	J	1.300	1.300	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.11	J	0.511	0.511	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.167	J	0.017	0.017	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.08	J	0.708	0.708	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	26.7	J	0.267	0.267	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.57	J	0.016	0.016	
Octachlorodibenzofuran	ng/kg	NV	0.0003	36.8	J	0.011	0.011	
			TEC Furans			**6.349**	6.349	**ng/kg**
			Total TEC Dioxin/Furan			8.858	8.858	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-121406-ILM-NTD2-009***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***63 to 65***
Sample Elevation (feet MLLW):	***-44.98 to -46.98***
Sample Elevation (feet NGVD):	***-51.3 to -53.3***
Sample Date:	***12/14/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.0887	J	0.089	0.089	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.483	J	0.483	0.483	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.576	J	0.058	0.058	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.64	J	0.164	0.164	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.96	J	0.196	0.196	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	26.3	J	0.263	0.263	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	218	J	0.065	0.065	
			TEC Dioxins			**1.318**	1.318	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	4.9	J	0.490	0.490	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.57	J	0.107	0.107	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	9.65	J	2.895	2.895	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	37.5	J	3.750	3.750	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.09	J	0.909	0.909	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.17	J	0.217	0.217	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	19.7	J	1.970	1.970	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	133	J	1.330	1.330	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	9.32	J	0.093	0.093	
Octachlorodibenzofuran	ng/kg	NV	0.0003	122	J	0.037	0.037	
			TEC Furans			**11.798**	11.798	**ng/kg**
			Total TEC Dioxin/Furan			13.116	13.116	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Navy-Todd Dump***
Sample Location:	***NTD-2***
Sample ID:	***S-121406-ILM-NTD2-010***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***73 to 75***
Sample Elevation (feet MLLW):	***-55 to -57***
Sample Elevation (feet NGVD):	***-61.3 to -63.3***
Sample Date:	***12/14/2006***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.06	U	-	0.030
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.052	U	-	0.026
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.132	J	0.013	0.013
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.419	JK	0.042	0.042
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.183	J	0.018	0.018
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	7.663		0.077	0.077
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	89.151		0.027	0.027
			TEC Dioxins			**0.177**	0.233 **ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.81	U	-	0.041
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.768	J	0.023	0.023
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.984	J	0.595	0.595
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.183	J	0.218	0.218
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.744	J	0.074	0.074
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.059	U	-	0.003
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.423	J	0.142	0.142
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.877	J	0.059	0.059
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.395	J	0.004	0.004
Octachlorodibenzofuran	ng/kg	NV	0.0003	11.022	J	0.003	0.003
			TEC Furans			**1.119**	1.163 **ng/kg**
			Total TEC Dioxin/Furan			1.296	1.395 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Pier 25***
Sample Location:	***PIER 25A***
Sample ID:	***SE-013007-BI-PIER25A-001***
Sample Depth (feet BML):	***0 - 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***7 to 6.67***
Sample Elevation (feet NGVD):	***0.68 to 0.35***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.39	J	1.390	1.390	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.92	J	4.920	4.920	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	6.96	J	0.696	0.696	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	26.9		2.690	2.690	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	19.6		1.960	1.960	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	616		6.160	6.160	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	52832		15.850	15.850	
			TEC Dioxins			**33.666**	33.666	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	54.1		5.410	5.410	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	26.2		0.786	0.786	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	24.7		7.410	7.410	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	51.8		5.180	5.180	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	17.7		1.770	1.770	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.07	J	0.107	0.107	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.97		0.997	0.997	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	161		1.610	1.610	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	21.7		0.217	0.217	
Octachlorodibenzofuran	ng/kg	NV	0.0003	632		0.190	0.190	
			TEC Furans			**23.677**	23.677	**ng/kg**
			Total TEC Dioxin/Furan			57.342	57.342	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Pier 25***
Sample Location:	***PIER 25A***
Sample ID:	***SE-013007-BI-PIER25A-002***
Sample Depth (feet BML):	***0 - 3***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***7 to 4***
Sample Elevation (feet NGVD):	***0.68 to -2.32***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.3	J	1.300	1.300	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	5.93	J	5.930	5.930	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	7	J	0.700	0.700	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	30.7		3.070	3.070	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	25.7		2.570	2.570	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	624		6.240	6.240	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	6946		2.084	2.084	
			TEC Dioxins			**21.894**	21.894	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	66		6.600	6.600	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	30.8		0.924	0.924	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	33.3		9.990	9.990	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	65		6.500	6.500	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	21.8		2.180	2.180	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.19	J	0.119	0.119	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	15.3		1.530	1.530	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	181		1.810	1.810	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	22		0.220	0.220	
Octachlorodibenzofuran	ng/kg	NV	0.0003	529		0.159	0.159	
			TEC Furans			**30.032**	30.032	**ng/kg**
			Total TEC Dioxin/Furan			51.926	51.926	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Pier 25***
Sample Location:	***PIER 25A***
Sample ID:	***SE-013007-BI-PIER25A-003***
Sample Depth (feet BML):	***3.3 - 5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***3.7 to -1.3***
Sample Elevation (feet NGVD):	***-2.62 to -4.32***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.52	J	1.520	1.520	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	6.17	J	6.170	6.170	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	8.25		0.825	0.825	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	27.5		2.750	2.750	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	23		2.300	2.300	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	467		4.670	4.670	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	4390		1.317	1.317	
			TEC Dioxins			**19.552**	19.552	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	63.8		6.380	6.380	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	29	J	0.870	0.870	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	22.3		6.690	6.690	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	54.2	J	5.420	5.420	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	16.1		1.610	1.610	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.08	J	0.108	0.108	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.26		0.926	0.926	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	153		1.530	1.530	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	20		0.200	0.200	
Octachlorodibenzofuran	ng/kg	NV	0.0003	476		0.143	0.143	
			TEC Furans			**23.877**	23.877	**ng/kg**
			Total TEC Dioxin/Furan			43.429	43.429	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Pier 25***
Sample Location:	***PIER 25B***
Sample ID:	***SE-013007-BI-PIER25B-001***
Sample Depth (feet BML):	***0 - 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***2.5 to 2.17***
Sample Elevation (feet NGVD):	***-3.82 to -4.15***
Sample Date:	***1/30/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.519	J	0.519	0.519	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.19	J	2.190	2.190	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.16	J	0.216	0.216	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	13.6		1.360	1.360	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	9.84		0.984	0.984	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	264		2.640	2.640	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2286		0.686	0.686	
			TEC Dioxins			**8.595**	8.595	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	39.6		3.960	3.960	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	18		0.540	0.540	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	22.6		6.780	6.780	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	32		3.200	3.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	10.6		1.060	1.060	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.46	J	0.046	0.046	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.2	J	0.720	0.720	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	72.5		0.725	0.725	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	9.84		0.098	0.098	
Octachlorodibenzofuran	ng/kg	NV	0.0003	229		0.069	0.069	
			TEC Furans			**17.198**	17.198	**ng/kg**
			Total TEC Dioxin/Furan			25.793	25.793	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***PIER 25***								
Sample Location:				***Pier 25B***		***Pier 25B***						
Sample ID:				***SE-013007-BI-PIER25B-002***		***SE-013007-BI-PIER25B-003***						
Sample Depth (feet BML):				***2 - 3.5***		***2 - 3.5***		***2 - 3.5***				
Sample Depth (feet BGS):				***NA***		***NA***		***NA***				
Sample Elevation (feet MLLW):				***0.5 to -3***		***0.5 to -3***		***0.5 to -3***				
Sample Elevation (feet NGVD):				***-5.82 to -7.32***		***-5.82 to -7.32***		***-5.82 to -7.32***				
Sample Date:				***1/30/2007***		***1/30/2007 duplicate***		***1/30/2007 average***				
		Cleanup Level	***TEF [1]***							***TEC***		
										ND = 0 [2]	***ND = 0.5xDL [3]***	
Dioxins												
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.158	U	0.15	U	0.154	U	-	0.077	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.135	U	0.15	U	0.1425	U	-	0.071	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.156	U	0.18	U	0.168	U	-	0.008	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.736	J	0.84	J	0.788	J	0.079	0.079	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.394	J	0.64	J	0.517	J	0.052	0.052	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	13.9		16.9		15.4	J	0.154	0.154	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	120		160		140	J	0.042	0.042	
			TEC Dioxins							**0.327**	0.483	**ng/kg**
Furans												
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	2.812		3.5		3.156		0.316	0.316	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.187	J	1.48	J	1.3335	J	0.040	0.040	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.336	J	1.69	J	1.513	J	0.454	0.454	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.962	J	2.46	J	2.211	J	0.221	0.221	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.607	J	0.7	J	0.6535	J	0.065	0.065	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.175	U	0.18	U	0.1775	U	-	0.009	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.181	U	0.63	J	0.63	J	0.063	0.063	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.924	J	5.41	J	4.667	J	0.047	0.047	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.222	U	0.7	J	0.7	J	0.007	0.007	
Octachlorodibenzofuran	ng/kg	NV	0.0003	9.838	J	13.3	J	11.569	J	0.003	0.003	
			TEC Furans							**1.216**	1.224	**ng/kg**
			Total TEC Dioxin/Furan							1.543	1.708	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25C***
Sample ID:	***SE-013107-BI-PIER25C-001***
Sample Depth (feet BML):	***0 - 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-1.2 to -1.53***
Sample Elevation (feet NGVD):	***-7.52 to -7.85***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.2	J	1.200	1.200	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.16	J	4.160	4.160	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.91	J	0.391	0.391	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	24.7		2.470	2.470	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	17.3		1.730	1.730	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	575		5.750	5.750	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	5758		1.727	1.727	
			TEC Dioxins			**17.428**	17.428	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	27.3		2.730	2.730	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	16.2		0.486	0.486	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	12.8		3.840	3.840	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	26.4		2.640	2.640	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	8.83	J	0.883	0.883	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.39	U	-	0.020	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.87	J	0.487	0.487	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	85.1		0.851	0.851	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.52	J	0.085	0.085	
Octachlorodibenzofuran	ng/kg	NV	0.0003	222		0.067	0.067	
			TEC Furans			**12.069**	12.088	**ng/kg**
			Total TEC Dioxin/Furan			29.497	29.517	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25C***
Sample ID:	***SE-013107-BI-PIER25C-002***
Sample Depth (feet BML):	***0 - 2***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-1.2 to -3.2***
Sample Elevation (feet NGVD):	***-7.52 to -9.52***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.24	U	-	0.120	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.77	J	1.770	1.770	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.45	J	0.145	0.145	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	10.3		1.030	1.030	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.81	J	0.581	0.581	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	179		1.790	1.790	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	1828		0.548	0.548	
			TEC Dioxins			**5.864**	5.984	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	15.3		1.530	1.530	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	7.14	J	0.214	0.214	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	5.67	J	1.701	1.701	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.57	J	0.957	0.957	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.75	J	0.375	0.375	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.28	U	-	0.014	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.26	J	0.226	0.226	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	29.7		0.297	0.297	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.34	J	0.033	0.033	
Octachlorodibenzofuran	ng/kg	NV	0.0003	70.1		0.021	0.021	
			TEC Furans			**5.355**	5.369	**ng/kg**
			Total TEC Dioxin/Furan			11.219	11.353	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25C***
Sample ID:	***SE-013107-BI-PIER25C-003***
Sample Depth (feet BML):	***2 - 3.5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-3.2 to -4.7***
Sample Elevation (feet NGVD):	***-9.52 to -11.02***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.21	U	-	0.105
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.47	J	3.470	3.470
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.59	J	0.359	0.359
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	23.24		2.324	2.324
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	12		1.200	1.200
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	489		4.890	4.890
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	4809		1.443	1.443
			TEC Dioxins			**13.686**	13.791 **ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	30.5		3.050	3.050
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	17.9		0.537	0.537
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	13.8		4.140	4.140
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	27.7		2.770	2.770
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	9.29		0.929	0.929
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.45	U	-	0.023
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.07	J	0.507	0.507
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	82.6		0.826	0.826
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	8.73	J	0.087	0.087
Octachlorodibenzofuran	ng/kg	NV	0.0003	184		0.055	0.055
			TEC Furans			**12.902**	12.924 **ng/kg**
			Total TEC Dioxin/Furan			26.587	26.715 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25D***
Sample ID:	***SE-013107-BI-PIER25D-001***
Sample Depth (feet BML):	***0 - 0.33***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***8.3 to 7.97***
Sample Elevation (feet NGVD):	***1.98 to 1.65***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.15	U	-	0.075	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	1.18	J	1.180	1.180	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.5	J	0.150	0.150	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.18	J	0.518	0.518	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.78	J	0.478	0.478	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	124		1.240	1.240	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	1297		0.389	0.389	
			TEC Dioxins			**3.955**	4.030	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	11.2		1.120	1.120	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	6.1	J	0.183	0.183	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	9.11		2.733	2.733	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	15		1.500	1.500	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.04	J	0.504	0.504	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.15	U	-	0.008	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.9	J	0.590	0.590	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	37.3		0.373	0.373	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.73	J	0.057	0.057	
Octachlorodibenzofuran	ng/kg	NV	0.0003	85.2		0.026	0.026	
			TEC Furans			**7.086**	7.093	**ng/kg**
			Total TEC Dioxin/Furan			11.041	11.123	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25D***
Sample ID:	***SE-013107-BI-PIER25D-002***
Sample Depth (feet BML):	***0.5 - 2***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***7.8 to 6.3***
Sample Elevation (feet NGVD):	***1.48 to -0.02***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.2	U	-	0.100	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.5	J	0.500	0.500	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.72	J	0.072	0.072	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.23	J	0.223	0.223	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.2	J	0.220	0.220	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	43.9		0.439	0.439	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	380		0.114	0.114	
			TEC Dioxins			**1.568**	1.668	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	3.07		0.307	0.307	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.57	J	0.047	0.047	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	1.86	J	0.558	0.558	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.21	J	0.321	0.321	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.12	J	0.112	0.112	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.06	U	-	0.003	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.2	J	0.120	0.120	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	9.38		0.094	0.094	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.13	J	0.011	0.011	
Octachlorodibenzofuran	ng/kg	NV	0.0003	26.7		0.008	0.008	
			TEC Furans			**1.578**	1.581	**ng/kg**
			Total TEC Dioxin/Furan			3.146	3.249	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***PIER 25***
Sample Location:	***Pier 25D***
Sample ID:	***SE-013107-BI-PIER25D-003***
Sample Depth (feet BML):	***2- 3.5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***6.3 to 4.8***
Sample Elevation (feet NGVD):	***-0.02 to -1.52***
Sample Date:	***1/31/2007***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.118	U	-	0.059
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.332	J	0.332	0.332
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.094	U	-	0.005
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.22	J	0.122	0.122
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.98	J	0.098	0.098
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	19		0.190	0.190
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	170		0.051	0.051
			TEC Dioxins			**0.793**	0.857 **ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.91		0.191	0.191
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.18	J	0.035	0.035
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.96	J	0.288	0.288
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.97	J	0.197	0.197
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.714	J	0.071	0.071
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.066	U	-	0.003
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.385	J	0.039	0.039
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	5.81	J	0.058	0.058
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.674	J	0.007	0.007
Octachlorodibenzofuran	ng/kg	NV	0.0003	16.2		0.005	0.005
			TEC Furans			**0.891**	0.894 **ng/kg**
			Total TEC Dioxin/Furan			1.684	1.751 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-13A***
Sample ID:	***SE-110905-PT-13A-001***
Sample Depth (feet BML):	***11.8 to 13.8***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-31.9 to -33.9***
Sample Elevation (feet NGVD):	***-38.22 to -40.22***
Sample Date:	***11/9/2005***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.867	U	-	0.434	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.337	U	-	2.169	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.337	U	-	0.217	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.337	U	-	0.217	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.337	U	-	0.217	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	4.337	U	-	0.022	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	14.1		0.004	0.004	
			TEC Dioxins			**0.004**	3.278	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	3.251		0.325	0.325	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	1.30	J	0.039	0.039	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	4.337	U	-	0.651	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.6	J	0.260	0.260	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.337	U	-	0.217	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.337	U	-	0.217	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.337	U	-	0.217	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.38	J	0.034	0.034	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.976	J	0.010	0.010	
Octachlorodibenzofuran	ng/kg	NV	0.0003	13.8		0.004	0.004	
			TEC Furans			**0.672**	1.973	**ng/kg**
			Total TEC Dioxin/Furan			0.676	5.251	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-13A***
Sample ID:	***SE-110905-PT-13A-002***
Sample Depth (feet BML):	***21.8 to 23.8***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-41.9 to -43.9***
Sample Elevation (feet NGVD):	***-48.22 to-50.22***
Sample Date:	***11/9/2005***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.927	U	-	0.464	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.638	U	-	2.319	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.638	U	-	0.232	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.638	U	-	0.232	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.638	U	-	0.232	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	2.6	J	0.026	0.026	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	17.2		0.005	0.005	
			TEC Dioxins			**0.031**	3.509	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	1.46		0.146	0.146	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.779	J	0.023	0.023	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.541	J	0.162	0.162	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.583	J	0.258	0.258	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.617	J	0.062	0.062	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.638	U	-	0.232	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.481	J	0.048	0.048	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.203	J	0.032	0.032	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.206	J	0.012	0.012	
Octachlorodibenzofuran	ng/kg	NV	0.0003	12.9		0.004	0.004	
			TEC Furans			**0.748**	0.980	**ng/kg**
			Total TEC Dioxin/Furan			0.779	4.489	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Area 5106***							
Sample Location:				***PT-15A***							
Sample ID:				***SE-110905-NR-PT-15A-001***		***SE-110905-FD-001***					
Sample Depth (feet BML):				***56 to 57***		***56 to 57***		***56 to 57***			
Sample Depth (feet BGS):				***NA***		***NA***		***NA***			
Sample Elevation (feet MLLW):				***-94 to -95***		***-94 to -95***		***-94 to -95***			
Sample Elevation (feet NGVD):				***-100.32 to -101.32***		***-100.32 to -101.32***		***-100.32 to -101.32***			
Sample Date:				***11/9/2005***		***11/9/2005 duplicate***		***11/9/2005 average***			
		Cleanup Level	***TEF [1]***							***TEC***	
										ND = 0 [2]	***ND = 0.5xDL [3]***
Dioxins											
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.136	J	0.266	J	0.201	J	0.201	0.201
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.149	U	4.393	U	4.271	U	-	2.136
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.149	U	4.393	U	4.271	U	-	0.214
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.364	J	5.32	J	3.842	J	0.384	0.384
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.149	U	4.393	U	4.271	U	-	0.214
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	52.76		117		84.88		0.849	0.849
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	442		1014		728		0.218	0.218
			TEC Dioxins							**1.652**	4.215 **ng/kg**
Furans											
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	109		242	J	176	J	17.550	17.550
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	105		231		168		5.040	5.040
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	40.8		86.7		63.75		19.125	19.125
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	296		662		479		47.900	47.900
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	59.3		142		100.65		10.065	10.065
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	6.66		19.4		13.03		1.303	1.303
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	26.9		60.0		43.45		4.345	4.345
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	192		440		316		3.160	3.160
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	154		365		259.5		2.595	2.595
Octachlorodibenzofuran	ng/kg	NV	0.0003	1700		4600	J	3150	J	0.945	0.945
			TEC Furans							**112.028**	112.028 **ng/kg**
			Total TEC Dioxin/Furan							113.680	116.243 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15A***
Sample ID:	***SE-110905-NR-PT-15A-002***
Sample Depth (feet BML):	***66 to 67***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-104 to -105***
Sample Elevation (feet NGVD):	***-110.32 to -111.32***
Sample Date:	***11/9/2005***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.864	U	-	0.432	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	4.332	U	-	2.166	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.332	U	-	0.217	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.332	U	-	0.217	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.332	U	-	0.217	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	5.53		0.055	0.055	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	49		0.015	0.015	
			TEC Dioxins			**0.070**	3.318	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	18.8		1.880	1.880	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	14.1		0.423	0.423	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	4.66		1.398	1.398	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	40.4		4.040	4.040	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	7.19		0.719	0.719	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	4.332	U	-	0.217	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.31	J	0.331	0.331	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	32.3		0.323	0.323	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	18		0.180	0.180	
Octachlorodibenzofuran	ng/kg	NV	0.0003	227		0.068	0.068	
			TEC Furans			**9.362**	9.579	**ng/kg**
			Total TEC Dioxin/Furan			9.432	12.897	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***S-122006-PT-15B-DR-001***
Sample Depth (feet BML):	***13 to 15***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-27 to -29***
Sample Elevation (feet NGVD):	***-33.32 to -35.32***
Sample Date:	***12/21/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.112	J	1.112	1.112	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.058	U	-	1.529	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	6.061	J	0.606	0.606	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.137	U	-	0.207	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	4.147	U	-	0.207	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	271.208		2.712	2.712	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2082.15		0.625	0.625	
			TEC Dioxins			**5.055**	6.998	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	785.801		78.580	78.580	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	984.58		29.537	29.537	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	312.728		93.818	93.818	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1926.059		192.606	192.606	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	25.379	U	-	1.269	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	54.846		5.485	5.485	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	93.682		9.368	9.368	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1009.332		10.093	10.093	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	785.529		7.855	7.855	
Octachlorodibenzofuran	ng/kg	NV	0.0003	7369.214		2.211	2.211	
			TEC Furans			**429.554**	430.823	**ng/kg**
			Total TEC Dioxin/Furan			434.609	437.821	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***S-122006-PT-15B-DR-002***
Sample Depth (feet BML):	***18 to 20***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-32 to -34***
Sample Elevation (feet NGVD):	***-38.32 to -40.32***
Sample Date:	***12/20/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.062	U	-	0.031	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.145	U	-	0.073	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.336	U	-	0.017	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.879	J	0.088	0.088	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.379	U	-	0.019	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	18.706		0.187	0.187	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	185.66		0.056	0.056	
			TEC Dioxins			**0.331**	0.470	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	13.7		1.370	1.370	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	12.664		0.380	0.380	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	4.313	J	1.294	1.294	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	27.958		2.796	2.796	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.045	J	0.505	0.505	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.909	U	-	0.045	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.349	J	0.135	0.135	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	21.021		0.210	0.210	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	13.883		0.139	0.139	
Octachlorodibenzofuran	ng/kg	NV	0.0003	145.255		0.044	0.044	
			TEC Furans			**6.872**	6.918	**ng/kg**
			Total TEC Dioxin/Furan			7.202	7.389	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***S-122006-PT-15B-DR-003***
Sample Depth (feet BML):	***28 to 30***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-42 to -44***
Sample Elevation (feet NGVD):	***-48.32 to -50.32***
Sample Date:	***12/20/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.082	U	-	0.041	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.238	U	-	0.119	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.397	U	-	0.020	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.571	J	0.057	0.057	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.437	U	-	0.022	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	1.298	U	-	0.006	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	1.286	U	-	0.000	
			TEC Dioxins			**0.057**	0.265	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	17.526		1.753	1.753	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	16.808		0.504	0.504	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	5.467	J	1.640	1.640	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	39.552		3.955	3.955	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	6.686	J	0.669	0.669	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.517	J	0.052	0.052	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.813	J	0.181	0.181	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	45.884		0.459	0.459	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	17.547		0.175	0.175	
Octachlorodibenzofuran	ng/kg	NV	0.0003	192.006		0.058	0.058	
			TEC Furans			**9.446**	9.446	**ng/kg**
			Total TEC Dioxin/Furan			9.503	9.711	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-15B***
Sample ID:	***S-122106-PT-15B-DR-004***
Sample Depth (feet BML):	***38 to 40***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-52 to -54***
Sample Elevation (feet NGVD):	***-58.32 to -60.32***
Sample Date:	***12/21/2006***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.062	U	-	0.031	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.122	U	-	0.061	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.315	U	-	0.016	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.374	U	-	0.019	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.35	U	-	0.018	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.563	U	-	0.003	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.945	U	-	0.000	
			TEC Dioxins			**0.000**	0.147	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	14.397		1.440	1.440	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	15.682		0.470	0.470	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	4.734	J	1.420	1.420	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	36.04		3.604	3.604	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	5.777	J	0.578	0.578	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.775	J	0.078	0.078	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1.672	J	0.167	0.167	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	42.703		0.427	0.427	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	15.987		0.160	0.160	
Octachlorodibenzofuran	ng/kg	NV	0.0003	128.41		0.039	0.039	
			TEC Furans			**8.382**	8.382	**ng/kg**
			Total TEC Dioxin/Furan			8.382	8.529	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Area 5106***
Sample Location:	***PT-17A***
Sample ID:	***SE-020107-ILM-PT-17A-001***
Sample Depth (feet BML):	***0.5 to 2.5***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-21.5 to -23.5***
Sample Elevation (feet NGVD):	***-27.82 to -29.82***
Sample Date:	***02/01/07***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	4.474	J	4.474	4.474	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.729	U	-	1.865	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	73.2	U	-	3.660	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	89.1	U	-	4.455	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	81.3	U	-	4.065	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	424		4.240	4.240	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	5149		1.545	1.545	
			TEC Dioxins			**10.259**	24.303	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	2166		216.600	216.600	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	671		20.130	20.130	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	300		90.000	90.000	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1292		129.200	129.200	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	213		21.300	21.300	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	21.4		2.140	2.140	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	34.6	J	3.460	3.460	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1244		12.440	12.440	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	376		3.760	3.760	
Octachlorodibenzofuran	ng/kg	NV	0.0003	7036		2.111	2.111	
			TEC Furans			**501.141**	501.141	**ng/kg**
			Total TEC Dioxin/Furan			511.400	525.444	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***Area 5106***						
Sample Location:				***PT-17A***						
Sample ID:				***SE-020107-ILM-PT-17A-002***						
Sample Depth (feet BML):				***10 - 12***		***10 - 12***		***10 - 12***		
Sample Depth (feet BGS):				***NA***		***NA***		***NA***		
Sample Elevation (feet MLLW):				***-31 to -33***		***-31 to -33***		***-31 to -33***		
Sample Elevation (feet NGVD):				***-37.32 to -39.32***		***-37.32 to -39.32***		***-37.32 to -39.32***		
Sample Date:				***2/1/2007***		***2/1/2007 duplicate***		***2/1/2007 average***		
		Cleanup Level	***TEF [1]***						***TEC***	
									ND = 0 [2]	***ND = 0.5xDL [3]***
Dioxins										
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	1.153	J	0.536	J	0.8445	J	0.845	0.845	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.578	U	0.444	U	0.511	U	-	0.256	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2	U	0.332	U	1.166	U	-	0.058	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	5.105	J	0.912	J	3.0085	J	0.301	0.301	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	1.9	U	0.338	U	1.119	U	-	0.056	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	49.755		13.454	J	31.6045	J	0.316	0.316	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	591.168		154.09		372.629		0.112	0.112	
			TEC Dioxins							**1.573**	1.944	**ng/kg**
Furans												
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	535		177.004		356.002		35.600	35.600	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	115		38.124		76.562		2.297	2.297	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	52.96		17.652		35.306		10.592	10.592	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	138		49.325		93.6625		9.366	9.366	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	27.8		9.953	J	18.8765	J	1.888	1.888	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.13	J	0.914	J	2.022	J	0.202	0.202	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	6.37	J	2.656	J	4.513	J	0.451	0.451	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	110		36.658		73.329		0.733	0.733	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	33.4		11.828	J	22.614	J	0.226	0.226	
Octachlorodibenzofuran	ng/kg	NV	0.0003	497		150.506		323.753		0.097	0.097	
			TEC Furans							**61.453**	61.453	**ng/kg**
			Total TEC Dioxin/Furan							63.026	63.397	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-11***
Sample ID:	***S-080206-LH-WMUA11-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***17 to 19***
Sample Elevation (feet MLLW):	***1 to -1***
Sample Elevation (feet NGVD):	***-5.3 to -7.3***
Sample Date:	***8/2/2007***

		Cleanup Level	***TEF*** [1]		***TEC***	
					ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins						
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.014 U	-	0.007
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.038 U	-	0.019
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.042 U	-	0.002
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.046 U	-	0.002
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.044 U	-	0.002
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.343 J	0.003	0.003
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2.309 J	0.001	0.001
			TEC Dioxins		**0.004**	0.037 **ng/kg**
Furans						
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.017 U	-	0.001
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.017 U	-	0.000
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.017 U	-	0.003
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.023 U	-	0.001
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.029 U	-	0.001
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.028 U	-	0.001
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.024 U	-	0.001
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.062 U	-	0.000
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.076 U	-	0.000
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.096 U	-	0.000
			TEC Furans		**0.000**	0.010 **ng/kg**
			Total TEC Dioxin/Furan		0.004	0.046 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-14***
Sample ID:	***S-080806-LH-WMUA14-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***18 to 20***
Sample Elevation (feet MLLW):	***0 to -2***
Sample Elevation (feet NGVD):	***-6.3 to -8.3***
Sample Date:	***8/8/2006***

		Cleanup Level	***TEF*** [1]		***TEC***	
					ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins						
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.036 U	-	0.018
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.041 U	-	0.021
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.09 U	-	0.005
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.101 U	-	0.005
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.097 U	-	0.005
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.099 U	0.001	0.001
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.234 U	0.000	0.000
			TEC Dioxins		**0.001**	0.054 **ng/kg**
Furans						
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.031 U	-	0.002
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.028 U	-	0.000
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.029 U	-	0.004
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.043 U	-	0.002
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.057 U	-	0.003
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.044 U	-	0.002
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.037 U	-	0.002
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.089 U	-	0.000
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.109 U	-	0.001
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.123 U	-	0.000
			TEC Furans		**0.000**	0.016 **ng/kg**
			Total TEC Dioxin/Furan		0.001	0.070 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-15***
Sample ID:	***S-080706-LH-WMUA15-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***14 to 16***
Sample Elevation (feet MLLW):	***4 to 2***
Sample Elevation (feet NGVD):	***-2.3 to -4.3***
Sample Date:	***8/7/2006***

		Cleanup Level	***TEF*** [1]			***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.101	U	-	0.051
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.146	U	-	0.073
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.469	U	-	0.023
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.562	U	-	0.028
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.517	U	-	0.026
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	1.373	J	0.014	0.014
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.234	U	-	0.000
			TEC Dioxins			**0.014**	0.215 **ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.062	U	-	0.003
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.055	U	-	0.001
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.057	U	-	0.009
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.069	U	-	0.003
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.084	U	-	0.004
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.083	U	-	0.004
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.086	U	-	0.004
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.082	U	-	0.000
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.086	U	-	0.000
Octachlorodibenzofuran	ng/kg	NV	0.0003	1.345	J	0.000	0.000
			TEC Furans			**0.000**	0.030 **ng/kg**
			Total TEC Dioxin/Furan			0.014	0.244 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-20***
Sample ID:	***S-071706-LH-WMUA20-003***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***15 to 17***
Sample Elevation (feet MLLW):	***3 to 1***
Sample Elevation (feet NGVD):	***-3.3 to -5.3***
Sample Date:	***7/17/2006***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.021 U	-	0.011	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.038 U	-	0.019	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.042 U	-	0.002	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.049 U	-	0.002	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.046 U	-	0.002	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.053 U	-	0.000	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.132 U	-	0.000	
			TEC Dioxins		**0.000**	0.037	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.019 U	-	0.001	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.019 U	-	0.000	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.02 U	-	0.003	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.024 U	-	0.001	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.031 U	-	0.002	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.03 U	-	0.002	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.027 U	-	0.001	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.046 U	-	0.000	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.057 U	-	0.000	
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.081 U	-	0.000	
			TEC Furans		**0.000**	0.010	**ng/kg**
			Total TEC Dioxin/Furan		0.000	0.047	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-26***
Sample ID:	***S-071306-DR-WMUA26-005***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***23 to 25***
Sample Elevation (feet MLLW):	***-5 to -7***
Sample Elevation (feet NGVD):	***-11.3 to -13.3***
Sample Date:	***7/13/2006***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.014 U	-	0.007	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.031 U	-	0.016	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.056 U	-	0.003	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.061 U	-	0.003	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.059 U	-	0.003	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.082 U	-	0.000	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.153 U	-	0.000	
			TEC Dioxins		**0.000**	0.032	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.015 U	-	0.001	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.02 U	-	0.000	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.02 U	-	0.003	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.021 U	-	0.001	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.028 U	-	0.001	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.027 U	-	0.001	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.023 U	-	0.001	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.044 U	-	0.000	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.057 U	-	0.000	
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.08 U	-	0.000	
			TEC Furans		**0.000**	0.010	**ng/kg**
			Total TEC Dioxin/Furan		0.000	0.041	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-26***
Sample ID:	***S-071306-DR-WMUA26-008***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***51 to 53***
Sample Elevation (feet MLLW):	***-33 to -35***
Sample Elevation (feet NGVD):	***-39.3 to -41.3***
Sample Date:	***7/13/2006***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.014 U	-	0.007	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.026 U	-	0.013	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.038 U	-	0.002	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.043 U	-	0.002	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.041 U	-	0.002	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.051 U	-	0.000	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.118 U	-	0.000	
			TEC Dioxins		**0.000**	0.026	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.013 U	-	0.001	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.013 U	-	0.000	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.013 U	-	0.002	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.018 U	-	0.001	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.022 U	-	0.001	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.022 U	-	0.001	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.019 U	-	0.001	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.033 U	-	0.000	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.039 U	-	0.000	
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.073 U	-	0.000	
			TEC Furans		**0.000**	0.007	**ng/kg**
			Total TEC Dioxin/Furan		0.000	0.034	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-31***
Sample ID:	***S-081506-BG-WMUA31-059***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***25 to 27***
Sample Elevation (feet MLLW):	***-7 to -9***
Sample Elevation (feet NGVD):	***-13.3 to -15.3***
Sample Date:	***8/15/2006***

		Cleanup Level	***TEF*** [1]		***TEC***	
					ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins						
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.085 U	-	0.043
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.077 U	-	0.039
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.064 U	-	0.003
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.075 U	-	0.004
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.07 U	-	0.004
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.427 J	0.004	0.004
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.171 U	-	0.000
			TEC Dioxins		**0.004**	0.096 **ng/kg**
Furans						
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.075 U	-	0.004
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.051 U	-	0.001
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.051 U	-	0.008
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.039 U	-	0.002
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.047 U	-	0.002
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.052 U	-	0.003
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.049 U	-	0.002
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.07 U	-	0.000
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.083 U	-	0.000
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.306 J	0.000	0.000
			TEC Furans		**0.000**	0.022 **ng/kg**
			Total TEC Dioxin/Furan		0.004	0.118 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-31***
Sample ID:	***S-081506-BG-WMUA31-063***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***55 to 57***
Sample Elevation (feet MLLW):	***-37 to -39***
Sample Elevation (feet NGVD):	***-43.3 to -45.3***
Sample Date:	***8/15/2006***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.073 U	-	0.037	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.067 U	-	0.034	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.054 U	-	0.003	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.061 U	-	0.003	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.058 U	-	0.003	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.105 U	-	0.001	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	3.475 J	0.001	0.001	
			TEC Dioxins		**0.001**	0.080	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.061 U	-	0.003	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.044 U	-	0.001	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.044 U	-	0.007	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.044 U	-	0.002	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.052 U	-	0.003	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.056 U	-	0.003	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.051 U	-	0.003	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.072 U	-	0.000	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.079 U	-	0.000	
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.356 J	0.000	0.000	
			TEC Furans		**0.000**	0.021	**ng/kg**
			Total TEC Dioxin/Furan		0.001	0.102	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-32***
Sample ID:	***S-020107-ILM-WMUA32-101***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***17 to 20***
Sample Elevation (feet MLLW):	***1 to -2***
Sample Elevation (feet NGVD):	***-5.3 to -8.3***
Sample Date:	***2/1/2007***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.145 U	-	0.073	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.236 U	-	0.118	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.804 U	-	0.040	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.87 U	-	0.044	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.843 U	-	0.042	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	1.893 U	-	0.009	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.702 U	-	0.000	
			TEC Dioxins		**0.000**	0.326	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.759 U	-	0.038	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.22 J	0.007	0.007	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.226 J	0.068	0.068	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.367 J	0.037	0.037	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.074 U	-	0.004	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.087 U	-	0.004	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.076 U	-	0.004	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.366 J	0.004	0.004	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.13 U	-	0.001	
Octachlorodibenzofuran	ng/kg	NV	0.0003	1.35 J	0.000	0.000	
			TEC Furans		**0.115**	0.166	**ng/kg**
			Total TEC Dioxin/Furan		0.115	0.492	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Waste Management Unit A***
Sample Location:	***WMUA-32***
Sample ID:	***S-081706-BG-WMUA32-104***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***55 to 57***
Sample Elevation (feet MLLW):	***-37 to -39***
Sample Elevation (feet NGVD):	***-43.3 to -45.3***
Sample Date:	***8/17/2006***

		Cleanup Level	***TEF*** [1]		***TEC***	
					ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins						
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.063 U	-	0.032
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	0.073 U	-	0.037
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.065 U	-	0.003
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.076 U	-	0.004
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.071 U	-	0.004
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.094 U	-	0.000
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	0.206 U	-	0.000
			TEC Dioxins		**0.000**	0.079 **ng/kg**
Furans						
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.07 U	-	0.004
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.043 U	-	0.001
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.043 U	-	0.006
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.029 U	-	0.001
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.034 U	-	0.002
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.034 U	-	0.002
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.035 U	-	0.002
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.059 U	-	0.000
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.065 U	-	0.000
Octachlorodibenzofuran	ng/kg	NV	0.0003	0.262 J	0.000	0.000
			TEC Furans		**0.000**	0.018 **ng/kg**
			Total TEC Dioxin/Furan		0.000	0.097 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***17C***
Sample ID:	***S-071312-KB-17C-001***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***5***
Sample Elevation (feet MLLW):	***12.99***
Sample Elevation (feet NGVD):	***6.67***
Sample Date:	***7/13/2012***

		Cleanup Level	***TEF*** [1]		***TEC***		
					ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	26.7	26.700	26.700	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	10.6	10.600	10.600	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	10.4	1.040	1.040	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	25	2.500	2.500	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	18.1	1.810	1.810	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	445	4.450	4.450	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	-	-	-	
			TEC Dioxins		**47.100**	47.100	**ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	434	43.400	43.400	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	397	11.910	11.910	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	169	50.700	50.700	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	1210	121.000	121.000	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	247	24.700	24.700	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	12.5	1.250	1.250	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	80.2	8.020	8.020	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1260	12.600	12.600	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	408	4.080	4.080	
Octachlorodibenzofuran	ng/kg	NV	0.0003	-	-	-	
			TEC Furans		**277.660**	277.660	**ng/kg**
			Total TEC Dioxin/Furan		324.760	324.760	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***17C***
Sample ID:	***S-071312-KB-17C-002***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***15.2***
Sample Elevation (feet MLLW):	***2.79***
Sample Elevation (feet NGVD):	***-3.53***
Sample Date:	***7/13/2012***

			Cleanup Level	***TEF*** [1]		***TEC***	
						ND = 0 [2]	***ND = 0.5xDL*** [3]
Dioxins							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV		1	0.692 U	-	0.346
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV		1	3.46 U	-	1.730
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV		0.1	1.41 J	0.141	0.141
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV		0.1	2.23 J	0.223	0.223
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV		0.1	2.21 J	0.221	0.221
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV		0.01	12	0.120	0.120
Octachlorodibenzo-p-dioxin	ng/kg	NV		0.0003	62.7	0.019	0.019
				TEC Dioxins		**0.724**	2.800 **ng/kg**
Furans							
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV		0.1	30.6	3.060	3.060
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV		0.03	24.2	0.726	0.726
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV		0.3	11.9	3.570	3.570
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV		0.1	94	9.400	9.400
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV		0.1	25.5	2.550	2.550
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV		0.1	3.46 U	-	1.730
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV		0.1	15.1	1.510	1.510
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV		0.01	124	1.240	1.240
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV		0.01	37	0.370	0.370
Octachlorodibenzofuran	ng/kg	NV		0.0003	461	0.138	0.138
				TEC Furans		**22.564**	24.294 **ng/kg**
			Total TEC Dioxin/Furan			23.288	27.094 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***17C***
Sample ID:	***S-071312-KB-17C-003***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***18.5***
Sample Elevation (feet MLLW):	***-0.51***
Sample Elevation (feet NGVD):	***-6.83***
Sample Date:	***7/13/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.575	U	-	0.288	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	2.88	U	-	1.440	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.88	U	-	1.440	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.88	U	-	1.440	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	2.88	U	-	1.440	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	0.485		0.005	0.005	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	3.56		0.001	0.001	
			TEC Dioxins			**0.006**	6.053	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.575	U	-	0.288	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.286		0.009	0.009	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.222		0.067	0.067	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.814		0.081	0.081	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.258		0.026	0.026	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.88	U	-	1.440	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	2.88	U	-	1.440	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	1.2		0.012	0.012	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	2.88	U	-	1.440	
Octachlorodibenzofuran	ng/kg	NV	0.0003	3.73		0.001	0.001	
			TEC Furans			**0.195**	4.803	**ng/kg**
			Total TEC Dioxin/Furan			0.201	10.856	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:				***N Landfill***						
Sample Location:				***17C***						
Sample ID:				***S-071412-KB-17C-004***			***S-071412-KB-FD001***			
Sample Depth (feet BML):				***NA***			***NA***			
Sample Depth (feet BGS):				***25.5***			***25.5***			
Sample Elevation (feet MLLW):				***-7.51***			***-7.51***			
Sample Elevation (feet NGVD):				***-13.83***			***-13.83***			
Sample Date:				***7/14/2012***			***7/14/2012 Duplicate***			
		Cleanup Level	***TEF [1]***		***TEC***			***TEC***		
					ND = 0 [2]	***ND = 0.5xDL [3]***			***ND = 0 [2]***	***ND = 0.5xDL [3]***
Dioxins										
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.605 U	-	0.303	0.579 U		-	0.290
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	3.91	0.039	0.039	2.89 U		-	1.445
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	15.4	0.005	0.005	2.05		0.001	0.001
			TEC Dioxins		**0.044**	6.406 **ng/kg**			**0.001**	7.515 **ng/kg**
Furans										
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.605 U	-	0.303	0.579 U		-	0.290
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.03 U	-	1.515	2.89 U		-	1.445
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.03 U	-	1.515	2.89 U		-	1.445
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.03 U	-	1.515	2.89 U		-	1.445
Octachlorodibenzofuran	ng/kg	NV	0.0003	1.39	0.000	0.000	5.79 U		-	2.895
			TEC Furans		**0.000**	12.423 **ng/kg**			**0.000**	14.745 **ng/kg**
			Total TEC Dioxin/Furan		0.044	18.829 **ng/kg**			0.001	22.260 **ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***17C***
Sample ID:	***S-071412-KB-17C-005***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***35.2***
Sample Elevation (feet MLLW):	***-17.21***
Sample Elevation (feet NGVD):	***-23.53***
Sample Date:	***7/14/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.675	U	-	0.338	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.38	U	-	1.690	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	3.38	U	-	1.690	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	2.41		0.001	0.001	
			TEC Dioxins			**0.001**	8.788	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.675	U	-	0.338	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.38	U	-	1.690	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	3.38	U	-	1.690	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.38	U	-	1.690	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.38	U	-	1.690	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.38	U	-	1.690	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.38	U	-	1.690	
Octachlorodibenzofuran	ng/kg	NV	0.0003	6.75	U	-	3.375	
			TEC Furans			**0.000**	17.233	**ng/kg**
			Total TEC Dioxin/Furan			0.001	26.021	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***N Landfill***
Sample Location:	***17C***
Sample ID:	***S-071412-KB-17C-006***
Sample Depth (feet BML):	***NA***
Sample Depth (feet BGS):	***45.1***
Sample Elevation (feet MLLW):	***-27.11***
Sample Elevation (feet NGVD):	***-33.43***
Sample Date:	***7/14/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	0.613	U	-	0.307	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.06	U	-	1.530	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	3.06	U	-	1.530	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	3.27		0.001	0.001	
			TEC Dioxins			**0.001**	7.957	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.613	U	-	0.307	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	3.06	U	-	1.530	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	3.06	U	-	1.530	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.06	U	-	1.530	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.06	U	-	1.530	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	3.06	U	-	1.530	
Octachlorodibenzofuran	ng/kg	NV	0.0003	6.13	U	-	3.065	
			TEC Furans			**0.000**	15.612	**ng/kg**
			Total TEC Dioxin/Furan			0.001	23.569	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Investigative Area:	***Hylebos Waterway***
Sample Location:	***WW-A1R***
Sample ID:	***S-082112-MD-WW-AIR-002***
Sample Depth (feet BML):	***4 - 6***
Sample Depth (feet BGS):	***NA***
Sample Elevation (feet MLLW):	***-38.18 to -40.18***
Sample Elevation (feet NGVD):	***-44.5 to -46.5***
Sample Date:	***8/21/2012***

		Cleanup Level	***TEF*** [1]			***TEC***		
						ND = 0 [2]	***ND = 0.5xDL*** [3]	
Dioxins								
2,3,7,8-Tetrachlorodibenzo-p-dioxin	ng/kg	NV	1	-		-	-	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	ng/kg	NV	1	3.06	U	-	1.530	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	0.079	J	0.008	0.008	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	ng/kg	NV	0.1	3.06	U	-	1.530	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	ng/kg	NV	0.01	3.06	U	-	1.530	
Octachlorodibenzo-p-dioxin	ng/kg	NV	0.0003	6.11	U	-	3.055	
			TEC Dioxins			**0.008**	9.183	**ng/kg**
Furans								
2,3,7,8-Tetrachlorodibenzofuran	ng/kg	NV	0.1	0.611	U	-	0.306	
1,2,3,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.03	0.18	J	0.005	0.005	
2,3,4,7,8-Pentachlorodibenzofuran	ng/kg	NV	0.3	0.115	J	0.035	0.035	
1,2,3,4,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.642	J	0.064	0.064	
1,2,3,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.131	J	0.013	0.013	
1,2,3,7,8,9-Hexachlorodibenzofuran	ng/kg	NV	0.1	3.06	U	-	1.530	
2,3,4,6,7,8-Hexachlorodibenzofuran	ng/kg	NV	0.1	0.071	J	0.007	0.007	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.806	J	0.008	0.008	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	ng/kg	NV	0.01	0.233	J	0.002	0.002	
Octachlorodibenzofuran	ng/kg	NV	0.0003	6.11	U	-	3.055	
			TEC Furans			**0.135**	5.025	**ng/kg**
			Total TEC Dioxin/Furan			0.143	14.208	**ng/kg**

TABLE Q.5

TEC CALCULATIONS - DIOXIN AND FURAN SOIL/SEDIMENT SAMPLES
SITE CHARACTERIZATION
OCCIDENTAL CHEMICAL CORPORATION
TACOMA, WASHINGTON

Notes:

(1)	World Health Organization, September 2006.
(2)	TEC calculated using only detected concentrations.
(3)	TEC calculated using 0.5 times the detection limit for non-detected concentrations.
++	Congener co-elutes with 2,3,3',4,4',5-HxCB (156). Result is the sum of both congeners.
BGS	Below ground surface.
BML	Below mudline.
MLLW	Mean lower low water.
NGVD	National geodetic vertical datum.
B	Compound present in the blank.
J	Estimated.
K	Estimated maximum possible concentration.
PCBs	Polychlorinated Biphenyls.
TEC	Toxicity Equivalency Concentration.
TEF	Toxicity Equivalency Factor.
U	Not-detected at associated value.
CE	Co-eluting congeners. Concentrations are based on a sum of the congeners. Co-elutions: PCB 20+28, PCB 50+53, PCB 70+74, PCB 83+99, PCB 129+138+160+163, PCB 180+193.

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PCB contamination in marine sediments from Golfo Dulce, Pacific coast of Costa Rica

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Abstract: Twenty-nine marine sediment samples collected from 1996 through 2002 from the Golfo Dulce embayment of Costa Rica were analyzed for PCB concentrations. The Esquinas River and Rincon Bay in the northern and western part of the gulf had relatively low overall concentrations of PCBs, with no samples having greater than 2.1 µg/g dw sediment. The Port of Golfito had the highest overall concentrations, ranging up to 15.7 µg/g dw sediment. These samples were also dominated by higher chlorinated congeners. Samples from the deeper (>100m) waters in the northern part of the gulf, as well as within the sediment plume from the Rio Coto Colorado had intermediate values. Within the Rio Coto Colorado sediment plume the concentrations did decrease with increasing depth and the congeners showed a shift towards less chlorinated congeners with depth. However, the deep northern basin had some of the highest PCB concentrations and the shift towards less chlorinated congeners was not apparent or significant. Whether the anoxic conditions that exist in the deep waters are capable of initiating dechlorination is still unknown. Overall, the data from Golfo Dulce show moderate PCB contamination, despite the pristine nature of the gulf and surrounding lands.

Keywords: Polychlorinated biphenyls (PCB), Golfo Dulce, organic contamination, marine pollution, Costa Rica.

PCBs are a class of man-made non-polar hydrocarbons with a biphenyl nucleus on which one to ten hydrogen atoms have been replaced by chlorines. Commercial PCBs were manufactured as complex mixtures of congeners from the 1930's through the 1960's. These commercial products were clear viscous liquids that were used widely in many industrial applications, especially in North America. They are soluble in most organic solvents, oils and fats and are very stable. Under certain conditions, however, they may be destroyed, either chemically, thermally, or biochemically. However, these degradation reactions are difficult and slow. After PCB contamination was recognized their use was restricted to a limited number of applications and production was banned since 1976 (Erickson 1997).

PCBs are one of several truly global environmental pollutants, including mercury, lead, and certain pesticides. They are highly lipophilic, and therefore, most PCB mass is found in soil and sediments and not in the water column. However, continued dissolution and volatilization from spills, *etc*. result in measurable aqueous and atmospheric emissions. Murphy *et al.* (1985) estimated that 0.9 x 10^9 g per year of PCBs cycle through the U.S. atmosphere. This is less that 1% of the total PCBs in the environment. Nevertheless, atmospheric transport is recognized as the primary mode of global PCB distribution. Eisenreich *et al.* (1981) estimated that the atmospheric pathway contributes 60-90% of PCB input into the Great Lakes. Therefore, their presence is recognizable in almost all

sediment and biological samples from around the world. However, practically no research has been done in tropical areas.

The presence of even low concentrations of PCB pollutants can be a continued and future source of in place contamination of the water column. Thus, they may continue to be an ecological threat, and possible human threat as well. This paper provides the detailed analyses of PCB congeners from various locations within the sediments of Golfo Dulce on the southwestern coast of Costa Rica. This is the first paper reporting their presence and concentrations in this area. A summary of previous PCB studies in other marine sediments in Costa Rica is included as an accompanying article for comparison (Spongberg 2004).

The gulf has become increasingly subjected to fishery, aquaculture, ecotourism, urbanization and port construction. Therefore, information on PCB concentrations in areas yet unaffected by extensive development is vital. As part of a larger project to evaluate the quality of Costa Rican waters, many samples/cores have been obtained from the coastal waters since 1997, including a more intensive investigation in Golfo Dulce. These sediment samples have been analyzed for many contaminants, including pesticides, heavy metals and polychlorinated biphenyls. The pesticide data were reported in Spongberg and Davis (1999). The PCB data for the complete sample set is presented as a companion to this paper (Spongberg, 2004). This paper presents a summary and details of the data collected from the Gulf of Dulce, as of 2003.

MATERIALS AND METHODS

Study area: Golfo Dulce is a deep fjord-like estuary at the southern end of the Pacific coast of Costa Rica. The depth exceeds 200 m in the inner basin and is sheltered against the open Pacific by a shallow sill (60 m) at the southern end. Water depths increase rapidly along fault scarp faces on the eastern side of the gulf (Hebbeln *et al.* 1996) and tidal ranges are as great as 6 m. Due to this morphology only a limited water exchange with the ocean takes place. Thus the deepest sediments are anoxic, at least temporarily, as compared to the shallow, well-oxygenated Golfo de Nicoya, further north along the Pacific coast (Richards *et al.* 1971). Thamdrup *et al.* (1996) re-investigated the geochemistry of the gulf and found steep gradients in both temperature and salinity to a depth of 60 m below a shallow mixed surface layer. The pycnocline is located about 10-20 m above the sill depth and rises about 10 m towards the head of the gulf. The photic zone extends to 30-40 m depth and surface water oxygen concentrations were 190-200 $\mu mol.L^{-1}$. A strong oxycline is associated with the pycnocline throughout the basin and no oxygen (<3 $\mu mol\ L^{-1}$) is detected below 100 m. Nitrate increases with depth to only 10 $\mu mol\ L^{-1}$ at the pycnocline and decreases below this depth to less than 1 $\mu mol\ L^{-1}$ at the basin floor.

Kuever *et al.* (1996) found that the number of microorganisms within the water column did not change with depth, despite the reduction in oxygen. The highest numbers of sulfate-reducing bacteria were found in or close to the sediment surface. The anoxic bottom water also contains sulfide-oxidizing bacteria of the *Thiovulum* and *Thiospira* genera. Dalsgaard *et al.* (2003) recently discovered that the anaerobic oxidation of ammonium with nitrite, or the 'anammox' reaction performed by bacteria, was responsible for 19–35% of the total N_2 formation in the deep water column in Golfo Dulce.

Analytical procedures: Details on the collection and analyses of the sediment samples is given in an adjoining paper (Spongberg 2004). Grab samples were prepared as follows. Estuary and shallow samples were collected by hand with a clean core barrel and immediately placed in either prewashed glass jars or plastic bags, depending on the subsequent analyses. Samples were sealed and frozen immediately after collection and transferred to the University of Toledo, Toledo, Ohio still frozen. Samples were dried

and re-frozen until analysis. Stations are indicated in Fig. 1.

The analysis of PCBs followed a modified version of EPA Methods 8081 and 3620 (USEPA, 1992). Approximately 10 to 20 g of dried, sieved sediment was extracted using a Soxtec Organic Extraction Unit, using methylene chloride or acetone:methylene chloride (1:1) as solvents. Separation and clean up were achieved by passing the extract through a florisil-filled glass column with diethylether in hexane (3:1) as the eluant.

Analyses were performed on a Hewlett Packard 6890 gas chromatograph equipped with a SPB-5 fused silica capillary column (30 m length, 0.25 mm ID, 0.25 µm film thickness, Supelco, Inc.) attached to either a ^{63}Ni electron capture detector (HP 5890 Series II) or a mass selective detector (HP 5972).

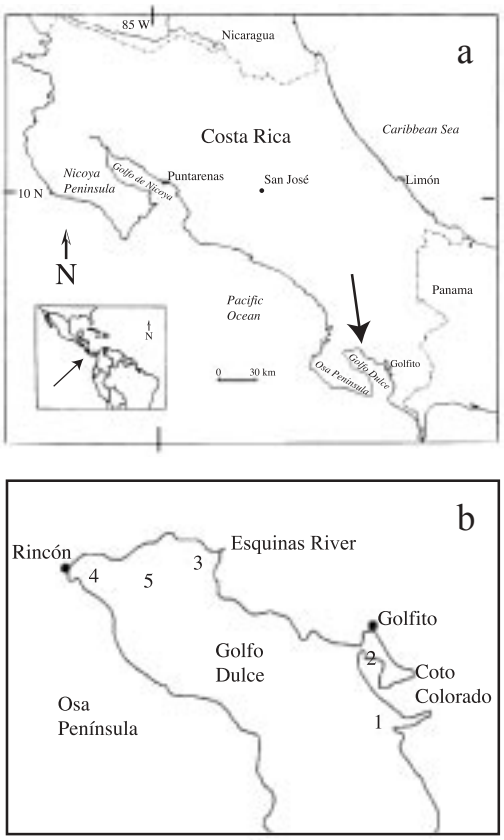

Fig. 1a, b. Location map of Golfo Dulce sediment samples. 1 = Rio Coto Colorado sediment plume emanating north-northwest from the mouth of the river. 2 = Golfito Port and bay, 3 = Rio Esquinas tidal flats, 4 = Río Rincón tidal flats and deforested shoreline, 5 = sediments within the deep northern basin (110-190 m).

Quality control included reagent blank determination, matrix spike (0.2 and 1.0 µg/g) recovery, and precision analyses. 2,3,5-trichlorobenzene was used as an internal standard. Calibration was checked routinely. Quantification of individual PCB congeners in samples was made by comparison to standard mixtures and confirmed using the extensive library of mass signatures of individual congeners. Recovery efficiencies varied between 65 and 95%. Detection limits were calculated using the area of the baseline noise over the elution time of each congener using low concentration standards. Limits of detection were three times the standard deviation of the baseline noise, and averaged 0.2 ng/g. Relative standard deviation of data from five consecutive duplicate runs was 3-5%. Data reported

TABLE 1
UPAC identification numbers, chlorine substitutions and classes of congeners used in the calculation of Total PCBs (after Vanier et al. 1996)

IUPAC number	Chlorine substitutions	Isomer Class
18*	2,2',5	3 Cl
31*	2,4',5	3 Cl
44*	2,2',3,5'	4 Cl
49*	2,2',4,5'	4 Cl
52*	2,2',5,5'	4 Cl
87*	2,2',3,4,5'	5 Cl
101*	2,2',4,5,5'	5 Cl
110*	2,3,3',4',6	5 Cl
118*	2,3',4,4',5	5 Cl
138*	2,2',3,4,4',5	6 Cl
151*	2,2',3,5,5',6	6 Cl
153*	2,2',4,4',5,5'	6 Cl
170*	2,2',3,3',4,4',5	7 Cl
180*	2,2',3,4,4',5,5'	7 Cl
194*	2,2',3,3',4,4',5,5'	8 Cl
195*	2,2',3,3',4,4',5,6	8 Cl
196*	2,2',3,3',4,4',5',6	8 Cl
199*	2,2',3,3',4,5,5',6'	8 Cl
209*	2,2',3,3',4,4',5,5',6,6'	10 Cl

* These 19 congeners are used in the calculation of Total PCBs.

TABLE 2

PCB congener data for Golfo Dulce, Costa Rican sediments taken from 1997 to 2002

	Internal ID	Sum (ng/g dw	Total* *1000)	15/17	18	31	40	44	49	52	60	87	101	110	118	121	138	151	153	170	180	183	194	195	196	199	209
				Percentages of sum																							
19D	Río Esquinas	1406	2059	7.47	3.01	4.43	8.38	6.64‡	2.06	3.32	0.00	12.97	**6.80†**	2.53	11.39	8.38	6.64	1.90	8.38	4.11	1.58	0.00	0.00	0.00	0.00	0.00	0.00
15C	Río Esquinas	1168	1783	4.54	6.30	6.62	6.09	7.37‡	5.13	5.55	3.63	1.71	**10.14**	2.88	6.51	5.98	6.19	5.02	6.62	5.13	2.78	0.53	1.28	0.00	0.00	0.00	0.00
20D	Río Esquinas	1162	1636	4.05	7.72	9.56	6.80‡	5.15	7.54	**11.40**	3.68	6.25	2.39	9.19	2.57	5.88	2.94	7.72	2.21	4.23	0.74	0.00	0.00	0.00	0.00	0.00	0.00
18D	Río Esquinas	995	1400	4.47	5.01	5.64	6.42	2.51	9.24‡	6.73	2.04	**9.71**	2.82	7.05	3.60	9.71	11.12	1.72	5.95	4.23	2.04	0.00	0.00	0.00	0.00	0.00	0.00
9D	Río Rincón	912	1334	6.08	5.28	6.94	4.95	5.84‡	3.96	7.82	4.95	**9.03**	7.27	4.73	9.03	6.17	1.54	5.73	6.94	2.64	1.10	0.00	0.00	0.00	0.00	0.00	0.00
8D	Río Rincón	526	764	5.35	11.83	6.40	7.24‡	9.88	3.62	0.56	2.92	**5.99**	3.62	8.21	6.54	3.62	8.21	1.95	7.80	5.15	1.11	0.00	0.00	0.00	0.00	0.00	0.00
6D	Deforested area	1301	1892	5.01	8.37	6.75	7.78‡	7.05	8.96	**10.57**	6.61	4.55	9.10	4.55	6.17	3.38	2.50	3.38	2.35	1.91	1.03	0.00	0.00	0.00	0.00	0.00	0.00
14D	Deforested area	1087	1462	5.90	7.99	4.66	9.32‡	13.98	5.10	**3.33**	9.32	11.32	2.89	3.11	4.22	5.10	6.88	2.22	1.11	0.89	2.66	0.00	0.00	0.00	0.00	0.00	0.00
23D	Río C. Colorado sediment plume,150 m	2703	3555	12.27	10.44	9.19	12.93	**7.64**	8.10	6.39	3.58	1.87	6.23	2.49	6.70	2.96	2.65	4.67	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22D	Río C. Colorado sediment plume, 95 m	3280	4703	7.42	9.59	8.37‡	5.95	7.04	11.28	**7.89**	5.58	9.95	5.70	4.37	6.31	4.97	3.15	0.00	1.46	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17D	Río C. Colorado sediment plume, 74 m	2563	3678	7.11	10.75	11.12‡	8.20	6.56	5.29	**10.39**	8.39	2.92	9.66	2.19	7.66	2.37	3.46	0.66	0.73	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21D	Río C. Colorado sediment plume, 60 m	3257	4604	8.53	10.71	9.73‡	6.03	10.96	**7.63**	5.54	7.51	5.29	6.40	2.09	2.22	5.17	2.83	1.97	5.17	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29D	Río C. Colorado sediment plume, 50 m	2347	2972	7.72	10.29	11.16‡	9.25	7.85	10.82	**2.79**	9.07	2.27	5.58	5.93	4.88	4.71	2.79	0.00	1.22	2.62	1.05	0.00	0.00	0.00	0.00	0.00	0.00
13D	Río C. Colorado sediment plume, 40 m	2361	3291	4.14	6.05	2.10	9.34	5.39‡	6.97	2.10	3.42	6.57	**8.94**	9.73	7.36	3.68	13.54	0.00	6.44	4.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D	Río C. Colorado sediment plume, 4 m	3151	4487	2.37	4.96	3.44	6.33	11.43‡	9.91	8.40	**5.78**	4.27	0.69	5.92	7.16	8.40	5.78	1.51	5.78	7.30	0.55	0.00	0.00	0.00	0.00	0.00	0.00
3D	Río C. Colorado sediment plume, 2.5 m	2275	3471	1.74	3.01	4.71	5.50	1.70	3.40	7.33‡	6.28	9.68	**7.98**	3.27	8.37	6.93	10.60	8.24	5.89	4.06	1.31	0.00	0.00	0.00	0.00	0.00	0.00
26D	Río C. Colorado sediment plume, 10 m	473	612	2.93	7.18	2.26	10.67	2.67‡	8.62	2.46	6.57	**9.24**	8.62	12.52	10.67	2.67	1.64	2.87	5.75	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GD-XC	Port of Golfito, Frente UCR	3923	6429	0.00	10.32	5.16	3.87	7.74‡	8.39	11.61	2.58	0.00	**5.16**	11.61	5.16	0.00	7.74	0.00	6.45	0.00	14.19	0.00	0.00	0.00	0.00	0.00	0.00
GD-XA2	Port of Golfito, Frente Hong Kong	7631	10875	0.00	5.00	0.00	13.75	6.25‡	0.00	0.00	2.50	5.00	11.25	**8.75**	13.75	3.75	20.00	0.00	6.25	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GD-XA	Port of Golfito, Frente Hong Kong	4524	7437	0.00	8.38	4.19	6.28	6.28‡	6.81	14.66	2.09	1.05	**4.19**	9.42	7.33	0.00	6.28	2.09	8.38	0.00	12.57	0.00	0.00	0.00	0.00	0.00	0.00
25D	Port of Golfito	12271	15688	0.73	3.20	4.38	2.37	3.93	4.75	5.75‡	4.47	5.39	8.95	**11.42**	5.94	17.08	6.30	7.49	5.75	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15D	Golfito Bay, south islet, sandy	3083	3970	4.24	2.81	7.21	5.62	2.81	1.95	3.91‡	6.60	10.87	**8.31**	10.38	7.45	8.79	4.40	9.04	4.40	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24D	Golfito Bay, south islet	3221	4515	0.97	5.58	4.12	1.73	5.58	6.77	1.73‡	7.04	9.56	**8.50**	12.35	6.37	7.83	4.78	5.44	8.23	1.73	1.73	0.00	0.00	0.00	0.00	0.00	0.00
10D	Deep samples, 190 m	9151	9929	16.81	10.38‡	6.07	**17.03**	6.88	8.40	1.87	6.53	4.90	4.78	2.68	5.37	2.68	2.10	1.40	0.70	1.17	0.23	0.00	0.00	0.00	0.00	0.00	0.00
27D	Deep samples, 190 m	3994	5802	12.40	8.64	10.02‡	7.56	11.57	**7.56**	12.34	2.47	8.17	1.85	1.85	2.47	3.08	2.62	1.39	2.31	3.55	0.15	0.00	0.00	0.00	0.00	0.00	0.00
11D	Deep samples, 165 m	7883	10722	9.93	9.68	6.97‡	8.25	2.28	10.24	12.95	**6.55**	7.40	4.84	5.12	3.41	2.13	2.70	3.27	2.28	1.71	0.28	0.00	0.00	0.00	0.00	0.00	0.00
7D	Deep samples, 130 m	9300	12353	12.07	10.41	8.37‡	14.00	**10.07**	2.22	7.17	2.22	10.59	5.98	3.59	4.10	1.71	5.46	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12D	Deep samples, 110 m	5015	6539	11.69	9.98	6.57‡	14.91	**8.46**	6.82	6.70	2.65	5.05	3.16	2.91	3.28	2.65	5.31	2.27	2.65	4.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30D	Deep samples, 110 m	3830	5106	12.06	19.30	4.65‡	9.65	3.40	**12.87**	6.79	2.68	7.15	2.32	3.57	3.22	5.36	3.40	0.00	1.61	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* See text for calculation of Total PCB concentration.

† Represents congener at 50% cumulative total.

‡ Underscored figures represent congener at 25% cumulative total.

are not corrected for blank concentrations or recovery efficiencies.

RESULTS

The data on these congeners are expressed in two ways. The sum of the congeners identified in this study is presented as ∑PCBs. Table 1 lists those congeners. However, because different studies usually identify different congeners and different numbers of congeners, these studies can be difficult to compare. In this study, twenty five chromatographic peaks could be definitively assigned to PCB congeners. Although the utmost care was taken to assign the correct IUPAC number to that peak, there often unavoidably are other congeners that may co-elute. Due to their geochemical characteristics and mass selective signatures, it is likely that the co-eluting compounds have an equal number of chlorine atoms on the molecule, however, their placement on the biphenyl structure might vary. Therefore, the data are also presented as Total PCBs. As stated in Vanier *et al.* (1996), 19 congeners make up about 50% by weight of all congeners in Arochlor 1242, 1253, 1262, 1254, and 1260 (Table 1). Therefore, the concentrations of these 19 congeners are summed and multiplied by 2 and reported as Total PCBs. This value can, hopefully, be more useful for comparisons in future studies.

Table 2 lists the PCB data for the Golfo Dulce sediments. Data are divided by geographic location and include the ∑PCB and Total PCB concentrations, as well as the percentage of the sum attributed to the specific identified congeners (given as the IUPAC number). The congener in **bold type** represents the IUPAC number where 50% of the total sample lies below (fewer Cl) and 50% heavier (more Cl atoms). The underscored congener percentage represents the 25% cumulative value.

DISCUSSION

Figure 2 is a cross plot of the ∑PCB and Total PCB concentrations. The two calculated values correlate to each other positively with

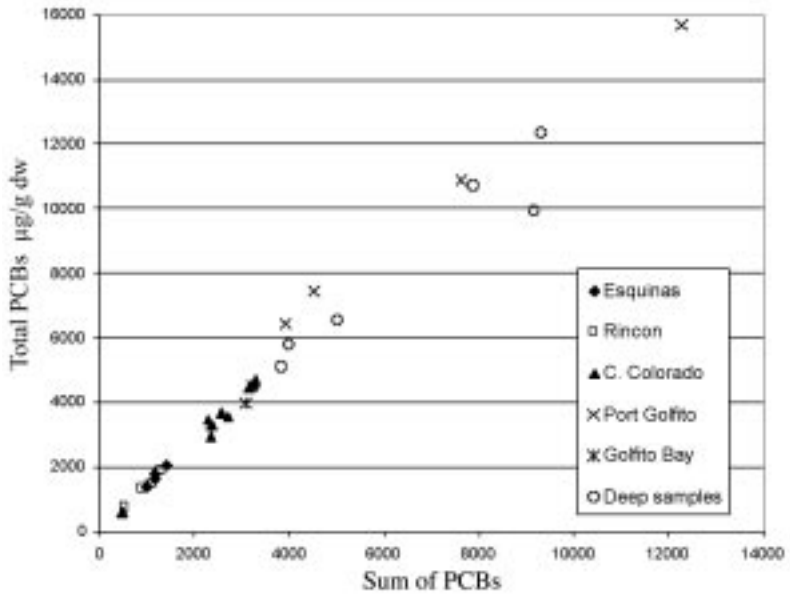

Fig. 2. Correlation between sum and Total PCB concentrations for the sediment samples from Golfo Dulce on the Pacific Coast of Costa Rica (1997-2003).

R-squared = 0.977. The sediments from the Port of Golfito stand out as having the highest concentrations (Average sum = 7.09 µg/g dw with S.E. = 1.91; Average total = 10.11 µg/g with S.E. 2.09). These samples consist of soupy black muds located within the port very near the large cargo boats. The presence of oils and other contaminants are visibly obvious. Within the Bay of Golfito, south of the port, the samples are sandier and show less than half the contamination of the port samples (Average sum = 2.15 µg/g , S.E. = 0.07; Average Total = 4.24 µg/g , S.E. = 0.03 µg/g dw). Evidently flow within the bay does not permit the transport of the contaminant-laden muds to this sheltered area of the bay.

The Río Rincón area, in the northwest part of Golfo Dulce is a pristine area, surrounded by National Parkland and little development, although the residents relied heavily on power generators and other less efficient or less environmentally-friendly power sources until very recently. Data on PCBs show some of the lowest values found in Costa Rica (Fig. 2), with average sum and total values of 0.96 and 1.05 (S.E. = 0.16 and 0.28) µg/g dw, respectively. These averages include samples from a deforested area only a few kilometers east of the mouth of the Río Rincón where erosion of the soils is fairly severe.

The Esquinas River in the Northeast of the Gulf and the Río Coto Colorado watersheds drain largely agricultural fields. The Esquinas River sediments were obtained on the tidal flats and among the mangrove roots and were fairly clay-rich. PCB contaminants had low overall concentrations averaging 1.18 and 1.72 (S.E. = 0.084 and 0.14 µg/g dw) for the sum and total, respectively (Fig. 2).

The Coto Colorado samples were obtained offshore within the sediment plume that extended from the river mouth to the north-northwest into the deeper waters of the gulf. These samples were also clay-rich, however, at a water depth of ~60 m the clays turned greenish, as compared to the usual dark grey clays found elsewhere. Figure 3 shows the trend of these data, normalized for organic matter, with depth. The two shallowest samples (2.5 and 4 m) had relatively high concentrations. These samples were actually closer to the outlet of Golfito Bay and may reflect an influence from the port's contaminants flowing from the bay into the main body of the gulf. The remaining plume samples showed an increase with depth, until the deepest samples where the values drop. In particular, when the data are normalized to organic matter content, the concentration seems to drop beneath a depth of 74 meters.

Also shown in Figure 3 are the data from the sediments retrieved from the deepest parts of the northern end of the gulf. These deep samples are centered between the Rios Esquinas and Rincon and would be expected to contain the fine-grained sediments from these watersheds. However, the concentrations in these sediments are some of the highest found in the entire Costa Rican study. The average sum and total concentrations were 6.53 and 8.41 (S.E. 1.04 and 1.22) µg/g dw respectively, while the average Total PCBs normalized for %OM was still 4.96 (S.E. = 0.93) µg/g dw. These sediments were found to contain relatively high concentrations of pesticides also (Spongberg and Davis 1999). Possibly these

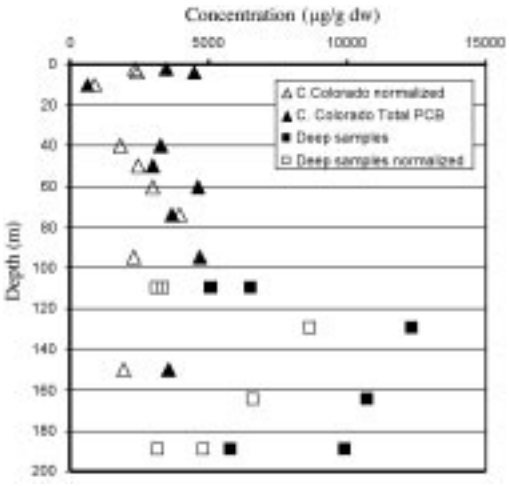

Fig. 3. Concentration (x 1000) of ∑PCBs and concentration normalized by percent organic matter for deep samples obtained within Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

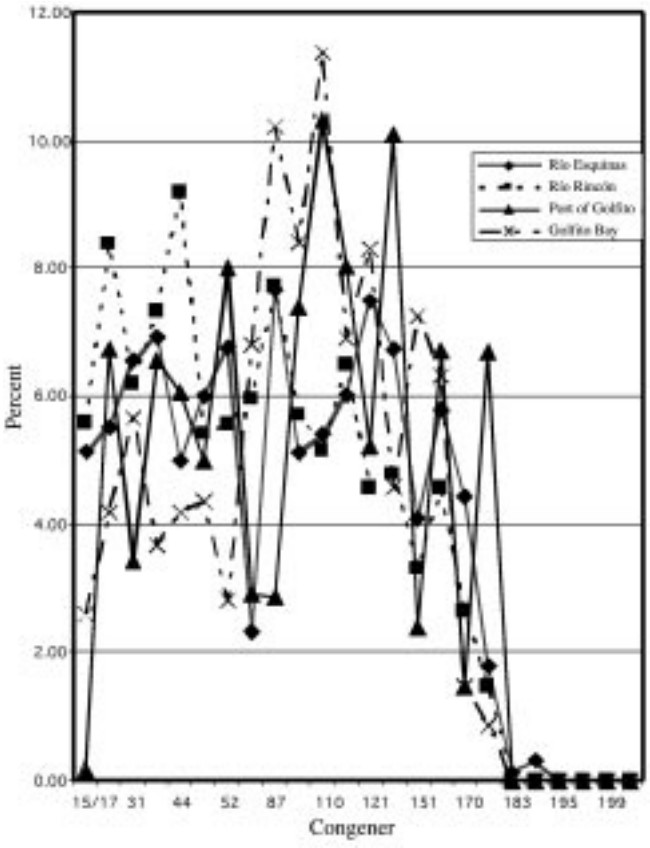

Fig. 4. Average percent of ∑PCB data for the four coastal areas sampled at Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

deeper sediments are a sink for many of the contaminants that move through the basin. However, the trend found in the Coto Colorado plume would indicate that the contaminants are either not moving into the deeper waters of the plume, or possibly that the deeper anoxic waters create conditions amenable to their degradation.

Figure 4 shows the average congener distribution for the four coastal areas sampled in Golfo Dulce. These data can also be evaluated in Table 2 by looking at the position of the 25th and 50th percentile groupings noted as the congener underscored and bold, respectively. None of the samples has a congener signature indicative of atmospheric deposition as was found in Golfo Papagayo (Spongberg 2004), or this signature is overwhelmed with congeners of higher chlorine numbers. Figure 5 illustrates the difference between the individual samples. The Rincon and Esquinas River samples show the distribution skewed somewhat to the lower chlorinated congeners. As degradation occurs the congeners lose their chlorines, however, these samples do not indicate extensive dechlorination. In fact, they may indicate that the contamination is recent, or that the compounds are not degrading in their present environment. However, the overall PCB concentrations of these samples were low. In comparison to this, the samples with the highest concentrations from the Port of Golfito show only a slightly higher degree of chlorination.

Table 2 shows the congener data for the deeper water samples both from sediment plume from the Coto Colorado River and the samples from the deep basin in the northern part of the gulf. Interestingly, the shallower samples have a preponderance of lower chlorinated congeners. However, in general the sediment plume shows an increase in congeners with lower chlorine atoms with increasing water depth. This trend is not apparent in the deep samples from the north part of the gulf. The Coto Colorado data is consistent with the lower concentrations found in the deeper samples and may indicate the capacity of the deep anoxic sediments in this area to degrade the compounds. This trend is not as apparent in the northern samples, however, these PCBs are more skewed towards the lower chlorinated congeners as compared to the PCBs within the Port of Golfito (Figure 5). However, if the deeper anoxic environment was indeed more amenable to dechlorination, the congeners would be expected to be more heavily skewed to the lighter congeners than is seen in these samples. Since the dechlorinated congeners have a higher water solubility, maybe they are being removed from the bottom sediments. We could be seeing concentrations more indicative

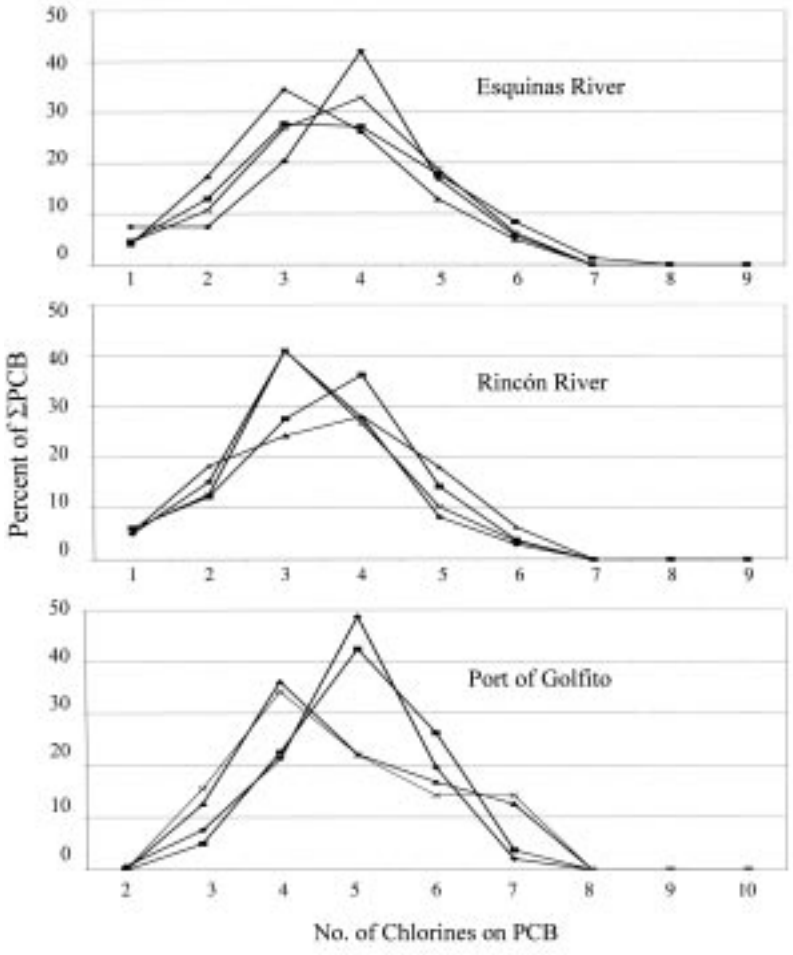

Fig. 5. Congener data for sediments from three coastal areas of Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

of the lower K_{ow} values of the lower chlorinated congeners in comparison to the higher chlorinated species.

In contrast to data from the Golfo de Nicoya (Spongberg 2004), the Golfo Dulce samples show greater variability. This most likely is a result of the varying environments present within Golfo Dulce and the lack of thorough mixing of sediments throughout the gulf. Despite the pristine nature of the land surrounding the Golfo Dulce area and the anoxic conditions at depth, there were many sediments showing moderate PCB contamination. In comparison, many PCB contaminated sites within the temperate regions have concentrations in excess of 100 or even 1000 µg/g sediment (Erickson 1997). Unfortunately, this preliminary evaluation of PCB contamination within the coastal waters of coastal Costa Rica has presented more questions than answers, however, this database should provide a starting point for comparison as development of the coastal lands increases throughout the coming years.

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RESUMEN

Un total de 29 muestras de sedimentos recolectadas de 1996 a 2002 en el Golfo Dulce, Costa Rica fueron analizadas determinar las concentraciones de bifenilos policlorinados (PCBs). La Bahía de Rincón y el Río Esquinas en la parte noroeste del Golfo tienen concentraciones relativamente bajas de PCBs, con ninguna muestras superando los 2.1 ug/ dw (peso seco) de sedimento. El puerto de Golfito tuvo las mayores concentraciones hasta un máximo de 15.7 ug/g dw de sedimento. Estas muestras también estuvieron dominadas por los congéneres más clorinados. Las muestras de los sedimentos profundos (>100 m) de las aguas de la parte norte del Golfo, así como las de la estela del Río Coto Colorado, tienen concentraciones intermedias. Dentro de la estela de sedimentos del Río Colorado las concentraciones aumentaron con la profundidad y los congéneres variaron con la profundidad hacia los menos clorinados. Sin embargo, la región profunda tuvo una de las más altas concentraciones de PCBs, pero la tendencia hacia los menos clorinados no fue aparente o significativa. No se conoce si las condiciones anóxicas en las aguas profundas son capaces de iniciar la declorización. En general, las muestras analizadas muestran concentraciones moderadas de PCBs, no obstante las condiciones pristinas del Golfo y su cuenca.

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Complete PCB Congener Distributions for 17 Aroclor Mixtures Determined by 3 HRGC Systems Optimized for Comprehensive, Quantitative, Congener-Specific Analysis

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GC-ECD
GC-MS-SIM
GC-Ion Trap MS

Summary

Three HRGC systems (1: 30m DB-XLB capillary with MS-SIM detection; 2: 60m DB-XLB capillary with full-scan, ion-trap MS detection; and 3: Parallel dual-column DB-17 and series-coupled HP5/HT5 with ECD detection) were used to completely characterize multiple lots of 8 different-numbered Aroclor mixtures by quantitative calibration against 9 solutions containing primary standards of all 209 PCB congeners. Despite lower absolute sensitivity and more Aroclor congener coelutions than the dual-column ECD system, the MS systems enabled measurement of more congeners per Aroclor since their greater linear response range did not require dilution of samples and standards. Pairs of different lots of Aroclors 1248 and 1254 displayed markedly different proportions of congeners, and the 1254 pair displayed strong differences in the extent of *ortho*-chlorine substitution. The tables of congener weight percent distributions among Aroclors are more comprehensive and quantitatively precise than those of prior publications. However, the limitations of single-level calibration precluded measurement of all congeners to the ±10% accuracy desirable for establishing these Aroclors as secondary standards for comprehensive, quantitative congener-specific PCB analysis.

1 Introduction

Polychlorinated biphenyls (PCBs) are comprised of 209 distinct chlorine-substituted biphenyl structures (congeners). About 140 to 150 of these are observed in the commercial mixtures produced by catalytic chlorination of biphenyl (Trade Name Aroclor in USA, formerly manufactured by Monsanto, Corp., St. Louis, MO, USA). The dispersion of these PCB congeners by uncontrolled releases into the environment, their long-term stability, their lipophilicity resulting in biomagnification up food chains, and questions of possible toxicity, together cause concern for their effects on the environment and have engendered a vast body of research over the past three decades. The measurement of the large number of PCB congeners in commercial or environmentally altered PCB mixtures requires the use of high resolution gas chromatography (HRGC) with sensitive, selective detection by electron capture detection (ECD) or selected-ion-monitoring mass spectrometry (MS-SIM). Current regulatory analytical methods in the USA and Europe simplify the analytical task by specifying quantitation either as a combination of one or more Aroclor congener distributions [1], or by specifying short lists of selected priority congeners for individual quantitation [2,3]. Analyses supporting some research applications, which must account for as many as possible of significant Aroclor congeners and sometimes additional congeners not originally in Aroclors, make even greater demands on HRGC systems. Examples include studies of Aroclors or PCBs in environmental samples which have undergone photolytic dechlorination [4], anaerobic microbial dechlorination [5], or aerobic microbial degradation [6]. The latter results in selective congener removal without production of new congeners. This most complete category of PCB analysis will be referred to herein as *comprehensive, quantitative, congener-specific* analysis (abbreviated CQCS). A CQCS PCB analysis is defined as one in which a substantial majority of congeners are resolved, all congeners at significant levels are correctly assigned to the HRGC peak in which they elute, and the PCB content of each resolved peak (including coeluting congeners of different chlorine number if separately quantified by MS) is accurately quantified against appropriate primary or secondary standards.

Hess *et al.* have recently provided a lengthy critical review of the analysis of non- and mono-*ortho*-chlorobiphenyls [7]. This covered all aspects of such analyses, with particularly useful and detailed discussions of the capabilities and problems of ECD,

MS-SIM, and full-scan ion-trap MS detection, as well as the shortcomings of single-point calibrations. Larsen [8] has recently provided in this journal a critical review of HRGC separations of PCB congeners. His laboratory has provided both an example of a dual-column HRGC-ECD system (parallel DB-17 and series-coupled Sil8/HT5) optimized for CQCS PCB analysis [9,10], as well as identifying a single column (HT8) particularly suited for CQCS and priority list congener PCB analysis when used with MS detection [11]. One of us (Frame) recently organized a worldwide consortium of laboratories to obtain complete retention and coelution data for all 209 PCB congeners on 27 HRGC systems encompassing 20 different stationary phase coatings [12]. Samples of Aroclors 1221, 1016, 1242, 1254, 1260, and 1262 were analyzed against the 209 individual congener standards on 18 of these systems, and the results were combined and averaged to produce comprehensive congener weight percent distributions for these 6 Aroclors [13]. Some of the most significant results from this pair of linked studies are the following:

1. The Aroclor distribution study enabled identification of all significant Aroclor congeners (about 140 of the 209), and when predicted coelutions of this subset were evaluated for all systems in the retention database, one newly developed stationary phase (DB-XLB, J&W Scientific, Folsom, CA, USA) displayed great promise, if used with MS-SIM detection, for enabling the CQCS measurements of an exceptional number of Aroclor congeners. The HT8 column (SGE Pty Ltd, Ringwood, Victoria, Australia) was likewise evaluated in the study, and Aroclor congener resolution information almost completely confirmed Larsen's evaluation of it [11,12]. While DB-XLB data predicted its ability to measure a slightly larger total of Aroclor congeners, it appeared unable to resolve extremely significant priority congeners 138 and 153 from 163 and 132, respectively, while HT8 isolated them from all significant Aroclor congeners. Both these phases have siloxane backbones modified by substitution of some oxygens with bulky organic groups to inhibit polymer thermal degradation leading to column bleed at high temperatures. This makes them especially suitable for CQCS PCB methods employing sensitive MS detection. The DB-XLB resolution predictions had not yet been confirmed by actual analysis of Aroclor mixtures.

2. Hewlett-Packard 5972 bench-top GC-MS-SIM systems operating with above-average new-model electron-multiplier tubes (either K&M or Galileo 5778 Channeltron) and similarly priced Varian Saturn Ion-Trap GC-MS systems operating in full-scan mode displayed exceptional ability to detect and quantify minor Aroclor components. Their *effective* sensitivity in this study was similar or slightly better than the inherently more sensitive ECD detectors because the MS detectors' wider linear response range did not require the dilution of samples and standards needed to include all Aroclor and internal standard peaks within the ECD linear range.

3. The retention database facilitated the distribution of almost all significant Aroclor congeners plus a few "non-Aroclor congeners" among only 5 calibration solutions totaling 144 congeners, while the remaining 65 "non-Aroclor congeners" plus a few very minor Aroclor congeners could be distributed among an additional 4 solutions. Each solution's congener distribution was structured such that there would be a minimum of close elutions on 12 of the stationary phases deemed most useful for CQCS PCB analysis. Tables of elution order for the components of each solution on each of the 12 phases were produced, enabling peak assignments and primary PCB congener standard single-level calibration to be made on a particular analyst's system using one of these phases after only 5 injections for the Aroclor congeners and an additional 4 injections for all 209. A commercial US standards supplier (AccuStandard, New Haven, CT, USA) has formulated the 9 congener mixture solutions according to this scheme, and provides them with the elution order tables described above.

A comparison of the GC-ECD and GC-MS Aroclor congener quantitations in the collaborative study suggested that even after dilution of the samples and standards for GC-ECD analysis, the ECD detectors were measuring many peaks in a non-linear response range rendering the single point calibration inadequate for accurate quantitation. Statistics on quantitation averages indicated that the values should be considered only "semi-quantitative" (*i.e.* between 10% and 50% different from actual values depending on concentration). Congener distributions for Aroclors 1232 and 1248 were compiled from only one pair of systems. Comparison with published congener weight percent distributions for other Aroclor 1254 lots [14], led us to suspect that the Aroclor 1254 used in the collaborative study might have an abnormal distribution. This raises a broader question of the degree of similarity of such distributions among different lots of the same numbered Aroclors over the whole range of chlorine weight percentages (denoted by the last two digits of the Aroclor designation [except Aroclor 1016]). This is significant since many CQCS PCB analysis methods specify calibration against secondary standards of Aroclors [15–18]. This method of calibration has advantages of convenience, cost of standards, and, in some cases, similarity of the standard and sample congener distributions, but its accuracy ultimately depends both on how well the Aroclor standards' congener distributions have been determined and how closely the lot being used matches the one from which the congener weight percent distributions have been compiled.

The purposes of the work reported here are: to confirm the predictions [12] and optimize the performance of DB-XLB columns by CQCS PCB analysis of actual Aroclor distributions using both MS-SIM and full-scan, ion-trap MS detection; to analyze the same sample set using a version of the Larsen/Bøwadt dual column GC-ECD system [9,10] and compare the congener resolution and quantitation performance with the GC-MS systems; and to use all three systems to compile complete congener weight percent distributions of multiple lots of the complete range of Aroclors (except Aroclors 1268 and 1270) by calibration against the 9 new AccuStandard primary standard congener mixtures.

2 Experimental

2.1 Materials

Aroclor lots were obtained from 3 sources, designated by letter-number(#) combinations in **Tables 3 and 4**. 1000 µg/ml iso-octane solutions in ampoules from AccuStandard (New Haven, CT, USA) are designated A# and those from Supelco (Bellefonte, PA, USA) are designated S#. A1, A2, A3, A4, A5, and A6 are the same solutions profiled in the study of reference [13]. Neat Aroclors obtained from the manufacturer (Monsanto Corp., St. Louis, MO, USA) are the same lots used as secondary HRGC calibration standards by GE Corporate R&D [17] and are designated G#. The MS internal standard (IS), 2-fluorobiphenyl (2F-BP), was purchased from Aldrich Chemical Co. (Milwaukee, WI, USA), and the ECD IS, decachlorobiphenyl (PCB 209), from AccuStandard. The primary calibration standards (containing 10 ppm each of all 209 PCBs distributed among 9 different mixtures) were purchased from AccuStandard. Iso-octane was OmniSolve (E. Merck, New Jersey, USA) distilled GC-grade. The DB-17 (50% diphenyl dimethylpolysiloxane) and DB-XLB (proprietary polysiloxane) capillary GC columns were obtained from J&W Scientific. The HP5 (5% diphenyl dimethylpolysiloxane) column was obtained from Hewlett-Packard (Palo Alto, CA, USA) and the HT5 (1,10-dicarba-*closo*-dodecaborane dimethylpolysiloxane) column from SGE, and they were series-coupled in that order using a Restek Press-Tight fused-silica column connecter.

2.2 Sample and Standards Preparation

1.00 ml of each of the 9 standard congener calibration mixtures was separately diluted together with appropriate volumes of the two IS stock solutions to 10.00 ml in volumetric flasks with iso-octane to produce solutions containing 1.00 µg/ml of each congener and 4.00 µg/ml of each IS. 1000 µg/ml stocks of Aroclors were similarly diluted with the 2 IS's and iso-octane in 25.00 ml volumetric flasks to produce solutions containing 40 µg/ml of Aroclor and 4.00 µg/ml of each IS. Because of the greater absolute sensitivity and non-linear response of ECD detectors to major Aroclor components and especially the high concentration of decachlorobiphenyl IS, samples and standards were diluted 16-fold with iso-octane prior to injection on the dual-column GC-ECD system.

2.3 Gas Chromatographic Analysis

Samples and standards were analyzed on the four systems summarized in **Table 1**. **Systems 1, 2, and 3** employed splitless injections of 1.0 µL, while that of **System 4** was a 1.0 µL on-column injection to a 0.53 mm i.d. × 2 m deactivated Hewlett-Packard capillary fused silica retention gap split to the series-coupled HP5/HT5 (**4A**) and DB-17 (**4B**) columns using a Restek Press-Tight fused-silica "T-piece". **System 1** employed MS-SIM detection at the most intense of either the M^+, $(M+2)^+$, or $(M+4)^+$ masses, with acquisition at 5 scans per second. The exact masses and SIM acquisition groups were the same as in [12]. The electron multiplier was upgraded to the K&M model employed in an HP 5972 GC-MS, and peak areas were integrated with the HP ChemStation integrator after Gaussian-smoothing, which caused slight losses of peak resolution but greatly improved the quantitative peak area measurement of minor peaks by enabling more accurate and consistent automated placement of peak baselines. **System 2** employed the new HP-1801-GCD GC-MS instrument. It was operated similarly to the HP 5971 of **System 1**, but its software limitations (maximum mass = 425 *m/z*) required acquisition of signals for 8, 9, and 10-chlorine-substituted biphenyl congeners at the $(M-2Cl)^+$ or $(M-4Cl)^+$ fragment masses (*i.e.* 359.8 or 395.8 *m/z* for 8 and 10, or 9 chlorobiphenyls respectively), and integration of unsmoothed peaks. Its new diffusion pump fluid permitted employment of hydrogen as carrier gas with a capillary GC column. **System 3** employed MS-Ion Trap detection which acquired full-scan spectra from 150 to 520 *m/z* at 1 scan/s. Peak areas were acquired by integration of peaks obtained by extraction of 2 or 3 of the major mass peaks of the M^+ cluster.

Table 1. HRGC systems used for CQCS PCB analysis.

Investigator	Frame	Frame	Cochran	Bøwadt	Bøwadt
Parameter	System 1	System 2	System 3	System 4A	System 4B
Column	DB-XLB	DB-XLB	DB-XLB	HP5/HT5	DB-17
Length (m)	29.6	28	60	25/25	60
I.D. (mm)	0.25	0.18	0.25	0.25/0.25	0.25
Film (µm)	0.50	0.18	0.25	0.25/0.10	0.25
Carrier Gas	He	H_2	He	H_2	H_2
Pressure (psi)	9.0	0.8ml/min	20.5	24.7	24.7
Flow (cm/s)	28.6	51.3	20.3	35.2	42.7
Flow Temp (°C)	225	205	225	202.5	202.5
Temp. Prog.					
Start (°C)	72	72	75	90	90
Hold (min)	2	2	2	2	2
Ramp 1 (°/min)	15	15	15	20	20
Stop (°C)	150	150	150	130	130
Ramp 2 (°/min)	2.5	2.0	1.5	2.0	2.0
Stop (°C)	300	260	300	275	275
Hold (min)	0	0	0	5	5
PCB209 (min)	65.9	60.3	102.0	67.8	75.6
Detector	MS-SIM	MS-SIM	MS-IT	ECD	ECD
Model	HP 5971	HP-GCD	Saturn	HP 5890	Dual ECD
Cost (~$)	$70,000	$50,000	$60,000	$40,000	$40,000

2.4 Calculation of Aroclor Congener Distributions

For **Systems 1 and 3** (**System 2** Aroclor data not calculated for incorporation into the summary distribution), the response factors relative to 2F-BP IS (RRFs) were calculated from peak areas in chromatograms of the 9 calibration mixtures. Only PCBs 37 and 103 in one mixture coeluted on the DB-XLB columns. The $(M+2)^+$ response for 103 could be measured without interference, but a separate standard containing PCB 37 and the IS needed to be injected to determine its M^+ RRF. Concentrations of each congener were calculated by multiplying the ratio of the sample peak's RRF to the corresponding standard peak's RRF by the standard's concentration of 1 µg/ml; *i.e.* a simple single point calibration. Contributions to a congener's M^+ peak area from single chlorine loss fragments from a coeluting next higher homolog congener were minor in all cases and were not compensated for. Only the major two-chlorine-loss signal contribution to PCB 77 values from coelution with PCB 144 required its subtraction to correct the PCB 77 values in the Aroclor 1254s.

The series-coupled HP5/HT5 column (**System 4A**) was not included in the original retention database study [12]. Therefore, the 30 mixtures totaling all 209 congeners used in that study were

initially employed to determine the elution order and coelutions of PCBs on this column and the parallel DB-17 (**System 4B**) column as well as the RRFs to decachlorobiphenyl IS. There were several congener coelutions on both it and the parallel DB-17 column when the 9 calibration mixtures used in this study were injected on **System 4**. In order to provide RRFs for congeners undergoing such coelutions, the RRF values obtained from the completely separated 30 mixtures runs were listed in order of increasing value. The RRF (obtained during the 9 mixture calibration) of a measurable (*i.e.* no coelution in one of the 9 calibration mixtures) congener with the value closest (usually $< \pm 2\%$) to that of each of the congeners suffering coelution in the calibration mix was selected from the ordered list to substitute for the latter. In many cases an interfering calibration mix congener would not appear at significant levels in an Aroclor, so the level of the desired congener could be measured on at least one of the columns of **System 4**. There were 6 categories of calculation from the combined data of the **System 4** columns (**4A and 4B**). These employed the same single point RRF ratio formula used with systems 1 and 3, and they enabled quantitation of 132 values; namely:

1. 41 PCBs as the *mean* of unique elutions on both **4A and 4B**
2. 47 PCBs eluting uniquely only on **4A**
3. 33 PCBs eluting uniquely only on **4B**
4. 5 PCBs as sum value on **4A** minus value of coeluter measured uniquely on **4B**
5. 3 PCBs as sum value on **4B** minus value of coeluter measured uniquely on **4A**
6. 6 PCBs measured as 3 sums of coeluting pairs on either of **4A or 4B**

These categories are defined for congeners significantly present in Aroclors (*i.e.* above ~ 0.05 weight%) as determined in the earlier Aroclor distribution study [13] and confirmed by the data in **Table 4** of this study.

3 Results and Discussion

3.1 PCB Congener Nomenclature

Column 1 of **Table 4** lists the 209 possible PCB congeners in order of their IUPAC number. Their presence in any of Aroclors 1242, 1254 or 1260 [13] as a major congener (>1.0 Wt%) is indicated by **Bold Underline**, as a minor congener (between 0.05 and 1.0 Wt%) by **Boldface**, and as a trace or undetected congener (<0.05 Wt%) by *italic* font. The numbers for congeners 107, 108, 109, 199, 200, and 201 in this paper are derived according to Guitart *et al.* [19], and they differ from the corresponding numbers assigned by Ballschmiter and Zell [20] as 108, 109, 107, 201, 199, and 200, respectively. Column 2 of **Table 4** displays the pairs of individual single phenyl-ring chlorine-substitution patterns according to the convention: 234-245 = 2,2',3,4,4',5'-hexachlorobiphenyl, where the hyphen represents the bond between the two phenyl rings. This permits easy visualization of the chlorination pattern on each ring and assists evaluation of the relative proportions of each pattern produced by the Aroclor synthesis process. Chlorines in the 2 or 6, the 3 or 5, and the 4 positions are described as *ortho-*, *meta-*, and *para-* substituted, respectively.

3.2 Comparisons of HRGC Systems Aroclor PCB Resolution Performance

Table 2A displays all Aroclor congener (i.e **Bold** numbers in **Table 4**) coelutions in each system by the convention X @ Y, where X is the minor component of the pair coeluting with Y.

Table 2A. Comparison of HRGC systems' performance.

System 1 29.6m DB-XLB 0.25mm x 0.5µm Helium		System 2 28m DB-XLB 0.18mm x 0.18µm Hydrogen		System 3 60m DB-XLB 0.25mm x 0.25µm Helium		System 4 HP5/HT5 + DB17 25/25m + 60m Hydrogen	
Isomer Coelutions of Aroclor Congeners (>0.05% in 1242, 1254 or 1260)							
	Wt%		Wt%		Wt%		Wt%
10@4	T	10@4	T	10@4	T		
20@33	5.7	20@33	5.7	20@33	5.7	41 NQ	0.8
59@42	2.0	59@42	2.0			56@60	3.0
43@52	T						
48@49	5.7					70 NQ	7.3
76@63	0.3	76@63	0.3	76@63	0.3		
89@84	T	89@84	T	89@84	T	92@84	3.8
115@85	2.2	115@85	2.2				
119@83	0.6	119@83	0.6	119@83	0.6		
123@109	0.8	123@109	0.8	123@109	0.8		
129@158	1.2	129@163	1.2	129@158	0.7		
131@133	0.3						
132@153	12.3			132@153	12.3		
163@138	9.0						
147@149	T						
193@180	T						
196@203	2.5					196@203	2.5
198@199	T						
SUM =	42.6		12.8		10.4		17.4

Table 2B. Additional classes of coelutions in System 3 (60m DB-XLB).

Different Chlorine Number ECD Unresolvable		Non-Aroclor PCB Coelution @ Aroclor PCB (Isomers)
11@18	T	21@33/20
13@27	0.7	62@75
53@31	8.1	68@40
91@66	7.1	58@67
84@56	4.3	88@74
117@136	0.7	90@101
139@124	0.5	120@110
141@105	6.1	143@139
128@185	1.1	168@153
201@171	1.4	182@175
198@170	T	162@128
207@195	T	169@196
SUM =	30.0	

XXX@YY = minor congener XXX coelutes with major congener YY.
NQ = Not quantifiable by dual-column difference calculation (categories 4 or 5).
T = 1st congener is trace component not quantifiable, but increases major component value by less than 10%.

Wt% is sum of largest mean weight percents for pair of coeluters in any of Aroclors 1242, 1248, 1254, or 1260.

Major congener coelutions are underlined.

The following comparisons and observations are made from these data:

1. Doubling the length of the DB-XLB column in **System 3** *versus* that in **System 1** doubled theoretical plates for n-tetradecane with hydrogen carrier from 124,000 to 249,000 (J&W test data). As a consequence, the number of Aroclor congener coelutions dropped from 17 to 6, and major coeluting pairs 48@49, 163@138, and 196@203 could be resolved. **Table 2B** shows additional different homolog (congeners of different chlorine number) coelutions on **System 3**, measurable by MS but not ECD, as well as those non-Aroclor congeners not measurable in the presence of some Aroclors.

2. The 28m narrow-bore, thin-film DB-XLB column used with hydrogen carrier (**System 2**, measured by J&W to have 170,000 theoretical plates) retained most of the above resolution improvements, and most importantly, achieved baseline resolution of the important 132/153 pair and also allowed measurement of PCB 138 without interference. Using longer, narrow-bore, thin-film DB-XLB capillaries both J&W and J. Cochran's labs [21] have also succeeded in resolving these pairs with *helium* carrier gas. Critical resolution comparisons between **Systems 1 and 2** are displayed in **Figure 1**. Note in the **System 2** segments of this figure that there is an enhancement of $(M - 1Cl)^+$ fragment-ion responses when hydrogen was used in **System 2**.This resulted both in several-fold lower signals at M^+ and larger one-chlorine-loss fragment interferences in cases of coeluting homologs. Such alteration of PCB fragmentation patterns was not observed when hydrogen was employed as GC carrier gas with the Varian Saturn ion-trap MS. Its higher capacity turbomolecular pumps may achieve a lower ion-source hydrogen pressure than the diffusion pump of the HP-GCD. An elucidation of the mechanism of the fragmentation pattern alteration by hydrogen requires further study. Analysts requiring hydrogen carrier to achieve critical congener resolutions in GC-MS-SIM CQCS PCB analyses should check their systems for the possible presence of this behavior.

3. Column 4 of **Table 2A** shows that the **System 4** combination of GC columns **4A** and **4B** yields the most complete Aroclor congener profile. In practice PCBs 41 and 70 could not be accurately measured in some Aroclors as required by the calculation categories 4 and 5 described in Section 2.4 above, and there remained 3 pairs of Aroclor congeners not resolved on either column. Fortunately **System 4** could quantify all congeners not measurable by **Systems 1 or 3**, thus enabling complete Aroclor congener distributions to be obtained. The multiple categories of measurement in more comprehensive **System 4** made reduction of data from it much more complex and time consuming than from **Systems 1 and 3**.

3.3 *Comparison of Systems Quantitation Performance*

The first 3 data columns of **Table 3** display the number of congeners measured in each Aroclor lot by **Systems 1, 3, and 4**.

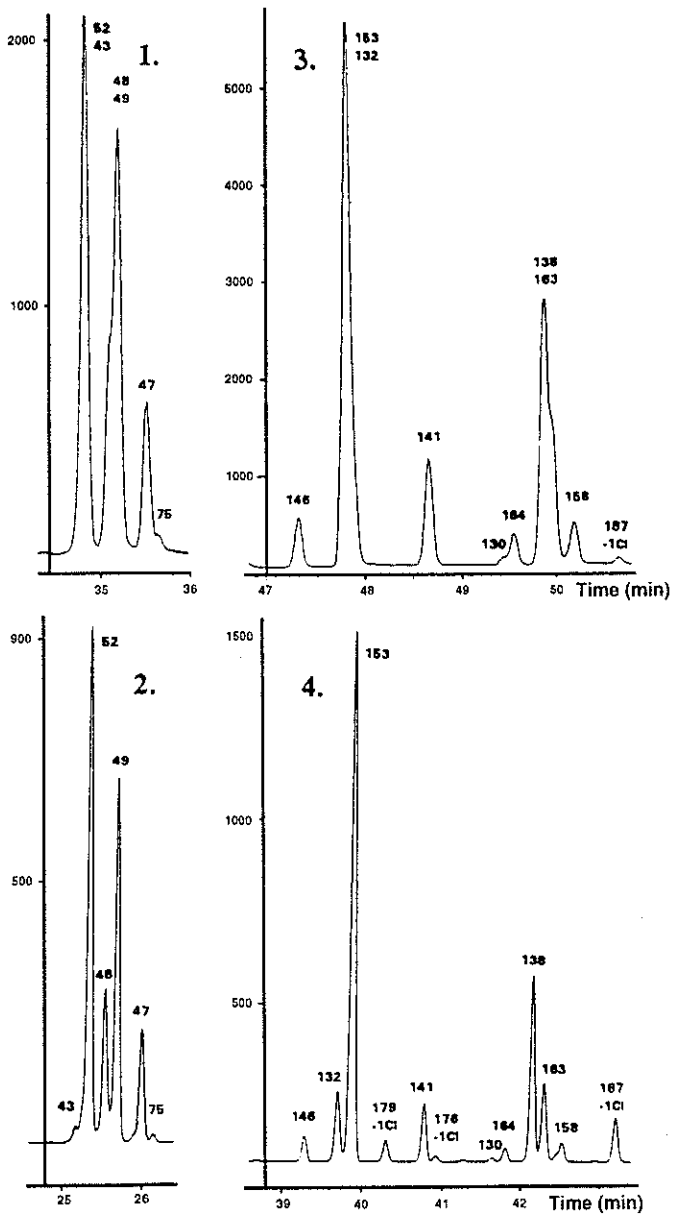

Figure 1. Critical congener resolution comparisons between GC-MS systems 1 and 2.
1. **System 1**, G3 Aroclor 1242, Mass = 291.9 (4-Cl M^+)
2. **System 2**, G3 Aroclor 1242, Mass = 291.9 (4-Cl M^+)
3. **System 1**, G5 Aroclor 1260, Mass = 359.8 (6-Cl M^+)
4. **System 2**, G5 Aroclor 1260, Mass = 359.8 (6-Cl M^+).

Note that dual-column ECD **System 4** employed 16-fold diluted standards and samples to reduce the effect of non-linearity of detector response. Assuming a near equal split to each column, the effective concentrations sampled by each ECD were 1.25 or 0.03 µg/ml for Aroclors or individual congener standards, respectively, compared to 40.0 or 1.0 µg/ml for the MS detectors. As in the predecessor study [13], where single point calibration was also employed, the individual calculated ECD congener concentrations ranged higher than the corresponding MS values; with the differences being inversely proportional to the absolute concentrations. Despite the effective 32-fold dilution, single point calibration was still clearly insufficient for accurate ECD measurements over portions of the concentration range due to non-

Table 3. No. of congeners measured by each system. Similarity of Aroclor congener distributions.

		No. of Congeners Measured			Sum of % Diffs. [a]	
Aroclor	Lot	Sys 1	Sys 3	Sys 4 [b]	Lots 1&2 Lots 2&3	Lots 1&3
1221	A1	59	63	45		
1232	A1.5	77	93	81	1.9	
1232	G1.5	75	91	88		
1016	A2	58	71	52	1.1	
1016	S2	58	70	54		
1242	A3	82	95	75	9.3	
1242	G3	79	93	76		6.3
1242	S3B	81	95	78	12.3	
1248	A3.5	92+	95+	88	19.8	
1248	G3.5	92+	95+	92		
1254	A4	92+	95+	81	52.5	
1254	G4	92+	95+	97		
1260	A5	89	93	67	1.7	
1260	S5	89	93	73		7.2
1260	G5	84	82	65	6.4	
1262	A6	91	95	78	10.3	
1262	G6	91	92	74		

"+" – additional trace congeners detected, not reported.

a) The absolute differences in Wt%s of pairwise comparisons are summed for all congeners for pairs of Aroclor lots using **Table 4** values.

b) The number of measured PCBs is reduced because of the 16-fold dilution needed to place the range of PCB congeners in a more linear region of the ECD response curve when using single-level calibration.

linearity of the detector response over the range from the lower Aroclor congener concentrations to the much higher level of the IS. A linearity study of **System 1** responses for 39 congeners covering all levels of chlorination (except decachlorobiphenyl) revealed concentration/response ratios constant to ±10% over the range equivalent to 0.1 to 10.0 Wt% of 1.0 µL of the 40 µg/ml Aroclor solutions injected. This suggests that the single point calibration was adequate over this range *for this particular GC-MS-SIM system.* More than 90% of the full-scan ion-trap **System 3** Aroclor congener weight% values were within ±10% of the corresponding **System 1** values over this range. The two GC-MS systems displayed similar sensitivity; the greater congener count of **System 3** in **Table 3** being primarily due to greater congener resolution, as outlined in **Table 2A**. Conversely, the even more comprehensive congener measurement capability of dual-column ECD **System 4** was offset by the need to analyze more dilute samples. This resulted in fewer detections of minor congeners: especially less chlorinated ones having lower ECD RRFs. **System 4** was incorporated in this study after solutions had been prepared for and analyzed only by **Systems 1 and 3.** Its quantitative accuracy would surely have improved in a study design employing multilevel calibration and use of a lower decachlorobiphenyl IS concentration requiring less dilution. With some extracts of environmental samples standard cleanup procedures [7] may be able to remove much higher levels of non-PCB contaminants which degrade either the chromatographic separation or the MS quantitation of PCBs in GC-MS systems. If the contaminant levels are low enough or can be reduced sufficiently to allow concentration of the extracts to attain the PCB levels measured in this study, then the GC-MS methods may provide better analyte selectivity and more facile quantitation than the more complex multicolumn analysis and multilevel calibration required for full CQCS implementation of **System 4**. On the other hand, the latter provides more comprehensive congener coverage at slightly lower equipment cost (**Table 1**), and provides dual chromatographic confirmation capability instead of mass spectrometric confirmation.

Figure 2 illustrates the remarkably sensitive detection by **System 1,** without further isolation and concentration, of only 1.4 picograms injected of critical coplanar PCB 126 from lot G4 Aroclor 1254 at 40 µg/ml. Note the much elevated level of this congener in lot A4, which is discussed further in Section 3.6. PCB 159 coelutes with PCB 126 on some DB-XLB columns, but its absence was demonstrated by the absence of its $(M + 2)^+$ ion one chlorine isotope mass above that of PCB 126. **Figure 3** illustrates the library-searchable full-scan mass spectrum obtained by **System 3** on the trace level (only 15 picograms injected) of PCB 138 measured in Aroclor 1232. The ability of the Ion-Trap MS to provide full-scan spectra of even minor Aroclor components provides more complete MS confirmation of PCB peaks than do the several masses usually monitored in MS-SIM methods. Additionally, in the event of contaminant interferences at the molecular ion cluster masses routinely monitored, one may be able to employ other fragment masses from the full-scan sample and standard data files to quantify the PCB content of a peak.

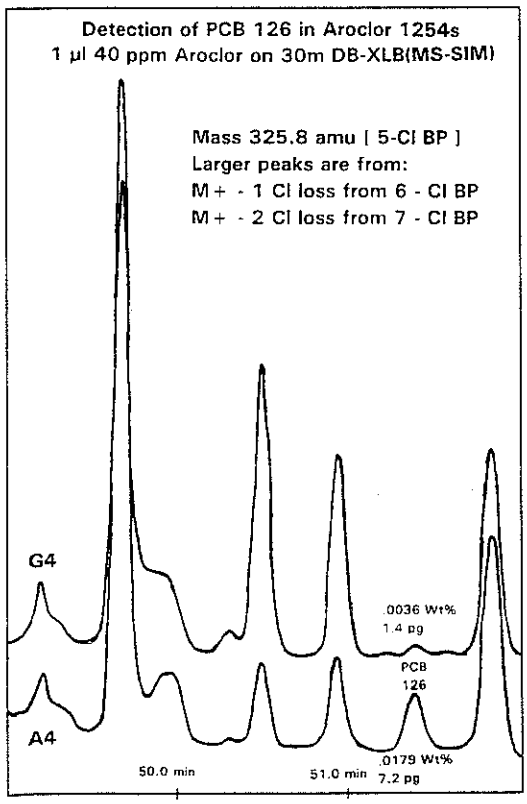

Figure 2. System 1. GC-MS-SIM detection of PCB 126 in A4 and G4 Aroclor 1254s.

Table 4A. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUPAC#	Aroclor - Structure Cl Pos.	1 A1 1221	2 A1.5 1232	3 G1.5 1232	4 A2 1016	5 S2 1016	6 A3 1242	7 G3 1242	8 S3B 1242	9 A3.5 1248	10 G3.5 1248	11 A4 1254	12 G4 1254	13 A5 1260	14 S5 1260	15 G5 1260	16 A6 1262	17 G6 1262
1	2	35.80	15.21	15.84	.52	.54	.51	.34	.78	.05	.02	.02		.03	.03	.01	.02	.03
2	3	3.81	1.98	1.94	.02	.03	.02	.02	.05									
3	4	20.44	10.36	10.20	.15	.16	.15	.11	.27	.01				.00				.01
4	2-2 +10	6.19	5.32	5.38	3.62	3.66	3.11	2.71	3.41	.32	.04	.02	.06	.03	.03	.00	.07	.04
5	23	.74	.49	.50	.17	.15	.13	.11	.19	.00				.00				
6	2-3	3.82	3.02	3.00	1.64	1.69	1.42	1.24	1.63	.13	.00	.00	.02	.01	.01		.03	.02
7	24	1.70	1.12	1.09	29	.30	.26	.18	.34	.02								
8	2-4	12.34	10.71	10.72	8.29	8.31	6.99	6.48	7.68	.81	.26	.05	.13	.06	.06	.00	.15	.08
9	25	1.74	1.25	1.29	.58	.59	.50	.40	.60	.04								.00
10	26	.80	.60	.58	.23	.23	.20	0.14	.25									
11	3-3	.16																
12	34	.59	.35	.35	.07	.07	.06	.04	.09									
13	3-4	1.12	.73	.72	.24	.25	.20	.17	.27	.02								
14	35	.00	.00	.02														
15	4-4	4.18	3.24	3.19	2.40	2.49	1.98	1.95	2.39	.22	.06	.01	.03	.00	.02		.03	.02
16	23-2	.31	1.79	1.79	3.88	3.88	3.03	3.44	2.94	1.04	.71	.02	.09	.02	.02	.00	.07	.03
17	24-2	.34	1.83	1.82	3.98	3.98	3.14	3.29	2.97	1.05	.93	.02	.08	.02	.02	.00	.07	.03
18	25-2	.78	4.89	4.83	10.86	10.75	8.53	9.14	7.93	4.29	3.29	.08	.25	.07	.07	.00	.19	.10
19	26-2	.08	.46	.47	.99	1.01	.79	.84	.75	.22	.14				.00		.02	
20	23-3	.07	.42	.42	.88	.89	.68	.77	.71	.14	.08							
21	234	NM	NM	NM	NM	NM	NM	NM	NM									
22	23-4	.26	1.62	1.62	3.50	3.51	2.71	3.08	2.73	1.33	1.38	.02	.04	.02	.02	.00	.06	.03
23	235		.00	.00	.01	.02	.01	.01	.01		.00							
24	236	.02	.08	.08	.16	.17	.13	.13	.14	.00								
25	24-3	.09	.37	.37	.72	.72	.57	.61	.60	.11	.04						.00	.00
26	25-3	.13	.75	.74	1.57	1.59	1.21	1.38	1.24	.40	.23	.00	.03	.00	.00	.00	.03	.01
27	26-3	.05	.12	.12	.51	.50	.40	.44	.39	.12	.07						.00	.00
28	24-4	.62	3.92	3.89	8.50	8.57	6.68	7.31	6.60	3.59	5.57	.06	.19	.05	.05	.00	.15	.08
29	245	.01	.05	.05	.10	.10	.08	.08	.09	.00	.00							
30	246				.00	.00												
31	25-4	.60	4.17	4.11	9.32	9.26	7.18	7.82	7.01	5.07	5.47	.11	.28	.06	.05	.00	.16	.08
32	26-4	.17	1.08	1.07	2.37	2.37	1.85	2.05	1.79	.88	.93	.01	.05	.01	.01	.00	.05	.02
33	34-2 + 20	.48	2.84	2.88	6.21	6.19	4.85	5.35	4.82	2.23	2.21	.05	.16	.04	.04	.00	.13	.07
34	35-2		.01	.01	.03	.03	.02	.02	.03	.00	.00							
35	34-3	.00	.06	.05	.05	.06	.07	.07	.09	.00								
36	35-3																	
37	34-4	.19	1.15	1.12	1.02	1.01	1.86	2.19	2.05	.79	.95	.01	.07	.01	.00	.00	.04	.02
38	345																	
39	35-4																	
40	23-23	.04	.40	.36	.58	.58	.77	.79	.72	1.13	.92	.15	.12	.00	.00		.00	.00
41	234-2	.03	.36	.35	.76	.76	.69	.69	.65	.77	.75	.02	.01		.00		.00	.00
42	23-24 + 59	.09	.66	.69	1.59	1.59	1.13	1.25	1.17	1.67	1.79	.09	.15	.00	.00	.00	.03	.01
43	235-2		.12	.09	.28	.25	.18	.19	.16	.30	.19							
44	23-25	.21	1.81	1.81	4.47	4.48	3.60	3.63	3.42	6.31	5.09	.67	2.31	.04	.04	.03	.10	.05
45	236-2	.04	.47	.45	1.23	1.22	.93	.91	.84	1.09	.91	.02	.05	.00	.00		.00	.00
46	23-26	.02	.19	.19	.49	.48	.37	.38	.33	.47	.39			.00				.00
47	24-24	.05	.49	.49	1.26	1.24	.97	.92	.91	1.49	2.41	.07	.14	.00	.00	.00	.01	.00
48	245-2	.06	.61	.62	1.61	1.59	1.18	1.17	1.19	1.66	1.54	.05	.12	.00	.00		.01	.00
49	24-25 + 48	.15	1.37	1.36	3.35	3.40	2.59	2.60	2.38	4.12	4.17	.26	1.10	.01	.02	.01	.07	.04
50	246-2				.01	.01	.00	.00	.00									
51	24-26	.00	.12	.13	.32	.32	.25	.23	.22	.30	.31							
52	25-25 + 43	.22	1.83	1.86	4.63	4.61	3.64	3.47	3.47	6.93	5.58	.83	5.38	.27	.25	.21	.17	.11
53	25-26	.04	.37	.37	.95	.94	.75	.71	.68	1.05	.88	.04	.12	.00	.00	.00	.00	.00
54	26-26		.00		.01	.02	.00	.00	.01		.00							
55	234-3		.05	.05			.09	.11	.10	.06	.05							
56	23-34	.12	.93	.92	.07	.06	1.80	1.85	1.80	3.16	3.19	1.70	.55	.02	.02	.00	.04	.02
57	235-3		.00	.01	.01	.01	.02	.00	.03	.02	.02							
58	23-35																	
59	236-3	.01	.20	.15	.41	.38	.37	.32	.27	.37	.23	.00	.02				.00	
60	234-4	.07	.61	.60	.04	.03	1.17	1.17	1.19	1.85	2.67	.95	.18	.04	.04	.03	.02	.02
61	2345																	
62	2346																	
63	235-4 + 76	.00	.10	.10	.06	.05	.13	.11	.12	.17	.19	.07	.02					
64	236-4	.10	.87	.87	1.87	1.84	1.76	1.68	1.67	3.01	3.32	.36	.59	.01	.01	.00	.04	.02
65	2356																	
66	24-34	.21	1.74	1.71	.39	.36	3.38	3.38	3.40	5.84	7.22	3.56	1.01	.03	.03	.01	.08	.05
67	245-3	.00	.09	.08	.06	.06	.15	.17	.16	.13	.10	.00						
68	24-35																	
69	246-3				.00	.00												
70	25-34	.24	1.90	1.90	.59	.56	3.76	3.70	3.73	7.28	7.39	6.83	3.49	.04	.04	.05	.12	.07

Table 4B. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUP	Aroclor - Structure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AC#	Cl Pos.	A1 1221	A1.5 1232	G1.5 1232	A2 1016	S2 1016	A3 1242	G3 1242	S3B 1242	A3.5 1248	G3.5 1248	A4 1254	G4 1254	A5 1260	S5 1260	G5 1260	A6 1262	G6 1262
71	26-34	.06	.54	.54	1.16	1.17	1.04	1.06	1.00	1.67	1.86	.11	.15	.00	.00	.00	.02	.00
72	25-35		.00		.00	.00	.01	.01	.01	.02	.01							
73	26-35				.00	.00		.00										
74	245-4	.12	.92	.92	.33	.33	1.83	1.76	1.84	3.14	4.67	2.19	.84	.05	.05	.04	.06	.04
75	246-4		.02	.02	.06	.06	.05	.03	.04	.08	.08							
76	345-2	.00					.08	.08	.09	.13	.13	.03	.02					
77	34-34	.01	.17	.16			.27	.33	.33	.41	.52	.20	.03					
78	345-3																	
79	34-35																	
80	35-35																	
81	345-4		.00				.00	.01	.01	.01	.02	.00						
82	234-23	.00	.12	.12			.29	.22	.28	.81	.62	1.53	1.11					
83	235-23 + 119		.05	.04			.12	.09	.12	.26	.20	.56	.48	.00	.00	.00	.00	.00
84	236-23 + 89	.02	.20	.18	.05	.05	.46	.35	.43	1.26	.91	1.58	2.32	.11	.12	.10	.05	.03
85	234-24 + 115	.03	.17	.17	.00		.36	.24	.32	.98	1.14	2.49	1.28	.00	.00	.02	.03	.01
86	2345-2		.01	.01			.03		.04	.11	.09	.10	.06					
87	234-25	.04	.22	.22			.52	.38	.49	1.45	1.11	3.41	3.99	.44	.42	.36	.11	.11
88	2346-2						.00	.00		.02	.02							
89	234-26		.05	.05			.10	.07	.09	.20	.17	.11	.09					
90	235-24									NM	NM	NM	NM					
91	236-24		.10	.10	.06	.06	.24	.17	.23	.63	.56	.53	.93	.00	.00	.01	.01	.00
92	235-25	.02	.05	.05			.06	.09	.13	.38	.25	.57	1.29	.34	.32	.25	.07	.09
93	2356-2								.00	.04	.03							
94	235-26					.00	.00	.00	.01	.03	.02	.00	.02					
95	236-25	.05	.30	.30	.31	.30	.68	.51	.64	1.96	1.43	1.84	6.25	2.56	2.54	2.27	.87	.99
96	236-26		.01	.01	.04	.04	.03	.02	.03	.08	.06	.01	.04					
97	245-23	.03	.18	.17	.00	.04	.43	.31	.41	1.22	.97	2.78	2.62	.10	.09	.08	.06	.03
98	246-23					.00												
99	245-24	.04	.21	.21	.01	.01	.53	.36	.49	1.47	1.81	4.53	3.02	.03	.04	.06	.06	.03
100	246-24																	
101	245-25	.07	.33	.32	.04	.03	.78	.57	.71	2.22	1.89	5.49	8.02	3.23	3.18	2.99	1.03	1.23
102	245-26		.03	.03	.04	.04	.08	.05	.07	.19	.17	.09	.15					
103	246-25									.02	.00		.03					
104	246-26																	
105	234-34	.05	.22	.21	.00		.52	.37	.52	1.60	1.45	7.37	2.99	.22	.21	.23	.18	
106	2345-3																	
107	234-35																	
108	2346-3																	
109	235-34 + 123		.03	.03			.08	.04	.06	.18	.13	.78	.37	.00	.00	.00	.00	.00
110	236-34	.05	.38	.38			.94	.68	.88	2.97	2.55	8.42	9.29	1.38	1.36	1.25	.36	.42
111	235-35																	
112	2356-3						.00											
113	236-35											.01		.00				
114	2345-4		.02	.01			.05	.03	.05	.12	.12	.50	.18	.00		.00		
115	2346-4		.01	.01			.04	.03	.05	.11	.11	.37	.20			.00		
116	23456																	
117	2356-4		.01	.00			.03	.02	.04	.09	.10	.19	.23					
118	245-34	.08	.29	.28			.78	.51	.69	2.29	2.35	13.59	7.35	.51	.50	.45	.17	.14
119	246-34									.06	.06	.12	.08					
120	245-35																	
121	246-35																	
122	345-23						.01	.00	.02	.06	.05	.25	.10					
123	345-24						.03	.02	.03	.07	.08	.32	.15					
124	345-25		.00				.03	.02	.03	.10	.07	.47	.29	.00	.00	.00	.00	.00
125	345-26		.00	.00			.02	.02	.02	.04	.03	.03	.02					
126	345-34									.00	.00	.02	.00					
127	345-35																	
128	234-234						.04	.00	.02	.12	.08	1.71	1.42	.56	.55	.50	.17	.20
129	2345-23							.00		.02		.39	.38	.15	.14	.12	.03	.04
130	234-235									.04	.01	.50	.60	.23	.22	.21	.03	.06
131	2346-23											.14	.19	.08	.07	.05		
132	234-236		.02	.02			.05	.03	.04	.15	.14	1.50	2.29	2.84	2.96	2.91	1.07	1.35
133	235-235 + 131												.11	.08	.06	.06	.03	.05
134	2356-23										.01	.20	.37	.36	.36	.31	.11	.14
135	235-236									.04	.04	.28	.61	1.14	1.09	1.02	.67	.65
136	236-236			.00					.00	.05	.06	.24	.70	1.48	1.45	1.44	1.02	.99
137	2345-24									.03	.02	.52	.42	.02	.02	.02	.01	.00
138	234-245 + 163		.06	.05			.16	.05	.10	.38	.41	5.95	5.80	6.47	6.41	6.73	2.33	3.14
139	2346-24											.14	.15					
140	234-246																	

Table 4C. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUPAC#	Aroclor - Structure Cl Pos.	1 A1 1221	2 A1.5 1232	3 G1.5 1232	4 A2 1016	5 S2 1016	6 A3 1242	7 G3 1242	8 S3B 1242	9 A3.5 1248	10 G3.5 1248	11 A4 1254	12 G4 1254	13 A5 1260	14 S5 1260	15 G5 1260	16 A6 1262	17 G6 1262
141	2345-25						.01	.00	.00	.07	.09	.69	.98	2.62	2.68	2.57	1.63	1.69
142	23456-2																	
143	2345-26																	
144	2346-25										.01	.12	.24	.61	.61	.61	.41	.41
145	2346-26																	
146	235-245									.04	.05	.45	.67	1.17	1.16	1.11	.57	.61
147	2356-24											.02	.10					
148	235-246																	
149	236-245 + 147		.05	.05			.07	.04	.06	.24	.33	1.82	3.65	8.74	8.78	8.73	6.36	6.44
150	236-246																	
151	2356-25		.01	.00					.00	.04	.08	.22	.69	3.04	3.04	3.03	3.14	2.81
152	2356-26																	
153	245-245 + 132	.00	.05	.05			.09	.04	.05	.23	.43	3.29	3.77	9.09	9.17	9.91	6.78	7.42
154	245-246											.02	.04					
155	246-246																	
156	2345-34						.02			.06	.04	1.13	.82	.53	.54	.50	.14	.18
157	234-345									.00	.00	.30	.19	.02	.02	.02	.00	.00
158	2346-34 + 129						.02		.01	.04	.04	.90	.81	.57	.58	.60	.18	.21
159	2345-35																	
160	23456-3																	
161	2346-35																	
162	235-345																	
163	2356-34		.02	.02			.00	.02	.00	.06	.08	.70	1.03	2.41	2.43	2.44	1.50	1.55
164	236-345						.00			.02	.03	.31	.40	.72	.70	.66	.23	.30
165	2356-35																	
166	23456-4											.05	.05					
167	245-345									.00	.00	.35	.27	.20	.20	.17	.02	.05
168	246-345																	
169	345-345																	
170	2345-234										.08	.35	.52	3.97	4.01	4.36	3.05	3.47
171	2346-234											.08	.14	1.09	1.08	1.17	.85	.89
172	2345-235											.03	.07	.71	.70	.69	.63	.62
173	23456-23													.11	.09	.09	.03	.05
174	2345-236										.08	.14	.34	4.92	4.96	4.99	6.56	6.10
175	2346-235													.18	.18	.17	.19	.16
176	2346-236											.00	.04	.59	.58	.59	.73	.66
177	2356-234										.03	.08	.20	2.54	2.52	2.64	2.82	2.73
178	2356-235												.03	.86	.84	.79	1.31	1.10
179	2356-236										.02	.02	.10	2.05	2.04	1.99	3.64	3.01
180	2345-245 + 193		.02	.00				.00		.02	.21	.42	.67	10.90	11.20	12.05	13.72	14.53
181	23456-24													.00	.00	.00		
182	2345-246																	
183	2346-245										.06	.09	.18	2.33	2.35	2.56	2.89	2.86
184	2346-246																	
185	23456-25													.56	.56	.53	.93	.81
186	23456-26																	
187	2356-245		.01	.00							.09	.09	.25	5.44	5.37	5.39	9.55	8.76
188	2356-246																	
189	2345-345											.00	.01	.08	.11	.12	.03	.04
190	23456-34											.05	.07	.82	.80	.85	.74	.77
191	2346-345													.16	.17	.17	.13	.13
192	23456-35																	
193	2356-345												.03	.54	.49	.57	.67	.65
194	2345-2345												.01	2.11	2.06	2.03	3.79	4.32
195	23456-234													.86	.81	.85	1.39	1.46
196	2345-2346													1.02	1.03	1.21	2.41	2.12
197	2346-2346													.07	.07	.07	.14	.13
198	23456-235													.10	.11	.09	.24	.22
199	2345-2356+198												.01	1.87	1.86	1.60	4.91	4.57
200	23456-236													.26	.26	.23	.69	.60
201	2346-2356													.25	.25	.23	.66	.58
202	2356-2356													.36	.36	.28	1.20	.96
203	23456-245+196												.02	1.50	1.45	1.25	4.11	4.37
204	23456-246																	
205	23456-345													.10	.10	.10	.16	.18
206	23456-2345											.03	.03	.66	.61	.31	1.19	1.33
207	23456-2346													.05	.06	.03	.17	.18
208	23456-2356											.01	.01	.16	.16	.06	.29	.26
209	23456-23456													NM	NM	NM	NM	NM
Sum		100.	100.	100.	100.	100.	100.0	100.2	100.2	100.2	100.4	100.3	100.2	100.3	101.4	101.1	100.0	100.0

1. High Resol. Chromatogr.

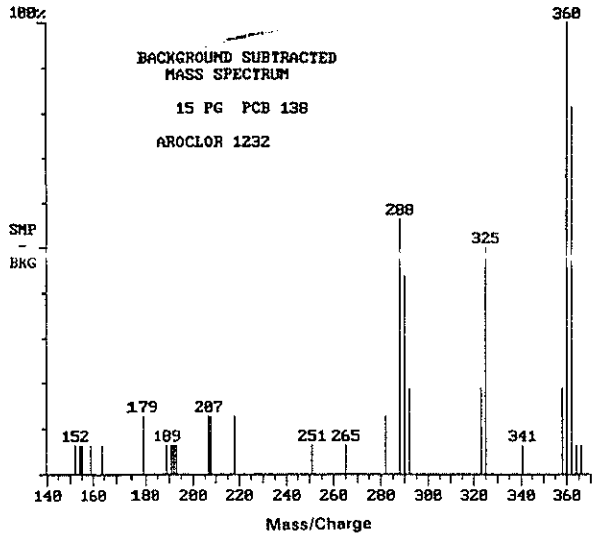

Figure 3. System 3, GC-Ion-trap MS, full-scan spectrum of PCB 138 in Aroclor 1232.

3.4 Aroclor Congener Weight% Distributions

Weight percentages for each congener in 17 Aroclor lots were calculated against the sum of all congener concentrations *found* in each Aroclor and are displayed in the 3 pages of **Table 4**. Since Aroclors 1221 and 1232 contain ~12% and ~6% unmeasured unchlorinated biphenyl [17], the reported weight percents should be adjusted by factors of 0.88 and 0.94 before using their distributions as a secondary calibration standard. Concentrations of individual PCB congeners were calculated in **Systems 1, 3, and 4** by single point calibration as described in Section 2.4. The values used to calculate the weight%s in **Table 4** were compiled in three ways:

1. MS detection does not enable separate quantitation of coeluting *isomers* (congeners of the same chlorine number). In cases where specific Aroclor *isomers* were not party to coelutions in either **Systems 1 and 3**, the calculated concentrations on each system agreed within ±10% more than 90% of the time, and the mean of the concentrations on each system was used.

2. **System 3** resolved more isomer pairs than **System 1** (**Table 2A**). Isomer coelutions on **System 1** are designated in weight% **Table 4** by adding the IUPAC number of the minor component of the pair to the major component structure designation in the Cl-position column. Such combinations are underlined for cases where **System 3** could resolve the pair, and in those cases the **System 3** concentration was used for each of the congeners coeluting on **System 1**.

3. In cases where neither **Systems 1 or 3** could resolve significant isomer coelutions (non-underlined), the average of the **System 1 and 3** concentrations measured using the major component's GC-MS RRF was calculated, and that value was apportioned between the two congener components according to the relative amounts measured on columns **4A** and/or **4B** of the dual-column ECD system. Congener weight%s calculated by this procedure are enclosed by outlines in **Table 4**. This method of calculation was chosen in order to base all congener quantitation in **Table 4** on the more linear MS responses.

Values below 0.05 Wt% are trace levels with poor quantitative accuracy due to difficulties of integrating small peaks close to background noise level. They are also more than 50-fold lower than the single standards, and 200-fold lower than the internal standard levels. As pointed out by Hess *et al.* [7], even with the greater linearity of the MS detector's responses, this is too great a span for accurate quantitation by single point calibration. The values are retained in **Table 4** as very rough approximations of the trace levels detected. Values calculated between 0.015 and 0.005 are rounded to .01 and those below 0.005 are displayed as .00. NM (not measurable) designates congeners verified elsewhere at trace levels in some Aroclors but not measurable because of coelutions with either other Aroclor congeners, or with the IS in the case of PCB 209. Contributions to the PCB 206 and 208 peaks from traces of these congeners in the PCB 209 IS were measured and subtracted to calculate the values displayed in **Table 4.**

3.5 Systematics of Chlorine Substitution in Aroclors

The weight% data of **Table 4** were converted to mole percents of each of 20 possible single phenyl-ring chlorine-substitution patterns and displayed for 5 biphenyl chlorination levels in **Table 5A**. The results are consistent with the theory of electrophilic substitution reactions on aromatic rings:

1. 246- and 35-substituted rings are highly suppressed (<0.1 mole% in any Aroclor). Their formation requires 2 unfavored substitutions *meta-* to either the other ring or prior chlorines, and once formed these ring substitution patterns direct rapid, strongly favored additional chlorination at positions *ortho-* or *para-* to multiple chlorine atoms.

2. 26-, 235-, and 345-substituted rings are less common (<3 mole% in any Aroclor) as a result of the same factors in **1.** above, but in these cases they act with lesser force.

3. 25-substitution occurs extensively and relatively rapidly, and it persists once formed; 24-substitution also occurs relatively rapidly but is then also rapidly removed by further chlorination above the percentages in Aroclor 1248; 34-substitution is initially slower but persists longer in higher Aroclors.

The 52 congeners listed in **Table 5B** were not detected above 0.01 Wt% in any Aroclor. All but PCB 182 should be observable without Aroclor congener coelution in at least one of **Systems 1, 3, 4A or 4B**. All 52 either possess one or more of the unfavored phenyl ring chlorination patterns described in **1.** or **2.** above, or display strong imbalance in the number of chlorines on each ring, (*e.g.* PCBs 38, 61, 62, 116, 142, 181), which is another feature unlikely to accumulate significantly. Measurable traces of PCBs 21 and 90 are anticipated on the basis of these correlations, but these PCBs suffer Aroclor congener coelutions on all systems of this study. The former has been detected in Aroclor mixtures on an HT8 column [11], and the latter has been reported in Aroclor 1254 by de Boer and Dao [22] and Frame [13] at levels considerable lower than those reported by Schulz *et al.* [14] in Aroclors 1242, 1254, and 1260.

Table 5A. Mole percents of PCB phenyl ring substitutions.

Lot → Aroclor-Ring Cl Pattern	A1 1221	Mean(3) 1242	Mean(2) 1248	G4 1254	Mean(3) 1260	Mean of all 5
none	34.89	1.33	.06		.02	7.26
2	33.12	21.01	7.05	.71	.18	12.41
3	4.59	2.85	.63	.05	.00	1.63
4	21.78	20.00	12.83	1.80	.19	11.32
23	.78	7.82	9.24	5.67	.51	4.80
24	1.40	10.18	12.94	4.62	.12	5.85
25	1.81	17.84	22.99	21.24	7.57	14.29
26	.52	2.86	2.61	.35	.01	1.27
34	.82	9.32	14.64	14.46	3.48	8.54
35	.00	.02	.00	.00	.00	.00
234	.07	1.60	3.98	10.56	10.03	5.25
235	.00	.30	.65	2.11	2.37	1.09
236	.10	2.27	5.24	13.86	14.43	7.18
245	.14	2.49	6.66	19.84	30.26	11.88
246		.02	.07	.07		.03
345	.00	.04	.14	.69	.90	.35
2345		.03	.23	2.01	15.04	3.46
2346		.02	.09	.88	3.43	0.88
2356		.02	.14	1.38	9.61	2.23
23456				.07	2.15	.45
SUM	100.05	100.03	100.19	100.37	100.29	100.19

Table 5B. Chlorine substitution patterns of PCBs not detected in Aroclors above 0.01 weight%.

PCB No.	Cl Pattern	Cl Diff.	PCB No.	Cl Pattern	Cl Diff.
14	**35**		116	23456	5
30	**246**	3	120	245 - **35**	
36	**35** - 3		121	**246** - **35**	
38	*345*	3	127	*345* - **35**	
39	**35** - 4		140	234 - **246**	
50	**246** - 2		142	23456 - 2	4
58	23 - **35**		143	2345 - *26*	2
61	2345	4	145	2346 - *26*	2
62	2346	4	148	*235* - **246**	
65	2356	4	150	236 - **246**	
68	24 - **35**		152	2356 - *26*	2
69	**246** - 3		155	**246** - **246**	
72	25 - **35**		159	2345 - **35**	2
73	*26* - **35**		160	23456 - 3	4
78	*345* - 3		161	2346 - **35**	2
79	34 - **35**		162	*235* - *345*	
80	**35** - **35**		165	2356 - **35**	2
98	**246** - 23		168	**246** - *345*	
100	**246** - 24		169	*345* - *345*	
104	**246** - 26		181	23456 - 24	3
106	2345 - 3	3	182	2345 - **246**	
107	234 - **35**		184	2346 - **246**	
108	2346 - 3	3	186	23456 - *26*	3
111	*235* - **35**		188	2356 - **246**	
112	2356 - 3	3	192	23456 - **35**	
113	236 - **35**	3	204	23456 - **246**	

BOLD indicates "suppressed" ring substitution.
Italic indicates "less common" ring substitution.

3.6 Comparison of Aroclor Lots

The last 2 columns of **Table 3** display pairwise comparisons of the congener distributions of different lots of the same numbered Aroclors as the sum of all the individual congener weight% differences calculated from the values in **Table 4**. The sums for pairs of Aroclors 1016s, 1232s, and one pair of 1260s are less than 2%. These pairs likely represent the same manufacturer's lot, and pairwise comparisons of the individual congener weight%s between these in **Table 4** may therefore provide an indication of the precision (*i.e.* the repeatability) of this study's analytical quantitation. Sums for pairs of 1242s, 1262s and an additional 1260 differ by 6 to 12%; values probably representing small lot-to-lot differences for these Aroclors. The sums for the pair of 1248s differ by 20% and for the pair of 1254s by 53%! Aroclors 1248 and 1254 are representative of the midpoint of the chlorination process for biphenyls. A number of tetra-, penta- and hexa- chloro-substituted PCBs are being rapidly created and destroyed in this range, so one might expect to find greater lot-to-lot variations among these.

A close examination of the differences between the AccuStandard (A4) and General Electric (G4) Aroclor 1254s reveals remarkable differences with respect to *ortho*-chlorine (2,6) substitution. When the G4/A4 ratio of weight%s is calculated for 11 non- or mono-*ortho*- substituted congeners (77, 126; 56, 60, 66, 74, 105, 114, 118, 122, 123) the ratios range from 0.15 to 0.54; while for 11 di-, tri- or tetra-*ortho*- chloro-substituted congeners (44, 49, 52, 92, 95; 135, 144, 149, 151, 187; 136) the ratios range from 2.00 to 6.72. A ratio of 1.00 would indicate that the proportions of a congener in each lot were the same. This striking difference suggests a rationale for many of the major differences in congener weight%s displayed between this pair of Aroclor 1254s in **Table 4**. The chlorination process for synthesis of the AccuStandard A4 lot (perhaps using an atypical chlorination catalyst or reaction conditions) may have been less favorable for *ortho*-chlorination than the one used for most other lots. Thus non- or mono- *ortho*- chloro-substituted congeners could build up, while further *ortho*-chlorination to produce di-, tri-, and tetra-*ortho*-chloro-substituted congeners was suppressed. By contrast the differences between the Aroclor 1248 lots do not display this *ortho*-substitution effect. The G4 Aroclor 1254 distribution is closer to that reported by Schulz *et al.* [14] and to the majority of other lots of Aroclor 1254 we have observed when simple comparisons of ECD or MS-SIM chromatographic patterns are made. The atypical A4 Aroclor 1254 lot is no longer distributed by AccuStandard.

4 Conclusion

The substantial differences between the Aroclor 1248 and 1254 lots emphasize the need to obtain the appropriate lots when using Aroclor mixtures as secondary standards for calibrating CQCS PCB analyses. All lots of Aroclors of the same chlorination level do NOT have similar congener distributions! The comprehensive Aroclor congener distributions in **Table 4** are considered to be more complete (especially for trace components) and accurate than those presented in earlier comprehensive studies [13, 14]. However, the shortcomings of the single level calibration which was employed indicate that the ±10% accuracy desirable for Aroclor-calibrated CQCS analysis has certainly not been achieved for all major and minor congeners over the full range of concentrations. **Table 6** compares our weight percentages for several minor mono-*ortho*- PCBs with the values accurately determined in other lots of 4 Aroclors by both 2D-GC-ECD and serial-coupled column GC-ECD [23]. The generally good agree-

Table 6. Wt% Comparisons of minor mono-*ortho*-substituted congeners.

PCB	A1242	A1248	A1254	A1260	Lab
74	2.30	4.10	1.30	.09	a
	2.10	4.00	1.10	.02	b
	1.81	3.91	.84	.05	c
114	.04	.13	.19	.03	a
	.04	.14	.25	<.01	b
	.04	.12	.18	<.01	c
123	<.02	.09	.14	<.05	a
	.04	.09	.25	<.01	b
	.03	.08	.15	<.01	c
157	<.01	<.01	.24	.08	a
	<.01	.02	.30	.15	b
	<.01	<.01	.19	.02	c
167	<.03	.03	.45	.18	a
	<.01	.03	.39	.13	b
	<.01	<.01	.27	.19	c
189	<.01	<.01	.04	.14	a
	<.01	<.01	.04	.10	b
	<.01	<.01	.01	.10	c

a = Data produced by 2D-GC-ECD [22] Netherlands Institute for Fisheries Research

.b = Data produced by serial coupled GC-ECD [22] CEC Joint Research Center.

c = Data produced by GC-MS and GC-ECD from **Tables 4 B, C:** This paper, means for each Aroclor, except A1254 is lot G4 only.

ment for most components, even at low levels one or more orders of magnitude less than the concentrations of the single point standards and IS, supports the claim of semi-quantitative accuracy for our weight% distributions. There remains a need for a set of *individual* Aroclor CQCS secondary standards (minimally including Aroclors 1221, 1242, a characteristic 1254, and 1262) to cover all Aroclor congeners at measurable levels. These need to have all congeners carefully quantified against multilevel certified primary standards on suitable HRGC columns, such as those employed in this study, and must be available to the PCB analytical community indefinitely. The best, readily available, documented Aroclor secondary standard for CQCS PCB analysis is presently that of Mullin's "Green Bay Method" [18], comprising a *single* mixture of Aroclors 1232 (itself a 50:50 blend of Aroclors 1221 and 1242): 1248: 1262 in proportions of 25:18:18. Aroclor 1262 is probably preferable to 1260 for this purpose, since it enhances the amounts of some of the most heavily chlorinated congeners. However, inspection of **Table 4** reveals that the chlorination-level gap between Aroclors 1248 and 1262 in the "Green Bay Standard" results in barely measurable levels of minor pentachlorobiphenyls 83, 109, 117, 122, 123, 124, and hexachlorobiphenyls 128, 129, 130, 131, 134, 137, 139, 147, 156, and 167 by comparison with the coverage obtained using an Aroclor 1242/1254 pair.

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The DB-XLB columns employed in **Systems 1, 2, and 3** were provided *gratis* by J&W Scientific (Folsom, CA. USA), and the HP 1801-GCD GC-MS instrument of **System 2** was provided on loan from the Hewlett-Packard Corp. (Palo Alto, CA, USA).

References

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The Occurrence of Polychlorinated Biphenyls

In Sediments Adjacent to Marine Fish Farms:

Results of Screening Surveys During 2001 & 2002

Report TR- 030905_LJS

November 2005

EXECUTIVE SUMMARY

To investigate the potential accumulation of polychlorinated biphenyls (PCBs) around marine cage fish farms as a possible result of accumulations in fish-meal, the levels of PCBs were determined in sediments taken from areas around 43 marine cage fish farms during 2001 and 29 fish farm sites during 2002.

PCBs were found in concentrations ranging from 0.45 to 34.3 μg/kg with higher concentrations generally being found at the cage edge. The majority of sites (> 90%) had PCB levels well below 10 μg/kg comparable with sediment sampled in Morecambe Bay, Cardigan Bay and the North Sea. The remaining sites had total-PCB content similar to levels seen in the south and outer Firth of Clyde. Using guidance limits set by Scottish Office Agriculture, Environment and Fisheries Department and the Florida Department of Environmental Protection it appears that the majority of sites would be considered only "slightly contaminated" and below "probable effects" levels.

Fish food has been shown to contain measurable levels of PCBs. No relation is apparent between the amount of food used and the level of total PCB detected, although some sites do show similar ratios of PCB congeners relative to PCB-180 to those found in the fish food. In the majority of cases however the ratios are highly variable, suggesting that possible multiple sources and/or metabolic processes within the salmon are complicating factors. The data does suggest that PCBs are elevated in sediments in the vicinity of some fish farms, although routine benthic monitoring would appear to indicate that they are unlikely to be having any major environmental impact at present. SEPA will keep the situation under review and may undertake further studies to check that PCBs and other persistent organic pollutants in sediments below fish farms do not reach concentrations which become a cause for concern.

CONTENTS

Section **Page**

1. INTRODUCTION

There has been public concern about the effect the marine fish farming industry is having on the environment including concerns that salmon feed may contain concentrations of ubiquitous bioaccumulative contaminants such as polychlorinated biphenyls (PCBs) and that these compounds may be present in the flesh of farmed salmon. The risk associated with this is adequately dealt with by the Food Standards Agency (Scotland) and information is available on the FSA(S) web-site on this aspect. SEPA has therefore confined its interest to the risk of such compounds accumulating in marine sediments around Scottish marine fish farms.

As part of an on-going surveillance monitoring programme in 2001 and 2002, samples of sediments were collected from the cage edges of marine cage fish farms. Samples were collected from 43 fish farms in 2001. At one of the sites a more detailed survey was taken. Reference samples were also taken at 5 sites. Samples were collected from 29 fish farms in 2002. At three of the sites a more detailed survey was taken.

Levels of PCBs were determined in the samples and results were compared to levels seen in marine sediments from other parts of the UK. Quality standards were used to assess the significance of any detected contamination.

2. BACKGROUND

Due to their global distribution, PCBs and perhaps other persistent/bio-accumulating pollutants present in measurable concentrations in fish meal used to make farmed fish diets, have the potential to accumulate in sediments surrounding Scottish cage fish farms.

PCBs are a mixture of chlorine substituted biphenyl congeners with differing degrees of chlorination (Tanabe, 1988) There are 209 theoretically possible PCB congeners. (Duinker *et al*., 1988). They are extremely stable compounds, resistant to oxidation, acids, bases and other strong chemical reagents. PCBs are ubiquitous environmental contaminants and residues have been detected in all parts of the world (Bommanna *et al*., 1994). Typical background concentrations of Total PCB in soils from around the UK are 2 - 32 μg/kg, typical concentrations in sewage sludge are between 106 and 712 μg/kg (DOE 1994).

It is not possible to quantify accurately all of the individual congeners present in environmental samples (Duinker *et al*., 1988). Therefore, the International Council for the Exploration of the Seas (ICES) have recommended that seven congeners, with chlorine numbers from 3 to 7, should be monitored in such samples. This allows comparison of results from different research groups. The so-called ICES 7 congeners are shown in Table 1. By convention total PCB concentration may be estimated as the sum of the ICES 7 congeners multiplied by 2.5.

Table 1 - ICES 7 congeners

Congener No.	Chemical Structure
28	2,4,4' trichlorobiphenyl
52	2,2',5,5' tetrachlorobiphenyl
101	2,2',4,5,5' pentachlorobiphenyl
118	2,3',4,4',5 pentachlorobiphenyl
138	2,2',3,4,4',5' hexachlorobiphenyl
153	2,2',4,4'5,5' hexachlorobiphenyl
180	2,2',3,4,4'5,5' heptachlorobiphenyl

There are no marine sediment quality standards for PCBs currently set in the UK. However, the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) have defined a series of concentration guidelines in order to categorise the levels of chlorinated biphenyls in marine sediments (Wells *et al*., 1989)

- those in the range 0.2-20 µg/kg are classed as "slightly contaminated"
- those in the range 21-100 µg/kg as "contaminated"
- those greater than 100 µg/kg as "highly contaminated".

The Florida Department of Environmental Protection (FDEP) has developed effects based sediment quality assessment guidelines for 34 priority substances in Florida coastal waters (Florida Department of Environmental Protection, 1994). The suggested threshold level for effects for PCBs is 21.6 µg/kg and the probable effect level is 189 µg/kg. These guidelines were designed for the evaluation of marine sediments around Florida and hence should be used with caution if applied to marine sediments from colder Scottish waters as different species often have different tolerances to pollutants.

The Joint Monitoring Group of the Oslo and Paris Commissions has also suggested standard sediment concentrations for PCBs below which the biological effects are unlikely to occur. The guidelines indicate that biological effects are unlikely at the 1-10 µg/kg level (normalised to 1% carbon). These were derived from studies containing biological effects data (Flemming *et al*., 1995). Again, as the majority of these studies were North American/Canadian, they should be used with caution when applied to marine sediments from colder Scottish waters.

3. METHODS

3.1. Sampling

2001

A total of 63 sediment samples were collected from 43 fish farms in 2001. An extensive survey was carried out at one site (Ardvourlie) to assist with model evaluation as well as environmental assessment. In each case a 0.025 m^2 van Veen grab was used to collect the sediment which was sub-sampled through top opening flaps on the grab and stored in 250 ml glass jars. The samples were frozen prior to transportation and they were stored frozen in the dark nominally at -20°C until taken for analysis.

At Ardvourlie on Loch Seaforth, Isle of Harris, samples were collected from the cage edge, the cage edge west and at 25, 50 and 75m west, the cage edge east and at 25, 50, 75 and 100 m east and at 25, 50, 75 and 100 m north. Site details are show in Annex 1, Table 3 and a map showing the locations of the sites is shown in Annex 1, Figure 1.

At the remaining sites, samples were collected at the cage edges except at Camas Na Sgainadin in the Sound of Raasay where the sample was collected at 100 m perpendicular to the current. In addition reference samples, taken more than 500 m from the cage edge were collected at Brei Geo, North Papa, Slocka and Ronas Voe. A sample was also collected at Cole Deep fallow. Site details are shown in Annex 1, Table 3 and maps of the locations of the sites are shown in Annex 1, Figures 2 - 14.

2002

A total of 66 sediment samples were collected from 29 fish farms. Extensive surveys were carried out at three sites (Bight of Cliffs, Brei Geo & North Nestings 2) to assist with model evaluation as well as environmental assessment. In each case a 0.025 m^2 van Veen grab was used to collect the sediment which was sub sampled through top opening flaps on the grab and stored in 250 ml glass jars. The samples were frozen prior to transportation and they were stored frozen in the dark at nominally -20°C until taken for analysis.

At Bight of Cliffs, Brei Geo & North Nestings 2, samples were collected from inshore transect, offshore transect, parallel towards head and parallel towards mouth all at cage edge, 25 and 100 metres from the cage. Site details are show in Annex 2, Table 6 and a map showing the locations of the sites is shown in Annex 2, Figures 15 to 17.

At the remaining sites, samples were collected at the cage edges. Site details are shown in Annex 2, Table 6 and maps of the locations of the sites are shown in Annex 2, Figures 18 - 23.

3.2. Polychlorinated Biphenyls (PCBs) Analysis

Samples were defrosted and a portion of wet sediment was mixed with sodium sulphate until a free flowing powder was formed and soxhlet extracted in acetone/hexane (33:67 v/v). Sulphur containing compounds were removed by reaction with elemental copper during extraction. The resultant extracts were concentrated using a TurboVap® concentrator and fats/lipids and any other co-extracted materials were removed by an acidic silica clean up followed by silver nitrate alumina adsorption. PCBs were separated, identified and quantified by gas chromatography (GC) with electron capture detection (ECD). A mid polarity HP Ultra 2 column of 50 m length, 0.2 mm inner diameter and 0.33 μm film thickness was used to perform the separation. Compounds were identified by comparison of their retention times to those of certified standards of individual PCB congeners. Quantification was by comparison of peak heights with multipoint calibration graphs of certified standards and internal standards. The final concentration was corrected for moisture content and weight of sediment used and hence the limit of detection (LOD) of the method is variable.

The procedure has been validated in-house in accordance with NS30 (Cheeseman *et al*., 1989). The routine precision and accuracy of the procedure were monitored by the analysis of a procedural blank, a recovery standard, a laboratory reference material and a duplicate sample with each batch of samples. In addition the accuracy of this method for the determination of PCBs has been validated by participation in inter laboratory comparison exercises such as the QUASIMEME European Quality Assurance Programme. All analyses were carried out at SEPA's East Kilbride laboratory which is UKAS accredited for the determination of PCBs in sediments.

3.3. Organic Carbon

45 sediment sub samples from 2001 and 29 from 2002 were analysed for total nitrogen and organic carbon using a CE instruments NA2500 nitrogen and carbon analyser. The samples were completely oxidised at 1000^{o}C and the combustion components separated and detected by a thermal conductivity detector.

4. RESULTS AND DISCUSSION

2001

Concentrations of total polychlorinated biphenyls (PCBs) were in the range 0.45 μg/kg to 22.03 μg/kg (corrected for %moisture) with the majority of sites well below 10 μg/kg and broadly comparable with levels seen in Morecambe Bay, Cardigan Bay and areas of the North Sea (see Table 2). The higher levels seen at six of the sites are broadly similar to levels seen in the south and outer Firth of Clyde. Unfortunately no data for remoter Scottish coastal waters where there are no fish farms is available, so no comparison with so-called "pristine sites" is presently possible. Organic carbon was in the range 1.23 % to 12.95 %. Full details are shown in Annex 1, Table 4. By comparison with the SOAEFD guidelines (see section 2) the majority of sites would be considered slightly contaminated. All of the sites were below the FDEP threshold effects level and all the sites were within the JMG sediment concentration range below which biological effects are unlikely to occur.

PCBs were detected at East of Hildasay, Brei Geo, North Papa, Slocka (Site C) and Ronas Voe, where the cage edge and a reference site more than 500 m away were sampled. At East of Hildasay, Brei Geo and Ronas Voe, they were detected at the cage edge and at lower concentrations at the reference site, whereas at North Papa and Slocka Site C higher concentrations were seen at the reference sites rather than at the cage edge. It is known that PCBs are more likely to accumulate in organic rich, finer grained sediments therefore the differences may simply reflect changes in substrate at the different sites. However, even when the results are normalised to organic carbon the trends remain broadly the same indicating the influence of other factors. The higher concentrations at the reference points for these two sites may therefore reflect sediment transport mechanisms at these sites or alternatively they may indicate other sources of input. One site, Uyea Sound Site 2 Cage, shows a significant anomaly when normalised to organic carbon suggesting a relatively high PCB loading (4.94 μg/kg) compared to other sites. This suggests that the sediment is enriched with PCBs at this site relative to organic carbon that may originate from fish feed but it is unsafe to draw any definite conclusions based on one sample.

At Ardvourlie, PCBs were detected at the cage edge, the cage edge west and at 25, 50 and 75 m west, the cage edge east and at 25, 50, and 100 m east and at 25 and 100 m north. The concentrations were highest at the cage edge east, decreased rapidly at 25 and 50 m east and were not detectable beyond 75 m east. The concentration of PCBs at the cage edge west were similar to the cage edge east and again decreased at 25, 50, and 75 m west although not to the same degree. The concentration also decreased at 25 m north and was not detected at 50 and 75 m north. Overall the distribution of the PCBs indicates a predominant gradient of movement from the cages out to the west of the site. Elevated levels to the north and east are less pronounced. Perhaps indicating a combination of local inputs via fish food and other sources.

2002

For the 2002 samples concentrations of total PCBs were in the range 1.25 µg/kg to 34.03 µg/kg (corrected for %moisture) with the majority of sites again well below 10 µg/kg. On this occasion higher levels were seen at five sites again with concentrations broadly similar to those seen in the south and outer Firth of Clyde. Organic carbon was in the range 0.40 % to 12.48 %. Full details are shown in Annex 2, Table 7. By comparison with the SOAEFD guidelines (see section 2) the majority of sites would be considered slightly contaminated. All of the sites were below the FDEP probable effects level and the majority below the threshold effects level. All the sites were within the JMG sediment concentration range below which biological effects are unlikely to occur.

At Brei Geo PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 25 and 100 m towards the mouth of the voe, at the cage edge towards the head of the voe and at the reference site. The concentration was highest at the cage edge towards the mouth of the voe and decreased at 25 and 100 m. The concentration of PCBs at the cage edge inshore was similar to the cage edge towards the mouth of the voe and again decreased at 25 and 100 m. The concentrations at the cage edge and at 25 and 100 m offshore were all relatively similar. PCBs were not detected at 25 and 100 m towards the head of the voe. Overall the distribution of the PCBs is showing a predominant reducing gradient towards the mouth of the voe.

At Bight of Cliffs PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 100 m towards the mouth of the voe and at the cage edge and at 25 and 100 m towards the head of the voe. The concentrations at the cage edge inshore, cage edge offshore and at the cage edge towards the head of the voe were similar and the concentration decreased at 25 and 100 m in all 3 directions. PCBs were not detected at 25 m from the cages in a direction parallel to the mouth of the voe but were detected at 100 m. The distribution of PCBs is showing a complex pattern of movement both inshore and offshore and towards the head of the voe. Elevated levels towards the mouth of the voe may perhaps reflect a combination of local inputs via fish food and other sources.

At North Nestings Site 2, PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 25 and 100 m towards the mouth of the voe and at the cage edge and at 25 and 100 m towards the head of the voe. The concentration was highest at the cage edge towards the head of the voe and decreased rapidly at 25 and 100 m. The concentration of PCBs at the

cage edge and at 25 and 100m inshore, at the cage edge and at 25 m offshore and at the cage edge and at 25 and 100 m towards the mouth of the voe were all relatively similar but the concentration increased slightly at 100 m offshore. Overall the distribution of the PCBs suggests a predominant gradient of movement from the cages out to the west of the site. Elevated levels to the North and East were less pronounced. Again the distribution of PCBs indicates a complex pattern of movement both inshore and offshore and towards the mouth and head of the voe. Again, elevated levels offshore may perhaps reflect a combination of local inputs via fish food and other sources.

Levels of PCBs were determined in fish food, and were detected at a concentration of 19.45 µg/kg. Salmon feeds are produced from fish-meal and generally have high oil content both from the fish used and other fish oils that may be added. PCBs and other persistent bioaccumulative pollutants are known to concentrate in lipids therefore it is not surprising to find that some feeds may contain measurable levels of such pollutants. Not all the feed will be eaten so there is the potential for any associated pollutants to reach elevated concentrations beneath the cages. It might be expected that farms maintaining a higher biomass of fish would result in more feed being used, which might in turn increase the chances of residues accumulating. However, no relation between the consented biomass limit of a farm and total PCB concentration was observed. This is not surprising as that the data set for this study was limited, the feed source and lipid content will vary considerably, and other factors such as food conversion ratio and stocking regime, varied tidal regimes and sediment transport and the influence of other pollutant sources will interfere with the establishment of any such simple correlation.

By standardizing or “normalising” PCB congener concentrations to PCB-180 (see Annex 1, Table 5) it was hoped that similarities between the feed and the underlying sediments would be seen. In the case of Ardvourlie the ratios do not match although sites to the west of the cages do show higher levels of PCB-153 and PCB-138 similar to the fish feed than sites to the east and north. If anything the levels in the sediments to the west and beneath the cages show even higher levels of PCB-153 and PCB-138 than the analysed fish food, which may reflect that the individual congeners are metabolised at different rates or indicate other sources of PCB contamination.

Using the same normalisation process for other sites there are 7 sites where the sediment PCB ratios are broadly similar to those in the analysed feed. These include Gorsten Ardgour, Garven Loch Eil, Loch Maddy (Rubha Nan Gall), Eilean Aird, Collafirth Ness Site 3, Sgeir Bhuidhe and Loch Shell (mid). The similarity of ratios may be coincidental and not represent use of feed similar to that analysed as the ratios of PCBs at Brei Geo, Eilean nam Mult, Eilean Trannay and Maaruig in the sediments did not match those of the analysed feed at these sites. Clearly a number of complex processes and potential sources all play a part. However, regardless of the processes involved it is clear that elevated concentrations of PCBs are present around the cages and that the most likely reason for this is due to inputs from fish feed over and above any other sources.

Overall the concentrations of total PCBs found around fish farms were similar to those reported in marine sediments from open locations around the UK and to background concentrations found in UK soil. They are considerably lower than those reported for industrialised estuaries and therefore although elevated around some fish farms they are unlikely to cause any immediate environmental problems. In addition, the affected

zones are localised to a small area beneath and close to the cages. A summary of total PCB concentration found at locations around the UK is shown in Table 2.

The results for total PCBs reported here are estimated as 2.5 times the sum of the ICES 7 congeners. However, the Food Standards Agency (FSA) routinely analyse PCBs in food and determine the levels of 25 PCBs including the ICES 7. In full they determine the levels of PCBs 18, 28, 31, 47, 49, 51, 52, 77, 81, 99, 101, 105, 114, 118, 123, 126 128, 138, 153, 156, 157, 167, 169, 180, 189. The analysis of this more complete range, when converted by an appropriate factor, may provide a closer approximation of total PCB's than the 2.5xΣICES 7 approach and may also indicate underlying trends, which are not noticeable in the current data. More importantly the wider range covers human health as well as environmental concerns, which is relevant in a fish-farming context although the low levels of PCBs measured in sediments at fish farm sites pose little direct risk to human health.

Table 2 – Summary of total PCB's found in UK marine sediments

Location	Year of analysis	Organic Carbon %	Total PCB µg/kg (dry weight)	References
Inner Firth of Clyde	1989	3.3 – 4	40-112.5	Kelly *& Campbell,* 1995
Firth of Clyde – Inchmarnock Water	1989	1.4 - 4.2	12.8-35	
Mid/ South Firth of Clyde	1989	0.9 - 3.1	4.5-17.2	
Outer Firth of Clyde	1989	0.5 - 1.4	1.2-16.7	
Garroch Head Former Sludge Dump Site	1989	1.1 - 5.1	102-1250	
Garroch Head Sludge Dump Site	1989	2.4 - 11.9	25-305	
Liverpool Bay	1988	Not Determined	13.7-37.9	Camacho-Ibar *& McEvoy,* 1996
Shandon Dock (Liverpool)	1988	Not Determined	320	
Inner Thames Estuary	1993	Not Determined	3-40	Scrimshaw *& Lester,* 1995
Tyne Estuary	1990	Not Determined	6.1-8.1	MAFF 1993
Humber	1990	Not Determined	3-7.6	
Cardigan Bay	1990	Not Determined	0.2-3.9	
Morecombe Bay	1990	Not Determined	0.2-4.7	
Humber, Tees, Tweed and Ribble Estuaries	1990	Not Determined	0.2-20	ENDS 1993
Tyne, Wear and Mersey Estuaries	1990	Not Determined	20-100	
North Sea	1986	0.1 - 15	0.1-4.4	Knickmeyer & Steinart., 1988
North Sea	1986-1987	0.4 –14.8	0.21-9.18	Knickmeyer *et al.*, 1990

5. CONCLUSIONS

The concentrations of polychlorinated biphenyls (PCBs) that were detected in sediments in the vicinity of Scottish marine cage fish farms were relatively low and can be considered as only slightly contaminated, based on existing guidance. The concentrations found are similar to levels found in marine sediments from open locations around the UK and were similar to background concentrations in soils around the UK. However SEPA does not currently have data for concentrations of PCB in remote undeveloped Scottish coastal waters and cannot therefore provide a comparison with levels at sites remote from any anthropogenic influence.

It was generally observed that the concentration of total PCBs was highest at the cage edge and it is likely that elevated levels of PCBs have resulted from fish farming activities. It was found that a sample of fish food analysed in the course of the study contained measurable levels of PCBs which may confirm the feed as a source for PCBs at the fish farms. No relation was seen between the consented biomass limit of a site and the detected level of total PCBs detected but ratios of different PCB congeners to PCB-180 at certain sites lend some support to the contention that elevated levels of PCBs below the cages are likely to originate at least in part from residues in the fish feed.

The concentrations of total-PCBs are comparatively low suggesting no immediate environmental problems are expected to arise from this. In addition, routine near-field monitoring has not indicated any biological effects inconsistent with the changes expected through carbon enrichment. As the study indicates an elevated concentration of PCBs appear to originate from farmed-fish diets it is likely that other persistent globally distributed pollutants may also be present. Given the half-lives of these compounds therefore, SEPA will keep the situation under review and may undertake further studies to check that concentrations of PCBs and other persistent organic pollutants do not reach concentrations that would give cause for concern.

Initiatives to reduce the content of these compounds in fish and other farmed animal diets in order to reduce human dietary intakes are expected to reduce the quantities which inevitably are released to the environment.

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ANNEX 1 – RESULTS 2001

Table 3 - Site details

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Camas Na Sgainadin, Perpendicular 100m	Sound of Rasaay	NG 6194 2662	2001	4419	WPC/N/59126 (00)	405
Gorsten, Ardgour, Fort William, cage	Loch Linnhe	NN 0593 7067	2001	4426	WPC/N/61689 (00)	642
Garven, Loch Eil, cage	Loch Linnhe	NM 9902 7808	2001	4427	WPC/N/61690 (00)	1300
Cairidh, cage	Loch Ainort	NH 1662 2787	2001	4428	T/B10/059/98 (00)	1000
Eilean Ard (Site 3), cage	Loch Laxford	NC 1894 5014	2001	4429	WPC/N/61547 (01)	1250
Bight of Cliffs, cage	Olnafirth	HU 3930 6448	11/06/01	8916	WPC/N/62086 (01)	500
North Knowe, Greetaing, cage	Busta Voe	HU 3460 6418	10/06/01	8917	WPC/N/62042 (01)	350
Basta Voe, East Site, cage	Basta Voe	HU 5471 9498	09/06/01	8918	WPC/N/61978 (01)	500
Olnafirth South, cage	OlnaFirth	HU 3740 6427	10/06/01	8919	WPC/N/62069 (01)	1600
Cole Deep, cage	Cole Deep	HU 3579 6327	09/06/01	8920	WPC/N/61916 (00)	800
Cole Deep, fallow		HU 3579 6427	09/06/01	8921		
NW of Turraness Uyea, Unst, cage	Skuda Sound	HU 6103 9933	07/06/01	8922	WPC/N/61981 (01)	500
NW of Winnaness Uyea, Unst, cage	Winnaness	HU 5871 9978	07/06/01	8923	T/B21/017/97 (00)	2200
Uyeasound, Unst, Site 1, cage	Uyea Sound	HP 5971 0020	07/06/01	8924	WPC/N/61976 (01)	400

Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Uyeasound, Unst, Site 2, cage	Uyea Sound	HP 5971 0076	08/06/01 07/06/01	8925 9186	WPC/N/61977 (01)	250
Site 2, Wick of Belmont North, cage	Blue Mull Sound	HU 5641 9998	08/06/01	8926	WPC/N/61982 (01)	900
Site 3, South Head of Mula, cage	Blue Mull Sound	HU 5707 9932	06/06/01	8927	WPC/N/61856 (00)	750
Site 5, Point of Burkwell, cage	Blue Mull Sound	HU 5840 9932	06/06/01	8928	WPC/N/61857 (00)	800
Boatsroom Voe, cage	Boatsroom Voe	HU 4948 7100	15/06/01	8929	WPC/N/62056 (01)	800
Setterness West - Poseidon Site, cage	Off Lunnaness	HU 4729 7064	14/06/01	8930	WPC/N/62059 (01)	3150
Setterness East - Bomlo, cage	Off Lunnaness	HU 4807 7121	14/06/01	8931	WPC/N/62058 (02)	3500
Swinnister Voe, cage	Swinnister Voe	HU 4531 7268	18/06/01	8932	WPC/N/62034 (01)	990
Collafirth, Delting Site 1 (S), cage	Colla Firth	HU 4320 6899	15/06/01	8933	WPC/N/62095 (01)	625
Collafirth, Delting Site 2 (N), cage	Colla Firth	HU 4410 6950	15/06/01	8934	WPC/N/62094 (01)	600
East of Hildasay, cage	Hildasay	HU 3630 4039	22/06/01	8935	WPC/N/62242	400
East of Hildasay, reference		HU 3630 4039	22/06/01	8936		
East of Bruna Ness, cage	Lang Sound	HU 3871 3756	23/06/01	8937	WPC/N/61646 (00)	1154
Brei Geo Offshore, cage	Sandsound Voe	HU 3571 4647	23/06/01	8938	WPC/N/61405 (01)	2635
Brei Geo Offshore, reference		HU 3571 4647	23/06/01	8939		

Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
North of Papa, W of Scalloway, cage	The Deeps	HU 3662 3837	22/06/01	8940	WPC/N/60784 (00)	40
North of Papa, W of Scalloway, reference		HU 3662 3837	22/06/01	8941		
Slocka (Site C), cage	Ronas Voe	HU 2853 8267	20/06/01	8942	WPC/N/61926 (00)	1000
Slocka (Site C), reference		HU 2853 8267	20/06/01	8943		
Pobie Sukka (Site A), cage	Ronas Voe	HU 3103 8075	21/06/01	8944	WPC/N/61925 (00)	400
Ronas Voe, cage	Ronas Voe	HU 3253 8075	20/06/01	8945	WPC/N/62304	600
Ronas Voe, reference		HU 3253 8075	20/06/01	8946		
Site 3, Collafirth Ness, cage	Swinning Voe	HU 4550 7039	21/06/01	8947	WPC/N/59542 (01)	1920
Loch a Laip (Inner), Site 1, Benbecula, cage	Loch a Laip	NF 6153 4738	16/08/01	17927	T/B19/81/98 (00)	750
Loch Skipport (Outer), Ornish, S. Uist, cage	Loch Skipport,	NF 5276 3850	16/08/01	17928	T/B19/080/98 (00)	1250
Loch Maddy (Rubha Nan Gall), N. Uist, cage	Loch Maddy	NF 2657 6884	17/08/01	17929	RP2/6B/93/017	550
Eilean nam Mult, N. Uist, cage	Loch Euphort	NF 7900 6364	17/08/01	17930	RP2/C6D/93/040	60
Eilean Trannay, cage	Loch Euphort	NF 9378 6373	17/08/01	17931	RP2/6D/93/041	60
Pecam Bay, Lewis, cage	Loch Erisort	NB 3941 2180	20/08/01	17932	T/B19/079/98 (00)	600
Sgeir Bhuidhe, Pecam Bay 3, cage	Loch Erisort	NB 4015 2207	20/08/01	17933	T/B19/090/98 (00)	800

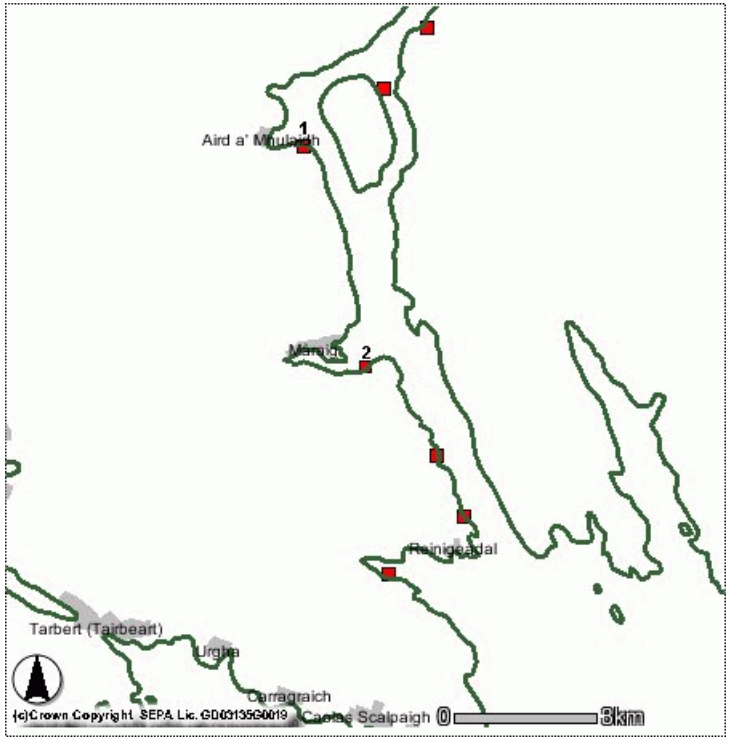
Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Loch Grimshader, Lewis, cage	Loch Grimshader	NB 3976 1432	22/08/01	17934	WPC/N/60983 (00)	622
Loch Shell (mid) Shell Pairc East, Lewis, cage	Loch Shell	NB 3549 1026	22/08/01	17935	WPC/N/60813 (00)	1700
Loch Shell (mid) Shell Pairc West, Lewis, cage		NB 3452 1031	22/08/01	17936		
Ardvourlie, Harris, cage	Loch Seaforth	NB 1958 1050	23/08/01	17937	WPC/N/62139 (00)	540
Maaruig, Harris, cage	Loch Seaforth	NB 2096 0577	23/08/01	17938	WPC/N/62138 (00)	540
Ardvourlie, Harris, cage west	Loch Seaforth	NB 1958 1050	23/08/01	17939	WPC/N/62139 (00)	540
Ardvourlie, Harris, 25m off west		NB 1956 1050	23/08/01	17940		
Ardvourlie, Harris, 50m off west		NB 1953 1050	23/08/01	17941		
Ardvourlie, Harris, 75m off west		NB 1951 1049	23/08/01	17942		
Ardvourlie, Harris, cage east		NB 1976 1049	23/08/01	17943		
Ardvourlie, Harris, 25m off east		NB 1978 1049	23/08/01	17944		
Ardvourlie, Harris, 50m off east		NB 1981 1048	23/08/01	17945		
Ardvourlie, Harris, 75m off east		NB 1984 1049	23/08/01	17946		
Ardvourlie, Harris, 100m off east		NB 1986 1050	23/08/01	17947		
Ardvourlie, Harris, 25m off north		NB 1960 1056	23/08/01	17948		

Table 3 - Site details continued

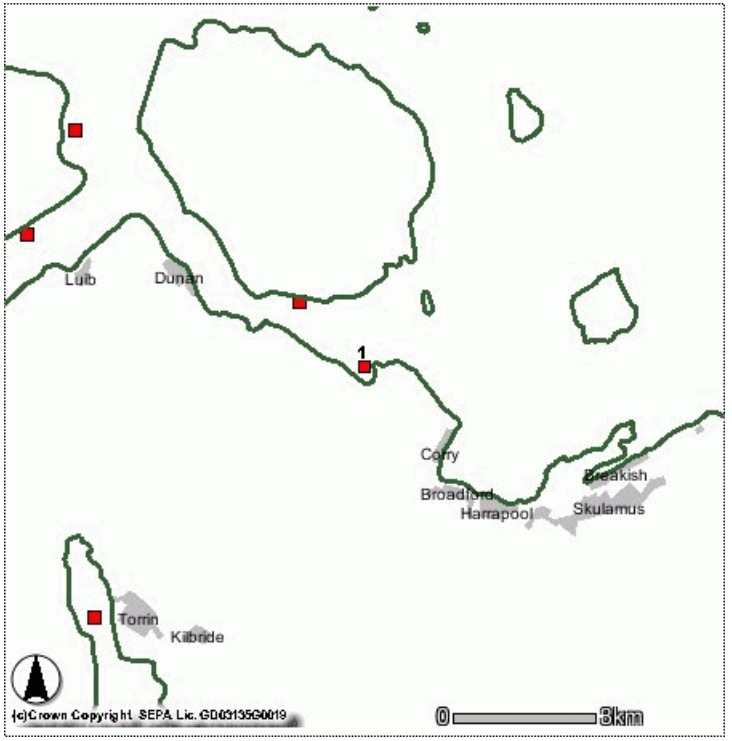
Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Ardvourlie, Harris, 50m off north	Loch Seaforth	NB 1961 1059	23/08/01	17949	WPC/N/62139 (00)	540
Ardvourlie, Harris, 75m off north		NB 1961 1062	23/08/01	17950		
Ardvourlie, Harris, 100m off north		NB 1961 1064	23/08/01	17951		

Figure 1 - Map of Loch Seaforth



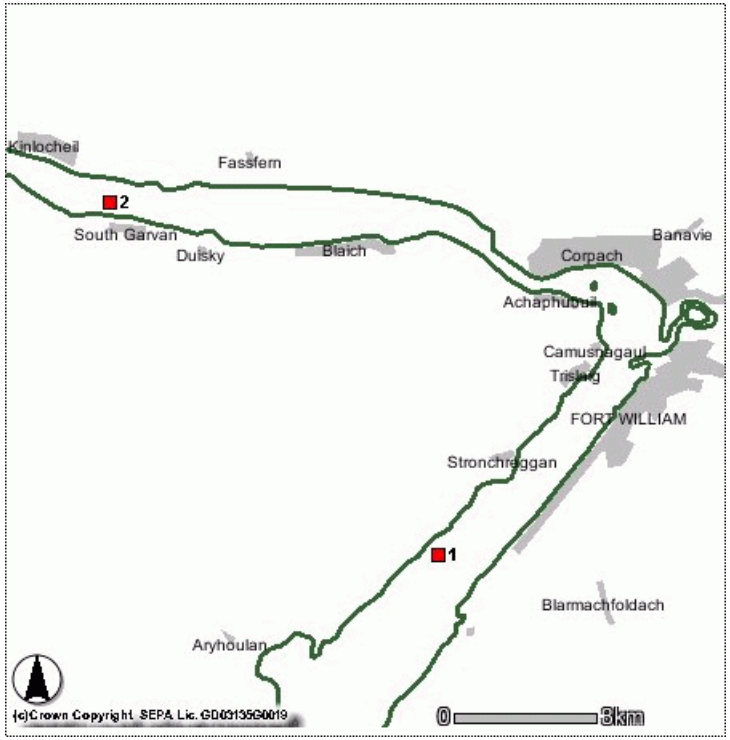
[1] - Ardvourlie
[2] - Maaruig

Figure 2 - Map of Sound of Raasay



[1] - Camas Na Sgainadin

Figure 3 - Map of Loch Linnhe

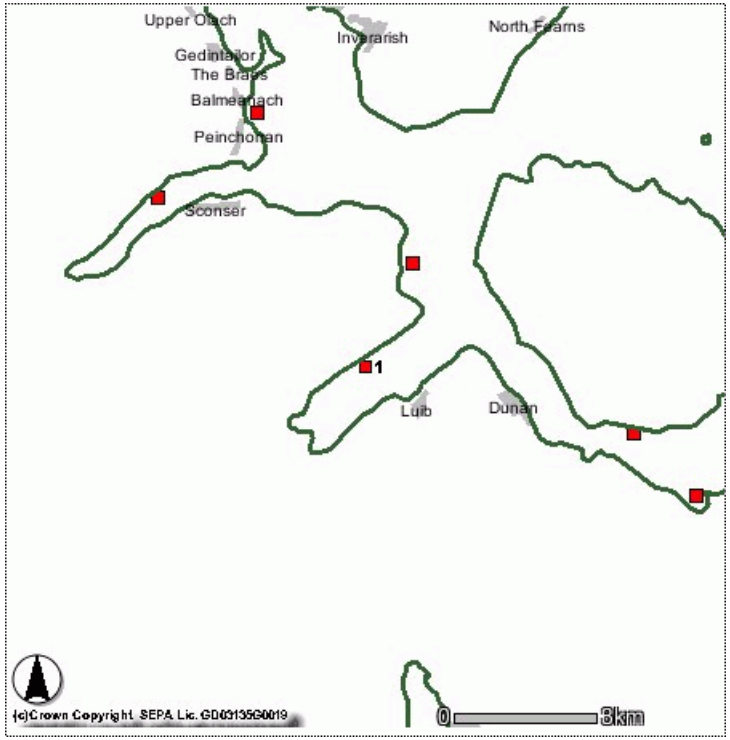


[1] – Gorsten, Ardgour
[2] – Garven, Loch Eil

Figure 4 - Map of Loch Laxford

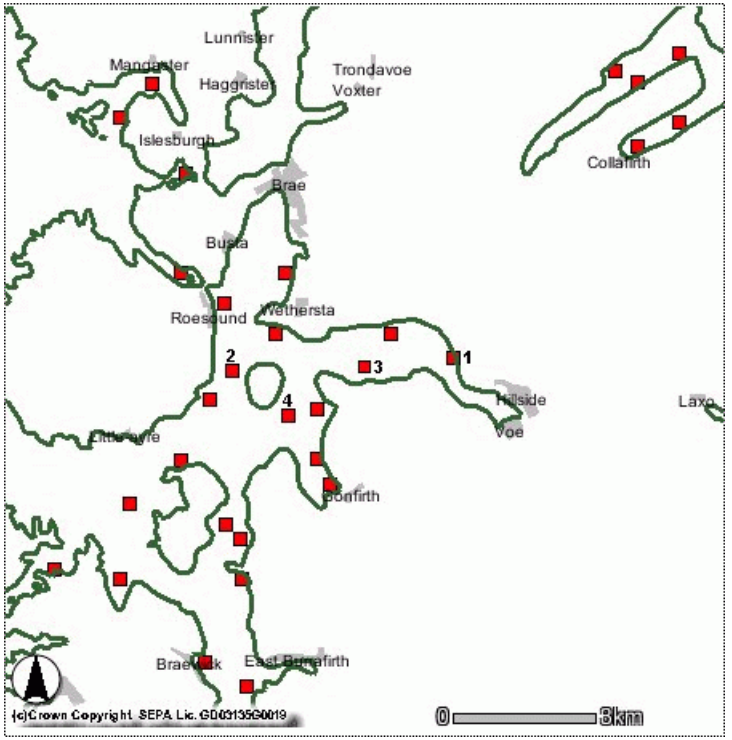
[1] – Eilean Ard

Figure 5 - Map of Loch Ainort



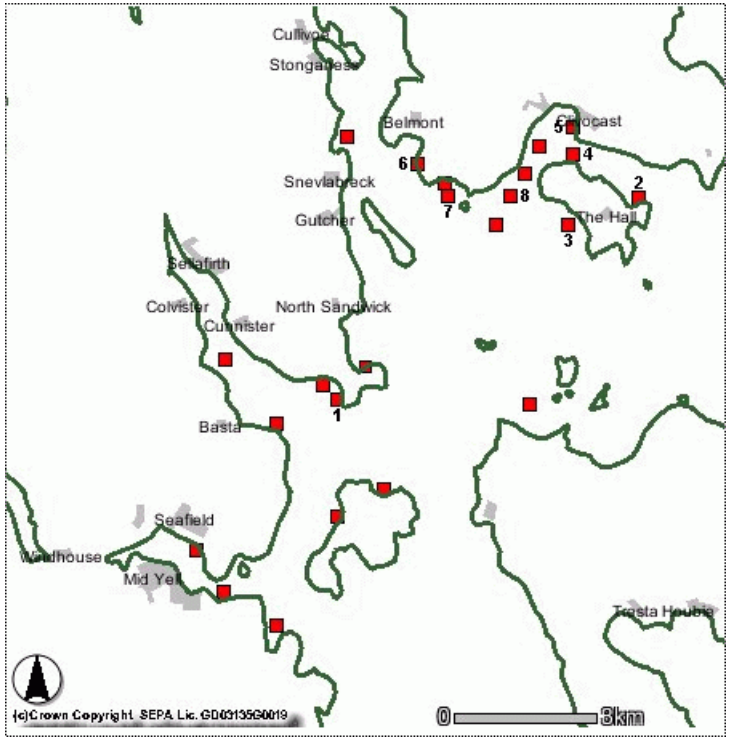
[1] - Cairidh

Figure 6 - Map of Busta Voe, Cole Deep and Olna Firth



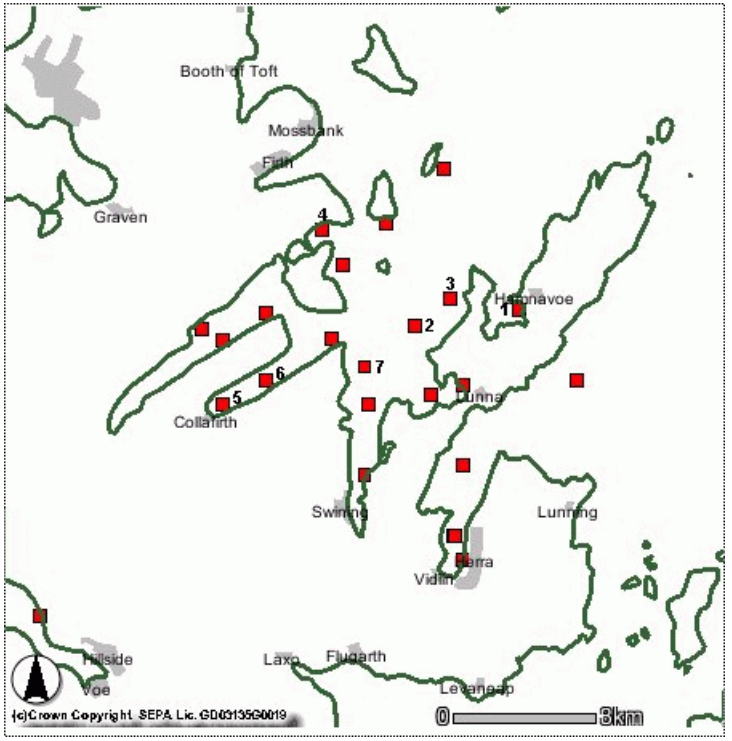
[1] - Bight of Cliffs
[2] - North Knowe, Greetaing
[3] - Olnafirth South
[4] - Cole Deep

Figure 7 - Map of Basta Voe, Blue Mull Sound, Uyea Sound and Winnaness



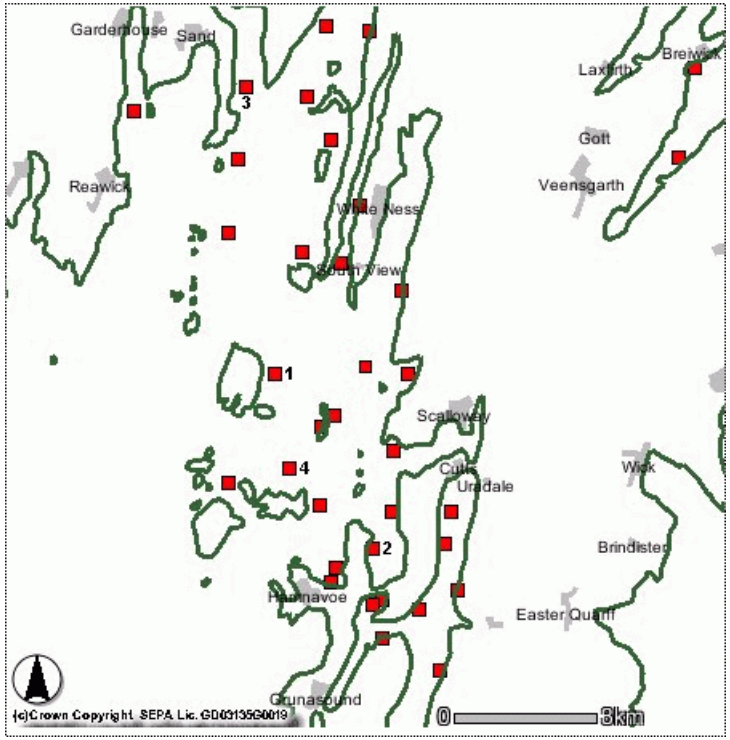
[1] – Basta Voe East Site
[2] - NW of Turraness
[3] - NW of Winnaness
[4] - Uyeasound Site 1
[5] - Uyeasound Site 2
[6] - Wick of Belmont North
[7] - South Head of Mula
[8] - Point of Burkwell

Figure 8 - Map of Boatsroom Voe, Colla Firth, Swinning Voe and Swinnister Voe



[1] - Boatsroom Voe
[2] - Setterness West - Poseidon Site
[3] - Setterness East - Bomlo
[4] - Swinnister Voe
[5] - Collafirth Delting Site 1 (South)
[6] - Collafirth Delting Site 2 (North)
[7] - Collafirth Ness

Figure 9 - Map of the Deeps, Hildasay, Lang Sound and Sandsound Voe

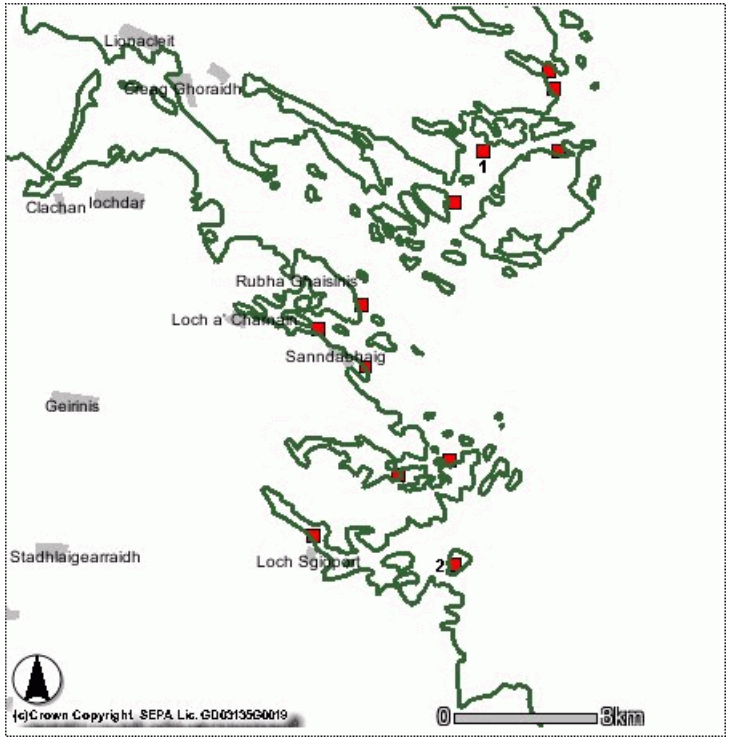


[1] - East of Hildasay
[2] - East of Bruna Ness
[3] - Brei Geo Offshore
[4] - North of Papa, W of Scalloway

Figure 10 - Map Figure of Ronas Voe

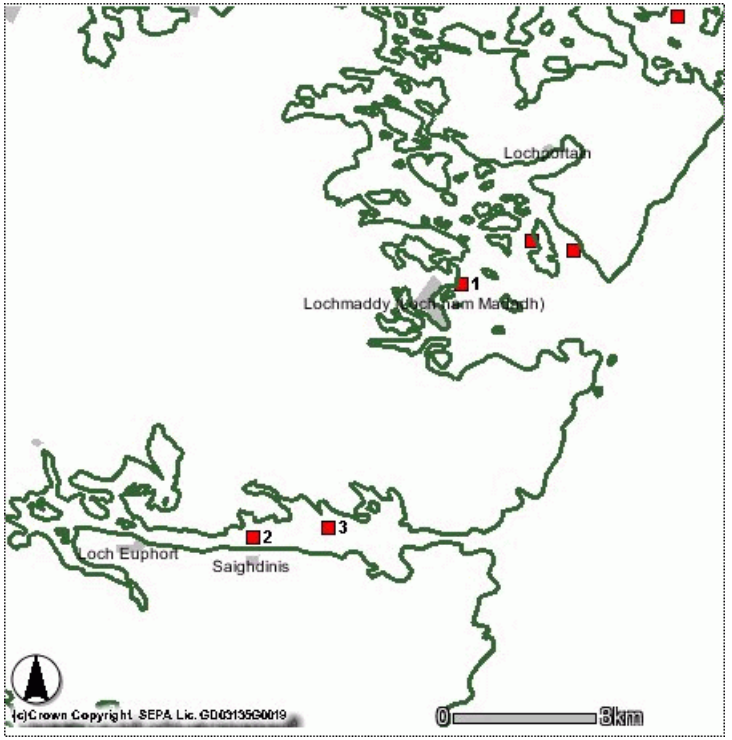
[1] - Slocka
[2] - Pobie Sukka
[3] - Ronas Voe

Figure 11 - Map of Loch a Laip and Loch Skipport



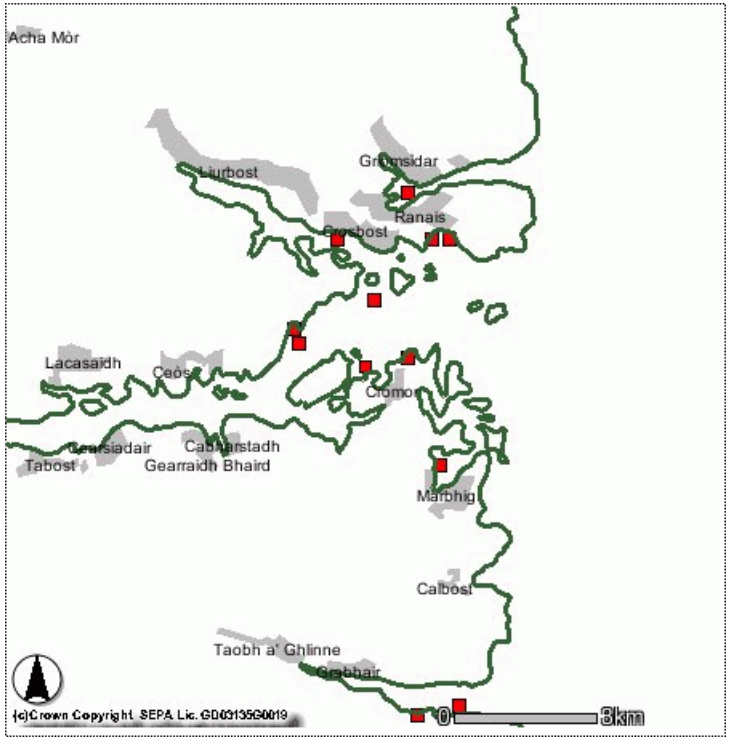
[1] - Loch a Laip (Inner)
[2] - Loch Skipport (Outer)

Figure 12 - Map of Loch Euphort and Loch Maddy



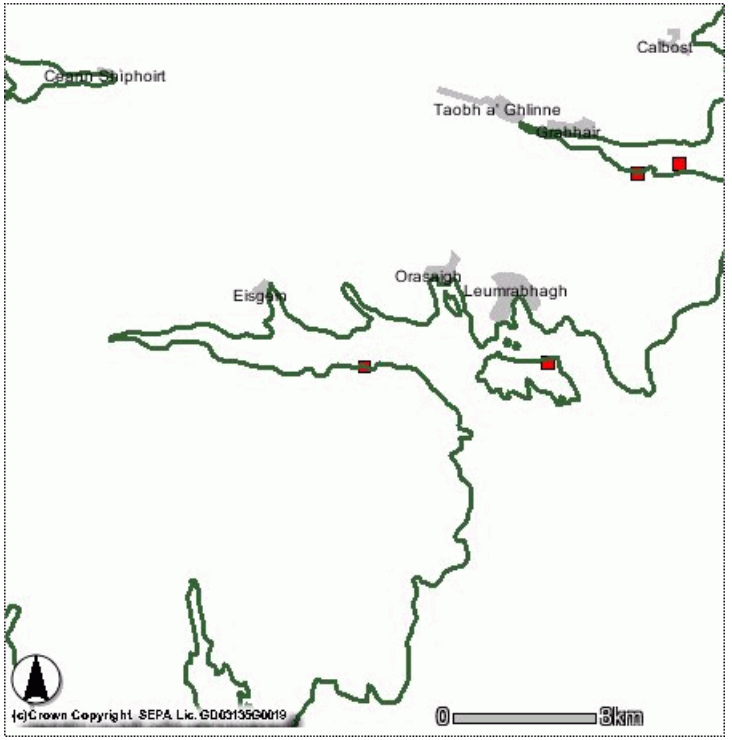
[1] - Loch Maddy (Rubha Nan Gall)
[2] - Eilean nam Mult
[3] - Eilean Trannay

Figure 13 - Map of Loch Erisort and Loch Grimshasder



[1] - Pecam Bay
[2] - Sgeir Bhuidhe
[3] - Loch Grimshader

Figure 14 - Map of Loch Shell



[1] – Loch Shell (mid) Shell Pairc East
[2] – Loch Shell (mid) Shell Pairc West

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content)

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Fish food sample	-	0.39	0.79	1.09	0.85	2.51	1.62	0.53	7.78	19.45	-	-
Camas Na Sgainadin, Perpendicular, 100m	4419	ND	ND	ND	ND	ND	ND	ND	ND	ND[a]	N/A	N/A
Gorsten, Ardgour, cage	4426	ND	**0.06**	**0.13**	**0.13**	**0.32**	**0.28**	**0.08**	**1.05**	**2.63[a]**	N/A	N/A
Garven, Loch Eil, cage	4427	**0.08**	**0.08**	**0.23**	**0.21**	**0.48**	**0.50**	**0.11**	**1.69**	**4.23[a]**	N/A	N/A
Cairidh, cage	4428	**0.27**	**0.60**	**0.70**	**0.53**	**1.10**	**0.89**	**0.21**	**4.30**	**10.75[a]**	N/A	N/A
Eilean Ard (Site 3), cage	4429	**0.03**	**0.03**	**0.10**	**0.11**	**0.23**	**0.20**	**0.05**	**0.75**	**1.88[a]**	N/A	N/A
Bight of Cliffs, cage	8916	**0.18**	**0.24**	**0.20**	**0.18**	**0.30**	**0.24**	**0.08**	**1.42**	**3.55**	**5.84**	**0.24**
North Knowe, Greetaing, cage	8917	ND	ND	**0.18**	**0.23**	**0.39**	**0.38**	**0.11**	**1.29**	**3.23**	**9.25**	**0.34**
Basta Voe, East Site, cage	8918	**0.40**	**0.15**	**0.18**	**0.16**	**0.21**	**0.19**	**0.07**	**1.36**	**3.40**	**3.86**	**0.88**
Olnafirth South, cage	8919	**0.13**	ND	**0.15**	**0.10**	**0.17**	**0.13**	**0.06**	**0.74**	**1.85**	**8.81**	**0.11**
Cole Deep, cage	8920	**0.13**	ND	**0.26**	**0.24**	**0.47**	**0.38**	**0.12**	**1.60**	**4.00**	**7.56**	**0.53**
Cole Deep, fallow	8921	**0.07**	**0.11**	**0.07**	**0.08**	**0.10**	**0.10**	**0.03**	**0.56**	**1.40**	**6.72**	**0.21**
NW of Turraness, cage	8922	**0.05**	ND	**0.17**	**0.16**	**0.32**	**0.24**	**0.18**	**1.12**	**2.80**	**6.47**	**0.43**
NW of Winnaness, cage	8923	**0.54**	**0.14**	**0.14**	**0.12**	**0.24**	**0.20**	**0.07**	**1.45**	**3.63**	**7.78**	**0.47**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; [a] – not corrected for %moisture; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Uyeasound, Site 1, cage	8924	**0.68**	**0.17**	**0.18**	**0.14**	**0.20**	**0.19**	**0.09**	**1.65**	**4.13**	**7.73**	**0.53**
Uyeasound, Site 2, cage	8925	1.40	0.21	0.19	0.16	0.20	0.20	0.07	2.43	6.08	1.23	4.94
Site 2, Wick of Belmont North, cage	8926	0.67	0.15	0.15	0.15	0.17	0.14	0.14	1.57	3.93	3.77	1.04
Site 3, South Head of Mula, cage	8927	**0.22**	ND	**0.07**	**0.05**	**0.06**	**0.04**	ND	**0.44**	**1.10**	**2.89**	**0.38**
Site 5, Point of Burkwell, cage	8928	**0.07**	ND	**0.17**	**0.11**	**0.17**	**0.15**	**0.05**	**0.65**	**1.63**	**8.64**	**0.19**
Boatsroom Voe, cage	8929	**0.07**	ND	**0.18**	**0.18**	**0.28**	**0.21**	**0.08**	**1.00**	**2.50**	**6.53**	**0.38**
Setterness West - Poseidon Site, cage	8930	**0.08**	ND	ND	**0.14**	**0.32**	**0.08**	ND	**0.94**	**2.35**	**7.32**	**0.32**
Setterness East - Bomlo, cage	8931	**0.06**	ND	**0.05**	**0.03**	**0.23**	**0.19**	ND	**0.89**	**2.23**	**7.18**	**0.31**
Swinnister Voe, cage	8932	**0.10**	**0.08**	**0.11**	ND	**0.09**	**0.08**	**0.03**	**0.49**	**1.23**	**6.79**	**0.18**
Collafirth, Delting Site 1 (S), cage	8933	**0.08**	**0.12**	**0.36**	**0.36**	**0.43**	**0.35**	**0.14**	**1.84**	**4.60**	**7.79**	**0.59**
Collafirth, Delting Site 2 (N), cage	8934	ND	ND	**0.09**	**0.22**	**0.34**	**0.35**	ND	**1.18**	**2.95**	**11.34**	**0.26**
East of Hildasay, cage	8935	**0.14**	**0.38**	**0.97**	**1.64**	**1.84**	**1.62**	**0.57**	**7.16**	**17.90**	**7.65**	**2.33**
East of Hildasay, reference	8936	**0.31**	**0.17**	**0.21**	ND	**0.16**	**0.17**	**0.05**	**1.07**	**2.68**	**7.51**	**0.35**
East of Bruna Ness, cage	8937	**0.43**	**0.98**	**2.40**	**0.37**	**1.86**	**2.34**	**0.43**	**8.81**	**22.03**	**6.87**	**3.21**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Brei Geo Offshore, cage	8938	**0.34**	**0.46**	**1.08**	**2.55**	**1.65**	**1.30**	**0.58**	**7.96**	**19.90**	**12.19**	**1.63**
Brei Geo Offshore, reference	8939	**0.15**	**0.21**	**0.18**	**0.05**	**0.22**	**0.25**	**0.08**	**1.14**	**2.85**	**6.28**	**0.45**
North of Papa, cage	8940	**0.37**	**0.19**	**0.24**	**0.15**	**0.26**	**0.22**	**0.09**	**1.52**	**3.80**	**8.80**	**0.43**
North of Papa, reference	8941	**0.73**	**0.40**	**0.27**	ND	**0.18**	**0.23**	**0.16**	**1.97**	**4.93**	**7.59**	**0.65**
Slocka (Site C), cage	8942	**0.12**	**0.15**	**0.26**	**0.04**	**0.07**	**0.06**	**0.02**	**0.72**	**1.80**	**4.76**	**0.38**
Slocka (Site C), reference	8943	**0.52**	**0.27**	ND	ND	**0.11**	**0.09**	**0.04**	**1.03**	**2.58**	**3.88**	**0.66**
Pobie Sukka (Site A), cage	8944	**0.06**	ND	**0.05**	**0.05**	**0.09**	**0.08**	**0.03**	**0.36**	**0.90**	**6.47**	**0.14**
Ronas Voe, cage	8945	**0.48**	**0.23**	**0.27**	**0.29**	**0.43**	**0.33**	**0.10**	**2.13**	**5.33**	**7.77**	**0.69**
Ronas Voe, reference	8946	**0.40**	**0.31**	**0.10**	**0.08**	**0.20**	**0.16**	**0.10**	**1.45**	**3.63**	**6.15**	**0.59**
Site 3, Collafirth Ness, cage	8947	**0.42**	**0.59**	**1.18**	**0.96**	**1.91**	**1.54**	**0.52**	**7.12**	**17.80**	**12.95**	**1.37**
Uyeasound, Site 2, cage	9186	0.58	ND	ND	ND	0.08	0.06	ND	0.72	1.80	2.69	0.67
Loch a Laip(Inner), Site1, cage	17927	0.25	1.08	1.01	1.03	1.47	1.41	0.39	6.64	16.60	10.64	1.56
Loch Skipport (Outer), cage	17928	**0.09**	**0.06**	**0.19**	**0.18**	**0.38**	**0.32**	**0.08**	**1.30**	**3.25**	**9.19**	**0.35**
Loch Maddy (Rubha Nan Gall), cage	17929	**0.13**	**0.30**	**0.38**	**0.36**	**0.74**	**0.62**	**0.17**	**2.70**	**6.75**	**6.37**	**1.06**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Eilean nam Mult, cage	17930	**0.07**	**0.16**	**0.16**	**0.18**	**0.24**	**0.24**	**0.07**	**1.12**	**2.80**	**4.99**	**0.56**
Eilean Trannay, cage	17931	**0.05**	ND	**0.10**	**0.09**	**0.15**	**0.14**	**0.03**	**0.56**	**1.40**	**6.04**	**0.23**
Pecam Bay, cage	17932	**0.04**	ND	ND	**0.15**	**0.27**	**0.24**	**0.07**	**0.77**	**1.93**	**6.30**	**0.31**
Sgeir Bhuidhe, Pecam Bay 3, cage	17933	**0.12**	**0.17**	**0.33**	**0.36**	**0.51**	**0.53**	**0.16**	**2.18**	**5.45**	**6.60**	**0.83**
Loch Grimshader, cage	17934	**0.06**	**0.03**	**0.07**	**0.06**	**0.11**	**0.09**	**0.02**	**0.44**	**1.10**	**6.88**	**0.15**
Loch Shell (mid) Shell Pairc East, cage	17935	**0.11**	**0.19**	**0.54**	**0.55**	**0.85**	**0.82**	**0.25**	**3.31**	**8.23**	**7.26**	**1.11**
Loch Shell (mid) Shell Pairc West, cage	17936	**0.21**	**0.34**	**0.62**	**0.53**	**1.21**	**1.05**	**0.30**	**4.26**	**10.65**	**7.18**	**1.48**
Ardvourlie, cage	17937	**0.09**	**0.08**	**0.13**	**0.13**	**0.26**	**0.23**	**0.06**	**0.98**	**2.45**	**6.95**	**0.35**
Maaruig, cage	17938	**0.15**	**0.18**	**0.24**	**0.34**	**0.38**	**0.41**	**0.67**	**2.37**	**5.93**	**5.26**	**1.13**
Ardvourlie, cage west	17939	ND	ND	**0.17**	**0.19**	**0.31**	**0.28**	**0.28**	**1.23**	**3.08**	N/A	N/A
Ardvourlie, 25m off west	17940	**0.06**	**0.05**	**0.09**	**0.13**	**0.12**	**0.16**	**0.04**	**0.65**	**1.63**	N/A	N/A
Ardvourlie, 50m off west	17941	**0.03**	**0.03**	**0.07**	**0.09**	**0.09**	**0.11**	**0.02**	**0.44**	**1.10**	N/A	N/A
Ardvourlie, 75m off west	17942	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, cage east	17943	**0.12**	**0.12**	**0.17**	**0.32**	**0.55**	**0.54**	ND	**1.82**	**4.55**	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Ardvourlie, 25m off east	17944	**0.04**	**0.01**	**0.03**	**0.04**	**0.06**	**0.05**	**0.02**	**0.25**	**0.63**	N/A	N/A
Ardvourlie, 50m off east	17945	**0.05**	ND	ND	**0.03**	**0.04**	**0.03**	**0.03**	**0.18**	**0.45**	N/A	N/A
Ardvourlie, 75m off east	17946	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 100m off east	17947	ND	ND	ND	ND	ND	ND	**0.35**	ND	ND	N/A	N/A
Ardvourlie, 25m off north	17948	**0.03**	**0.03**	**0.04**	**0.05**	**0.05**	**0.05**	**0.02**	**0.27**	**0.68**	N/A	N/A
Ardvourlie, 50m off north	17949	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 75m off north	17950	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 100m off north	17951	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 5 – PCB congeners normalised to PCB-180

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Camas Na Sgainadin, Perpendicular, 100m	4419	Not determined since all results below LOD						
Ardvourlie, cage	17937	1.50	1.33	2.17	2.17	4.33	3.83	1.00
Ardvourlie, cage west	17939	ND	ND	0.61	0.68	1.11	1.00	1.00
Ardvourlie, 25m off west	17940	1.50	1.25	2.25	3.25	3.00	4.00	1.00
Ardvourlie, 50m off west	17941	1.50	1.50	3.50	4.50	4.50	5.50	1.00
Ardvourlie, 75m off west	17942	Not determined since all results below LOD						
Ardvourlie, cage east	17943	2.40	2.40	3.40	6.40	11.00	10.80	1.00
Ardvourlie, 25m off east	17944	2.00	0.50	1.50	2.00	3.00	2.50	1.00
Ardvourlie, 50m off east	17945	1.67	ND	ND	1.00	1.33	1.00	1.00
Ardvourlie, 75m off east	17946	Not determined since all results below LOD						
Ardvourlie, 100m off east	17947	Not determined since all results below LOD						
Ardvourlie, 25m off north	17948	1.50	1.50	2.00	2.50	2.50	2.50	1.00
Ardvourlie, 50m off north	17949	Not determined since all results below LOD						
Ardvourlie, 75m off north	17950	Not determined since all results below LOD						
Ardvourlie, 100m off north	17951	Not determined since all results below LOD						
Gorsten, Ardgour, cage	4426	ND	**0.75**	**1.63**	**1.63**	**4.00**	**3.50**	**1.00**
Garven, Loch Eil, cage	4427	**0.73**	**0.73**	**2.09**	**1.91**	**4.30**	**4.50**	**1.00**
Cairidh, cage	4428	1.28	2.80	3.30	2.50	5.24	4.24	1.00
Eilean Ard (Site 3), cage	4429	0.60	0.60	2.00	2.20	4.60	4.00	1.00
Bight of Cliffs, cage	8916	2.25	3.00	2.50	2.25	3.75	3.00	1.00
North Knowe, Greetaing, cage	8917	ND	ND	1.64	2.09	3.50	3.45	1.00
Basta Voe, East Site, cage	8918	5.21	2.14	2.57	2.29	3.00	2.71	1.00
Olnafirth South, cage	8919	2.17	ND	2.50	1.67	2.83	2.17	1.00
Cole Deep, cage	8920	1.08	ND	2.17	2.00	3.92	3.17	1.00
Cole Deep, fallow	8921	2.30	3.67	2.33	2.67	3.33	3.33	1.00
NW of Turraness, cage	8922	0.28	ND	0.94	0.88	1.78	1.33	1.00
NW of Winnaness, cage	8923	7.71	2.00	2.00	1.71	3.43	2.86	1.00

Table 5 – PCB congeners normalised to PCB-180 (continued)

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Uyeasound, Site 1, cage	8924	7.55	1.89	2.00	1.56	2.22	2.11	1.00
Uyeasound, Site 2, cage	8925	20.00	3.00	2.71	2.29	2.86	2.86	1.00
Site 2, Wick of Belmont North, cage	8926	4.78	1.07	1.07	1.07	1.21	1.00	1.00
Site 3, South Head of Mula, cage	8927	Not determined since PCB-180 below LOD						
Site 5, Point of Burkwell, cage	8928	1.40	ND	3.40	2.20	3.40	3.00	1.00
Boatsroom Voe, cage	8929	1.40	ND	2.25	2.25	3.50	2.64	1.00
Setterness West - Poseidon Site, cage	8930	Not determined since PCB-180 below LOD						
Setterness East - Bomlo, cage	8931	Not determined since PCB-180 below LOD						
Swinnister Voe, cage	8932	3.33	2.67	3.67	ND	3.00	2.67	1.00
Collafirth, Delting Site 1 (S), cage	8933	0.57	0.86	2.57	2.57	3.07	2.50	1.00
Collafirth, Delting Site 2 (N), cage	8934	Not determined since PCB-180 below LOD						
East of Hildasay, cage	8935	0.25	0.66	1.70	2.88	3.23	2.84	1.00
East of Hildasay, reference	8936	6.20	3.40	4.20	ND	3.20	3.40	1.00
East of Bruna Ness, cage	8937	1.00	2.28	5.58	0.86	4.33	5.44	1.00
Brei Geo Offshore, cage	8938	0.59	0.79	1.86	4.40	2.84	2.24	1.00
Brei Geo Offshore, reference	8939	1.88	2.62	2.25	0.63	2.75	3.13	1.00
North of Papa, cage	8940	4.11	2.11	2.66	1.66	2.88	2.44	1.00
North of Papa, reference	8941	4.56	2.50	1.69	ND	1.13	1.44	1.00
Slocka (Site C), cage	8942	6.00	7.50	13.00	2.00	3.50	3.00	1.00
Slocka (Site C), reference	8943	13.00	6.75	ND	ND	2.75	2.25	1.00
Pobie Sukka (Site A), cage	8944	2.00	ND	1.67	1.67	3.00	2.67	1.00
Ronas Voe, cage	8945	4.80	2.30	2.70	2.90	4.30	3.30	1.00
Ronas Voe, reference	8946	4.00	3.10	1.00	0.80	2.00	1.60	1.00
Site 3, Collafirth Ness, cage	8947	0.80	1.13	2.27	1.85	3.67	2.96	1.00
Uyeasound, Site 2, cage	9186	Not determined since PCB-180 below LOD						
Loch a Laip(Inner), Site1, cage	17927	0.64	2.77	2.59	2.64	3.77	3.62	1.00
Loch Skipport (Outer), cage	17928	1.13	0.75	2.38	2.25	4.75	4.00	1.00
Loch Maddy (Rubha Nan Gall), cage	17929	**0.76**	**1.76**	**2.24**	**2.12**	**4.35**	**3.65**	**1.00**

Table 5 – PCB congeners normalised to PCB-180 (continued)

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Eilean nam Mult, cage	17930	1.00	2.29	2.29	2.57	3.43	3.43	1.00
Eilean Trannay, cage	17931	1.66	ND	3.33	3.00	5.00	4.67	1.00
Pecam Bay, cage	17932	0.57	ND	ND	2.14	3.86	3.43	1.00
Sgeir Bhuidhe, Pecam Bay 3, cage	17933	**0.75**	**1.06**	**2.06**	**2.25**	**3.19**	**3.31**	**1.00**
Loch Grimshader, cage	17934	3.00	1.50	3.50	3.00	5.50	4.50	1.00
Loch Shell (mid) Shell Pairc East, cage	17935	0.44	0.76	2.16	2.20	3.40	3.28	1.00
Loch Shell (mid) Shell Pairc West, cage	17936	**0.70**	**1.13**	**2.07**	**1.77**	**4.03**	**3.50**	**1.00**
Maaruig, cage	17938	0.22	0.26	0.35	0.51	0.56	0.61	1.00

ANNEX 2 – RESULTS 2002

Table 6 - Site details

BreiGeo Fish Farm sampled on 21/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Sandsound Voe	HU 357 465 SE	22052	WPC/N/61405 (01)	2635
Parallel transect to head of loch 25m		HU 357 465 SE	22053		
Parallel transect to head of loch 100m		HU 357 466 SE	22054		
Offshore transect at cage edge		HU 357 463 SE	22055		
Offshore transect 25m		HU 357 463 SE	22056		
Offshore transect 100m		HU 357 463 SE	22057		
Inshore transect at cage edge		HU 356 464 SE	22058		
Inshore transect 25m		HU 356 464 SE	22059		
Inshore transect 100m		HU 355 464 SE	22060		
Parallel transect to mouth of loch at cage edge		HU 356 461 SE	22061		
Parallel transect to mouth of loch 25m		HU 356 461 SE	22062		
Parallel transect to mouth of loch 100m		HU 356 460 SE	22063		
Reference		HU 352 482 SW	22064		

Table 6 - Site details continued

Bight of Cliffs Fish Farm sampled on 22/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Olna Firth	HU 392 644 NW	22068	WPC/62086 (01)	500
Parallel transect to head of loch 25m		HU 393 644 NW	22069		
Parallel transect to head of loch 100m		HU 393 643 NW	22070		
Offshore transect at cage edge		HU 392 645 NW	22081		
Offshore transect 25m		HU 391 645 NW	22082		
Offshore transect 100m		HU 391 645 NW	22083		
Inshore transect at cage edge		HU 392 645 NW	22065		
Inshore transect 25m		HU 392 645 NW	22066		
Inshore transect 100m		HU 392 646 NW	22067		
Parallel transect to mouth of loch at cage edge		HU 391 646 NW	22071		
Parallel transect to mouth of loch 25m		HU 391 646 NW	22072		
Parallel transect to mouth of loch 100m		HU 390 647 NW	22073		
Reference		HU 391 642 SW	22085		

Table 6 - Site details continued

North Nestings 2 Fish Farm sampled on 20/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Dury Voe	HU 462 621 SW	22095	WPC/N/61956 (00)	995
Parallel transect to head of loch 25m		HU 462 621 SW	22096		
Parallel transect to head of loch 100m		HU 462 620 SW	22097		
Offshore transect at cage edge		HU 463 623 SW	22089		
Offshore transect 25m		HU 463 623 SW	22090		
Offshore transect 100m		HU 464 623 SW	22091		
Inshore transect at cage edge		HU 462 623 SW	22086		
Inshore transect 25m		HU 462 623 SW	22087		
Inshore transect 100m		HU 461 624 SW	22088		
Parallel transect to mouth of loch at cage edge		HU 462 624 SW	22092		
Parallel transect to mouth of loch 25m		HU 462 625 SW	22093		
Parallel transect to mouth of loch 100m		HU 463 625 SW	22094		
Reference		HU 479 629 NE			

Table 6 - Site details continued

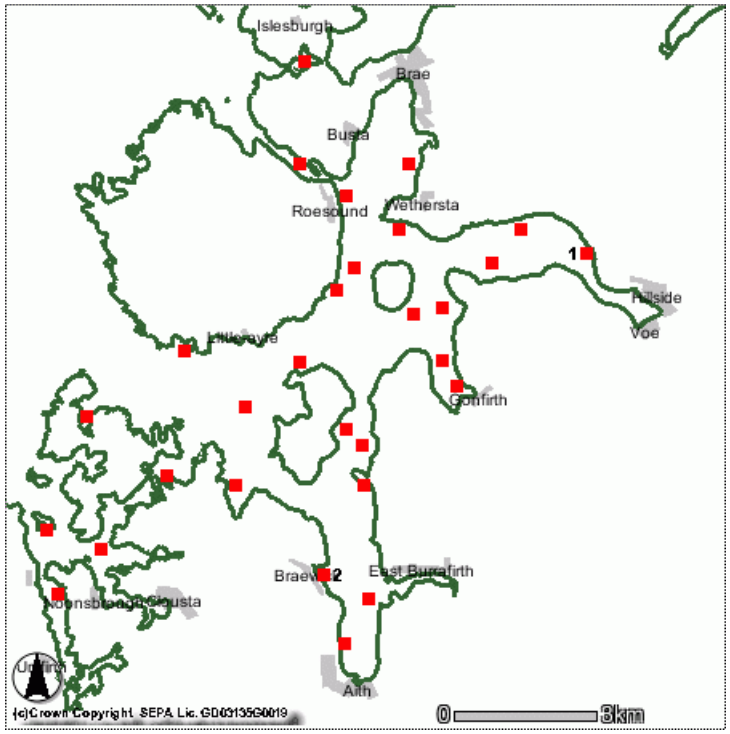
Other Fish Farm Sites

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Basta Voe North	Basta Voe	HU 522 961 SW	13/6/02	32375	WPC/N/61625 (00)	600
Basta Voe North West		HU 544 952 SW	13/6/02	22103	WPC/N/61979 (01)	500
Basta Voe East		HU 546 950 NE	13/6/02	22104	WPC/N/61978 (01)	500
Basta Voe East Inner Rep 2			13/6/02	22105	WPC/N/61978 (01)	500
Basta Voe South		HU 531 949 NW	13/6/02	22079	WPC/N/61966 (02)	950
Bight of Braewick	Aith Voe	HU 343 579 NW	22/6/02	22106	WPC/N/62074 (02)	990
Hildasay	Hildasay	HU 363 402 SW	21/6/02	22107	WPC/N/62077 (01)	400
Kallee Ness	Clift Sound	HU 393 352 SW	16/6/02	22108	WPC/N/59549 (01)	300
Lippie Geo	Clift Sound	HU 393 324 SW	15/6/02	22109	WPC/N/60952 (01)	407
Vatsetter	South Sound Yell	HU 535 902 SW		22110	WPC/N/61968 (01)	950
Holms Geo	Clift Sound	HU 388 310 SE	15/6/02	22111	WPC/N/60953 (00)	509 1999
Djuba Wick cage	Hascosay	HU 558 934 SE		22112	WPC/N/61973 (02)	
Bunya Sand	Mid Yell Voe	HU 524 909 NW		22113	WPC/N/60720 (00)	425

Table 6 - Site details continued

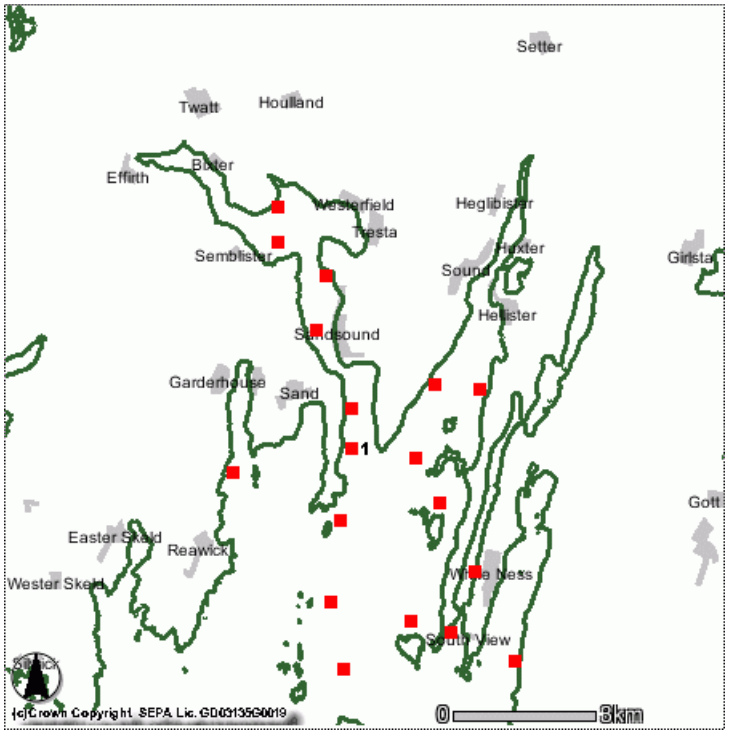
Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No	Maximum Biomass
Trondra	Clift Sound	HU 400 369 NE	16/6/02	22114	WPC/N/62085 (01)	257
Louva Voe site 3	Dury Voe	HU 473 620 NW		22115	WPC/N/61957 (01)	995
Wester Quarff	Clift Sound	HU 400 358 NW	16/6/02	22080	WPC/N/62084 (02)	500
Cloudin	Valia Sound	HU 233 476 NW	29/6/02	29428	WPC/N/62049 (01)	1995
Burraston	Valia Sound	HU 227 477 NE	29/6/02	29429	WPC/N/62052 (01)	600
Foraness	Dales Voe	HU 455 470 NE	26/6/02	29430	WPC/N/62214 (01)	800
Hogan	Gruting Voe	HU 273 477 NW	28/6/02	29431	WPC/N/62036 (01)	1500
Aith Voe	Bressay	HU 507 437 NE	25/6/02	29432	WPC/N/62080 (01)	400
Dales Voe	Dales Voe	HU 450 452 SE	26/6/02	29433	WPC/N/62078 (01)	800
White Ness	Valia Sound	HU 233 476 NW	29/6/02	29434	WPC/N/62011 (01)	600
Mid Taing	Gruting Voe	HU 259 472 SE		29435	WPC/N/62440 (00)	500
East Loch Seaforth	Loch Seaforth	NB 212 117 NW	19/8/02	29436	WPC/N/61845 (00)	871
Scotasay	East Loch Tarbet	NG 190 977 NW	16/8/02	29437	WPC/N/62387 (00)	750
Miavaig	East Loch Tarbet	NG 168 968 NE	16/8/02	29438	WPC/N/62392 (00)	500

Figure 15 - Map of Olna Firth and Aith Voe



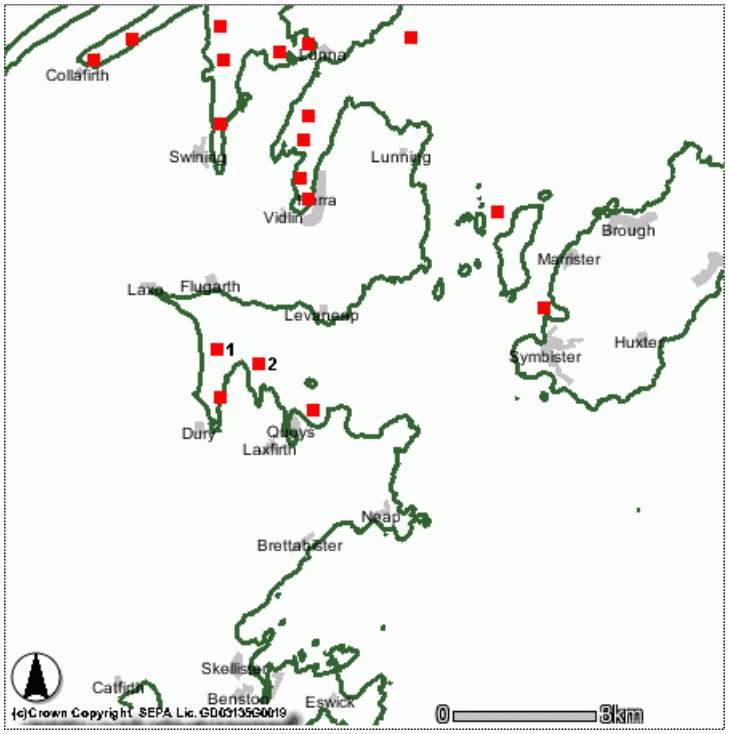
[1] – Bight of Cliffs
[2] – Bight of Braewick

Figure 16 - Map of Sandsound Voe



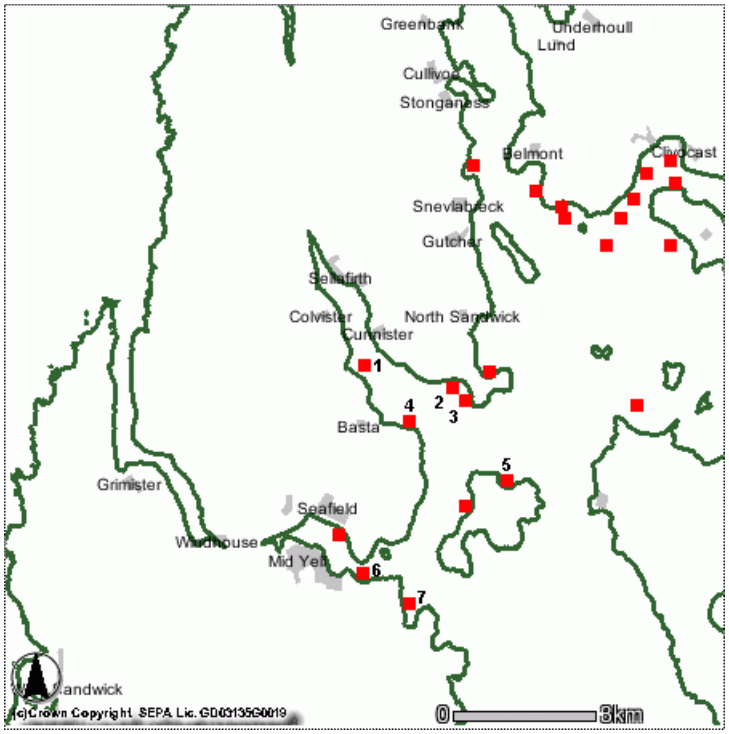
[1] – Brei Geo

Figure 17 - Map of Dury Voe



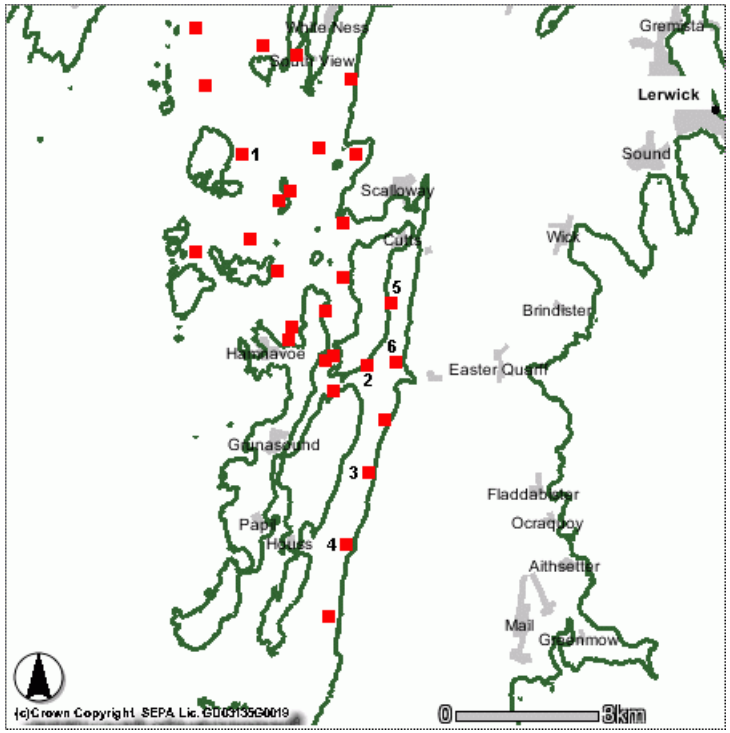
[1] – North Nestings Site 2
[2] – Loura Voe Site 3

Figure 18 - Map of Basta Voe, Hascosay and Yell Voe



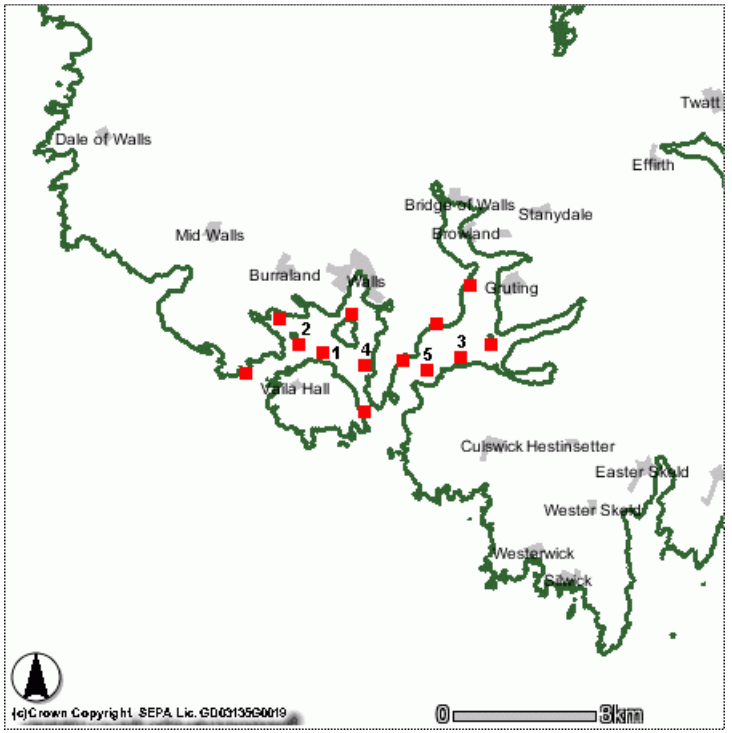
[1] – Basta Voe North
[2] – Basta Voe North West
[3] – Basta Voe East
[4] – Basta Voe South
[5] – Djuba Wick
[6] – Bunya Sand
[7] – Vatsetter

Figure 19 - Map of Hildasay and Clift Sounds



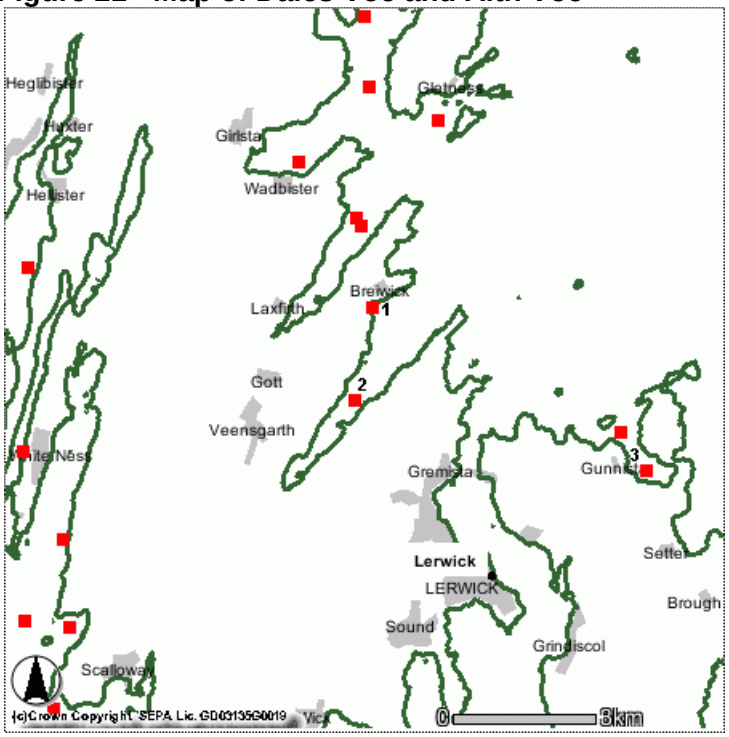
[1] – East of Hildasay
[2] – Killee Ness
[3] – Lippie Geo Site 2
[4] – Holms Geo
[5] – Lea Trondra
[6] – Wester Quarff

Figure 20 - Map of Valia Sound and Gruting Voe



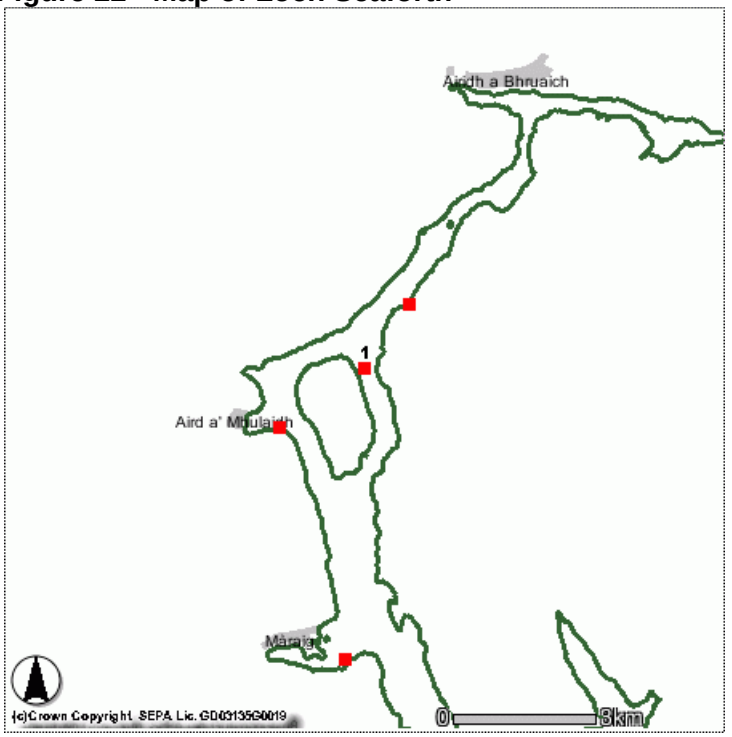
[1] – Cloudin
[2] – Burrastow
[3] – Hogan
[4] – Whitesness
[5] – Mid Taing

Figure 21 - Map of Dales Voe and Aith Voe



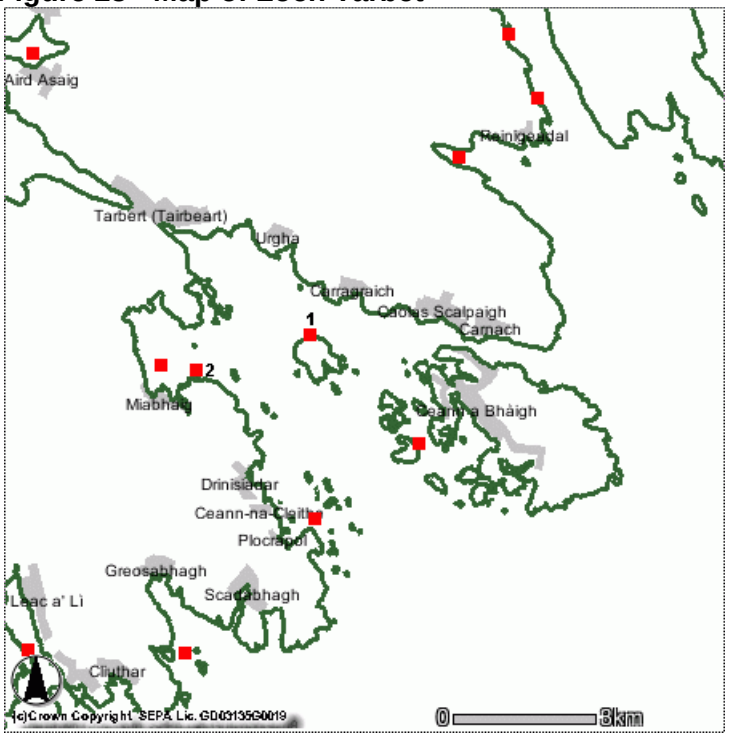
[1] – Fora Ness
[2] – Dales Voe
[3] – Aith Voe

Figure 22 - Map of Loch Seaforth



[1] - East Loch Seaforth

Figure 23 - Map of Loch Tarbet



[1] - Scotasay
[2] - Miavaig

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content)

Brei Geo Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22052	**0.63**	**0.57**	**0.48**	**0.34**	**0.52**	**0.51**	**0.14**	**3.2**	**8.0**	N/A	N/A
Parallel to head 25m	22053	ND	**0.15**	**0.22**	**0.09**	**0.21**	**0.2**	ND	ND	ND	N/A	N/A
Parallel to head 100m	22054	ND	**0.11**	**0.32**	**0.08**	**0.22**	**0.21**	ND	ND	ND	N/A	N/A
Offshore at cage	22055	**0.17**	**0.21**	**0.37**	**0.2**	**0.42**	**0.38**	**0.12**	**1.87**	**4.68**	N/A	N/A
Offshore 25m	22056	**0.13**	**0.36**	**0.42**	**0.23**	**0.45**	**0.41**	**0.09**	**2.09**	**5.23**	N/A	N/A
Offshore 100m	22057	**0.17**	**0.22**	**0.3**	**0.14**	**0.29**	**0.28**	**0.11**	**1.51**	**3.77**	N/A	N/A
Inshore at cage	22058	**1.28**	**0.6**	**1.46**	**0.97**	**1.81**	**1.58**	**0.6**	**8.32**	**20.8**	N/A	N/A
Inshore 25m	22059	**0.11**	**0.09**	**0.14**	**0.06**	**0.18**	**0.18**	**0.07**	**0.82**	**2.04**	N/A	N/A
Inshore 100m	22060	**0.27**	**0.23**	**0.12**	**0.04**	**0.09**	**0.05**	**0.02**	**0.81**	**2.02**	N/A	N/A
Parallel to mouth at cage	22061	**1.49**	**1.03**	**1.73**	**1.31**	**2.26**	**2.04**	**0.61**	**10.45**	**26.1**	N/A	N/A
Parallel to mouth 25m	22062	**0.18**	**0.23**	**0.36**	**0.25**	**0.52**	**0.49**	**0.16**	**2.18**	**5.45**	N/A	N/A
Parallel to mouth 100m	22063	**0.57**	**0.22**	**0.19**	**0.13**	**0.26**	**0.19**	**0.06**	**1.62**	**4.05**	N/A	N/A
Reference	22064	**0.44**	**0.16**	**0.13**	**0.05**	**0.08**	**0.06**	**0.01**	**0.94**	**2.36**	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Bight of Cliffs Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22065	**0.53**	**0.41**	**0.39**	**0.2**	**0.4**	**0.33**	**0.11**	**2.36**	**5.91**	N/A	N/A
Parallel to head 25m	22066	**0.09**	**0.13**	**0.3**	**0.13**	**0.23**	**0.24**	**0.07**	**1.18**	**2.95**	N/A	N/A
Parallel to head 100m	22067	**0.14**	**0.17**	**0.24**	**0.14**	**0.3**	**0.25**	**0.06**	**1.31**	**3.27**	N/A	N/A
Offshore at cage	22081	**0.66**	**0.59**	**0.15**	**0.22**	**0.45**	**0.37**	**0.11**	**2.54**	**6.36**	N/A	N/A
Offshore 25m	22082	**0.1**	**0.09**	**0.32**	**0.09**	**0.36**	**0.35**	**0.1**	**1.41**	**3.53**	N/A	N/A
Offshore 100m	22083	**0.15**	**0.18**	**0.26**	**0.14**	**0.27**	**0.23**	**0.04**	**1.25**	**3.12**	N/A	N/A
Inshore at cage	22068	**0.39**	**0.26**	**0.44**	**0.25**	**0.54**	**0.4**	**0.15**	**2.42**	**6.05**	N/A	N/A
Inshore 25m	22069	**0.49**	**0.26**	**0.06**	**0.14**	**0.3**	**0.21**	**0.09**	**1.56**	**3.9**	N/A	N/A
Inshore 100m	22070	**0.06**	**0.27**	**0.19**	**0.1**	**0.17**	**0.2**	**0.06**	**1.04**	**2.61**	N/A	N/A
Parallel to mouth at cage	22071	**0.1**	**0.19**	**0.23**	**0.19**	**0.41**	**0.39**	**0.04**	**1.55**	**3.87**	N/A	N/A
Parallel to mouth 25m	22072	**0.66**	**0.65**	**0.02**	**0.11**	**0.28**	**0.14**	ND	ND	ND	N/A	N/A
Parallel to mouth 100m	22073	**0.43**	**0.6**	**0.48**	**0.19**	**0.43**	**0.36**	**0.14**	**2.62**	**6.56**	N/A	N/A
Reference	22085	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.98**	ND

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

North Nestings 2 Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22095	**0.71**	**0.32**	**0.34**	**0.18**	**0.28**	**0.24**	**0.09**	**2.16**	**5.41**	N/A	N/A
Parallel to head 25m	22078	**0.08**	**0.13**	**0.24**	**0.11**	**0.26**	**0.26**	**0.08**	**1.16**	**2.9**	N/A	N/A
Parallel to head 100m	22075	**0.07**	**0.06**	**0.17**	**0.07**	**0.13**	**0.16**	**0.1**	**0.76**	**1.9**	N/A	N/A
Offshore at cage	22077	**0.08**	**0.17**	**0.24**	**0.07**	**0.12**	**0.22**	**0.02**	**0.93**	**2.33**	N/A	N/A
Offshore 25m	22090	**0.05**	**0.05**	**0.25**	**0.12**	**0.19**	**0.21**	**0.05**	**0.94**	**2.35**	N/A	N/A
Offshore 100m	22091	**0.37**	**0.34**	**0.39**	**0.13**	**0.23**	**0.18**	**0.1**	**1.76**	**4.32**	N/A	N/A
Inshore at cage	22086	**0.08**	**0.04**	**0.14**	**0.04**	**0.13**	**0.2**	**0.04**	**0.68**	**1.69**	N/A	N/A
Inshore 25m	22087	**0.13**	**0.03**	**0.19**	**0.05**	**0.11**	**0.15**	**0.07**	**0.73**	**1.83**	N/A	N/A
Inshore 100m	22088	**0.1**	**0.15**	**0.18**	**0.05**	**0.11**	**0.17**	**0.16**	**0.93**	**2.32**	N/A	N/A
Parallel to mouth at cage	22092	**0.16**	**0.07**	**0.18**	**0.08**	**0.13**	**0.17**	**0.08**	**0.85**	**2.13**	N/A	N/A
Parallel to mouth 25m	22093	**0.18**	**0.08**	**0.17**	**0.07**	**0.1**	**0.18**	**0.04**	**0.82**	**2.05**	N/A	N/A
Parallel to mouth 100m	22094	**0.13**	**0.1**	**0.2**	**0.07**	**0.13**	**0.17**	**0.15**	**0.96**	**2.4**	N/A	N/A
Reference	22098	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.98**	ND

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Other Fish Farm Sites

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Basta Voe North	32375	**0.22**	**0.19**	**0.34**	**0.22**	**0.37**	**0.35**	**0.1**	**1.8**	**4.5**	**7.3**	**0.62**
Basta Voe North West	22103	**0.06**	**0.08**	**0.05**	**0.03**	**0.06**	**0.04**	ND	ND	ND	**3.42**	ND
Basta Voe East	22104	**0.05**	**0.17**	**0.02**	**0.03**	**0.02**	**0.01**	ND	ND	ND	**7.25**	ND
Basta Voe East Inner Rep 2	22105	**0.09**	**0.22**	**0.2**	**0.14**	**0.21**	**0.19**	**0.06**	**1.11**	**2.78**	**0.4**	**6.95**
Basta Voe South	22079	**0.22**	**0.29**	**0.29**	**0.25**	**0.46**	**0.4**	**0.16**	**2.07**	**5.18**	**2.34**	**2.21**
Bight of Braewick	22106	**0.22**	**0.36**	**0.07**	**0.08**	**0.13**	**0.12**	**0.05**	**1.02**	**2.56**	**6.63**	**0.39**
Hildasay	22107	**0.33**	**0.28**	**0.2**	**0.28**	**0.55**	**0.65**	**0.2**	**2.48**	**6.21**	**8.27**	**0.75**
Kallee Ness	22108	**1.11**	**1.1**	**0.3**	**0.4**	**0.84**	**1.2**	**0.2**	**5.15**	**12.9**	**6.51**	**1.98**
Lippie Geo	22109	**0.09**	**0.36**	**0.86**	**0.28**	**0.55**	**0.56**	**0.14**	**2.84**	**7.1**	**6.48**	**1.1**
Vatsetter	22110	**0.11**	**0.33**	**0.94**	**0.34**	**0.8**	**0.66**	**0.25**	**3.43**	**8.58**	**3.17**	**2.71**
Holms Geo	22111	**0.1**	**0.49**	**1.29**	**0.47**	**0.78**	**0.7**	**0.21**	**4.04**	**10.1**	**5.76**	**1.75**
Djuba Wick cage	22112	**0.05**	**0.2**	**0.07**	**0.04**	**0.06**	**0.04**	**0.04**	**0.5**	**1.25**	**0.46**	**2.72**
Bunya Sand	22113	**0.03**	**0.17**	**0.07**	**0.06**	**0.11**	**0.09**	**0.03**	**0.55**	**1.38**	**1.42**	**0.97**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Trondra	2214	**0.16**	**1.51**	**3.36**	**2.28**	**2.23**	**3.72**	**0.43**	**13.7**	**34.3**	**8.84**	**3.88**
Louva Voe site 3	22115	**0.17**	**0.17**	**0.16**	**0.1**	**0.24**	**0.21**	**0.06**	**1.1**	**2.75**	**2.6**	**1.06**
Wester Quarff	22080	**0.14**	**0.3**	**0.66**	**0.48**	**0.57**	**0.72**	**0.14**	**3.01**	**7.53**	**6.63**	**1.14**
Cloudin	29428	**0.64**	**0.61**	**0.33**	**0.13**	**0.27**	**0.59**	**0.2**	**2.77**	**6.93**	**8.81**	**0.79**
Burraston	29429	**0.12**	**0.2**	**0.15**	**0.09**	**0.18**	**0.16**	**0.05**	**0.95**	**2.38**	**2.78**	**0.86**
Foraness	29430	**0.39**	**0.21**	**0.3**	**0.15**	**0.32**	**0.29**	**0.12**	**1.77**	**4.43**	**2.4**	**1.85**
Hogan	29431	**0.16**	**0.11**	**0.24**	**0.12**	**0.23**	**0.22**	**0.07**	**1.15**	**2.88**	**12.28**	**0.23**
Aith Voe	29432	**0.13**	**0.27**	**0.15**	**0.06**	**0.12**	**0.08**	**0.03**	**0.85**	**2.13**	**0.56**	**3.8**
Dales Voe	29433	**0.07**	**0.09**	**0.25**	**0.04**	**0.09**	**0.07**	**0.03**	**0.64**	**1.6**	**2.65**	**0.6**
White Ness	29434	**0.21**	**0.23**	**0.38**	**0.27**	**0.45**	**0.47**	**0.17**	**2.18**	**5.45**	**8.5**	**0.64**
Mid Taing	29435	**0.8**	**0.61**	**0.5**	**0.34**	**0.48**	**0.54**	**0.16**	**3.44**	**8.6**	**11.11**	**0.77**
East Loch Seaforth	29436	**0.28**	**0.36**	**0.32**	**0.18**	**0.31**	**0.3**	**0.13**	**1.89**	**4.73**	**5.16**	**0.92**
Scotasay	29437	**0.06**	**0.21**	**0.17**	**0.07**	**0.13**	**0.13**	**0.03**	**0.81**	**2.03**	**8.83**	**0.23**
Miavaig	29438	**0.13**	**0.14**	**0.26**	**0.14**	**0.23**	**0.24**	**0.08**	**1.22**	**3.05**	**5.89**	**0.52**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 8 – PCB congeners normalised to PCB-180

Brei Geo Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22052	4.43	4.03	3.38	2.4	3.67	3.57	1.0
Parallel to head 25m	22053	0.59	Not determined since all results below LOD					1.0
Parallel to head 100m	22054	1.28	Not determined since all results below LOD					1.0
Offshore at cage	22055	1.4	1.73	3.06	1.7	3.48	3.15	1.0
Offshore 25m	22056	1.35	3.87	4.44	2.44	4.81	4.36	1.0
Offshore 100m	22057	1.52	1.93	2.62	1.21	2.52	2.51	1.0
Inshore at cage	22058	2.15	1.01	2.44	1.63	3.04	2.65	1.0
Inshore 25m	22059	1.61	1.34	2.08	0.94	2.7	2.72	1.0
Inshore 100m	22060	12.0	10.4	5.16	1.68	3.82	2.14	1.0
Parallel to mouth at cage	22061	2.44	1.68	2.84	2.14	3.7	3.34	1.0
Parallel to mouth 25m	22062	1.16	1.44	2.24	1.54	3.25	3.07	1.0
Parallel to mouth 100m	22063	10.0	3.85	3.31	2.36	4.52	3.33	1.0
Reference	22064	32.47	11.6	9.73	3.75	6.1	4.36	1.0

Table 8 – PCB congeners normalised to PCB-180

Bight of Cliffs Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22065	4.83	3.76	3.61	1.85	3.67	3.05	1.0
Parallel to head 25m	22066	1.21	1.80	4.24	1.9	3.21	3.37	1.0
Parallel to head 100m	22067	2.4	2.96	4.17	2.39	5.05	4.3	1.0
Offshore at cage	22081	5.89	5.26	1.38	1.94	4.04	3.29	1.0
Offshore 25m	22082	1.05	0.93	3.21	0.89	3.61	3.49	1.0
Offshore 100m	22083	4.13	5.14	7.39	3.88	7.55	6.51	1.0
Inshore at cage	22068	2.65	1.77	3.04	1.72	3.67	2.75	1.0
Inshore 25m	22069	5.21	2.8	0.66	1.46	3.17	2.21	1.0
Inshore 100m	22070	1.01	4.74	3.22	1.68	3.02	3.42	1.0
Parallel to mouth at cage	22071	2.63	5.02	5.96	4.9	10.7	10.0	1.0
Parallel to mouth 25m	22072	Not determined since PCB 180 result below LOD						
Parallel to mouth 100m	22073	3.13	4.44	3.55	1.4	3.15	2.64	1.0
Reference	22085	1.35	1.37	1.29	1.25	0.2	0.25	1.0

Table 8 – PCB congeners normalised to PCB-180

North Nestings 2 Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22095	7.87	3.48	3.72	1.95	3.11	2.68	1.0
Parallel to head 25m	22078	1.01	1.71	3.06	1.47	3.29	3.29	1.0
Parallel to head 100m	22075	0.67	0.56	1.73	0.74	1.25	1.58	1.0
Offshore at cage	22077	3.68	7.72	11.0	3.17	5.38	9.92	1.0
Offshore 25m	22090	1.0	1.0	4.73	2.17	3.64	3.97	1.0
Offshore 100m	22091	3.77	3.41	3.9	1.31	2.31	1.82	1.0
Inshore at cage	22086	1.75	1.02	3.3	0.85	3.04	4.46	1.0
Inshore 25m	22087	1.74	0.44	2.5	0.65	1.52	2.0	1.0
Inshore 100m	22088	0.67	0.97	1.17	0.32	0.8	1.06	1.0
Parallel to mouth at cage	22092	2.11	0.87	2.37	0.99	1.65	2.15	1.0
Parallel to mouth 25m	22093	4.04	1.72	3.92	1.56	2.2	4.0	1.0
Parallel to mouth 100m	22094	0.89	0.65	1.36	0.46	0.9	1.15	1.0
Reference	22098	Not determined since all results below LOD						

Table 8 – PCB congeners normalised to PCB-180

Other Fish Farm Sites

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Basta Voe North	32375	2.19	1.88	3.33	2.18	3.63	3.4	1.0
Basta Voe North West	22103	Not determined since PCB 180 result below LOD						
Basta Voe East	22104	Not determined since PCB 180 result below LOD						
Basta Voe East Inner Rep 2	22105	1.58	3.65	3.29	2.34	3.57	3.11	1.0
Basta Voe South	22079	1.4	1.82	1.79	1.54	2.89	2.47	1.0
Bight of Braewick	22106	4.56	7.5	1.52	1.63	2.77	2.42	1.0
Hildasay	22107	1.65	1.37	0.99	1.38	2.71	3.24	1.0
Kallee Ness	22108	5.68	5.62	1.55	2.02	4.28	6.14	1.0
Lippie Geo	22109	0.63	2.33	6.08	1.99	3.85	3.98	1.0
Vatsetter	22110	0.42	1.3	3.7	1.35	3.15	2.58	1.0
Holms Geo	22111	0.49	2.33	6.19	2.27	3.73	3.34	1.0
Djuba Wick cage	22112	1.31	5.28	1.84	0.94	1.67	1.01	1.0
Bunya Sand	22113	1.01	6.56	2.7	2.34	4.1	3.38	1.0
Trondra	2214	0.38	3.49	7.77	5.27	5.16	8.6	1.0
Louva Voe site 3	22115	2.95	2.84	2.7	1.67	4.12	3.53	1.0
Wester Quarff	22080	1.0	2.13	4.62	3.38	3.97	5.03	1.0
Cloudin	29428	3.16	3.02	1.64	0.62	1.33	2.93	1.0
Burraston	29429	2.35	3.95	2.84	1.72	3.58	3.05	1.0
Foraness	29430	3.2	1.71	2.45	1.25	2.66	2.35	1.0
Hogan	29431	2.18	1.56	3.28	1.62	3.07	2.95	1.0
Aith Voe	29432	4.06	8.17	4.7	1.89	3.53	2.6	1.0
Dales Voe	29433	2.28	3.25	8.72	1.51	2.98	2.6	1.0
White Ness	29434	1.22	1.36	2.24	1.58	2.66	2.79	1.0
Mid Taing	29435	4.89	3.73	3.08	2.11	2.94	3.34	1.0
East Loch Seaforth	29436	2.1	2.71	2.38	1.34	2.28	2.23	1.0
Scotasay	29437	1.89	7.05	5.71	2.46	4.26	4.23	1.0
Miavaig	29438	1.67	1.82	3.44	1.82	3.04	3.17	1.0

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Organochlorines and breast cancer risk by receptor status, tumor size, and grade (Canada)

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Abstract

Objective: We evaluated the association between organochlorines and breast cancer subtype defined by the tumor characteristics: estrogen receptor status, progesterone receptor status, tumor size, and grade.
Methods: A case–control study was conducted from 1995 to 1997 in Kingston and Toronto, Canada. Breast adipose tissue, taken from 217 cases and 213 biopsy controls frequency-matched on age, was analysed for 14 polychlorinated biphenyl (PCB) congeners and 10 pesticides.
Results: Adjusting for age, geometric means of several organochlorines differed by estrogen receptor status and tumor grade ($p < 0.05$). Odds ratios (ORs) for each organochlorine relative to the common control group for breast cancers of differing subtype were compared using polytomous logistic regression. Although the ORs did not differ significantly by subtype, the ORs of PCBs and p, p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (DDE) were higher with risk of estrogen receptor-negative breast cancer than estrogen receptor-positive breast cancer. One of the most extreme differences was with DDE, where the OR for the association with risk of estrogen receptor-negative breast cancer was 2.4 (95% confidence interval (CI) 1.0–5.4) in the uppermost tertile relative to the lowest, whereas the corresponding OR for risk of estrogen receptor-positive breast cancer was 1.1 (95% CI 0.6–1.9). PCBs also tended to be more strongly positively associated with risk of larger and higher-grade tumors.
Conclusions: The association between organochlorines and breast cancer risk did not significantly differ by subtype, but many PCBs were more strongly associated with tumors of poor prognosis.

Introduction

Persistent organochlorines, including the pesticide, 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane (DDT), and the industrial chemicals, polychlorinated biphenyls (PCBs), have been widely used in the past and are now ubiquitous in the environment. Organochlorines have been studied extensively in relation to breast cancer since the general population is exposed to them through their diet, and many organochlorines accumulate in fatty tissues of the breast and can mimic the action of estrogen. In some studies, compared with controls, women with breast cancer had higher levels of some chlorinated compounds including PCBs and pesticides [1–7], but in others, the cases had lower or similar levels [8–16]. The inconsistencies in the results of these studies may be due to the study populations and their different susceptibilities.

Many studies have found different risk factor profiles for breast cancer with different characteristics. The most

studied characteristic has been estrogen receptor (ER) status, where the supposition is that hormonal risk factors are more strongly related with ER-positive cancer, which is more sensitive to hormonal treatments. Differences in risks by ER status have been found with reproductive factors [17–20]. With respect to organochlorines specifically, one study has found that p,p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (DDE), a metabolite of the pesticide, DDT, was associated with ER-positive breast cancer, but not with ER-negative cancer [21].

We have conducted a hospital-based case–control study in which we observed that breast cancer risk was associated with breast adipose tissue concentrations of PCBs 105 and 118 [22]. The objective of the present report was to determine the associations between organochlorines measured in breast adipose tissue and different subtypes of breast cancer, and to investigate whether the associations differed by subtype. Subtypes of breast cancer were defined according to the tumor characteristics: hormone receptors (estrogen and progesterone), tumor size, and grade.

Materials and methods

The methods of this hospital biopsy case–control study have been reported in detail elsewhere [22] and will be described briefly here. The protocol was approved by the ethics committees at Women's College Hospital and Queen's University/Kingston General Hospital and all subjects provided informed consent.

Subjects

In order to obtain a sample of breast adipose tissue in which to measure organochlorines, subjects were women who had a diagnostic breast biopsy at Women's College Hospital in Toronto and Kingston General Hospital in Kingston. Before biopsy, the study was presented by the surgeons to women who did not have previous cancer or breast implants and were under the age of 80. Of the 824 eligible women, 663 (80.5%) completed a questionnaire.

The questionnaire collected information about known and suspected risk factors that were considered as potential confounders in the analyses. Important variables derived from the questionnaire included age (continuous), site (Toronto/Kingston), menopausal status (pre/post), parity (no/yes), lactation duration (continuous), age last breast-fed (never/<30/≥ 30 years), ethnicity (British/Canadian/other), family history (no/breast cancer in first or second-degree relative), body mass index (continuous), fat intake (continuous), alcohol intake ($<1/\geq 1$ drink per week), current smoking (no/yes), and cumulative smoking (continuous). Subjects who reported that their menstrual periods had stopped permanently were classified as postmenopausal. However, six subjects who had a hysterectomy in the absence of bilateral oophorectomy, and were under the mean age of menopause of subjects having a natural menopause (49 years), were classified as premenopausal.

Approximately 0.2–1 g of benign breast tissue were frozen and sent to the laboratory for analysis of organochlorines. After the biopsy, pathology records were reviewed to determine which subjects were cases (*in situ* or invasive breast cancer) and which were controls (biopsy negative for malignancy). Organochlorines were determined in the 217 cases for whom enough breast adipose tissue was available and in 213 controls frequency-matched to the cases by age in 5-year groups and study site.

Organochlorine analysis

The organochlorines measured were: 14 PCB congeners (International Union of Pure and Applied Chemists no. 28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, and 187), p,p′-DDT, p,p′-DDE, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, hexachlorobenzene (HCB), Mirex, and β-hexachlorocyclohexane (β-HCH), α-chlordane, and γ-chlordane. Total PCB was calculated as the sum of PCBs 138 and 153, multiplied by 5.2 to approximate the level of the commercial PCB mixture, Arochlor 1260.

Samples were analyzed at Le Centre de Toxicologie du Québec blind to case–control status. Le Centre de Toxicologie du Québec is accredited by the Canadian Association for Environmental Analytical Laboratories, and participates in many quality assurance/quality control programs including the Great Lakes Research Program's QA/QC Project of the Community Public Health Agency in Michigan, and Environment Canada's Arctic Environment Strategy's QA/QC Program.

Organochlorines were determined using a Hewlett Packard 5890 series II gas chromatograph with dual capillary columns and dual Ni-63 electron-capture detectors. The percentage of lipids in each sample was determined and the concentrations of the organochlorines were expressed as the concentration in lipid. The instrument detection limits were set at three times the average standard deviation of background and were, on a wet-weight basis, 3 μg/kg for total PCBs, 0.6 μg/kg for p,p′-DDT and β-HCH, and 0.3 μg/kg for the rest of the organochlorines determined. The detection limits on a lipid basis depend on the sample weight and the percentage of lipids in the sample, and therefore vary by subject.

Tumor characteristics

Levels of ER and PR in the tumors of the cases were determined by one or both of immunohistochemistry or enzyme immunoassay. The enzyme immunoassay, although considered a more sensitive indicator of receptor status, was missing in several cases due to the lack of tissue for the assay. Using the immunohistochemical assay, tumors were classified as receptor-positive if more than 10% of the cells stained for the receptor. Using the enzyme immunoassay, tumors were classified as receptor-positive if the concentration of receptor was greater than 10 fmol/mg cytosolic protein. Cases who were positive by at least one assay were considered to have positive receptor status.

Tumor size and grade were abstracted from the pathology reports, or were reported separately to us by the pathologist at the hospital. Tumors were graded at both hospitals according to the Scarff–Bloom–Richardson (SBR) system which classifies tumors into three grades: I (well differentiated), II (moderately differentiated), and III (poorly differentiated), according to the tumor architecture, nuclear pleomorphism, and the number of mitotic figures. Only invasive ductal carcinomas were graded. Where pathology reports were missing grade information, or had grade reported by a different grading system, the pathologist (S.K.S.) reviewed the report or the slide.

Statistical analyses

More than 30% of subjects had undetectable levels of PCBs 28, 52, 101, and 128, α-chlordane, and γ-chlordane, and these organochlorines were not considered further. The distributions of organochlorines were positively skewed; therefore geometric means were used to describe the central tendency in controls and cases stratified by the pathology variables. Differences in the concentration of each organochlorine (log-transformed) between cases with different pathology characteristics while controlling for age were tested using two-way analysis of variance.

ORs were calculated as estimates of the relative risk for each subtype of breast cancer associated with exposure to organochlorines. For these analyses, exposure to organochlorines was examined in tertiles based on the distribution in controls. Subjects with undetected levels were included in the lowermost category if the detection limit of the organochlorine was below the first tertile. The remaining subjects with undetected levels were excluded because they could not be placed reliably in any category; if a subject's detection limit was above the first tertile cutpoint, it would be unclear whether the true concentration of that organochlorine in her breast adipose tissue was in the first tertile or the second tertile. Thus, at most six subjects were excluded from the analyses of PCB 105, PCB 183, *cis*-nonachlor, and Mirex.

All ORs were adjusted for age, site, and menopausal status. A confounder model was then built for each individual organochlorine based on a logistic model in which all cases were combined and compared to controls. Additional covariates were included in the model if their deletion caused any organochlorine OR to change more than 10% from the model saturated with all covariates. Polytomous logistic regression was used to estimate risk of breast cancer subtypes relative to the control group associated with exposure to each organochlorine using the SAS CATMOD procedure (SAS Institute, Cary, NC, USA). Each polytomous model was fit with the outcomes being defined by one pathology variable at a time. For example, one model would have three outcomes: ER-positive, ER-negative, and controls. A likelihood ratio test was performed to evaluate the significance of the organochlorine variable in a logistic model comparing one case subgroup with another case subgroup. The significance of this test indicated if heterogeneity existed in the associations between organochlorines and risk of different subtypes of breast cancer.

Results

ER assays were available for 201 cases. Of these, 111 cases had ER status determined by both the immunohistochemical assay and the enzyme immunoassay, and the concordance between the two assays was 94%. Overall, 51 (25%) were ER-negative and 150 (75%) were ER-positive. PR assays were available for 202 cases. Of these, 111 had PR status determined by both the immunohistochemical assay and the enzyme immunoassay, and the concordance between the two assays was 83%. Overall, 72 (36%) were PR-negative and 130 (64%) were PR-positive. The majority (75%) with missing receptor status had carcinoma *in situ*.

Histologic grade was available only for 169 cases with invasive ductal carcinomas since invasive lobular carcinomas and carcinoma *in situ* are not given an overall SBR grade. Of these, 27 (16%) were SBR grade I, 79 cases (47%) were SBR grade II, and 63 (37%) were SBR grade III. Grades I and II were combined for the analyses to ensure a sufficient sample size in each category of organochlorine exposure. Tumor size was available from the pathology reports of 198 (91%). Of these, 49 (25%) had tumors less than 1 cm in diameter,

83 (42%) had tumors between 1 and 1.9 cm, and 66 (33%) had tumors 2 cm or larger. The first two categories of size were combined to ensure a sufficient sample size in categories of exposure and for comparability to another study of the same issue [23]. All of the associations between ER status, PR status, tumor size, and tumor grade were significant ($p < 0.001$), except PR status and tumor size ($p = 0.5$).

A description of the controls and cases by the pathology variables with respect to selected covariates is shown in Table 1. The greatest differences by ER status were that, compared with ER-positive cases, ER-negative cases were younger, had a higher body mass index, and more were from Toronto, had ethnic background other than British or Canadian, and a negative family history. Large differences in the covariates by PR status were not evident, and thus are not shown. More cases with tumors 2 cm or larger in diameter were from Toronto than cases with smaller tumors. When cases were examined by tumor grade, cases with tumors of high grade were younger and more were from Toronto, had ethnicity other than British or Canadian, and had a negative family history than cases with low or medium grade tumors.

In general, the control group had lower breast adipose tissue concentrations of all organochlorines (Table 2) [22]. While adjusting for age, the concentration of PCBs 99, 138, 153, and 183, total PCBs, DDE, and β-HCH was higher in ER-negative than ER-positive cases ($p < 0.05$). The concentrations of organochlorines did not differ significantly between PR-negative and PR-positive cases, and thus are not shown. The concentration of *cis*-nonachlor and β-HCH was significantly higher in cases with larger tumors than cases with smaller tumors ($p < 0.05$). The concentration of PCBs 153 and 183, DDE, DDT, HCB, and β-HCH was higher

Table 1. Characteristics of controls and cases by tumor characteristics with respect to covariates

Covariate	Controls	ER		Size		Grade	
		Negative	Positive	<2 cm	≥2 cm	I/II	III
Continuous	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (years)	53.9 (10.9)	54.2 (11.0)	58.8 (11.6)	59.1 (11.5)	56.5 (11.7)	58.6 (11.4)	55.3 (11.5)
Lactation (months)	6.0 (12.9)	5.5 (9.2)	6.0 (8.9)	5.4 (8.3)	6.5 (10.0)	5.7 (9.0)	6.6 (9.7)
Body mass index (kg/m^2)	25.2 (4.3)	25.9 (4.7)	24.9 (4.4)	24.9 (4.4)	26.0 (4.8)	25.0 (4.6)	25.4 (4.3)
Fat intake (g/day)	34.8 (19.0)	39.0 (16.5)	39.4 (16.2)	39.9 (16.7)	38.3 (15.3)	40.0 (16.3)	38.1 (17.6)
Categorical	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Site							
Toronto	104 (48.8)	29 (56.9)	67 (44.7)	57 (43.2)	41 (62.1)	35 (33.0)	29 (54.7)
Kingston	109 (51.2)	22 (43.1)	83 (55.3)	75 (56.8)	25 (37.9)	71 (67.0)	24 (45.3)
Menopausal status							
Premenopausal	94 (44.1)	18 (35.3)	48 (32.0)	40 (30.3)	22 (33.3)	33 (31.1)	24 (38.1)
Postmenopausal	119 (55.9)	33 (64.7)	102 (68.0)	92 (69.7)	44 (66.7)	73 (68.9)	39 (61.9)
Ever pregnant							
No	33 (15.5)	9 (17.6)	27 (18.0)	21 (15.9)	14 (21.2)	21 (19.8)	9 (14.3)
Yes	180 (84.5)	42 (82.4)	123 (82.0)	111 (84.1)	52 (78.8)	85 (80.2)	54 (85.7)
Age last breast-fed							
Never	112 (52.6)	24 (47.1)	66 (44.0)	61 (46.2)	29 (43.9)	51 (48.1)	28 (44.4)
<30 years	56 (26.3)	10 (11.8)	40 (26.7)	38 (28.8)	13 (19.7)	29 (27.4)	11 (17.5)
≥30	45 (21.1)	17 (41.2)	44 (29.3)	33 (25.0)	24 (36.4)	26 (24.5)	24 (38.1)
Current use of hormone replacement therapy							
No	174 (81.7)	48 (94.1)	136 (90.7)	119 (90.2)	62 (93.9)	95 (89.6)	60 (95.2)
Yes	39 (18.3)	3 (5.9)	14 (9.3)	13 (9.8)	4 (6.1)	11 (10.4)	3 (4.8)
Ethnicity							
British	113 (53.6)	24 (47.1)	90 (60.4)	77 (58.8)	36 (54.5)	66 (62.9)	29 (46.0)
Canadian	14 (6.6)	6 (11.8)	16 (10.7)	18 (13.7)	4 (6.1)	12 (11.4)	8 (12.7)
Other	84 (39.8)	21 (41.2)	43 (28.9)	36 (27.5)	26 (39.4)	27 (25.7)	26 (41.3)
Family history							
No	142 (66.7)	38 (74.5)	81 (54.0)	77 (58.3)	42 (63.6)	58 (54.7)	44 (69.8)
Yes	71 (33.3)	13 (25.5)	69 (46.0)	55 (41.7)	24 (36.4)	48 (45.3)	19 (30.2)
Alcohol intake							
<1 drinks/week	107 (50.7)	31 (62.0)	86 (57.7)	74 (56.1)	43 (67.2)	63 (60.0)	39 (61.9)
≥1	104 (49.3)	19 (38.0)	63 (42.3)	58 (43.9)	21 (32.8)	42 (40.0)	24 (38.1)

Table 2. Geometric means of organochlorines with 95% confidence intervals for controls and cases by tumor characteristics

Organochlorine	Controls	Cases, by ER status		Cases, by tumor size		Cases, by grade	
		Negative	Positive	<2 cm	>2 cm	I or II	III
PCB 99 (μg/kg)	17.7 (16.2–19.3)	21.9 (18.2–26.4)	18.9 (17.1–21.0)	19.7 (17.7–21.9)	20.5 (17.5–24.1)	19.7 (17.7–21.9)	20.5 (17.6–23.9)
PCB 138 (μg/kg)	66.8 (62.1–71.9)	81.8 (68.6–97.4)	71.7 (66.2–77.7)	73.7 (67.8–80.1)	77.2 (67.4–88.5)	73.7 (67.8–80.1)	78.0 (67.1–90.7)
PCB 153 (μg/kg)	98.3 (91.8–105.3)	114.6 (96.9–135.5)	102.8 (95.4–110.9)	104.6 (96.6–113.3)	110.6 (97.3–125.9)	104.6 (96.6–113.3)	113.8 (98.2–131.9)
PCB 156 (μg/kg)	17.2 (16.0–18.5)	20.1 (17.1–23.6)	18.3 (17.0–19.8)	18.9 (17.6–20.3)	19.1 (16.7–22.0)	18.9 (17.6–20.3)	19.7 (17.0–22.9)
PCB 170 (μg/kg)	32.0 (29.7–34.4)	36.1 (30.4–42.8)	33.8 (31.4–36.4)	33.9 (31.4–36.5)	37.0 (32.2–42.5)	33.9 (31.4–36.5)	36.2 (31.2–42.1)
PCB 180 (μg/kg)	65.7 (61.5–70.2)	75.0 (63.9–88.1)	71.4 (66.5–76.7)	71.7 (66.6–77.2)	76.0 (66.6–86.8)	71.7 (66.6–77.2)	75.8 (65.8–87.4)
PCB 183 (μg/kg)	9.5 (8.8–10.2)	11.8 (9.9–14.0)	9.9 (9.1–10.8)	10.1 (9.2–11.0)	11.4 (10.0–13.2)	10.1 (9.2–11.0)	11.2 (9.6–13.0)
PCB 187 (μg/kg)	24.2 (22.6–26.0)	27.1 (22.6–32.5)	25.3 (23.3–27.6)	25.1 (22.8–27.5)	27.5 (23.8–31.8)	25.1 (22.8–27.5)	27.2 (23.3–31.9)
Total PCB (mg/kg)	0.87 (0.81–0.92)	1.02 (0.86–1.21)	0.92 (0.85–0.99)	0.94 (0.86–1.02)	0.98 (0.86–1.12)	0.94 (0.86–1.02)	1.00 (0.86–1.16)
DDE (μg/kg)	596 (530–670)	906 (682–1203)	638 (557–730)	693 (597–804)	768 (616–958)	693 (597–804)	781 (618–988)
DDT (μg/kg)	19.3 (17.3–21.6)	23.5 (17.3–32.0)	21.3 (18.8–24.1)	20.9 (18.3–24.0)	25.3 (19.7–32.5)	20.9 (18.3–24.0)	24.5 (18.7–32.0)
cis-Nonachlor (μg/kg)	6.0 (5.6–6.5)	6.2 (5.1–7.6)	5.9 (5.3–6.5)	5.6 (5.1–6.3)	6.8 (5.8–8.0)	5.6 (5.1–6.3)	6.2 (5.2–7.5)
trans-Nonachlor (μg/kg)	41.1 (38.7–43.6)	43.3 (36.5–51.3)	39.1 (35.6–43.0)	39.8 (35.6–44.4)	43.5 (38.8–48.8)	39.8 (35.6–44.4)	41.6 (36.6–47.2)
HCB (μg/kg)	30.1 (27.8–32.5)	34.9 (27.3–44.7)	31.0 (28.3–33.9)	31.0 (28.1–34.4)	35.2 (29.4–42.3)	31.0 (28.1–34.3)	35.8 (29.2–43.7)
β-HCH (μg/kg)	41.5 (36.1–47.6)	56.2 (38.3–82.3)	39.3 (34.7–44.5)	39.8 (34.8–45.6)	54.9 (40.9–73.7)	39.8 (34.8–45.6)	54.9 (40.1–75.2)

among cases with more poorly differentiated tumors than cases with moderately or well differentiated tumors ($p < 0.05$).

Risk estimates for the associations between organochlorines and breast cancer risk by the pathology variables are shown in Tables 3–6. Results are shown always for total PCBs and DDE, to facilitate comparison with other studies. The results for other organochlorines are also shown where heterogeneity existed in the associations with the risk of breast cancer between the subtypes at a liberal $p \leq 0.30$. That is, although none of the ORs differed significantly by subtype at $p < 0.05$, the results in which the ORs are most different by subtype are shown. Therefore, the risk estimates that are not shown were similar to those for the whole case group as previously reported [22].

Breast adipose tissue concentrations of all the PCBs and DDE were more strongly positively associated with risk of ER-negative breast cancer (Table 3). The OR for risk of ER-negative breast cancer in the uppermost tertile, compared with the lowest tertile, was elevated for DDE (OR 2.4; CI 1.0–5.4) and the *p*-value for the test of linear trend was 0.03. Breast adipose tissue concentrations of *trans*-nonachlor and β-HCH were more strongly negatively associated with risk of ER-positive breast cancer. The OR for ER-positive breast cancer in the uppermost tertile of *trans*-nonachlor was 0.5 (CI 0.3–0.9).

Risk estimates for the associations between organochlorines and PR-negative breast cancer risk and PR-positive breast cancer risk are shown in Table 4. The association between PCB 180 and PR-negative breast cancer risk was stronger than that with PR-positive breast cancer risk, but the OR for PR-negative breast cancer was highest in the second tertile.

Breast adipose tissue concentrations of the PCB congeners tended to be more strongly positively associated with risk of breast tumors of greater size than of lesser size (Table 5). Conversely, breast adipose tissue concentrations of DDE were only weakly associated with risk of tumors less than 2 cm in diameter, but were not associated at all with tumors 2 cm or larger.

Table 3. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to estrogen receptor status

Organochlorine	Controls	ER-negative		ER-positive	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 99[a]					
≤12 μg/kg	63	12	1.0	29	1.0
13–22	74	13	0.9 (0.4–2.3)	59	1.7 (0.9–3.2)
≥23	71	26	2.1 (0.9–5.0)	59	1.8 (0.9–3.6)
PCB 153[b]					
≤80 μg/kg	69	14	1.0	40	1.0
81–122	69	14	1.0 (0.4–2.3)	61	1.1 (0.6–2.0)
≥123	71	23	1.7 (0.7–3.9)	47	1.0 (0.5–1.8)
PCB 156[c]					
≤13 μg/kg	63	7	1.0	32	1.0
14–21	70	25	3.9 (1.5–10.2)	65	1.7 (0.9–3.1)
≥22	76	19	2.5 (0.9–6.7)	51	1.2 (0.6–2.2)
PCB 170[d]					
≤25 μg/kg	68	14	1.0	33	1.0
26–39	70	16	1.4 (0.6–3.1)	69	1.7 (1.0–3.0)
≥40	74	21	1.5 (0.7–3.3)	47	0.9 (0.5–1.6)
Total PCB[e]					
≤0.70 mg/kg	69	14	1.0	38	1.0
0.71–1.0	68	14	1.1 (0.5–2.7)	56	1.3 (0.8–2.4)
≥1.1	72	23	1.7 (0.8–3.9)	54	1.3 (0.7–2.3)
DDE[f]					
≤432 μg/kg	69	13	1.0	46	1.0
433–869	70	11	0.8 (0.3–2.1)	49	0.9 (0.5–1.6)
≥870	69	27	2.4 (1.0–5.4)	52	1.1 (0.6–1.9)
cis-Nonachlor[g]					
≤4.5 μg/kg	67	22	1.0	46	1.0
4.6–7.3	72	13	0.5 (0.2–1.1)	58	0.9 (0.5–1.7)
≥7.4	68	16	0.5 (0.2–1.2)	43	0.7 (0.4–1.2)
trans-Nonachlor[h]					
≤33 μg/kg	70	16	1.0	51	1.0
34–49	69	16	1.0 (0.5–2.3)	54	0.8 (0.5–1.4)
≥50	70	19	1.1 (0.5–2.4)	43	0.5 (0.3–0.9)
β-HCH[i]					
≤27 μg/kg	69	15	1.0	51	1.0
28–44	71	13	0.8 (0.3–1.9)	52	0.8 (0.4–1.4)
≥45	68	23	1.4 (0.6–3.2)	44	0.7 (0.4–1.3)

[a] ORs adjusted for age, site, menopausal status, lactation duration, age last breast-fed, current use of hormone replacement therapy, ethnicity, family history, body mass index, and intake of fat and alcohol.

[b] ORs adjusted for age, site, menopausal status, lactation duration, age last breast-fed, current use of hormone replacement therapy, ethnicity, and intake of fat and alcohol.

[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, family history, and intake of fat.

[d] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and body mass index.

[e] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.

[f] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

[g] ORs adjusted for age, site, menopausal status, age last breast-fed, ethnicity, and intake of fat.

[h] ORs adjusted for age, site, menopausal status, ethnicity, and intake of fat.

[i] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, family history, body mass index, and intake of fat and alcohol.

Table 4. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to progesterone receptor status

Organochlorine	Controls	PR-negative		PR-positive	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 180[a]					
≤0.54 μg/kg	70	11	1.0	33	1.0
0.55–81	69	31	2.6 (1.2–5.9)	50	1.4 (0.8–2.6)
≥82	73	30	1.9 (0.9–4.4)	46	1.1 (0.6–2.0)
Total PCB[b]					
≤0.70 mg/kg	69	17	1.0	35	1.0
0.71–1.0	68	27	1.4 (0.7–3.0)	44	1.2 (0.7–2.2)
≥1.1	72	28	1.4 (0.6–2.9)	49	1.4 (0.8–2.6)
DDE[c]					
432 μg/kg	69	21	1.0	38	1.0
433–869	70	18	0.7 (0.3–1.5)	43	1.0 (0.6–1.8)
≥870	69	33	1.5 (0.7–3.1)	46	1.3 (0.7–2.3)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and body mass index.
[b] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.
[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

Table 5. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to tumor size

Organochlorine	Controls	Size < 2 cm		Size ≥ 2 cm	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 187[a]					
≤17 μg/kg	63	34	1.0	14	1.0
18–29	75	51	1.1 (0.6–2.0)	22	1.4 (0.6–2.9)
≥30	73	46	0.9 (0.5–1.6)	30	1.6 (0.7–3.5)
Total PCB[b]					
≤0.70 mg/kg	69	30	1.0	17	1.0
0.71–1.0	68	51	1.6 (0.9–2.9)	21	1.2 (0.6–2.7)
≥1.1	72	50	1.5 (0.8–2.8)	26	1.5 (0.7–3.1)
DDE[c]					
≤432 μg/kg	69	35	1.0	20	1.0
433–869	70	43	1.1 (0.6–2.0)	19	0.9 (0.4–1.8)
≥870	69	53	1.6 (0.9–2.9)	25	1.1 (0.5–2.4)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and ethnicity.
[b] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.
[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

Risk estimates for the association between organochlorines and breast cancer risk by grade are shown in Table 6. The ORs for all the PCBs and DDE were only slightly higher with risk of breast cancer of a higher grade than the risk of breast cancer of a low or medium grade.

Discussion

Concentrations of organochlorines were almost always higher in cases with tumors of poorer prognosis (ER-negative, PR-negative, size ≥ 2 cm, grade III) than in cases with tumors of better prognosis (ER-positive, PR-positive, size < 2 cm, grade I/II). Geometric means differed significantly by ER status and tumor grade for several organochlorines while adjusting for age. However, when all confounders were taken into account, associations between the organochlorines and breast cancer did not differ significantly by subtype of breast cancer as defined by either ER, PR, tumor size, or tumor grade. The risk estimates for ER-negative breast cancer with PCBs and DDE remained nonsignificantly higher

Table 6. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to tumor grade

Organochlorine	Controls	Grade I or II		Grade III	
		Cases	OR (95% CI)	Cases	OR (95% CI)
Total PCB[a]					
≤0.70 mg/kg	69	29	1.0	17	1.0
0.71–1.0	68	37	1.2 (0.7–2.3)	19	1.2 (0.5–2.5)
≥1.1	72	38	1.2 (0.6–2.4)	27	1.5 (0.7–3.2)
DDE[b]					
≤432 μg/kg	69	34	1.0	18	1.0
433–869	70	31	0.7 (0.4–1.4)	20	1.1 (0.5–2.2)
≥870	69	38	1.1 (0.6–2.1)	25	1.4 (0.6–3.1)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.

[b] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

than for ER-positive breast cancer. PCBs also tended to be more strongly positively associated with risk of larger and higher grade tumors.

Only some studies of organochlorines and breast cancer risk have included analyses by hormone receptor status. Of these, some have found no significant difference between ER-positive and ER-negative cases in mean levels for the array of contaminants measured in our study [23], total PCBs and DDE [16, 24], β-HCH [25], or HCB [26]. We also observed no difference between age-adjusted mean levels of total PCBs and HCB, but mean levels of β-HCH and some specific PCB congeners did differ. Others have also reported no difference in risk estimates either between ER-negative and ER-positive breast cancer, or excluding ER-negative cases from the analysis, for total PCBs [9, 10, 27], noncoplanar PCBs [6], and DDE [6, 9, 10, 13, 27]; these observations are similar to our study in that no statistically significant difference was found. However, higher risk among ER-positive cases was reported for DDE in one study [21], and for coplanar PCBs (PCBs 77, 126, 169) [6].

Some factors may help explain the discrepancies between studies. In some studies it is not clear whether age and other covariates were taken into account. Many publications did not present data, and only noted in the text that organochlorine levels did not differ by ER status. It is not clear if levels were nonsignificantly different between cases by ER status and if these differences were in a consistent direction for all the contaminants.

The rationale for investigating risk by hormone receptor status is that receptor-positive tumors are responsive to hormones and, therefore, to agents such as organochlorines that are hypothesized to act as hormone mimics. The natural history of breast cancer may involve a progression from ER-positive disease to ER-negative disease [28]. Therefore, receptor-negative disease may have been ER-positive at the critical time in cancer induction. However, in our study this is not supported by the observation that subjects with ER-negative tumors were younger than subjects with ER-positive tumors. The PCBs that were found to be higher in ER-negative cases were those that are dioxin-like and potentially antiestrogenic [29].

One possible explanation for the slightly higher risk estimates seen for ER-negative breast cancer in our study is that tumors that are receptor-negative when diagnosed may have a faster rate of progression than tumors that are receptor-positive when diagnosed. Demers and colleagues [23] observed that, among cases, the risk of having a tumor that was aggressive as defined by higher stage and size was associated with some organochlorines. Similarly, cases with high levels of an organochlorine pesticide, dieldrin, had poorer survival than cases with lower levels in a Danish study [30]. Therefore, higher levels of organochlorines may increase the aggressiveness of the tumor. Alternatively, the risk associated with organochlorines and ER-negative disease is truly the same as the risk associated with ER-positive disease, but the risk appears to be stronger for ER-negative disease because the critical time period for exposure for this more aggressive tumor is closer to the time of diagnosis than that for ER-positive tumors. The apparent difference in risk may appear because exposure would be misclassified less for subjects with ER-negative disease than subjects with ER-positive disease.

In this study, women with ER-negative tumors, larger tumor size and grade were more likely to be from Toronto than from Kingston. This raises the possibility that, in Toronto, tumors were rated more highly in

terms of these factors than they may have been rated in Kingston. A central review of the slides was not done; previous collaborative work between these two centers found good between-center comparability of steroid receptor assays (unpublished observations). However, it is also possible that the tumors in Kingston were diagnosed earlier because an active screening program existed there. Also, analyses stratified by study site tended to support the results of the combined group although they were slightly unstable due to small sample sizes.

This study was one of the largest to date to report the associations between breast cancer risk by several tumor characteristics and a broad range of organochlorines measured in breast adipose tissue. Measures made in adipose tissue have the advantage over measures made in blood because they provide a good measure of cumulative internal exposure at the target site for breast cancer [31, 32]. Also, since the concentrations of organochlorines are 200–1000 times higher in adipose tissue than in blood, even small samples have detectable levels. Another advantage of this study was the virtually complete information about the tumor characteristics. Although this study had a large sample size compared to other studies of organochlorines and breast cancer risk, it had insufficient precision to detect differences in risk by the tumor characteristics presented in this paper, and also had too little statistical power to examine risk by joint ER/PR status. Differences in other studies have been found within the ER-positive cases by PR status [20, 33, 34].

In summary, these data suggest that organochlorines may be more strongly related to breast tumors that have poorer prognosis, but larger studies are needed to confirm this finding. Further research is needed to investigate the natural history of breast tumors that have different pathological characteristics as defined by extent of disease and various tumor markers. Research is also needed to investigate the possibility that hormone receptor levels in benign tissue are associated with breast cancer risk and may influence the susceptibility to other risk factors. To date, only one study has been published on this issue [35], and our group is also presently examining this as an extension to this study.

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Breast Adipose Tissue Concentrations of Polychlorinated Biphenyls and Other Organochlorines and Breast Cancer Risk[1]

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Abstract

Numerous studies have examined the relationship between organochlorines and breast cancer, but the results are not consistent. In most studies, organochlorines were measured in serum, but levels in breast adipose tissue are higher and represent cumulative internal exposure at the target site for breast cancer. Therefore, a hospital-based case-control study was conducted in Ontario, Canada to evaluate the association between breast cancer risk and breast adipose tissue concentrations of several organochlorines. Women scheduled for excision biopsy of the breast were enrolled and completed a questionnaire. The biopsy tissue of 217 cases and 213 benign controls frequency matched by study site and age in 5-year groups was analyzed for 14 polychlorinated biphenyl (PCB) congeners, total PCBs, and 10 other organochlorines, including p,p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene. Multiple logistic regression was used to assess the magnitude of risk. While adjusting for age, menopausal status, and other factors, odds ratios (ORs) were above 1.0 for almost all organochlorines except five pesticide residues. The ORs were above two in the highest concentration categories of PCB congeners 105 and 118, and the ORs for these PCBs increased linearly across categories (*P*s for trend ≤0.01). Differences by menopausal status are noted especially for PCBs 105 and 118, with risks higher among premenopausal women, and for PCBs 170 and 180, with risks higher among postmenopausal women. Clear associations with breast cancer risk were demonstrated in this study for some PCBs measured in breast adipose tissue.

Introduction

Organochlorines, a class of 15,000 chlorine-containing organic chemicals, including DDT[3] and 209 PCB congeners, have been widely used in the past in industrial applications and as pesticides. Some are resistant to degradation and are very lipid soluble and therefore, have persisted in the environment and have biomagnified up the food chain to humans (1). The general population is exposed to organochlorines through many commonly eaten foods but also through water, ambient and indoor air, dust, and soil (2, 3). As a result, several organochlorines are now detectable in most human serum, adipose tissue, and breast milk.

Studies in animals have lead to a consensus that DDT, its metabolite DDE, and other related pesticides and chemicals are known animal and suspected human carcinogens (4, 5). PCBs have produced liver cancer in rats and are classified as probable human carcinogens (4, 6). Organochlorines have been studied with respect to breast cancer due to the potential to act as direct carcinogens or as indirect carcinogens by mimicking the action of estrogen, interfering with intercellular communication, inducing cytochrome p450 enzymes in humans, and disrupting immune function (7–10). Because known risk factors for breast cancer do not account for all cases, it is reasonable to investigate as potential risk factors chemicals that persist in the environment, accumulate in humans, and for which a plausible biological mechanism of action exists.

Nineteen epidemiological studies have been published examining breast cancer risk in relation to organochlorines (11–31). In some, compared with controls, women with breast cancer had higher levels of some chlorinated compounds, including total PCBs, some PCB congeners, DDE, and the pesticides, β-HCH, HCB, and dieldrin (11, 13, 20, 22–25, 28). In others, compared with controls, cases had lower concentrations or similar levels of DDE (11, 12, 14–16, 18, 19, 26, 27, 31), β-HCH (11, 29), and HCB (30). Some researchers also have found increased risks associated with some PCBs, DDE, and the pesticide, Mirex, in subgroups defined by estrogen receptor status of cases, lactation status, or CYP1A1 polymorphisms (17, 21, 32). Considered together, the relationship between the

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[3] The abbreviations used are: DDT, 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane; DDE, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)-ethylene; BBD, benign breast disease; BMI, body mass index; CI, confidence interval; GM, geometric mean; HCB, hexachlorobenzene; β-HCH, β-hexachlorocyclohexane; OR, odds ratio; PCB, polychlorinated biphenyl; HRT, hormone replacement therapy.

organochlorines investigated and breast cancer risk is not consistent (for review, see Refs. 33 and 34).

In most studies, organochlorines were measured in serum (11–20), whereas only small studies and one recent larger study have measured these chemicals in breast adipose tissue (21–26, 28–31). In humans, adipose tissue levels are 200-1000 times higher than levels in serum (35–38). Therefore, even small samples of adipose tissue have organochlorine compounds in the detectable range and are more suitable for congener-specific analyses (39). Congener-specific analyses are important because individual congeners have been shown to have different biological activity (40). Finally, organochlorines measured in breast adipose tissue provide a good measure of cumulative internal exposure at the target site for breast cancer, accounting for all routes and sources of exposure (41, 42). To evaluate the association between breast cancer risk and breast adipose tissue concentrations of several persistent organochlorines, a hospital-based case-control study was conducted in the province of Ontario, Canada between July 1995 and June 1997.

Materials and Methods

Subjects. Women under the age of 80 were enrolled by their surgeons at Women's College Hospital in Toronto and Kingston General Hospital in Kingston when they were being scheduled for excision biopsy of suspected breast cancer. Women were excluded if they had a previous diagnosis of any cancer except nonmelanoma skin cancer, had breast implants, were participating in a Tamoxifen trial, or were too ill. Of the 824 eligible women, 735 (89%) agreed to participate and signed informed consent. Following biopsy, pathology records were reviewed. Cases were subjects diagnosed with *in situ* or invasive breast cancer. Controls were subjects with biopsies negative for malignancy, but most were diagnosed with some form of BBD.

A questionnaire providing information about known and suspected risk factors for breast cancer was completed by 663 women (80.5% of those eligible) by telephone interview or by mail. Seventy-two women who had originally agreed to participate were unreachable after at least eight attempts made at different times of the day and different days, had phone numbers that were not in service and were not listed in the telephone directory, or found they were too anxious about their biopsy to complete the questionnaire. Because no information was obtained from these women, it is unknown if they were different from the women who completed a questionnaire except that more were from Toronto (90%), a large metropolitan area. Answers to the questionnaire were recorded by a trained interviewer (91%) or the questionnaires were received by mail (9%); most (60%) were received before the subject's biopsy date. The majority of questionnaires were received before participants knew their diagnosis.

The questionnaire included demographics, menopausal status, weight at age 25 and two years prior to interview, height, reproductive history variables, use of exogenous hormones, physical activity and diet variables, and family history of breast cancer. Subjects who reported that their menstrual periods had stopped permanently were classified as postmenopausal except those who had a hysterectomy in the absence of bilateral oophorectomy and were under the mean age of menopause of the subjects having a natural menopause (49 years); these six subjects were classified as premenopausal. Those who reported that a first or second degree relative had breast cancer were classified as having a family history of breast cancer. Ethnicity was coded to Statistics Canada groupings used for the census of the population (43), where British referred to those with British, Scottish, Irish, or Welsh ancestry and Canadian referred to those with native or aboriginal ancestry. The rest of the ethnic groups were collapsed together into one category.

The food frequency section of the questionnaire, which was used to record the consumption of 67 foods two years before the interview, was used to create indices of intake of nutrients and foods within the major groups. The food frequency questionnaire was based on that developed by Jain *et al.* (44) for a similar population (*i.e.,* Ontario women undergoing mammography), but it was modified to take into account foods, especially those high in animal fat, that contribute significantly to organochlorine exposure (2). A standard table of nutritive contents based on the Canadian Nutrient File was used to assign nutrient values to the food on the questionnaire (45).

Organochlorines were determined in all cases for whom enough tissue was available ($n = 217$) as well as in a subset of controls frequency matched by age in 5-year groups and study site ($n = 213$). Those with organochlorine concentrations analyzed differed from those without this analysis in a few respects. Among the cases, the 50 women without enough breast tissue to analyze were younger (by a mean of about 4 years), had a lower BMI, and a higher proportion were premenopausal and from Toronto. Among the controls, the 183 not analyzed for organochlorines were much younger than those analyzed because this group was frequency matched by age to cases. The controls not analyzed also had a lower BMI, and a lower proportion were from Toronto, were ever pregnant, were of British ethnicity, and had a negative family history of breast cancer.

Tissue Analysis. Approximately 0.2–1 g of benign tissue taken during the breast biopsy was frozen in a glass vial at −70°C. Samples, labeled only with identification numbers to conceal case-control status, were shipped to Le Center de Toxicologie du Québec on ice and kept at −20°C. Levels of 14 PCB congeners (International Union of Pure and Applied Chemists nos. 28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, and 187) and total PCBs were determined. Total PCBs was calculated as the sum of PCBs 138 and 153 multiplied by 5.2 to approximate a level of the commercial PCB mixture, Aroclor 1260. This approximates the measurement of total PCBs using older analytic techniques. Levels of 10 organochlorinated pesticides were also determined (p,p′-DDT, p,p′-DDE, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, HCB, Mirex, and β-HCH, α-chlordane, and γ-chlordane).

Samples were analyzed in batches of 5–10, each batch containing samples from both cases and controls randomly selected from the pool of subjects to be analyzed. Laboratory personnel were blind to case-control status. A polar extract of lipids was obtained. The sample was cleaned on Florosil columns, concentrated, and analyzed on a Hewlett Packard 5890 series II gas chromatograph with dual capillary columns and dual Ni-63 electron capture detectors. Peaks were identified by their relative retention times obtained from the two columns and quantified (46–48). The percentage of lipids in each sample was determined in a portion of the extracted samples, and the concentrations of the organochlorines were expressed in micrograms per kilogram of lipid. The instrument detection limits were set at three times the average SD of background and were, on a wet weight basis, 3 μg/kg for total PCBs, 0.6 μg/kg for p,p′-DDT and β-HCH, and 0.3 μg/kg for the rest of the organochlorines determined. The detection limits on a lipid basis depend on the sample weight and the percentage of lipids in the sample and therefore, vary by subject.

For each batch, two references were used. A nonextracted verification standard containing PCB congeners and organochlorines at concentrations of 10 μg/kg was run at the beginning of each batch to check the performance of the columns and the sensitivity of the detectors. An extracted verification standard was run to calculate the relative response factors. Le Centre de Toxicologie du Québec is accredited by the Canadian Association for Environmental Analytical Laboratories and participates in many quality assurance/quality control programs, including the Great Lakes Research Program's Quality Assurance/Quality Control Project of the Community Public Health Agency in Michigan and the Environment Canada's Arctic Environment Strategy's Quality Assurance/Quality Control Program.

Statistical Analyses. Because >30% of subjects had undetectable levels of PCBs 28, 52, 101, and 128, α-chlordane, and γ-chlordane, these organochlorines were not considered further. The distributions of organochlorines in adipose tissue were positively skewed and, therefore, were log-transformed to improve normality. The GMs and associated 95% CIs were calculated in cases and controls. Associations among organochlorines were investigated by calculating the Pearson correlation coefficient (r) on log-transformed organochlorine concentrations. Associations between age and the organochlorines were investigated by calculating the Spearman correlation coefficient (r_s).

Exposure to organochlorines was examined in four categories. To form a relatively extreme uppermost exposure category with an adequate number of subjects, the cutpoint for the upper category was at the 85th percentile. The first three categories were formed by dividing the distribution of controls with detectable levels into thirds below the 85th percentile (*i.e.*, cutpoints were at the 28th and 57th percentiles). Subjects with undetectable levels were included in the lowermost category if their detection limit of the organochlorine was below the 28th percentile. The remaining subjects with undetectable levels were excluded because their detection limits were above the cutpoint for the first category, and they could not be reliably placed in either the first or the second category. Eight subjects were excluded from the PCB 105 analysis, one from the PCB 183 analysis, three from the *cis*-nonachlor analysis, and three from the Mirex analysis.

To estimate breast cancer risk associated with exposure to each substance, unconditional logistic regression was used to calculate ORs and associated two-sided 95% CIs (49) using EGRET (Cytel Software, Cambridge, MA). All ORs were adjusted for age (continuous), site (Toronto/Kingston), and menopausal status (pre/post). Of the many covariates measured in the questionnaire, those that were included in a model built by a forward selection procedure and were associated with breast cancer risk at $P < 0.3$ were further tested as confounders. This model included the variables in Table 1 plus use of HRT (never/ever), age at menarche (<12/≥12 years), and duration of oral contraceptive use. To make an even more parsimonious confounder model for each organochlorine, these covariates were then modeled with the organochlorine exposure variable and kept in the confounder model if their deletion caused any organochlorine OR to change >10% from the model saturated with all of the additional covariates. The covariates that were confounders in the analyses of each organochlorine are shown in the "Appendix." Within the subset of 150 cases and 152 controls for whom digitized mammographic density was available, inclusion of this variable did not change ORs associated with the organochlorine variables and so was not included in confounder models.

Table 1 Characteristics of cases and controls with respect to covariates

Covariate	Mean (SD) or *n* (%)	
	Cases	Controls
Age (yr)	57.7 (11.6)[a]	53.9 (10.9)[a]
Site		
Toronto	102 (47.0%)	104 (48.8%)
Kingston	115 (53.0%)	109 (51.2%)
Menopausal status		
Premenopausal	74 (34.1%)	97 (45.5%)
Postmenopausal	143 (65.9%)	116 (54.5%)
Ever pregnant		
No	37 (17.1%)	33 (15.5%)
Yes	180 (82.9%)	180 (84.5%)
Lactation (mo)	5.8 (8.9)	6.0 (12.9)
Age last breast fed		
Never	98 (45.2%)	112 (52.6%)
<30 yr	54 (28.9%)	56 (26.3%)
≥30	65 (30.0%)	45 (21.1%)
Present use of hormone replacement therapy		
No	199 (91.7%)	174 (81.7%)
Yes	18 (8.3%)	39 (18.3%)
Ethnicity		
British	123 (56.9%)	113 (53.6%)
Canadian	24 (11.1%)	14 (6.6%)
Other	69 (31.9%)	84 (39.8%)
Family history		
No	129 (59.4%)	142 (66.7%)
Yes	88 (40.6%)	71 (33.3%)
BMI (kg/m^2)	25.2 (4.4)	25.2 (4.3)
Fat intake (g/day)	39.1 (16.0)	34.8 (19.0)
Alcohol intake (drinks/wk)		
<1	130 (60.5%)	107 (50.7%)
≥1	85 (39.5%)	104 (49.3%)
Present smoking		
No	182 (83.9%)	162 (76.1%)
Yes	35 (16.1%)	51 (23.9%)
Cumulative smoking (pack-yr)	11.3 (16.4)	10.0 (15.7)

[a] Mean age of premenopausal cases was 45.7 (5.5) and that of controls was 45.2 (5.3). Mean age of postmenopausal cases was 63.9 (8.5) and that of controls was 61.2 (8.8).

ORs were calculated for the whole sample and by menopausal status, the latter derived from one model with an interaction term between the organochlorine variable and menopausal status. ORs were calculated by menopausal status to improve comparability to other studies that have included only postmenopausal women (17, 27) and because it is hypothesized that premenopausal and postmenopausal breast cancer are distinct diseases and, therefore, risk factors may be related differently to each (50). To examine the modification of effects by other risk factors, interaction terms between organochlorine variables and the variables in the confounder models were examined. The hypothesis proposed by Moysich and colleagues (17), that breast cancer risk related to Mirex and some PCBs among postmenopausal parous women may differ by lactation, was also tested by including an interaction term between the organochlorine variable and lactation status (never/ever). To examine the effect of using only cases with invasive cancers and controls with nonproliferative BBD, ORs were also calculated among this subgroup while excluding cases with carcinoma *in situ* and controls with hyperplasia with or without atypia or papillomas.

Table 2 GMs of organochlorines with 95% CIs among those with detectable levels by case-control status

Organochlorine	GM (95% CI)	
	Cases	Controls
PCB 99 (μg/kg)	19.5 (17.9–21.2)	17.7 (16.2–19.3)
PCB 105 (μg/kg)	7.1 (6.4–7.8)	6.3 (5.7–7.0)
PCB 118 (μg/kg)	30.3 (27.7–33.2)	24.7 (22.4–27.3)
PCB 138 (μg/kg)	73.8 (68.9–79.1)	66.8 (62.1–71.9)
PCB 153 (μg/kg)	105.2 (98.5–112.3)	98.3 (91.8–105.3)
PCB 156 (μg/kg)	18.6 (17.5–19.9)	17.2 (16.0–18.5)
PCB 170 (μg/kg)	34.3 (32.1–36.6)	32.0 (29.7–34.4)
PCB 180 (μg/kg)	71.9 (67.5–76.5)	65.7 (61.5–70.2)
PCB 183 (μg/kg)	10.3 (9.6–11.1)	9.5 (8.8–10.2)
PCB 187 (μg/kg)	25.7 (23.9–27.7)	24.2 (22.6–26.0)
Aroclor 1260 (mg/kg)	0.94 (0.88–1.00)	0.87 (0.81–0.92)
p,p′-DDE (μg/kg)	693 (615–780)	596 (530–670)
p,p′-DDT (μg/kg)	22.0 (19.6–24.7)	19.3 (17.3–21.6)
cis-nonachlor (μg/kg)	6.0 (5.5–6.5)	6.0 (5.6–6.5)
trans-nonachlor (μg/kg)	40.4 (37.4–43.6)	41.1 (38.7–43.6)
oxychlordane (μg/kg)	30.4 (28.6–32.3)	30.5 (28.8–32.2)
HCB (μg/kg)	32.0 (29.3–34.8)	30.1 (27.8–32.5)
Mirex (μg/kg)	9.0 (8.1–10.0)	9.9 (8.8–11.2)
β-HCH (μg/kg)	43.1 (38.0–48.9)	41.5 (36.1–47.6)

Results

Table 1 provides summary descriptive information on study subjects with respect to covariates that were included in at least one confounder model. Cases are on average 4 years older than controls because not enough controls were in the older age groups to satisfy the frequency matching requirements. Related to this, a higher proportion of cases are postmenopausal. Fewer cases than controls presently use HRT, possibly because use of HRT increases the false-positive rate of mammography (51). More cases than controls have been pregnant, and although more have breast fed, cases breast fed for a shorter time, and more have last breast fed after 30 years of age. More cases are of British or Canadian ethnicity and have a family history of breast cancer in first or second degree relatives. Cases also have higher average dietary fat and BMI than controls, and more cases drink less than one alcoholic beverage per week and presently do not smoke.

The GMs of the organochlorine concentrations measured in breast adipose tissue are seen in Table 2. The more highly chlorinated PCBs, 138, 153, 156, 170, 180, 183, and 187, are very highly correlated with each other ($0.74 \leq r \leq 0.98$), but correlations with the less chlorinated PCBs, 99, 105, and 118, tend to be lower ($0.42 \leq r \leq 0.83$). Correlations between the PCBs and the organochlorinated pesticides, and among the organochlorinated pesticides, also tend to be lower ($0.03 \leq r \leq 0.80$). Cases have higher levels of almost all of the organochlorines measured, but organochlorines bioaccumulate and thus, their levels are associated with age ($0.10 \leq r_s \leq 0.48$; all Ps < 0.05). Therefore, all further analyses are controlled for age.

Risk estimates for the whole sample and by menopausal status for the association between breast cancer and PCBs adjusted for confounders are presented in Table 3, and those for the other organochlorines are presented in Table 4. The covariates that are confounders in the analyses of each organochlorine are shown in the "Appendix." For the whole sample, ORs are above 1.0 for almost all organochlorines except *cis*- and *trans*-nonachlor, oxychlordane, HCB, and β-HCH. Breast cancer risk is elevated most notably for PCBs 105 and 118, but risk is not elevated for most other substances. The magnitude of the risk is above two in the highest concentration categories of PCBs 105 and 118, and the ORs for these PCBs increase linearly across categories (Ps for trend ≤ 0.013). Differences by menopausal status are noted for many PCB congeners, with risks higher among postmenopausal women for PCBs 170 and 180 and higher among premenopausal women for PCBs 105 and 118. However, only the interaction term between menopausal status and PCB 170 is significant at the $\alpha = 0.05$ level.

Breast cancer risk associated with Mirex, but not other organochlorines, among postmenopausal parous women differs by lactation (P for interaction $= 0.050$; Table 5). Increases are clear among those who have never lactated, with the OR in the uppermost category above 4 (P for trend $= 0.08$). Risks among those who had lactated are reduced in the upper categories of Mirex.

Additional analyses investigating possible interactions between organochlorines and covariates in each of the confounder models indicate that estimated dietary fat and present HRT interact with some organochlorines. To explore this interaction with fat, intake was categorized by the median among controls (33.1 g/day). Differences in the association between organochlorines and breast cancer risk by dietary fat are not consistent across the organochlorines or across the levels of each organochlorine, but the ORs for PCBs 105 and 118 are higher among those with higher levels of fat intake (>33.1 g/day; data not shown).

Too few subjects presently use HRT to do a subgroup analysis. When present users are excluded, ORs are generally similar to those for the whole sample with some exceptions. ORs are increased in the upper categories for PCB 105 (third category: 2.6; 95% CI, 1.3–4.9; fourth category: 4.3; 95% CI, 1.9–9.8) and PCB 118 (third category: 2.1; 95% CI, 1.1–4.3; fourth category: 2.6; 95% CI, 1.2–5.8). The OR in the fourth category of p,p′-DDE is also increased (OR $= 2.0$; 95% CI, 1.0–4.2).

Dietary fat can be conceptualized as a confounder, independently related to the body burden of organochlorines and possibly to breast cancer risk. However, because dietary fat is a major source of persistent organochlorines, it could instead be hypothesized as part of the causal pathway between organochlorines and breast cancer. If so, it should not be included in confounder models. Reanalysis excluding fat from confounder models in which it had been included reveals no changes in ORs large enough to change conclusions from the results in Tables 3 and 4 (data not shown).

Results from additional analyses conducted to understand the effect of including only cases with invasive cancer and controls with nonproliferative BBD show that exclusion of the 27 carcinoma *in situ* cases consistently leads to very slightly reduced ORs compared to the whole sample. Excluding the 80 controls with proliferative BBD consistently results in slightly higher ORs for the uppermost category of chemical concentration and conclusions identical to those made for the whole sample. When excluding both *in situ* cases and proliferative BBD controls, most ORs increase slightly compared to those for the whole sample, and PCBs 105 and 118 remain associated with increased risk at the highest categories of concentration.

Discussion

This study demonstrates increased breast cancer risk associated with the breast adipose tissue concentrations of some specific PCB congeners, but inconsistent or null results for the other compounds that were measured. Among the total sample, PCBs 105 and 118 were associated consistently with breast cancer risk. Among premenopausal women, the risk estimates for PCBs 105 and 118 were even higher. Among postmenopausal women, risk estimates for PCBs 170 and 180 were elevated but

Table 3 Frequencies of breast cancer cases and controls by tissue concentration of PCBs and menopausal status and ORs with 95% CIs

Tissue concentration	Whole sample OR[a] (95% CI)	Premenopausal			Postmenopausal		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
PCB 99							
≤11 μg/kg	1.00	23	31	1.00	16	20	1.00
12–18	1.41 (0.77–2.60)	21	37	0.95 (0.42–2.16)	40	25	2.20 (0.87–5.52)
19–29	1.40 (0.75–2.62)	19	15		42	42	
≥30	1.92 (0.95–3.86)	9	11	1.63 (0.71–3.72)	43	27	1.70 (0.74–3.91)
PCB 105							
≤4.1 μg/kg	1.00	25	46	1.00	29	24	1.00
4.2–6.1	1.16 (0.62–2.14)	12	24	1.29 (0.52–3.20)	25	31	0.89 (0.38–2.06)
6.2–12	2.03 (1.12–3.68)	23	13		49	38	
≥13	3.17 (1.51–6.68)	7	6	3.91 (1.73–8.86)	37	21	1.49 (0.70–3.16)
PCB 118							
≤16 μg/kg	1.00	24	38	1.00	19	20	1.00
17–27	1.25 (0.68–2.29)	19	35	1.04 (0.46–2.35)	30	25	1.39 (0.57–3.41)
28–49	1.88 (1.00–3.55)	20	13		50	44	
≥50	2.31 (1.11–4.78)	8	7	2.85 (1.24–6.52)	41	25	1.58 (0.70–3.58)
PCB 138							
≤50 μg/kg	1.00	27	38	1.00	19	22	1.00
51–71	1.38 (0.79–2.42)	24	31	1.19 (0.56–2.54)	38	28	1.65 (0.71–3.83)
72–112	1.55 (0.86–2.80)	14	16		52	41	
≥113	1.56 (0.80–3.06)	8	10	1.52 (0.69–3.35)	32	23	1.69 (0.79–3.60)
PCB 153							
≤75 μg/kg	1.00	29	36	1.00	16	21	1.00
76–105	1.28 (0.71–2.30)	20	30	0.88 (0.40–1.93)	47	30	2.01 (0.84–4.79)
106–167	1.32 (0.72–2.40)	18	17		49	42	
≥168	1.04 (0.51–2.11)	6	12	1.06 (0.48–2.34)	29	21	1.61 (0.72–3.63)
PCB 156							
≤12 μg/kg	1.00	23	36	1.00	17	20	1.00
13–18	1.99 (1.12–3.53)	28	28	1.90 (0.87–4.13)	48	31	2.09 (0.90–4.86)
19–28	1.38 (0.76–2.49)	15	17		49	44	
≥29	1.35 (0.68–2.69)	7	14	1.35 (0.61–2.98)	27	19	1.41 (0.65–3.06)
PCB 170							
≤23 μg/kg	1.00	24	29	1.00	16	25	1.00
24–34	1.60 (0.92–2.78)	24	35	0.83 (0.39–1.78)	51	27	3.27 (1.44–7.44)
35–53	1.09 (0.61–1.96)	16	17		48	45	
≥54	1.15 (0.60–2.22)	9	15	0.89 (0.41–1.91)	28	19	1.63 (0.77–3.45)
PCB 180							
≤51 μg/kg	1.00	24	32	1.00	17	25	1.00
52–71	1.56 (0.90–2.70)	26	31	1.07 (0.51–2.27)	46	31	2.43 (1.09–5.43)
72–105	1.21 (0.68–2.14)	17	22		47	38	
≥106	1.27 (0.66–2.46)	6	11	0.89 (0.42–1.91)	33	22	1.77 (0.85–3.69)
PCB 183							
≤7.0 μg/kg	1.00	28	36	1.00	25	24	1.00
7.1–10	0.97 (0.55–1.71)	19	29	0.99 (0.44–2.22)	30	28	0.94 (0.42–2.10)
11–16	1.23 (0.71–2.14)	18	18		57	41	
≥17	1.27 (0.66–2.45)	8	11	1.37 (0.63–2.96)	29	21	1.16 (0.58–2.33)
PCB 187							
≤16 μg/kg	1.00	27	29	1.00	21	18	1.00
17–25	0.77 (0.44–1.36)	21	31	0.75 (0.35–1.64)	35	36	0.82 (0.36–1.85)
26–39	0.84 (0.48–1.48)	15	22		49	41	
≥40	1.26 (0.66–2.40)	11	14	0.86 (0.41–1.83)	37	20	1.08 (0.52–2.28)
Aroclor 1260							
≤0.67 mg/kg	1.00	31	38	1.00	19	21	1.00
0.68–0.92	1.13 (0.64–1.98)	19	29	0.86 (0.40–1.87)	42	31	1.52 (0.66–3.49)
0.93–1.4	1.41 (0.79–2.52)	18	17		48	37	
≥1.5	1.15 (0.58–2.25)	5	11	1.24 (0.58–2.66)	32	25	1.53 (0.71–3.30)

[a] Adjusted for age, study site, menopausal status, and confounders listed in the "Appendix."

did not follow a clear linear trend across categories. The only increased risk found for p,p′-DDE was among a subgroup excluding present HRT users. Among postmenopausal women who were parous but had never lactated, increased risk was apparent for Mirex.

Only a handful of studies can be directly compared with this study because they have used breast adipose tissue to quantify organochlorine levels (21–26, 28–31). Of the studies that examined the PCB congeners for which an association was found with breast cancer in this study, one found a higher risk for PCB 118 (23) and another found that PCB 118 was lower among estrogen receptor-negative cases compared with controls but no difference with PCB 105 (21). Also in agreement with this study, many have found a lack of a convincing

Table 4 Frequencies of breast cancer cases and controls by tissue concentrations of organochlorinated pesticides and menopausal status and ORs with 95% CIs

Tissue concentration	Whole sample OR[a] (95% CI)	Premenopausal			Postmenopausal		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
p,p′-DDE							
≤368 μg/kg	1.00	31	41	1.00	24	19	1.00
369–727	0.96 (0.55–1.68)	20	31	0.75 (0.34–1.62)	39	30	1.15 (0.50–2.63)
728–1389	0.92 (0.51–1.67)	10	17		44	42	
≥1390	1.62 (0.84–3.11)	13	8	1.52 (0.70–3.33)	36	25	1.05 (0.50–2.19)
p,p′-DDT							
≤12 μg/kg	1.00	26	31	1.00	32	27	1.00
13–20	0.82 (0.47–1.43)	19	36	0.54 (0.24–1.21)	37	26	1.20 (0.55–2.63)
21–37	0.93 (0.53–1.61)	20	18		40	41	
≥38	1.18 (0.61–2.29)	9	12	1.09 (0.49–2.40)	34	22	1.05 (0.53–2.06)
cis-nonachlor							
≤4.3 μg/kg	1.00	37	40	1.00	34	22	1.00
4.4–6.5	0.81 (0.47–1.39)	17	21	0.74 (0.33–1.70)	47	36	0.81 (0.39–1.68)
6.6–10	0.48 (0.27–0.86)	11	23		33	37	
≥11	0.80 (0.41–1.53)	8	11	0.67 (0.31–1.44)	29	21	0.54 (0.27–1.08)
trans-nonachlor							
≤31 μg/kg	1.00	33	38	1.00	25	18	1.00
32–43	0.93 (0.54–1.60)	24	33	0.93 (0.45–1.93)	39	31	0.93 (0.41–2.08)
44–64	0.69 (0.39–1.23)	13	18		46	41	
≥65	0.78 (0.40–1.53)	4	8	0.73 (0.33–1.63)	33	26	0.72 (0.34–1.49)
Oxychlordane							
≤24 μg/kg	1.00	38	40	1.00	23	16	1.00
25–32	0.68 (0.40–1.17)	16	33	0.46 (0.21–0.97)	44	29	1.00 (0.44–2.26)
33–46	0.61 (0.35–1.07)	16	16		44	46	
≥47	0.59 (0.31–1.16)	4	8	0.78 (0.37–1.67)	32	25	0.66 (0.31–1.40)
HCB							
≤21 μg/kg	1.00	31	42	1.00	24	16	1.00
22–31	0.97 (0.56–1.69)	27	32	1.27 (0.62–2.60)	31	29	0.62 (0.25–1.49)
32–51	0.75 (0.42–1.36)	9	18		52	43	
≥52	1.15 (0.57–2.34)	7	5	1.03 (0.45–2.37)	36	28	0.62 (0.28–1.40)
Mirex							
≤5.8 μg/kg	1.00	24	32	1.00	37	31	1.00
5.9–9.7	1.22 (0.71–2.09)	20	35	0.94 (0.42–2.10)	41	25	1.53 (0.73–3.20)
9.8–24	1.35 (0.79–2.30)	21	17		48	40	
≥25	1.18 (0.59–2.38)	8	12	1.72 (0.78–3.76)	17	19	1.13 (0.60–2.13)
β-HCH							
≤24 μg/kg	1.00	34	39	1.00	24	18	1.00
25–38	0.73 (0.42–1.29)	17	30	0.59 (0.27–1.30)	38	31	0.86 (0.37–1.99)
39–79	1.02 (0.57–1.83)	14	16		60	46	
≥80	0.69 (0.34–1.40)	9	12	1.01 (0.46–2.18)	21	21	0.89 (0.41–1.93)

[a] Adjusted for age, study site, menopausal status, and confounders listed in the "Appendix."

Table 5 ORs with 95% CIs for the association between tissue concentration of Mirex by lactation status among postmenopausal parous women

Mirex tissue concentration	All postmenopausal parous women OR[a] (95% CI)	Never lactators			Lactators		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
≤5.8 μg/kg	1.00	15	7	1.00	12	21	1.00
5.9–9.7	1.95 (0.86–4.44)	11	10	2.64 (0.65–10.8)	11	27	1.54 (0.53–4.45)
9.8–24	1.13 (0.54–2.39)	15	15	1.91 (0.53–6.88)	20	26	0.87 (0.33–2.31)
≥25	0.97 (0.37–2.50)	10	11	4.23 (1.01–17.8)	8	4	0.27 (0.06–1.15)

[a] Adjusted for age, study site, and confounders listed in the "Appendix" except age last breast fed.

association with total PCBs (21, 24–26), some PCB congeners (21, 23), DDE (22, 24–26, 31), and other organochlorinated pesticides, including HCB, β-HCH, and chlordane residues (21–25, 29, 30). However, some found that cases had higher levels than controls of some organochlorines, including total PCBs (22), DDE (21–23), or β-HCH (25). Adjustment for confounding in some of these studies was limited to only a few variables. One larger study using buttocks adipose tissue to measure DDE concentration in 265 cases and 341 controls found that DDE was associated with a reduced risk of breast cancer (27), a finding not replicated in this study.

The majority of studies investigating the association between organochlorines and breast cancer have used serum or plasma to quantify organochlorine levels and can be compared cautiously with this study. Many of these studies did not conduct congener-specific analyses due to limitations of using serum and older quantification techniques. Three of the studies with congener-specific analyses and with the congeners found

to be associated with breast cancer in this study either did not show the results but noted that no association existed (12, 13) or created indices based on the sum of PCBs in various classes based on the degree of chlorination (17). A fourth study, however, found no increased risk with either PCB 118 or PCB 138 (11). The difference by lactation status in the association between breast cancer risk and Mirex among parous postmenopausal women seen in this study was also found in one other study (17), but not a more recent study (12). Like this study, most other studies found no convincing association with total PCBs (11–15, 17), DDE (11–19), HCB (17), or β-HCH (11, 13). Only in one early nested case-control study measuring total PCBs and DDE were increased risks observed, but this study had a small sample size and did not adjust for serum lipids (20).

One of the main advantages of this study was that breast adipose tissue was chosen over serum in which to measure organochlorines. Because organochlorines theoretically will come to an equilibrium where the concentration is equal throughout the lipids in the body (52), most researchers have measured organochlorines in serum, and some have removed the variation introduced by fluctuating lipid levels in the blood either by using fasting samples or calculating concentrations on a lipid basis. However, more recent studies have shown that the ratio of adipose to serum levels is greater than one, even when adjusted for lipids (36, 53, 54). Not only do measurements made in serum or plasma not represent the concentration in adipose tissue on an absolute level, but they also do not represent concentrations closely on a relative level. Correlations between serum and adipose tissue concentrations in the general population are variable, with most reported correlation coefficients being above 0.8, but sometimes as low as 0.3–0.6, or even negative (36, 53–55). Therefore, measurements in adipose tissue may be more representative of exposure accumulated in breast tissue proximal to the epithelial cells, which give rise to breast tumors, and because this results in less misclassification, measurements in adipose tissue will be more powerful in an epidemiological study. Also, because adipose tissue is largely composed of lipid (>80%), concentrations on a wet weight basis will be much higher than in blood, which has much less lipid (<1%), and even small samples of adipose tissue will have organochlorine compounds in the detectable range and are more suitable for congener-specific analyses (39).

The use of breast adipose tissue in this study has necessitated the use of women who had a negative breast biopsy as controls. The use of this control group strengthened the design of this study by minimizing two important biases. First, cases and controls have come from the same hospital catchment areas and have undergone the same diagnostic tests. Therefore, the control group is drawn from the same population as the cases, and the absence of breast cancer in controls was histologically confirmed. Second, because subjects were enrolled before their biopsy, most of the questionnaire answers were received before the biopsy date and even more were completed before the participants' knowledge of their diagnosis. Therefore, differences in recall on the basis of case-control status were minimized. Because the main exposure, organochlorines, was measured as a biomarker, it cannot be subject to observation bias.

Women with biopsies negative for breast cancer generally have some form of BBD. Some exposures, including hormonal factors, are risk factors for both breast cancer and BBDs (56–58). If organochlorine exposure is positively related to both BBD and breast cancer, the risk estimates in this study would be underestimated. As well, some types of BBDs are thought to be part of the causal chain or risk factors for breast cancer (59) and could contaminate the control group by including subjects with precursor conditions. This was investigated by doing a sensitivity analysis excluding controls with diseases most strongly linked to breast cancer, and as expected, risk estimates associated with organochlorines were increased.

Differences between studies may be due to noncomparable levels of organochlorines in the subjects, although different measurement techniques, including use of different tissue compartments, analytical protocols and quantification techniques, especially of total PCBs, and inappropriate reporting of average levels (*i.e.*, using arithmetic means for positively skewed distributions) make the levels difficult to compare. However, the levels of organochlorines in this study can be compared generally to other studies using adipose tissue. The levels in this study are similar to another Canadian study (21), but DDT, DDE, and the higher PCB congeners seem to be in lower concentration in this study than studies conducted outside Canada (22–25, 27), and β-HCH and HCB seem to be at a higher concentration in this study than the one conducted in Connecticut (29, 30). Although the concentration of these organochlorines is low in this population, the compounds are detected in most of the subjects, and this study provides the opportunity to assess the association between organochlorines and breast cancer at a lower section of the dose-response curve.

Some older studies measured only DDE, DDT, and total PCBs. This study and several other recent studies have used high performance gas chromatography to quantify more organochlorinated pesticides and individual PCB congeners (13, 17, 21, 23, 24). Levels of individual organochlorines are correlated due to their common sources of exposure, particularly in the diet. This is especially true for the PCB congeners because they had been used as mixtures. However, the amounts and proportions of PCB congeners and other organochlorines do vary widely from individual to individual. Thus, the PCB congeners and other organochlorines were treated as separate entities in this study to help identify whether specific organochlorines are associated with breast cancer risk and to suggest groupings of organochlorines that may be relevant.

Examining each PCB congener and organochlorine individually leads to testing numerous associations, where even if true associations did not exist, some measured associations would appear significant by chance. However, the approach taken in the interpretation of this study was to look for patterns in the measured associations and consistency across the categories of compounds, not isolated occurrences of statistical significance. Of note in this study is that the PCBs found to be associated with breast cancer risk, PCBs 105, 118, and 156, are all mono-*ortho* substituted, a quality that makes them have some dioxin-like activity, but at a much lower level than dioxins or coplanar PCBs. However, because they are at higher concentrations than the dioxins or the PCB congeners that have greater dioxin-like activity, they, especially PCB 118, are the major contributors of dioxin-like activity in the body (60).

Even if environmental factors account for only a small percentage of breast cancer cases, given the tremendous number of women newly diagnosed each year, associations with some PCBs of the magnitude demonstrated in this study could translate into a large number of breast cancer cases if the association is truly causal. Further release of these compounds into the environment can be prevented with the careful disposal of existing stores and with public health education to prevent exposure through highly contaminated sources, such as fish in the Great Lakes. However, evidence for causality cannot be drawn on the basis of this study alone.

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Appendix

Table A1 Covariates included in the confounder models[a]

Organochlorine	Covariate										
	Ever pregnant	Lactation	Age last breast fed	Present use of HRT	Ethnicity	Family history	BMI	Fat intake	Alcohol intake	Present smoking	Cumulative smoking
PCB 99		•	•	•	•	•	•	•	•		
PCB 105	•	•	•	•	•	•	•	•	•		•
PCB 118				•	•	•	•	•	•	•	•
PCB 138				•	•	•		•	•		
PCB 153		•	•	•	•			•	•		
PCB 156				•	•	•		•			
PCB 170				•			•				
PCB 180				•			•				
PCB 183	•	•	•		•			•			
PCB 187				•	•						
Aroclor 1260				•	•	•		•	•		
p,p′-DDE				•	•		•	•			
p,p′-DDT			•		•		•	•	•		
cis-nonachlor			•		•			•			
trans-nonachlor					•			•			
oxychlordane									•		
HCB				•	•	•	•				
Mirex			•	•	•	•		•			
β-HCH				•	•	•	•	•	•		

[a] All confounder models included age, study site, and menopausal status plus the covariates indicated for each organochlorine in this table.

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Complete PCB Congener Distributions for 17 Aroclor Mixtures Determined by 3 HRGC Systems Optimized for Comprehensive, Quantitative, Congener-Specific Analysis

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HP-5/HT-5 serial coupled phases
GC-ECD
GC-MS-SIM
GC-Ion Trap MS

Summary

Three HRGC systems (1: 30m DB-XLB capillary with MS-SIM detection; 2: 60m DB-XLB capillary with full-scan, ion-trap MS detection; and 3: Parallel dual-column DB-17 and series-coupled HP5/HT5 with ECD detection) were used to completely characterize multiple lots of 8 different-numbered Aroclor mixtures by quantitative calibration against 9 solutions containing primary standards of all 209 PCB congeners. Despite lower absolute sensitivity and more Aroclor congener coelutions than the dual-column ECD system, the MS systems enabled measurement of more congeners per Aroclor since their greater linear response range did not require dilution of samples and standards. Pairs of different lots of Aroclors 1248 and 1254 displayed markedly different proportions of congeners, and the 1254 pair displayed strong differences in the extent of *ortho*-chlorine substitution. The tables of congener weight percent distributions among Aroclors are more comprehensive and quantitatively precise than those of prior publications. However, the limitations of single-level calibration precluded measurement of all congeners to the ±10% accuracy desirable for establishing these Aroclors as secondary standards for comprehensive, quantitative congener-specific PCB analysis.

1 Introduction

Polychlorinated biphenyls (PCBs) are comprised of 209 distinct chlorine-substituted biphenyl structures (congeners). About 140 to 150 of these are observed in the commercial mixtures produced by catalytic chlorination of biphenyl (Trade Name Aroclor in USA, formerly manufactured by Monsanto, Corp., St. Louis, MO, USA). The dispersion of these PCB congeners by uncontrolled releases into the environment, their long-term stability, their lipophilicity resulting in biomagnification up food chains, and questions of possible toxicity, together cause concern for their effects on the environment and have engendered a vast body of research over the past three decades. The measurement of the large number of PCB congeners in commercial or environmentally altered PCB mixtures requires the use of high resolution gas chromatography (HRGC) with sensitive, selective detection by electron capture detection (ECD) or selected-ion-monitoring mass spectrometry (MS-SIM). Current regulatory analytical methods in the USA and Europe simplify the analytical task by specifying quantitation either as a combination of one or more Aroclor congener distributions [1], or by specifying short lists of selected priority congeners for individual quantitation [2,3]. Analyses supporting some research applications, which must account for as many as possible of significant Aroclor congeners and sometimes additional congeners not originally in Aroclors, make even greater demands on HRGC systems. Examples include studies of Aroclors or PCBs in environmental samples which have undergone photolytic dechlorination [4], anaerobic microbial dechlorination [5], or aerobic microbial degradation [6]. The latter results in selective congener removal without production of new congeners. This most complete category of PCB analysis will be referred to herein as *comprehensive, quantitative, congener-specific* analysis (abbreviated CQCS). A CQCS PCB analysis is defined as one in which a substantial majority of congeners are resolved, all congeners at significant levels are correctly assigned to the HRGC peak in which they elute, and the PCB content of each resolved peak (including coeluting congeners of different chlorine number if separately quantified by MS) is accurately quantified against appropriate primary or secondary standards.

Hess *et al.* have recently provided a lengthy critical review of the analysis of non- and mono-*ortho*-chlorobiphenyls [7]. This covered all aspects of such analyses, with particularly useful and detailed discussions of the capabilities and problems of ECD,

MS-SIM, and full-scan ion-trap MS detection, as well as the shortcomings of single-point calibrations. Larsen [8] has recently provided in this journal a critical review of HRGC separations of PCB congeners. His laboratory has provided both an example of a dual-column HRGC-ECD system (parallel DB-17 and series-coupled Sil8/HT5) optimized for CQCS PCB analysis [9,10], as well as identifying a single column (HT8) particularly suited for CQCS and priority list congener PCB analysis when used with MS detection [11]. One of us (Frame) recently organized a worldwide consortium of laboratories to obtain complete retention and coelution data for all 209 PCB congeners on 27 HRGC systems encompassing 20 different stationary phase coatings [12]. Samples of Aroclors 1221, 1016, 1242, 1254, 1260, and 1262 were analyzed against the 209 individual congener standards on 18 of these systems, and the results were combined and averaged to produce comprehensive congener weight percent distributions for these 6 Aroclors [13]. Some of the most significant results from this pair of linked studies are the following:

1. The Aroclor distribution study enabled identification of all significant Aroclor congeners (about 140 of the 209), and when predicted coelutions of this subset were evaluated for all systems in the retention database, one newly developed stationary phase (DB-XLB, J&W Scientific, Folsom, CA, USA) displayed great promise, if used with MS-SIM detection, for enabling the CQCS measurements of an exceptional number of Aroclor congeners. The HT8 column (SGE Pty Ltd, Ringwood, Victoria, Australia) was likewise evaluated in the study, and Aroclor congener resolution information almost completely confirmed Larsen's evaluation of it [11,12]. While DB-XLB data predicted its ability to measure a slightly larger total of Aroclor congeners, it appeared unable to resolve extremely significant priority congeners 138 and 153 from 163 and 132, respectively, while HT8 isolated them from all significant Aroclor congeners. Both these phases have siloxane backbones modified by substitution of some oxygens with bulky organic groups to inhibit polymer thermal degradation leading to column bleed at high temperatures. This makes them especially suitable for CQCS PCB methods employing sensitive MS detection. The DB-XLB resolution predictions had not yet been confirmed by actual analysis of Aroclor mixtures.

2. Hewlett-Packard 5972 bench-top GC-MS-SIM systems operating with above-average new-model electron-multiplier tubes (either K&M or Galileo 5778 Channeltron) and similarly priced Varian Saturn Ion-Trap GC-MS systems operating in full-scan mode displayed exceptional ability to detect and quantify minor Aroclor components. Their *effective* sensitivity in this study was similar or slightly better than the inherently more sensitive ECD detectors because the MS detectors' wider linear response range did not require the dilution of samples and standards needed to include all Aroclor and internal standard peaks within the ECD linear range.

3. The retention database facilitated the distribution of almost all significant Aroclor congeners plus a few "non-Aroclor congeners" among only 5 calibration solutions totaling 144 congeners, while the remaining 65 "non-Aroclor congeners" plus a few very minor Aroclor congeners could be distributed among an additional 4 solutions. Each solution's congener distribution was structured such that there would be a minimum of close elutions on 12 of the stationary phases deemed most useful for CQCS PCB analysis. Tables of elution order for the components of each solution on each of the 12 phases were produced, enabling peak assignments and primary PCB congener standard single-level calibration to be made on a particular analyst's system using one of these phases after only 5 injections for the Aroclor congeners and an additional 4 injections for all 209. A commercial US standards supplier (AccuStandard, New Haven, CT, USA) has formulated the 9 congener mixture solutions according to this scheme, and provides them with the elution order tables described above.

A comparison of the GC-ECD and GC-MS Aroclor congener quantitations in the collaborative study suggested that even after dilution of the samples and standards for GC-ECD analysis, the ECD detectors were measuring many peaks in a non-linear response range rendering the single point calibration inadequate for accurate quantitation. Statistics on quantitation averages indicated that the values should be considered only "semi-quantitative" (*i.e.* between 10% and 50% different from actual values depending on concentration). Congener distributions for Aroclors 1232 and 1248 were compiled from only one pair of systems. Comparison with published congener weight percent distributions for other Aroclor 1254 lots [14], led us to suspect that the Aroclor 1254 used in the collaborative study might have an abnormal distribution. This raises a broader question of the degree of similarity of such distributions among different lots of the same numbered Aroclors over the whole range of chlorine weight percentages (denoted by the last two digits of the Aroclor designation [except Aroclor 1016]). This is significant since many CQCS PCB analysis methods specify calibration against secondary standards of Aroclors [15–18]. This method of calibration has advantages of convenience, cost of standards, and, in some cases, similarity of the standard and sample congener distributions, but its accuracy ultimately depends both on how well the Aroclor standards' congener distributions have been determined and how closely the lot being used matches the one from which the congener weight percent distributions have been compiled.

The purposes of the work reported here are: to confirm the predictions [12] and optimize the performance of DB-XLB columns by CQCS PCB analysis of actual Aroclor distributions using both MS-SIM and full-scan, ion-trap MS detection; to analyze the same sample set using a version of the Larsen/Bøwadt dual column GC-ECD system [9,10] and compare the congener resolution and quantitation performance with the GC-MS systems; and to use all three systems to compile complete congener weight percent distributions of multiple lots of the complete range of Aroclors (except Aroclors 1268 and 1270) by calibration against the 9 new AccuStandard primary standard congener mixtures.

2 Experimental

2.1 Materials

Aroclor lots were obtained from 3 sources, designated by letter-number(#) combinations in **Tables 3 and 4**. 1000 µg/ml iso-octane solutions in ampoules from AccuStandard (New Haven, CT, USA) are designated A# and those from Supelco (Bellefonte, PA, USA) are designated S#. A1, A2, A3, A4, A5, and A6 are the same solutions profiled in the study of reference [13]. Neat Aroclors obtained from the manufacturer (Monsanto Corp., St. Louis, MO, USA) are the same lots used as secondary HRGC calibration standards by GE Corporate R&D [17] and are designated G#. The MS internal standard (IS), 2-fluorobiphenyl (2F-BP), was purchased from Aldrich Chemical Co. (Milwaukee, WI, USA), and the ECD IS, decachlorobiphenyl (PCB 209), from AccuStandard. The primary calibration standards (containing 10 ppm each of all 209 PCBs distributed among 9 different mixtures) were purchased from AccuStandard. Iso-octane was OmniSolve (E. Merck, New Jersey, USA) distilled GC-grade. The DB-17 (50% diphenyl dimethylpolysiloxane) and DB-XLB (proprietary polysiloxane) capillary GC columns were obtained from J&W Scientific. The HP5 (5% diphenyl dimethylpolysiloxane) column was obtained from Hewlett-Packard (Palo Alto, CA, USA) and the HT5 (1,10-dicarba-*closo*-dodecaborane dimethylpolysiloxane) column from SGE, and they were series-coupled in that order using a Restek Press-Tight fused-silica column connecter.

2.2 Sample and Standards Preparation

1.00 ml of each of the 9 standard congener calibration mixtures was separately diluted together with appropriate volumes of the two IS stock solutions to 10.00 ml in volumetric flasks with iso-octane to produce solutions containing 1.00 µg/ml of each congener and 4.00 µg/ml of each IS. 1000 µg/ml stocks of Aroclors were similarly diluted with the 2 IS's and iso-octane in 25.00 ml volumetric flasks to produce solutions containing 40 µg/ml of Aroclor and 4.00 µg/ml of each IS. Because of the greater absolute sensitivity and non-linear response of ECD detectors to major Aroclor components and especially the high concentration of decachlorobiphenyl IS, samples and standards were diluted 16-fold with iso-octane prior to injection on the dual-column GC-ECD system.

2.3 Gas Chromatographic Analysis

Samples and standards were analyzed on the four systems summarized in **Table 1**. **Systems 1, 2, and 3** employed splitless injections of 1.0 µL, while that of **System 4** was a 1.0 µL on-column injection to a 0.53 mm i.d. × 2 m deactivated Hewlett-Packard capillary fused silica retention gap split to the series-coupled HP5/HT5 (**4A**) and DB-17 (**4B**) columns using a Restek Press-Tight fused-silica "T-piece". **System 1** employed MS-SIM detection at the most intense of either the M^+, $(M+2)^+$, or $(M+4)^+$ masses, with acquisition at 5 scans per second. The exact masses and SIM acquisition groups were the same as in [12]. The electron multiplier was upgraded to the K&M model employed in an HP 5972 GC-MS, and peak areas were integrated with the HP ChemStation integrator after Gaussian-smoothing, which caused slight losses of peak resolution but greatly improved the quantitative peak area measurement of minor peaks by enabling more accurate and consistent automated placement of peak baselines. **System 2** employed the new HP-1801-GCD GC-MS instrument. It was operated similarly to the HP 5971 of **System 1**, but its software limitations (maximum mass = 425 *m/z*) required acquisition of signals for 8, 9, and 10-chlorine-substituted biphenyl congeners at the $(M-2Cl)^+$ or $(M-4Cl)^+$ fragment masses (*i.e.* 359.8 or 395.8 *m/z* for 8 and 10, or 9 chlorobiphenyls respectively), and integration of unsmoothed peaks. Its new diffusion pump fluid permitted employment of hydrogen as carrier gas with a capillary GC column. **System 3** employed MS-Ion Trap detection which acquired full-scan spectra from 150 to 520 *m/z* at 1 scan/s. Peak areas were acquired by integration of peaks obtained by extraction of 2 or 3 of the major mass peaks of the M^+ cluster.

Table 1. HRGC systems used for CQCS PCB analysis.

Investigator	Frame	Frame	Cochran	Bøwadt	Bøwadt
Parameter	System 1	System 2	System 3	System 4A	System 4B
Column	DB-XLB	DB-XLB	DB-XLB	HP5/HT5	DB-17
Length (m)	29.6	28	60	25/25	60
I.D. (mm)	0.25	0.18	0.25	0.25/0.25	0.25
Film (µm)	0.50	0.18	0.25	0.25/0.10	0.25
Carrier Gas	He	H_2	He	H_2	H_2
Pressure (psi)	9.0	0.8ml/min	20.5	24.7	24.7
Flow (cm/s)	28.6	51.3	20.3	35.2	42.7
Flow Temp (°C)	225	205	225	202.5	202.5
Temp. Prog.					
Start (°C)	72	72	75	90	90
Hold (min)	2	2	2	2	2
Ramp 1 (°/min)	15	15	15	20	20
Stop (°C)	150	150	150	130	130
Ramp 2 (°/min)	2.5	2.0	1.5	2.0	2.0
Stop (°C)	300	260	300	275	275
Hold (min)	0	0	0	5	5
PCB209 (min)	65.9	60.3	102.0	67.8	75.6
Detector	MS-SIM	MS-SIM	MS-IT	ECD	ECD
Model	HP 5971	HP-GCD	Saturn	HP 5890	Dual ECD
Cost (~$)	$70,000	$50,000	$60,000	$40,000	$40,000

2.4 Calculation of Aroclor Congener Distributions

For **Systems 1 and 3** (**System 2** Aroclor data not calculated for incorporation into the summary distribution), the response factors relative to 2F-BP IS (RRFs) were calculated from peak areas in chromatograms of the 9 calibration mixtures. Only PCBs 37 and 103 in one mixture coeluted on the DB-XLB columns. The $(M+2)^+$ response for 103 could be measured without interference, but a separate standard containing PCB 37 and the IS needed to be injected to determine its M^+ RRF. Concentrations of each congener were calculated by multiplying the ratio of the sample peak's RRF to the corresponding standard peak's RRF by the standard's concentration of 1 µg/ml; *i.e.* a simple single point calibration. Contributions to a congener's M^+ peak area from single chlorine loss fragments from a coeluting next higher homolog congener were minor in all cases and were not compensated for. Only the major two-chlorine-loss signal contribution to PCB 77 values from coelution with PCB 144 required its subtraction to correct the PCB 77 values in the Aroclor 1254s.

The series-coupled HP5/HT5 column (**System 4A**) was not included in the original retention database study [12]. Therefore, the 30 mixtures totaling all 209 congeners used in that study were

initially employed to determine the elution order and coelutions of PCBs on this column and the parallel DB-17 (**System 4B**) column as well as the RRFs to decachlorobiphenyl IS. There were several congener coelutions on both it and the parallel DB-17 column when the 9 calibration mixtures used in this study were injected on **System 4**. In order to provide RRFs for congeners undergoing such coelutions, the RRF values obtained from the completely separated 30 mixtures runs were listed in order of increasing value. The RRF (obtained during the 9 mixture calibration) of a measurable (*i.e.* no coelution in one of the 9 calibration mixtures) congener with the value closest (usually $< \pm 2\%$) to that of each of the congeners suffering coelution in the calibration mix was selected from the ordered list to substitute for the latter. In many cases an interfering calibration mix congener would not appear at significant levels in an Aroclor, so the level of the desired congener could be measured on at least one of the columns of **System 4**. There were 6 categories of calculation from the combined data of the **System 4** columns (**4A and 4B**). These employed the same single point RRF ratio formula used with systems 1 and 3, and they enabled quantitation of 132 values; namely:

1. 41 PCBs as the *mean* of unique elutions on both **4A and 4B**
2. 47 PCBs eluting uniquely only on **4A**
3. 33 PCBs eluting uniquely only on **4B**
4. 5 PCBs as sum value on **4A** minus value of coeluter measured uniquely on **4B**
5. 3 PCBs as sum value on **4B** minus value of coeluter measured uniquely on **4A**
6. 6 PCBs measured as 3 sums of coeluting pairs on either of **4A or 4B**

These categories are defined for congeners significantly present in Aroclors (*i.e.* above ~ 0.05 weight%) as determined in the earlier Aroclor distribution study [13] and confirmed by the data in **Table 4** of this study.

3 Results and Discussion

3.1 PCB Congener Nomenclature

Column 1 of **Table 4** lists the 209 possible PCB congeners in order of their IUPAC number. Their presence in any of Aroclors 1242, 1254 or 1260 [13] as a major congener (>1.0 Wt%) is indicated by **Bold Underline**, as a minor congener (between 0.05 and 1.0 Wt%) by **Boldface**, and as a trace or undetected congener (<0.05 Wt%) by *italic* font. The numbers for congeners 107, 108, 109, 199, 200, and 201 in this paper are derived according to Guitart *et al.* [19], and they differ from the corresponding numbers assigned by Ballschmiter and Zell [20] as 108, 109, 107, 201, 199, and 200, respectively. Column 2 of **Table 4** displays the pairs of individual single phenyl-ring chlorine-substitution patterns according to the convention: 234-245 = 2,2',3,4,4',5'-hexachlorobiphenyl, where the hyphen represents the bond between the two phenyl rings. This permits easy visualization of the chlorination pattern on each ring and assists evaluation of the relative proportions of each pattern produced by the Aroclor synthesis process. Chlorines in the 2 or 6, the 3 or 5, and the 4 positions are described as *ortho-*, *meta-*, and *para-* substituted, respectively.

3.2 Comparisons of HRGC Systems Aroclor PCB Resolution Performance

Table 2A displays all Aroclor congener (i.e **Bold** numbers in **Table 4**) coelutions in each system by the convention X @ Y, where X is the minor component of the pair coeluting with Y.

Table 2A. Comparison of HRGC systems' performance.

System 1 29.6m DB-XLB 0.25mm x 0.5µm Helium		System 2 28m DB-XLB 0.18mm x 0.18µm Hydrogen		System 3 60m DB-XLB 0.25mm x 0.25µm Helium		System 4 HP5/HT5 + DB17 25/25m + 60m Hydrogen	
Isomer Coelutions of Aroclor Congeners (>0.05% in 1242, 1254 or 1260)							
	Wt%		Wt%		Wt%		Wt%
10@4	T	10@4	T	10@4	T		
20@33	5.7	20@33	5.7	20@33	5.7	41 NQ	0.8
59@42	2.0	59@42	2.0			56@60	3.0
43@52	T						
48@49	5.7					70 NQ	7.3
76@63	0.3	76@63	0.3	76@63	0.3		
89@84	T	89@84	T	89@84	T	92@84	3.8
115@85	2.2	115@85	2.2				
119@83	0.6	119@83	0.6	119@83	0.6		
123@109	0.8	123@109	0.8	123@109	0.8		
129@158	1.2	129@163	1.2	129@158	0.7		
131@133	0.3						
132@153	12.3			132@153	12.3		
163@138	9.0						
147@149	T						
193@180	T						
196@203	2.5					196@203	2.5
198@199	T						
SUM =	42.6		12.8		10.4		17.4

Table 2B. Additional classes of coelutions in System 3 (60m DB-XLB).

Different Chlorine Number ECD Unresolvable		Non-Aroclor PCB Coelution @ Aroclor PCB (Isomers)
11@18	T	21@33/20
13@27	0.7	62@75
53@31	8.1	68@40
91@66	7.1	58@67
84@56	4.3	88@74
117@136	0.7	90@101
139@124	0.5	120@110
141@105	6.1	143@139
128@185	1.1	168@153
201@171	1.4	182@175
198@170	T	162@128
207@195	T	169@196
SUM =	30.0	

XXX@YY = minor congener XXX coelutes with major congener YY.
NQ = Not quantifiable by dual-column difference calculation (categories 4 or 5).
T = 1st congener is trace component not quantifiable, but increases major component value by less than 10%.

Wt% is sum of largest mean weight percents for pair of coeluters in any of Aroclors 1242, 1248, 1254, or 1260.

Major congener coelutions are underlined.

The following comparisons and observations are made from these data:

1. Doubling the length of the DB-XLB column in **System 3** *versus* that in **System 1** doubled theoretical plates for n-tetradecane with hydrogen carrier from 124,000 to 249,000 (J&W test data). As a consequence, the number of Aroclor congener coelutions dropped from 17 to 6, and major coeluting pairs 48@49, 163@138, and 196@203 could be resolved. **Table 2B** shows additional different homolog (congeners of different chlorine number) coelutions on **System 3**, measurable by MS but not ECD, as well as those non-Aroclor congeners not measurable in the presence of some Aroclors.

2. The 28m narrow-bore, thin-film DB-XLB column used with hydrogen carrier (**System 2**, measured by J&W to have 170,000 theoretical plates) retained most of the above resolution improvements, and most importantly, achieved baseline resolution of the important 132/153 pair and also allowed measurement of PCB 138 without interference. Using longer, narrow-bore, thin-film DB-XLB capillaries both J&W and J. Cochran's labs [21] have also succeeded in resolving these pairs with *helium* carrier gas. Critical resolution comparisons between **Systems 1 and 2** are displayed in **Figure 1**. Note in the **System 2** segments of this figure that there is an enhancement of $(M - 1Cl)^+$ fragment-ion responses when hydrogen was used in **System 2**.This resulted both in several-fold lower signals at M^+ and larger one-chlorine-loss fragment interferences in cases of coeluting homologs. Such alteration of PCB fragmentation patterns was not observed when hydrogen was employed as GC carrier gas with the Varian Saturn ion-trap MS. Its higher capacity turbomolecular pumps may achieve a lower ion-source hydrogen pressure than the diffusion pump of the HP-GCD. An elucidation of the mechanism of the fragmentation pattern alteration by hydrogen requires further study. Analysts requiring hydrogen carrier to achieve critical congener resolutions in GC-MS-SIM CQCS PCB analyses should check their systems for the possible presence of this behavior.

3. Column 4 of **Table 2A** shows that the **System 4** combination of GC columns **4A** and **4B** yields the most complete Aroclor congener profile. In practice PCBs 41 and 70 could not be accurately measured in some Aroclors as required by the calculation categories 4 and 5 described in Section 2.4 above, and there remained 3 pairs of Aroclor congeners not resolved on either column. Fortunately **System 4** could quantify all congeners not measurable by **Systems 1 or 3**, thus enabling complete Aroclor congener distributions to be obtained. The multiple categories of measurement in more comprehensive **System 4** made reduction of data from it much more complex and time consuming than from **Systems 1 and 3**.

3.3 *Comparison of Systems Quantitation Performance*

The first 3 data columns of **Table 3** display the number of congeners measured in each Aroclor lot by **Systems 1, 3, and 4**.

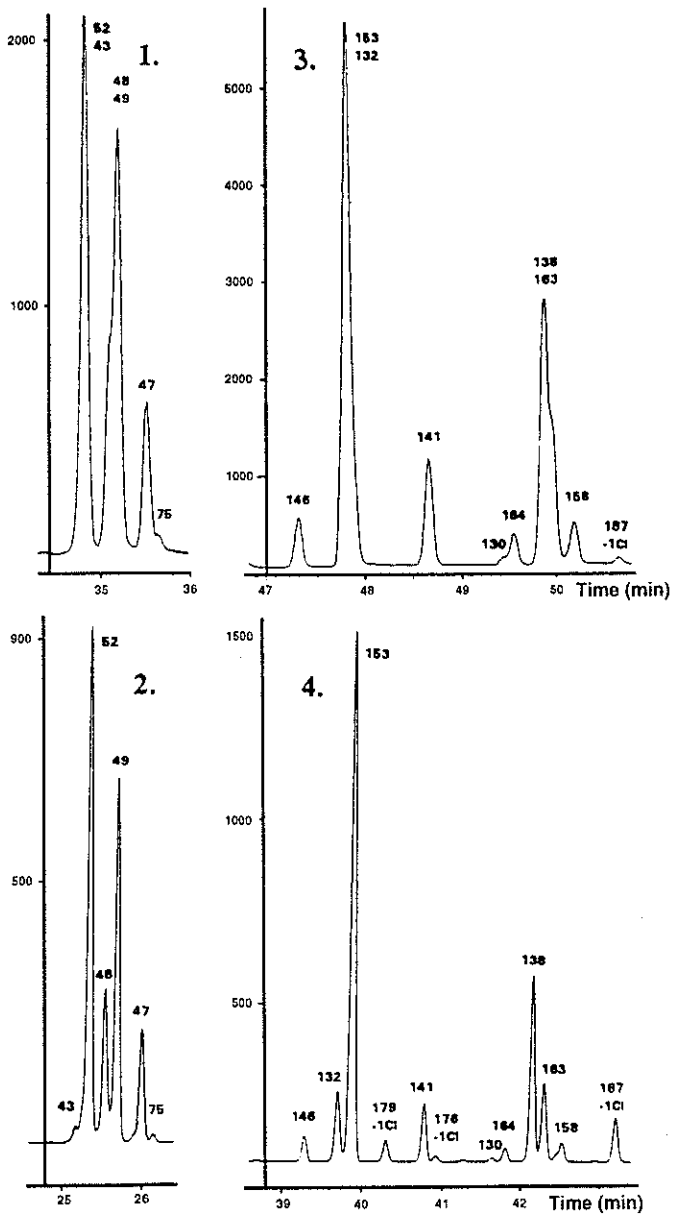

Figure 1. Critical congener resolution comparisons between GC-MS systems 1 and 2.
1. **System 1**, G3 Aroclor 1242, Mass = 291.9 (4-Cl M^+)
2. **System 2**, G3 Aroclor 1242, Mass = 291.9 (4-Cl M^+)
3. **System 1**, G5 Aroclor 1260, Mass = 359.8 (6-Cl M^+)
4. **System 2**, G5 Aroclor 1260, Mass = 359.8 (6-Cl M^+).

Note that dual-column ECD **System 4** employed 16-fold diluted standards and samples to reduce the effect of non-linearity of detector response. Assuming a near equal split to each column, the effective concentrations sampled by each ECD were 1.25 or 0.03 µg/ml for Aroclors or individual congener standards, respectively, compared to 40.0 or 1.0 µg/ml for the MS detectors. As in the predecessor study [13], where single point calibration was also employed, the individual calculated ECD congener concentrations ranged higher than the corresponding MS values; with the differences being inversely proportional to the absolute concentrations. Despite the effective 32-fold dilution, single point calibration was still clearly insufficient for accurate ECD measurements over portions of the concentration range due to non-

Table 3. No. of congeners measured by each system. Similarity of Aroclor congener distributions.

		No. of Congeners Measured			Sum of % Diffs. [a]	
Aroclor	Lot	Sys 1	Sys 3	Sys 4 [b]	Lots 1&2 Lots 2&3	Lots 1&3
1221	A1	59	63	45		
1232	A1.5	77	93	81	1.9	
1232	G1.5	75	91	88		
1016	A2	58	71	52	1.1	
1016	S2	58	70	54		
1242	A3	82	95	75	9.3	
1242	G3	79	93	76		6.3
1242	S3B	81	95	78	12.3	
1248	A3.5	92+	95+	88	19.8	
1248	G3.5	92+	95+	92		
1254	A4	92+	95+	81	52.5	
1254	G4	92+	95+	97		
1260	A5	89	93	67	1.7	
1260	S5	89	93	73		7.2
1260	G5	84	82	65	6.4	
1262	A6	91	95	78	10.3	
1262	G6	91	92	74		

"+" – additional trace congeners detected, not reported.

a) The absolute differences in Wt%s of pairwise comparisons are summed for all congeners for pairs of Aroclor lots using **Table 4** values.

b) The number of measured PCBs is reduced because of the 16-fold dilution needed to place the range of PCB congeners in a more linear region of the ECD response curve when using single-level calibration.

linearity of the detector response over the range from the lower Aroclor congener concentrations to the much higher level of the IS. A linearity study of **System 1** responses for 39 congeners covering all levels of chlorination (except decachlorobiphenyl) revealed concentration/response ratios constant to ±10% over the range equivalent to 0.1 to 10.0 Wt% of 1.0 µL of the 40 µg/ml Aroclor solutions injected. This suggests that the single point calibration was adequate over this range *for this particular GC-MS-SIM system.* More than 90% of the full-scan ion-trap **System 3** Aroclor congener weight% values were within ±10% of the corresponding **System 1** values over this range. The two GC-MS systems displayed similar sensitivity; the greater congener count of **System 3** in **Table 3** being primarily due to greater congener resolution, as outlined in **Table 2A**. Conversely, the even more comprehensive congener measurement capability of dual-column ECD **System 4** was offset by the need to analyze more dilute samples. This resulted in fewer detections of minor congeners: especially less chlorinated ones having lower ECD RRFs. **System 4** was incorporated in this study after solutions had been prepared for and analyzed only by **Systems 1 and 3.** Its quantitative accuracy would surely have improved in a study design employing multilevel calibration and use of a lower decachlorobiphenyl IS concentration requiring less dilution. With some extracts of environmental samples standard cleanup procedures [7] may be able to remove much higher levels of non-PCB contaminants which degrade either the chromatographic separation or the MS quantitation of PCBs in GC-MS systems. If the contaminant levels are low enough or can be reduced sufficiently to allow concentration of the extracts to attain the PCB levels measured in this study, then the GC-MS methods may provide better analyte selectivity and more facile quantitation than the more complex multicolumn analysis and multilevel calibration required for full CQCS implementation of **System 4**. On the other hand, the latter provides more comprehensive congener coverage at slightly lower equipment cost (**Table 1**), and provides dual chromatographic confirmation capability instead of mass spectrometric confirmation.

Figure 2 illustrates the remarkably sensitive detection by **System 1,** without further isolation and concentration, of only 1.4 picograms injected of critical coplanar PCB 126 from lot G4 Aroclor 1254 at 40 µg/ml. Note the much elevated level of this congener in lot A4, which is discussed further in Section 3.6. PCB 159 coelutes with PCB 126 on some DB-XLB columns, but its absence was demonstrated by the absence of its $(M + 2)^+$ ion one chlorine isotope mass above that of PCB 126. **Figure 3** illustrates the library-searchable full-scan mass spectrum obtained by **System 3** on the trace level (only 15 picograms injected) of PCB 138 measured in Aroclor 1232. The ability of the Ion-Trap MS to provide full-scan spectra of even minor Aroclor components provides more complete MS confirmation of PCB peaks than do the several masses usually monitored in MS-SIM methods. Additionally, in the event of contaminant interferences at the molecular ion cluster masses routinely monitored, one may be able to employ other fragment masses from the full-scan sample and standard data files to quantify the PCB content of a peak.

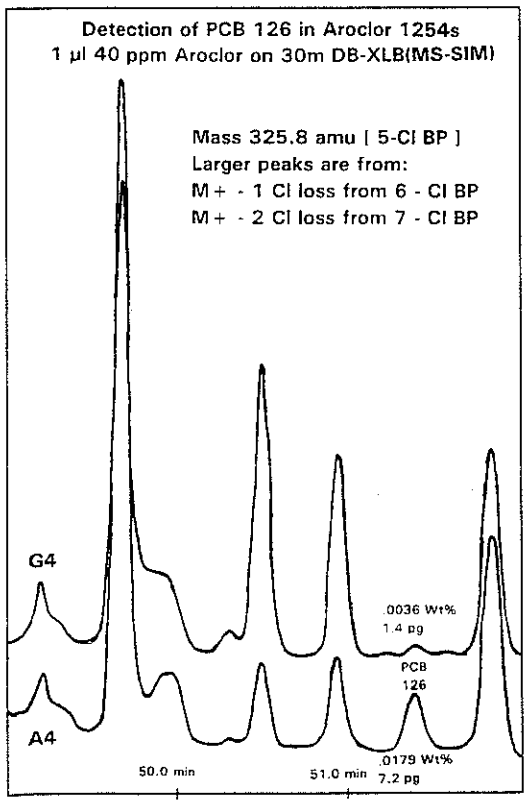

Figure 2. System 1. GC-MS-SIM detection of PCB 126 in A4 and G4 Aroclor 1254s.

Table 4A. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUPAC#	Aroclor - Structure Cl Pos.	1 A1 1221	2 A1.5 1232	3 G1.5 1232	4 A2 1016	5 S2 1016	6 A3 1242	7 G3 1242	8 S3B 1242	9 A3.5 1248	10 G3.5 1248	11 A4 1254	12 G4 1254	13 A5 1260	14 S5 1260	15 G5 1260	16 A6 1262	17 G6 1262
1	2	35.80	15.21	15.84	.52	.54	.51	.34	.78	.05	.02	.02		.03	.03	.01	.02	.03
2	3	3.81	1.98	1.94	.02	.03	.02	.02	.05									
3	4	20.44	10.36	10.20	.15	.16	.15	.11	.27	.01				.00				.01
4	2-2 +10	6.19	5.32	5.38	3.62	3.66	3.11	2.71	3.41	.32	.04	.02	.06	.03	.03	.00	.07	.04
5	23	.74	.49	.50	.17	.15	.13	.11	.19	.00				.00				
6	2-3	3.82	3.02	3.00	1.64	1.69	1.42	1.24	1.63	.13	.00	.00	.02	.01	.01		.03	.02
7	24	1.70	1.12	1.09	29	.30	.26	.18	.34	.02								
8	2-4	12.34	10.71	10.72	8.29	8.31	6.99	6.48	7.68	.81	.26	.05	.13	.06	.06	.00	.15	.08
9	25	1.74	1.25	1.29	.58	.59	.50	.40	.60	.04								.00
10	26	.80	.60	.58	.23	.23	.20	0.14	.25									
11	3-3	.16																
12	34	.59	.35	.35	.07	.07	.06	.04	.09									
13	3-4	1.12	.73	.72	.24	.25	.20	.17	.27	.02								
14	35	.00	.00	.02														
15	4-4	4.18	3.24	3.19	2.40	2.49	1.98	1.95	2.39	.22	.06	.01	.03	.00	.02		.03	.02
16	23-2	.31	1.79	1.79	3.88	3.88	3.03	3.44	2.94	1.04	.71	.02	.09	.02	.02	.00	.07	.03
17	24-2	.34	1.83	1.82	3.98	3.98	3.14	3.29	2.97	1.05	.93	.02	.08	.02	.02	.00	.07	.03
18	25-2	.78	4.89	4.83	10.86	10.75	8.53	9.14	7.93	4.29	3.29	.08	.25	.07	.07	.00	.19	.10
19	26-2	.08	.46	.47	.99	1.01	.79	.84	.75	.22	.14				.00		.02	
20	23-3	.07	.42	.42	.88	.89	.68	.77	.71	.14	.08							
21	234	NM	NM	NM	NM	NM	NM	NM	NM									
22	23-4	.26	1.62	1.62	3.50	3.51	2.71	3.08	2.73	1.33	1.38	.02	.04	.02	.02	.00	.06	.03
23	235		.00	.00	.01	.02	.01	.01	.01		.00							
24	236	.02	.08	.08	.16	.17	.13	.13	.14	.00								
25	24-3	.09	.37	.37	.72	.72	.57	.61	.60	.11	.04						.00	.00
26	25-3	.13	.75	.74	1.57	1.59	1.21	1.38	1.24	.40	.23	.00	.03	.00	.00	.00	.03	.01
27	26-3	.05	.12	.12	.51	.50	.40	.44	.39	.12	.07						.00	.00
28	24-4	.62	3.92	3.89	8.50	8.57	6.68	7.31	6.60	3.59	5.57	.06	.19	.05	.05	.00	.15	.08
29	245	.01	.05	.05	.10	.10	.08	.08	.09	.00	.00							
30	246				.00	.00												
31	25-4	.60	4.17	4.11	9.32	9.26	7.18	7.82	7.01	5.07	5.47	.11	.28	.06	.05	.00	.16	.08
32	26-4	.17	1.08	1.07	2.37	2.37	1.85	2.05	1.79	.88	.93	.01	.05	.01	.01	.00	.05	.02
33	34-2 + 20	.48	2.84	2.88	6.21	6.19	4.85	5.35	4.82	2.23	2.21	.05	.16	.04	.04	.00	.13	.07
34	35-2		.01	.01	.03	.03	.02	.02	.03	.00	.00							
35	34-3	.00	.06	.05	.05	.06	.07	.07	.09	.00								
36	35-3																	
37	34-4	.19	1.15	1.12	1.02	1.01	1.86	2.19	2.05	.79	.95	.01	.07	.01	.00	.00	.04	.02
38	345																	
39	35-4																	
40	23-23	.04	.40	.36	.58	.58	.77	.79	.72	1.13	.92	.15	.12	.00	.00		.00	.00
41	234-2	.03	.36	.35	.76	.76	.69	.69	.65	.77	.75	.02	.01		.00		.00	.00
42	23-24 + 59	.09	.66	.69	1.59	1.59	1.13	1.25	1.17	1.67	1.79	.09	.15	.00	.00	.00	.03	.01
43	235-2		.12	.09	.28	.25	.18	.19	.16	.30	.19							
44	23-25	.21	1.81	1.81	4.47	4.48	3.60	3.63	3.42	6.31	5.09	.67	2.31	.04	.04	.03	.10	.05
45	236-2	.04	.47	.45	1.23	1.22	.93	.91	.84	1.09	.91	.02	.05	.00	.00		.00	.00
46	23-26	.02	.19	.19	.49	.48	.37	.38	.33	.47	.39			.00				.00
47	24-24	.05	.49	.49	1.26	1.24	.97	.92	.91	1.49	2.41	.07	.14	.00	.00	.00	.01	.00
48	245-2	.06	.61	.62	1.61	1.59	1.18	1.17	1.19	1.66	1.54	.05	.12	.00	.00		.01	.00
49	24-25 + 48	.15	1.37	1.36	3.35	3.40	2.59	2.60	2.38	4.12	4.17	.26	1.10	.01	.02	.01	.07	.04
50	246-2				.01	.01	.00	.00	.00									
51	24-26	.00	.12	.13	.32	.32	.25	.23	.22	.30	.31							
52	25-25 + 43	.22	1.83	1.86	4.63	4.61	3.64	3.47	3.47	6.93	5.58	.83	5.38	.27	.25	.21	.17	.11
53	25-26	.04	.37	.37	.95	.94	.75	.71	.68	1.05	.88	.04	.12	.00	.00	.00	.00	.00
54	26-26		.00		.01	.02	.00	.00	.01		.00							
55	234-3		.05	.05			.09	.11	.10	.06	.05							
56	23-34	.12	.93	.92	.07	.06	1.80	1.85	1.80	3.16	3.19	1.70	.55	.02	.02	.00	.04	.02
57	235-3		.00	.01	.01	.01	.02	.00	.03	.02	.02							
58	23-35																	
59	236-3	.01	.20	.15	.41	.38	.37	.32	.27	.37	.23	.00	.02				.00	
60	234-4	.07	.61	.60	.04	.03	1.17	1.17	1.19	1.85	2.67	.95	.18	.04	.04	.03	.02	.02
61	2345																	
62	2346																	
63	235-4 + 76	.00	.10	.10	.06	.05	.13	.11	.12	.17	.19	.07	.02					
64	236-4	.10	.87	.87	1.87	1.84	1.76	1.68	1.67	3.01	3.32	.36	.59	.01	.01	.00	.04	.02
65	2356																	
66	24-34	.21	1.74	1.71	.39	.36	3.38	3.38	3.40	5.84	7.22	3.56	1.01	.03	.03	.01	.08	.05
67	245-3	.00	.09	.08	.06	.06	.15	.17	.16	.13	.10	.00						
68	24-35																	
69	246-3				.00	.00												
70	25-34	.24	1.90	1.90	.59	.56	3.76	3.70	3.73	7.28	7.39	6.83	3.49	.04	.04	.05	.12	.07

Table 4B. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUP	Aroclor - Structure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
AC#	Cl Pos.	A1 1221	A1.5 1232	G1.5 1232	A2 1016	S2 1016	A3 1242	G3 1242	S3B 1242	A3.5 1248	G3.5 1248	A4 1254	G4 1254	A5 1260	S5 1260	G5 1260	A6 1262	G6 1262
71	26-34	.06	.54	.54	1.16	1.17	1.04	1.06	1.00	1.67	1.86	.11	.15	.00	.00	.00	.02	.00
72	25-35		.00		.00	.00	.01	.01	.01	.02	.01							
73	26-35				.00	.00		.00										
74	245-4	.12	.92	.92	.33	.33	1.83	1.76	1.84	3.14	4.67	2.19	.84	.05	.05	.04	.06	.04
75	246-4		.02	.02	.06	.06	.05	.03	.04	.08	.08							
76	345-2	.00					.08	.08	.09	.13	.13	.03	.02					
77	34-34	.01	.17	.16			.27	.33	.33	.41	.52	.20	.03					
78	345-3																	
79	34-35																	
80	35-35																	
81	345-4		.00				.00	.01	.01	.01	.02	.00						
82	234-23	.00	.12	.12			.29	.22	.28	.81	.62	1.53	1.11					
83	235-23 + 119		.05	.04			.12	.09	.12	.26	.20	.56	.48	.00	.00	.00	.00	.00
84	236-23 + 89	.02	.20	.18	.05	.05	.46	.35	.43	1.26	.91	1.58	2.32	.11	.12	.10	.05	.03
85	234-24 + 115	.03	.17	.17	.00		.36	.24	.32	.98	1.14	2.49	1.28	.00	.00	.02	.03	.01
86	2345-2		.01	.01			.03		.04	.11	.09	.10	.06					
87	234-25	.04	.22	.22			.52	.38	.49	1.45	1.11	3.41	3.99	.44	.42	.36	.11	.11
88	2346-2						.00	.00		.02	.02							
89	234-26		.05	.05			.10	.07	.09	.20	.17	.11	.09					
90	235-24									NM	NM	NM	NM					
91	236-24		.10	.10	.06	.06	.24	.17	.23	.63	.56	.53	.93	.00	.00	.01	.01	.00
92	235-25	.02	.05	.05			.06	.09	.13	.38	.25	.57	1.29	.34	.32	.25	.07	.09
93	2356-2								.00	.04	.03							
94	235-26					.00	.00	.00	.01	.03	.02	.00	.02					
95	236-25	.05	.30	.30	.31	.30	.68	.51	.64	1.96	1.43	1.84	6.25	2.56	2.54	2.27	.87	.99
96	236-26		.01	.01	.04	.04	.03	.02	.03	.08	.06	.01	.04					
97	245-23	.03	.18	.17	.00	.04	.43	.31	.41	1.22	.97	2.78	2.62	.10	.09	.08	.06	.03
98	246-23					.00												
99	245-24	.04	.21	.21	.01	.01	.53	.36	.49	1.47	1.81	4.53	3.02	.03	.04	.06	.06	.03
100	246-24																	
101	245-25	.07	.33	.32	.04	.03	.78	.57	.71	2.22	1.89	5.49	8.02	3.23	3.18	2.99	1.03	1.23
102	245-26		.03	.03	.04	.04	.08	.05	.07	.19	.17	.09	.15					
103	246-25									.02	.00		.03					
104	246-26																	
105	234-34	.05	.22	.21	.00		.52	.37	.52	1.60	1.45	7.37	2.99	.22	.21	.23	.18	
106	2345-3																	
107	234-35																	
108	2346-3																	
109	235-34 + 123		.03	.03			.08	.04	.06	.18	.13	.78	.37	.00	.00	.00	.00	.00
110	236-34	.05	.38	.38			.94	.68	.88	2.97	2.55	8.42	9.29	1.38	1.36	1.25	.36	.42
111	235-35																	
112	2356-3						.00											
113	236-35											.01		.00				
114	2345-4		.02	.01			.05	.03	.05	.12	.12	.50	.18	.00		.00		
115	2346-4		.01	.01			.04	.03	.05	.11	.11	.37	.20			.00		
116	23456																	
117	2356-4		.01	.00			.03	.02	.04	.09	.10	.19	.23					
118	245-34	.08	.29	.28			.78	.51	.69	2.29	2.35	13.59	7.35	.51	.50	.45	.17	.14
119	246-34									.06	.06	.12	.08					
120	245-35																	
121	246-35																	
122	345-23						.01	.00	.02	.06	.05	.25	.10					
123	345-24						.03	.02	.03	.07	.08	.32	.15					
124	345-25		.00				.03	.02	.03	.10	.07	.47	.29	.00	.00	.00	.00	.00
125	345-26		.00	.00			.02	.02	.02	.04	.03	.03	.02					
126	345-34									.00	.00	.02	.00					
127	345-35																	
128	234-234						.04	.00	.02	.12	.08	1.71	1.42	.56	.55	.50	.17	.20
129	2345-23							.00		.02		.39	.38	.15	.14	.12	.03	.04
130	234-235									.04	.01	.50	.60	.23	.22	.21	.03	.06
131	2346-23											.14	.19	.08	.07	.05		
132	234-236		.02	.02			.05	.03	.04	.15	.14	1.50	2.29	2.84	2.96	2.91	1.07	1.35
133	235-235 + 131												.11	.08	.06	.06	.03	.05
134	2356-23										.01	.20	.37	.36	.36	.31	.11	.14
135	235-236									.04	.04	.28	.61	1.14	1.09	1.02	.67	.65
136	236-236			.00					.00	.05	.06	.24	.70	1.48	1.45	1.44	1.02	.99
137	2345-24									.03	.02	.52	.42	.02	.02	.02	.01	.00
138	234-245 + 163		.06	.05			.16	.05	.10	.38	.41	5.95	5.80	6.47	6.41	6.73	2.33	3.14
139	2346-24											.14	.15					
140	234-246																	

Table 4C. Summary weight% PCB congener distributions in Aroclors compiled from data from HRGC Systems 1, 3, and 4.

IUPAC#	Aroclor - Structure Cl Pos.	1 A1 1221	2 A1.5 1232	3 G1.5 1232	4 A2 1016	5 S2 1016	6 A3 1242	7 G3 1242	8 S3B 1242	9 A3.5 1248	10 G3.5 1248	11 A4 1254	12 G4 1254	13 A5 1260	14 S5 1260	15 G5 1260	16 A6 1262	17 G6 1262
141	2345-25						.01	.00	.00	.07	.09	.69	.98	2.62	2.68	2.57	1.63	1.69
142	23456-2																	
143	2345-26																	
144	2346-25										.01	.12	.24	.61	.61	.61	.41	.41
145	2346-26																	
146	235-245									.04	.05	.45	.67	1.17	1.16	1.11	.57	.61
147	2356-24											.02	.10					
148	235-246																	
149	236-245 + 147		.05	.05			.07	.04	.06	.24	.33	1.82	3.65	8.74	8.78	8.73	6.36	6.44
150	236-246																	
151	2356-25		.01	.00					.00	.04	.08	.22	.69	3.04	3.04	3.03	3.14	2.81
152	2356-26																	
153	245-245 + 132	.00	.05	.05			.09	.04	.05	.23	.43	3.29	3.77	9.09	9.17	9.91	6.78	7.42
154	245-246											.02	.04					
155	246-246																	
156	2345-34						.02			.06	.04	1.13	.82	.53	.54	.50	.14	.18
157	234-345									.00	.00	.30	.19	.02	.02	.02	.00	.00
158	2346-34 + 129						.02		.01	.04	.04	.90	.81	.57	.58	.60	.18	.21
159	2345-35																	
160	23456-3																	
161	2346-35																	
162	235-345																	
163	2356-34		.02	.02			.00	.02	.00	.06	.08	.70	1.03	2.41	2.43	2.44	1.50	1.55
164	236-345						.00			.02	.03	.31	.40	.72	.70	.66	.23	.30
165	2356-35																	
166	23456-4											.05	.05					
167	245-345									.00	.00	.35	.27	.20	.20	.17	.02	.05
168	246-345																	
169	345-345																	
170	2345-234										.08	.35	.52	3.97	4.01	4.36	3.05	3.47
171	2346-234											.08	.14	1.09	1.08	1.17	.85	.89
172	2345-235											.03	.07	.71	.70	.69	.63	.62
173	23456-23													.11	.09	.09	.03	.05
174	2345-236										.08	.14	.34	4.92	4.96	4.99	6.56	6.10
175	2346-235													.18	.18	.17	.19	.16
176	2346-236											.00	.04	.59	.58	.59	.73	.66
177	2356-234										.03	.08	.20	2.54	2.52	2.64	2.82	2.73
178	2356-235												.03	.86	.84	.79	1.31	1.10
179	2356-236										.02	.02	.10	2.05	2.04	1.99	3.64	3.01
180	2345-245 + 193		.02	.00				.00		.02	.21	.42	.67	10.90	11.20	12.05	13.72	14.53
181	23456-24													.00	.00	.00		
182	2345-246																	
183	2346-245										.06	.09	.18	2.33	2.35	2.56	2.89	2.86
184	2346-246																	
185	23456-25													.56	.56	.53	.93	.81
186	23456-26																	
187	2356-245		.01	.00							.09	.09	.25	5.44	5.37	5.39	9.55	8.76
188	2356-246																	
189	2345-345											.00	.01	.08	.11	.12	.03	.04
190	23456-34											.05	.07	.82	.80	.85	.74	.77
191	2346-345													.16	.17	.17	.13	.13
192	23456-35																	
193	2356-345												.03	.54	.49	.57	.67	.65
194	2345-2345												.01	2.11	2.06	2.03	3.79	4.32
195	23456-234													.86	.81	.85	1.39	1.46
196	2345-2346													1.02	1.03	1.21	2.41	2.12
197	2346-2346													.07	.07	.07	.14	.13
198	23456-235													.10	.11	.09	.24	.22
199	2345-2356+198												.01	1.87	1.86	1.60	4.91	4.57
200	23456-236													.26	.26	.23	.69	.60
201	2346-2356													.25	.25	.23	.66	.58
202	2356-2356													.36	.36	.28	1.20	.96
203	23456-245+196												.02	1.50	1.45	1.25	4.11	4.37
204	23456-246																	
205	23456-345													.10	.10	.10	.16	.18
206	23456-2345											.03	.03	.66	.61	.31	1.19	1.33
207	23456-2346													.05	.06	.03	.17	.18
208	23456-2356											.01	.01	.16	.16	.06	.29	.26
209	23456-23456													NM	NM	NM	NM	NM
Sum		100.	100.	100.	100.	100.	100.0	100.2	100.2	100.2	100.4	100.3	100.2	100.3	101.4	101.1	100.0	100.0

1. High Resol. Chromatogr.

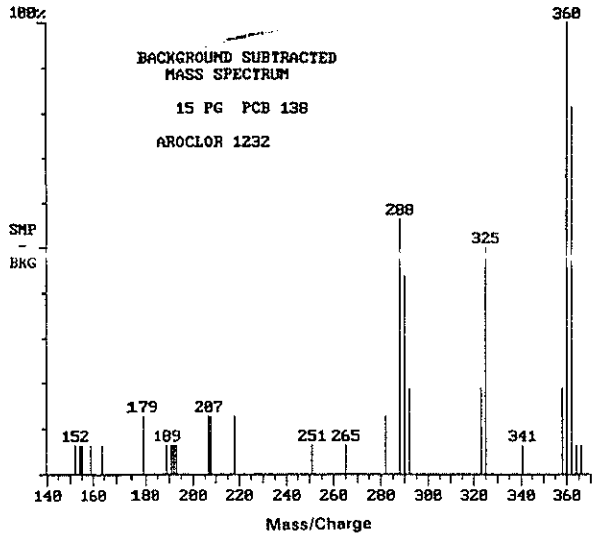

Figure 3. System 3, GC-Ion-trap MS, full-scan spectrum of PCB 138 in Aroclor 1232.

3.4 Aroclor Congener Weight% Distributions

Weight percentages for each congener in 17 Aroclor lots were calculated against the sum of all congener concentrations *found* in each Aroclor and are displayed in the 3 pages of **Table 4**. Since Aroclors 1221 and 1232 contain ~12% and ~6% unmeasured unchlorinated biphenyl [17], the reported weight percents should be adjusted by factors of 0.88 and 0.94 before using their distributions as a secondary calibration standard. Concentrations of individual PCB congeners were calculated in **Systems 1, 3, and 4** by single point calibration as described in Section 2.4. The values used to calculate the weight%s in **Table 4** were compiled in three ways:

1. MS detection does not enable separate quantitation of coeluting *isomers* (congeners of the same chlorine number). In cases where specific Aroclor *isomers* were not party to coelutions in either **Systems 1 and 3**, the calculated concentrations on each system agreed within ±10% more than 90% of the time, and the mean of the concentrations on each system was used.

2. **System 3** resolved more isomer pairs than **System 1** (**Table 2A**). Isomer coelutions on **System 1** are designated in weight% **Table 4** by adding the IUPAC number of the minor component of the pair to the major component structure designation in the Cl-position column. Such combinations are underlined for cases where **System 3** could resolve the pair, and in those cases the **System 3** concentration was used for each of the congeners coeluting on **System 1**.

3. In cases where neither **Systems 1 or 3** could resolve significant isomer coelutions (non-underlined), the average of the **System 1 and 3** concentrations measured using the major component's GC-MS RRF was calculated, and that value was apportioned between the two congener components according to the relative amounts measured on columns **4A** and/or **4B** of the dual-column ECD system. Congener weight%s calculated by this procedure are enclosed by outlines in **Table 4**. This method of calculation was chosen in order to base all congener quantitation in **Table 4** on the more linear MS responses.

Values below 0.05 Wt% are trace levels with poor quantitative accuracy due to difficulties of integrating small peaks close to background noise level. They are also more than 50-fold lower than the single standards, and 200-fold lower than the internal standard levels. As pointed out by Hess *et al.* [7], even with the greater linearity of the MS detector's responses, this is too great a span for accurate quantitation by single point calibration. The values are retained in **Table 4** as very rough approximations of the trace levels detected. Values calculated between 0.015 and 0.005 are rounded to .01 and those below 0.005 are displayed as .00. NM (not measurable) designates congeners verified elsewhere at trace levels in some Aroclors but not measurable because of coelutions with either other Aroclor congeners, or with the IS in the case of PCB 209. Contributions to the PCB 206 and 208 peaks from traces of these congeners in the PCB 209 IS were measured and subtracted to calculate the values displayed in **Table 4.**

3.5 Systematics of Chlorine Substitution in Aroclors

The weight% data of **Table 4** were converted to mole percents of each of 20 possible single phenyl-ring chlorine-substitution patterns and displayed for 5 biphenyl chlorination levels in **Table 5A**. The results are consistent with the theory of electrophilic substitution reactions on aromatic rings:

1. 246- and 35-substituted rings are highly suppressed (<0.1 mole% in any Aroclor). Their formation requires 2 unfavored substitutions *meta-* to either the other ring or prior chlorines, and once formed these ring substitution patterns direct rapid, strongly favored additional chlorination at positions *ortho-* or *para-* to multiple chlorine atoms.

2. 26-, 235-, and 345-substituted rings are less common (<3 mole% in any Aroclor) as a result of the same factors in **1.** above, but in these cases they act with lesser force.

3. 25-substitution occurs extensively and relatively rapidly, and it persists once formed; 24-substitution also occurs relatively rapidly but is then also rapidly removed by further chlorination above the percentages in Aroclor 1248; 34-substitution is initially slower but persists longer in higher Aroclors.

The 52 congeners listed in **Table 5B** were not detected above 0.01 Wt% in any Aroclor. All but PCB 182 should be observable without Aroclor congener coelution in at least one of **Systems 1, 3, 4A or 4B**. All 52 either possess one or more of the unfavored phenyl ring chlorination patterns described in **1.** or **2.** above, or display strong imbalance in the number of chlorines on each ring, (*e.g.* PCBs 38, 61, 62, 116, 142, 181), which is another feature unlikely to accumulate significantly. Measurable traces of PCBs 21 and 90 are anticipated on the basis of these correlations, but these PCBs suffer Aroclor congener coelutions on all systems of this study. The former has been detected in Aroclor mixtures on an HT8 column [11], and the latter has been reported in Aroclor 1254 by de Boer and Dao [22] and Frame [13] at levels considerable lower than those reported by Schulz *et al.* [14] in Aroclors 1242, 1254, and 1260.

Table 5A. Mole percents of PCB phenyl ring substitutions.

Lot → Aroclor-Ring Cl Pattern	A1 1221	Mean(3) 1242	Mean(2) 1248	G4 1254	Mean(3) 1260	Mean of all 5
none	34.89	1.33	.06		.02	7.26
2	33.12	21.01	7.05	.71	.18	12.41
3	4.59	2.85	.63	.05	.00	1.63
4	21.78	20.00	12.83	1.80	.19	11.32
23	.78	7.82	9.24	5.67	.51	4.80
24	1.40	10.18	12.94	4.62	.12	5.85
25	1.81	17.84	22.99	21.24	7.57	14.29
26	.52	2.86	2.61	.35	.01	1.27
34	.82	9.32	14.64	14.46	3.48	8.54
35	.00	.02	.00	.00	.00	.00
234	.07	1.60	3.98	10.56	10.03	5.25
235	.00	.30	.65	2.11	2.37	1.09
236	.10	2.27	5.24	13.86	14.43	7.18
245	.14	2.49	6.66	19.84	30.26	11.88
246		.02	.07	.07		.03
345	.00	.04	.14	.69	.90	.35
2345		.03	.23	2.01	15.04	3.46
2346		.02	.09	.88	3.43	0.88
2356		.02	.14	1.38	9.61	2.23
23456				.07	2.15	.45
SUM	100.05	100.03	100.19	100.37	100.29	100.19

Table 5B. Chlorine substitution patterns of PCBs not detected in Aroclors above 0.01 weight%.

PCB No.	Cl Pattern	Cl Diff.	PCB No.	Cl Pattern	Cl Diff.
14	**35**		116	23456	5
30	**246**	3	120	245 - **35**	
36	**35** - 3		121	**246** - **35**	
38	*345*	3	127	*345* - **35**	
39	**35** - 4		140	234 - **246**	
50	**246** - 2		142	23456 - 2	4
58	23 - **35**		143	2345 - *26*	2
61	2345	4	145	2346 - *26*	2
62	2346	4	148	*235* - **246**	
65	2356	4	150	236 - **246**	
68	24 - **35**		152	2356 - *26*	2
69	**246** - 3		155	**246** - **246**	
72	25 - **35**		159	2345 - **35**	2
73	*26* - **35**		160	23456 - 3	4
78	*345* - 3		161	2346 - **35**	2
79	34 - **35**		162	*235* - *345*	
80	**35** - **35**		165	2356 - **35**	2
98	**246** - 23		168	**246** - *345*	
100	**246** - 24		169	*345* - *345*	
104	**246** - 26		181	23456 - 24	3
106	2345 - 3	3	182	2345 - **246**	
107	234 - **35**		184	2346 - **246**	
108	2346 - 3	3	186	23456 - *26*	3
111	*235* - **35**		188	2356 - **246**	
112	2356 - 3	3	192	23456 - **35**	
113	236 - **35**	3	204	23456 - **246**	

BOLD indicates "suppressed" ring substitution.
Italic indicates "less common" ring substitution.

3.6 Comparison of Aroclor Lots

The last 2 columns of **Table 3** display pairwise comparisons of the congener distributions of different lots of the same numbered Aroclors as the sum of all the individual congener weight% differences calculated from the values in **Table 4**. The sums for pairs of Aroclors 1016s, 1232s, and one pair of 1260s are less than 2%. These pairs likely represent the same manufacturer's lot, and pairwise comparisons of the individual congener weight%s between these in **Table 4** may therefore provide an indication of the precision (*i.e.* the repeatability) of this study's analytical quantitation. Sums for pairs of 1242s, 1262s and an additional 1260 differ by 6 to 12%; values probably representing small lot-to-lot differences for these Aroclors. The sums for the pair of 1248s differ by 20% and for the pair of 1254s by 53%! Aroclors 1248 and 1254 are representative of the midpoint of the chlorination process for biphenyls. A number of tetra-, penta- and hexa- chloro-substituted PCBs are being rapidly created and destroyed in this range, so one might expect to find greater lot-to-lot variations among these.

A close examination of the differences between the AccuStandard (A4) and General Electric (G4) Aroclor 1254s reveals remarkable differences with respect to *ortho*-chlorine (2,6) substitution. When the G4/A4 ratio of weight%s is calculated for 11 non- or mono-*ortho*- substituted congeners (77, 126; 56, 60, 66, 74, 105, 114, 118, 122, 123) the ratios range from 0.15 to 0.54; while for 11 di-, tri- or tetra-*ortho*- chloro-substituted congeners (44, 49, 52, 92, 95; 135, 144, 149, 151, 187; 136) the ratios range from 2.00 to 6.72. A ratio of 1.00 would indicate that the proportions of a congener in each lot were the same. This striking difference suggests a rationale for many of the major differences in congener weight%s displayed between this pair of Aroclor 1254s in **Table 4**. The chlorination process for synthesis of the AccuStandard A4 lot (perhaps using an atypical chlorination catalyst or reaction conditions) may have been less favorable for *ortho*-chlorination than the one used for most other lots. Thus non- or mono- *ortho*- chloro-substituted congeners could build up, while further *ortho*-chlorination to produce di-, tri-, and tetra-*ortho*-chloro-substituted congeners was suppressed. By contrast the differences between the Aroclor 1248 lots do not display this *ortho*-substitution effect. The G4 Aroclor 1254 distribution is closer to that reported by Schulz *et al.* [14] and to the majority of other lots of Aroclor 1254 we have observed when simple comparisons of ECD or MS-SIM chromatographic patterns are made. The atypical A4 Aroclor 1254 lot is no longer distributed by AccuStandard.

4 Conclusion

The substantial differences between the Aroclor 1248 and 1254 lots emphasize the need to obtain the appropriate lots when using Aroclor mixtures as secondary standards for calibrating CQCS PCB analyses. All lots of Aroclors of the same chlorination level do NOT have similar congener distributions! The comprehensive Aroclor congener distributions in **Table 4** are considered to be more complete (especially for trace components) and accurate than those presented in earlier comprehensive studies [13, 14]. However, the shortcomings of the single level calibration which was employed indicate that the ±10% accuracy desirable for Aroclor-calibrated CQCS analysis has certainly not been achieved for all major and minor congeners over the full range of concentrations. **Table 6** compares our weight percentages for several minor mono-*ortho*- PCBs with the values accurately determined in other lots of 4 Aroclors by both 2D-GC-ECD and serial-coupled column GC-ECD [23]. The generally good agree-

Table 6. Wt% Comparisons of minor mono-*ortho*-substituted congeners.

PCB	A1242	A1248	A1254	A1260	Lab
74	2.30	4.10	1.30	.09	a
	2.10	4.00	1.10	.02	b
	1.81	3.91	.84	.05	c
114	.04	.13	.19	.03	a
	.04	.14	.25	<.01	b
	.04	.12	.18	<.01	c
123	<.02	.09	.14	<.05	a
	.04	.09	.25	<.01	b
	.03	.08	.15	<.01	c
157	<.01	<.01	.24	.08	a
	<.01	.02	.30	.15	b
	<.01	<.01	.19	.02	c
167	<.03	.03	.45	.18	a
	<.01	.03	.39	.13	b
	<.01	<.01	.27	.19	c
189	<.01	<.01	.04	.14	a
	<.01	<.01	.04	.10	b
	<.01	<.01	.01	.10	c

a = Data produced by 2D-GC-ECD [22] Netherlands Institute for Fisheries Research

.b = Data produced by serial coupled GC-ECD [22] CEC Joint Research Center.

c = Data produced by GC-MS and GC-ECD from **Tables 4 B, C:** This paper, means for each Aroclor, except A1254 is lot G4 only.

ment for most components, even at low levels one or more orders of magnitude less than the concentrations of the single point standards and IS, supports the claim of semi-quantitative accuracy for our weight% distributions. There remains a need for a set of *individual* Aroclor CQCS secondary standards (minimally including Aroclors 1221, 1242, a characteristic 1254, and 1262) to cover all Aroclor congeners at measurable levels. These need to have all congeners carefully quantified against multilevel certified primary standards on suitable HRGC columns, such as those employed in this study, and must be available to the PCB analytical community indefinitely. The best, readily available, documented Aroclor secondary standard for CQCS PCB analysis is presently that of Mullin's "Green Bay Method" [18], comprising a *single* mixture of Aroclors 1232 (itself a 50:50 blend of Aroclors 1221 and 1242): 1248: 1262 in proportions of 25:18:18. Aroclor 1262 is probably preferable to 1260 for this purpose, since it enhances the amounts of some of the most heavily chlorinated congeners. However, inspection of **Table 4** reveals that the chlorination-level gap between Aroclors 1248 and 1262 in the "Green Bay Standard" results in barely measurable levels of minor pentachlorobiphenyls 83, 109, 117, 122, 123, 124, and hexachlorobiphenyls 128, 129, 130, 131, 134, 137, 139, 147, 156, and 167 by comparison with the coverage obtained using an Aroclor 1242/1254 pair.

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The DB-XLB columns employed in **Systems 1, 2, and 3** were provided *gratis* by J&W Scientific (Folsom, CA. USA), and the HP 1801-GCD GC-MS instrument of **System 2** was provided on loan from the Hewlett-Packard Corp. (Palo Alto, CA, USA).

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The Occurrence of Polychlorinated Biphenyls

In Sediments Adjacent to Marine Fish Farms:

Results of Screening Surveys During 2001 & 2002

Report TR- 030905_LJS

November 2005

EXECUTIVE SUMMARY

To investigate the potential accumulation of polychlorinated biphenyls (PCBs) around marine cage fish farms as a possible result of accumulations in fish-meal, the levels of PCBs were determined in sediments taken from areas around 43 marine cage fish farms during 2001 and 29 fish farm sites during 2002.

PCBs were found in concentrations ranging from 0.45 to 34.3 μg/kg with higher concentrations generally being found at the cage edge. The majority of sites (> 90%) had PCB levels well below 10 μg/kg comparable with sediment sampled in Morecambe Bay, Cardigan Bay and the North Sea. The remaining sites had total-PCB content similar to levels seen in the south and outer Firth of Clyde. Using guidance limits set by Scottish Office Agriculture, Environment and Fisheries Department and the Florida Department of Environmental Protection it appears that the majority of sites would be considered only "slightly contaminated" and below "probable effects" levels.

Fish food has been shown to contain measurable levels of PCBs. No relation is apparent between the amount of food used and the level of total PCB detected, although some sites do show similar ratios of PCB congeners relative to PCB-180 to those found in the fish food. In the majority of cases however the ratios are highly variable, suggesting that possible multiple sources and/or metabolic processes within the salmon are complicating factors. The data does suggest that PCBs are elevated in sediments in the vicinity of some fish farms, although routine benthic monitoring would appear to indicate that they are unlikely to be having any major environmental impact at present. SEPA will keep the situation under review and may undertake further studies to check that PCBs and other persistent organic pollutants in sediments below fish farms do not reach concentrations which become a cause for concern.

CONTENTS

Section **Page**

1. INTRODUCTION

There has been public concern about the effect the marine fish farming industry is having on the environment including concerns that salmon feed may contain concentrations of ubiquitous bioaccumulative contaminants such as polychlorinated biphenyls (PCBs) and that these compounds may be present in the flesh of farmed salmon. The risk associated with this is adequately dealt with by the Food Standards Agency (Scotland) and information is available on the FSA(S) web-site on this aspect. SEPA has therefore confined its interest to the risk of such compounds accumulating in marine sediments around Scottish marine fish farms.

As part of an on-going surveillance monitoring programme in 2001 and 2002, samples of sediments were collected from the cage edges of marine cage fish farms. Samples were collected from 43 fish farms in 2001. At one of the sites a more detailed survey was taken. Reference samples were also taken at 5 sites. Samples were collected from 29 fish farms in 2002. At three of the sites a more detailed survey was taken.

Levels of PCBs were determined in the samples and results were compared to levels seen in marine sediments from other parts of the UK. Quality standards were used to assess the significance of any detected contamination.

2. BACKGROUND

Due to their global distribution, PCBs and perhaps other persistent/bio-accumulating pollutants present in measurable concentrations in fish meal used to make farmed fish diets, have the potential to accumulate in sediments surrounding Scottish cage fish farms.

PCBs are a mixture of chlorine substituted biphenyl congeners with differing degrees of chlorination (Tanabe, 1988) There are 209 theoretically possible PCB congeners. (Duinker *et al*., 1988). They are extremely stable compounds, resistant to oxidation, acids, bases and other strong chemical reagents. PCBs are ubiquitous environmental contaminants and residues have been detected in all parts of the world (Bommanna *et al*., 1994). Typical background concentrations of Total PCB in soils from around the UK are 2 - 32 μg/kg, typical concentrations in sewage sludge are between 106 and 712 μg/kg (DOE 1994).

It is not possible to quantify accurately all of the individual congeners present in environmental samples (Duinker *et al*., 1988). Therefore, the International Council for the Exploration of the Seas (ICES) have recommended that seven congeners, with chlorine numbers from 3 to 7, should be monitored in such samples. This allows comparison of results from different research groups. The so-called ICES 7 congeners are shown in Table 1. By convention total PCB concentration may be estimated as the sum of the ICES 7 congeners multiplied by 2.5.

Table 1 - ICES 7 congeners

Congener No.	Chemical Structure
28	2,4,4' trichlorobiphenyl
52	2,2',5,5' tetrachlorobiphenyl
101	2,2',4,5,5' pentachlorobiphenyl
118	2,3',4,4',5 pentachlorobiphenyl
138	2,2',3,4,4',5' hexachlorobiphenyl
153	2,2',4,4'5,5' hexachlorobiphenyl
180	2,2',3,4,4'5,5' heptachlorobiphenyl

There are no marine sediment quality standards for PCBs currently set in the UK. However, the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) have defined a series of concentration guidelines in order to categorise the levels of chlorinated biphenyls in marine sediments (Wells *et al*., 1989)

- those in the range 0.2-20 µg/kg are classed as "slightly contaminated"
- those in the range 21-100 µg/kg as "contaminated"
- those greater than 100 µg/kg as "highly contaminated".

The Florida Department of Environmental Protection (FDEP) has developed effects based sediment quality assessment guidelines for 34 priority substances in Florida coastal waters (Florida Department of Environmental Protection, 1994). The suggested threshold level for effects for PCBs is 21.6 µg/kg and the probable effect level is 189 µg/kg. These guidelines were designed for the evaluation of marine sediments around Florida and hence should be used with caution if applied to marine sediments from colder Scottish waters as different species often have different tolerances to pollutants.

The Joint Monitoring Group of the Oslo and Paris Commissions has also suggested standard sediment concentrations for PCBs below which the biological effects are unlikely to occur. The guidelines indicate that biological effects are unlikely at the 1-10 µg/kg level (normalised to 1% carbon). These were derived from studies containing biological effects data (Flemming *et al*., 1995). Again, as the majority of these studies were North American/Canadian, they should be used with caution when applied to marine sediments from colder Scottish waters.

3. METHODS

3.1. Sampling

2001

A total of 63 sediment samples were collected from 43 fish farms in 2001. An extensive survey was carried out at one site (Ardvourlie) to assist with model evaluation as well as environmental assessment. In each case a 0.025 m^2 van Veen grab was used to collect the sediment which was sub-sampled through top opening flaps on the grab and stored in 250 ml glass jars. The samples were frozen prior to transportation and they were stored frozen in the dark nominally at -20°C until taken for analysis.

At Ardvourlie on Loch Seaforth, Isle of Harris, samples were collected from the cage edge, the cage edge west and at 25, 50 and 75m west, the cage edge east and at 25, 50, 75 and 100 m east and at 25, 50, 75 and 100 m north. Site details are show in Annex 1, Table 3 and a map showing the locations of the sites is shown in Annex 1, Figure 1.

At the remaining sites, samples were collected at the cage edges except at Camas Na Sgainadin in the Sound of Raasay where the sample was collected at 100 m perpendicular to the current. In addition reference samples, taken more than 500 m from the cage edge were collected at Brei Geo, North Papa, Slocka and Ronas Voe. A sample was also collected at Cole Deep fallow. Site details are shown in Annex 1, Table 3 and maps of the locations of the sites are shown in Annex 1, Figures 2 - 14.

2002

A total of 66 sediment samples were collected from 29 fish farms. Extensive surveys were carried out at three sites (Bight of Cliffs, Brei Geo & North Nestings 2) to assist with model evaluation as well as environmental assessment. In each case a 0.025 m^2 van Veen grab was used to collect the sediment which was sub sampled through top opening flaps on the grab and stored in 250 ml glass jars. The samples were frozen prior to transportation and they were stored frozen in the dark at nominally -20°C until taken for analysis.

At Bight of Cliffs, Brei Geo & North Nestings 2, samples were collected from inshore transect, offshore transect, parallel towards head and parallel towards mouth all at cage edge, 25 and 100 metres from the cage. Site details are show in Annex 2, Table 6 and a map showing the locations of the sites is shown in Annex 2, Figures 15 to 17.

At the remaining sites, samples were collected at the cage edges. Site details are shown in Annex 2, Table 6 and maps of the locations of the sites are shown in Annex 2, Figures 18 - 23.

3.2. Polychlorinated Biphenyls (PCBs) Analysis

Samples were defrosted and a portion of wet sediment was mixed with sodium sulphate until a free flowing powder was formed and soxhlet extracted in acetone/hexane (33:67 v/v). Sulphur containing compounds were removed by reaction with elemental copper during extraction. The resultant extracts were concentrated using a TurboVap® concentrator and fats/lipids and any other co-extracted materials were removed by an acidic silica clean up followed by silver nitrate alumina adsorption. PCBs were separated, identified and quantified by gas chromatography (GC) with electron capture detection (ECD). A mid polarity HP Ultra 2 column of 50 m length, 0.2 mm inner diameter and 0.33 μm film thickness was used to perform the separation. Compounds were identified by comparison of their retention times to those of certified standards of individual PCB congeners. Quantification was by comparison of peak heights with multipoint calibration graphs of certified standards and internal standards. The final concentration was corrected for moisture content and weight of sediment used and hence the limit of detection (LOD) of the method is variable.

The procedure has been validated in-house in accordance with NS30 (Cheeseman *et al*., 1989). The routine precision and accuracy of the procedure were monitored by the analysis of a procedural blank, a recovery standard, a laboratory reference material and a duplicate sample with each batch of samples. In addition the accuracy of this method for the determination of PCBs has been validated by participation in inter laboratory comparison exercises such as the QUASIMEME European Quality Assurance Programme. All analyses were carried out at SEPA's East Kilbride laboratory which is UKAS accredited for the determination of PCBs in sediments.

3.3. Organic Carbon

45 sediment sub samples from 2001 and 29 from 2002 were analysed for total nitrogen and organic carbon using a CE instruments NA2500 nitrogen and carbon analyser. The samples were completely oxidised at 1000^{o}C and the combustion components separated and detected by a thermal conductivity detector.

4. RESULTS AND DISCUSSION

2001

Concentrations of total polychlorinated biphenyls (PCBs) were in the range 0.45 μg/kg to 22.03 μg/kg (corrected for %moisture) with the majority of sites well below 10 μg/kg and broadly comparable with levels seen in Morecambe Bay, Cardigan Bay and areas of the North Sea (see Table 2). The higher levels seen at six of the sites are broadly similar to levels seen in the south and outer Firth of Clyde. Unfortunately no data for remoter Scottish coastal waters where there are no fish farms is available, so no comparison with so-called "pristine sites" is presently possible. Organic carbon was in the range 1.23 % to 12.95 %. Full details are shown in Annex 1, Table 4. By comparison with the SOAEFD guidelines (see section 2) the majority of sites would be considered slightly contaminated. All of the sites were below the FDEP threshold effects level and all the sites were within the JMG sediment concentration range below which biological effects are unlikely to occur.

PCBs were detected at East of Hildasay, Brei Geo, North Papa, Slocka (Site C) and Ronas Voe, where the cage edge and a reference site more than 500 m away were sampled. At East of Hildasay, Brei Geo and Ronas Voe, they were detected at the cage edge and at lower concentrations at the reference site, whereas at North Papa and Slocka Site C higher concentrations were seen at the reference sites rather than at the cage edge. It is known that PCBs are more likely to accumulate in organic rich, finer grained sediments therefore the differences may simply reflect changes in substrate at the different sites. However, even when the results are normalised to organic carbon the trends remain broadly the same indicating the influence of other factors. The higher concentrations at the reference points for these two sites may therefore reflect sediment transport mechanisms at these sites or alternatively they may indicate other sources of input. One site, Uyea Sound Site 2 Cage, shows a significant anomaly when normalised to organic carbon suggesting a relatively high PCB loading (4.94 μg/kg) compared to other sites. This suggests that the sediment is enriched with PCBs at this site relative to organic carbon that may originate from fish feed but it is unsafe to draw any definite conclusions based on one sample.

At Ardvourlie, PCBs were detected at the cage edge, the cage edge west and at 25, 50 and 75 m west, the cage edge east and at 25, 50, and 100 m east and at 25 and 100 m north. The concentrations were highest at the cage edge east, decreased rapidly at 25 and 50 m east and were not detectable beyond 75 m east. The concentration of PCBs at the cage edge west were similar to the cage edge east and again decreased at 25, 50, and 75 m west although not to the same degree. The concentration also decreased at 25 m north and was not detected at 50 and 75 m north. Overall the distribution of the PCBs indicates a predominant gradient of movement from the cages out to the west of the site. Elevated levels to the north and east are less pronounced. Perhaps indicating a combination of local inputs via fish food and other sources.

2002

For the 2002 samples concentrations of total PCBs were in the range 1.25 µg/kg to 34.03 µg/kg (corrected for %moisture) with the majority of sites again well below 10 µg/kg. On this occasion higher levels were seen at five sites again with concentrations broadly similar to those seen in the south and outer Firth of Clyde. Organic carbon was in the range 0.40 % to 12.48 %. Full details are shown in Annex 2, Table 7. By comparison with the SOAEFD guidelines (see section 2) the majority of sites would be considered slightly contaminated. All of the sites were below the FDEP probable effects level and the majority below the threshold effects level. All the sites were within the JMG sediment concentration range below which biological effects are unlikely to occur.

At Brei Geo PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 25 and 100 m towards the mouth of the voe, at the cage edge towards the head of the voe and at the reference site. The concentration was highest at the cage edge towards the mouth of the voe and decreased at 25 and 100 m. The concentration of PCBs at the cage edge inshore was similar to the cage edge towards the mouth of the voe and again decreased at 25 and 100 m. The concentrations at the cage edge and at 25 and 100 m offshore were all relatively similar. PCBs were not detected at 25 and 100 m towards the head of the voe. Overall the distribution of the PCBs is showing a predominant reducing gradient towards the mouth of the voe.

At Bight of Cliffs PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 100 m towards the mouth of the voe and at the cage edge and at 25 and 100 m towards the head of the voe. The concentrations at the cage edge inshore, cage edge offshore and at the cage edge towards the head of the voe were similar and the concentration decreased at 25 and 100 m in all 3 directions. PCBs were not detected at 25 m from the cages in a direction parallel to the mouth of the voe but were detected at 100 m. The distribution of PCBs is showing a complex pattern of movement both inshore and offshore and towards the head of the voe. Elevated levels towards the mouth of the voe may perhaps reflect a combination of local inputs via fish food and other sources.

At North Nestings Site 2, PCBs were detected at the cage edge and at 25 and 100 m inshore, at the cage edge and at 25 and 100 m offshore, at the cage edge and at 25 and 100 m towards the mouth of the voe and at the cage edge and at 25 and 100 m towards the head of the voe. The concentration was highest at the cage edge towards the head of the voe and decreased rapidly at 25 and 100 m. The concentration of PCBs at the

cage edge and at 25 and 100m inshore, at the cage edge and at 25 m offshore and at the cage edge and at 25 and 100 m towards the mouth of the voe were all relatively similar but the concentration increased slightly at 100 m offshore. Overall the distribution of the PCBs suggests a predominant gradient of movement from the cages out to the west of the site. Elevated levels to the North and East were less pronounced. Again the distribution of PCBs indicates a complex pattern of movement both inshore and offshore and towards the mouth and head of the voe. Again, elevated levels offshore may perhaps reflect a combination of local inputs via fish food and other sources.

Levels of PCBs were determined in fish food, and were detected at a concentration of 19.45 µg/kg. Salmon feeds are produced from fish-meal and generally have high oil content both from the fish used and other fish oils that may be added. PCBs and other persistent bioaccumulative pollutants are known to concentrate in lipids therefore it is not surprising to find that some feeds may contain measurable levels of such pollutants. Not all the feed will be eaten so there is the potential for any associated pollutants to reach elevated concentrations beneath the cages. It might be expected that farms maintaining a higher biomass of fish would result in more feed being used, which might in turn increase the chances of residues accumulating. However, no relation between the consented biomass limit of a farm and total PCB concentration was observed. This is not surprising as that the data set for this study was limited, the feed source and lipid content will vary considerably, and other factors such as food conversion ratio and stocking regime, varied tidal regimes and sediment transport and the influence of other pollutant sources will interfere with the establishment of any such simple correlation.

By standardizing or “normalising” PCB congener concentrations to PCB-180 (see Annex 1, Table 5) it was hoped that similarities between the feed and the underlying sediments would be seen. In the case of Ardvourlie the ratios do not match although sites to the west of the cages do show higher levels of PCB-153 and PCB-138 similar to the fish feed than sites to the east and north. If anything the levels in the sediments to the west and beneath the cages show even higher levels of PCB-153 and PCB-138 than the analysed fish food, which may reflect that the individual congeners are metabolised at different rates or indicate other sources of PCB contamination.

Using the same normalisation process for other sites there are 7 sites where the sediment PCB ratios are broadly similar to those in the analysed feed. These include Gorsten Ardgour, Garven Loch Eil, Loch Maddy (Rubha Nan Gall), Eilean Aird, Collafirth Ness Site 3, Sgeir Bhuidhe and Loch Shell (mid). The similarity of ratios may be coincidental and not represent use of feed similar to that analysed as the ratios of PCBs at Brei Geo, Eilean nam Mult, Eilean Trannay and Maaruig in the sediments did not match those of the analysed feed at these sites. Clearly a number of complex processes and potential sources all play a part. However, regardless of the processes involved it is clear that elevated concentrations of PCBs are present around the cages and that the most likely reason for this is due to inputs from fish feed over and above any other sources.

Overall the concentrations of total PCBs found around fish farms were similar to those reported in marine sediments from open locations around the UK and to background concentrations found in UK soil. They are considerably lower than those reported for industrialised estuaries and therefore although elevated around some fish farms they are unlikely to cause any immediate environmental problems. In addition, the affected

zones are localised to a small area beneath and close to the cages. A summary of total PCB concentration found at locations around the UK is shown in Table 2.

The results for total PCBs reported here are estimated as 2.5 times the sum of the ICES 7 congeners. However, the Food Standards Agency (FSA) routinely analyse PCBs in food and determine the levels of 25 PCBs including the ICES 7. In full they determine the levels of PCBs 18, 28, 31, 47, 49, 51, 52, 77, 81, 99, 101, 105, 114, 118, 123, 126 128, 138, 153, 156, 157, 167, 169, 180, 189. The analysis of this more complete range, when converted by an appropriate factor, may provide a closer approximation of total PCB's than the 2.5xΣICES 7 approach and may also indicate underlying trends, which are not noticeable in the current data. More importantly the wider range covers human health as well as environmental concerns, which is relevant in a fish-farming context although the low levels of PCBs measured in sediments at fish farm sites pose little direct risk to human health.

Table 2 – Summary of total PCB's found in UK marine sediments

Location	Year of analysis	Organic Carbon %	Total PCB µg/kg (dry weight)	References
Inner Firth of Clyde	1989	3.3 – 4	40-112.5	Kelly *& Campbell,* 1995
Firth of Clyde – Inchmarnock Water	1989	1.4 - 4.2	12.8-35	
Mid/ South Firth of Clyde	1989	0.9 - 3.1	4.5-17.2	
Outer Firth of Clyde	1989	0.5 - 1.4	1.2-16.7	
Garroch Head Former Sludge Dump Site	1989	1.1 - 5.1	102-1250	
Garroch Head Sludge Dump Site	1989	2.4 - 11.9	25-305	
Liverpool Bay	1988	Not Determined	13.7-37.9	Camacho-Ibar *& McEvoy,* 1996
Shandon Dock (Liverpool)	1988	Not Determined	320	
Inner Thames Estuary	1993	Not Determined	3-40	Scrimshaw *& Lester,* 1995
Tyne Estuary	1990	Not Determined	6.1-8.1	MAFF 1993
Humber	1990	Not Determined	3-7.6	
Cardigan Bay	1990	Not Determined	0.2-3.9	
Morecombe Bay	1990	Not Determined	0.2-4.7	
Humber, Tees, Tweed and Ribble Estuaries	1990	Not Determined	0.2-20	ENDS 1993
Tyne, Wear and Mersey Estuaries	1990	Not Determined	20-100	
North Sea	1986	0.1 - 15	0.1-4.4	Knickmeyer & Steinart., 1988
North Sea	1986-1987	0.4 –14.8	0.21-9.18	Knickmeyer *et al.*, 1990

5. CONCLUSIONS

The concentrations of polychlorinated biphenyls (PCBs) that were detected in sediments in the vicinity of Scottish marine cage fish farms were relatively low and can be considered as only slightly contaminated, based on existing guidance. The concentrations found are similar to levels found in marine sediments from open locations around the UK and were similar to background concentrations in soils around the UK. However SEPA does not currently have data for concentrations of PCB in remote undeveloped Scottish coastal waters and cannot therefore provide a comparison with levels at sites remote from any anthropogenic influence.

It was generally observed that the concentration of total PCBs was highest at the cage edge and it is likely that elevated levels of PCBs have resulted from fish farming activities. It was found that a sample of fish food analysed in the course of the study contained measurable levels of PCBs which may confirm the feed as a source for PCBs at the fish farms. No relation was seen between the consented biomass limit of a site and the detected level of total PCBs detected but ratios of different PCB congeners to PCB-180 at certain sites lend some support to the contention that elevated levels of PCBs below the cages are likely to originate at least in part from residues in the fish feed.

The concentrations of total-PCBs are comparatively low suggesting no immediate environmental problems are expected to arise from this. In addition, routine near-field monitoring has not indicated any biological effects inconsistent with the changes expected through carbon enrichment. As the study indicates an elevated concentration of PCBs appear to originate from farmed-fish diets it is likely that other persistent globally distributed pollutants may also be present. Given the half-lives of these compounds therefore, SEPA will keep the situation under review and may undertake further studies to check that concentrations of PCBs and other persistent organic pollutants do not reach concentrations that would give cause for concern.

Initiatives to reduce the content of these compounds in fish and other farmed animal diets in order to reduce human dietary intakes are expected to reduce the quantities which inevitably are released to the environment.

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ANNEX 1 – RESULTS 2001

Table 3 - Site details

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Camas Na Sgainadin, Perpendicular 100m	Sound of Rasaay	NG 6194 2662	2001	4419	WPC/N/59126 (00)	405
Gorsten, Ardgour, Fort William, cage	Loch Linnhe	NN 0593 7067	2001	4426	WPC/N/61689 (00)	642
Garven, Loch Eil, cage	Loch Linnhe	NM 9902 7808	2001	4427	WPC/N/61690 (00)	1300
Cairidh, cage	Loch Ainort	NH 1662 2787	2001	4428	T/B10/059/98 (00)	1000
Eilean Ard (Site 3), cage	Loch Laxford	NC 1894 5014	2001	4429	WPC/N/61547 (01)	1250
Bight of Cliffs, cage	Olnafirth	HU 3930 6448	11/06/01	8916	WPC/N/62086 (01)	500
North Knowe, Greetaing, cage	Busta Voe	HU 3460 6418	10/06/01	8917	WPC/N/62042 (01)	350
Basta Voe, East Site, cage	Basta Voe	HU 5471 9498	09/06/01	8918	WPC/N/61978 (01)	500
Olnafirth South, cage	OlnaFirth	HU 3740 6427	10/06/01	8919	WPC/N/62069 (01)	1600
Cole Deep, cage	Cole Deep	HU 3579 6327	09/06/01	8920	WPC/N/61916 (00)	800
Cole Deep, fallow		HU 3579 6427	09/06/01	8921		
NW of Turraness Uyea, Unst, cage	Skuda Sound	HU 6103 9933	07/06/01	8922	WPC/N/61981 (01)	500
NW of Winnaness Uyea, Unst, cage	Winnaness	HU 5871 9978	07/06/01	8923	T/B21/017/97 (00)	2200
Uyeasound, Unst, Site 1, cage	Uyea Sound	HP 5971 0020	07/06/01	8924	WPC/N/61976 (01)	400

Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Uyeasound, Unst, Site 2, cage	Uyea Sound	HP 5971 0076	08/06/01 07/06/01	8925 9186	WPC/N/61977 (01)	250
Site 2, Wick of Belmont North, cage	Blue Mull Sound	HU 5641 9998	08/06/01	8926	WPC/N/61982 (01)	900
Site 3, South Head of Mula, cage	Blue Mull Sound	HU 5707 9932	06/06/01	8927	WPC/N/61856 (00)	750
Site 5, Point of Burkwell, cage	Blue Mull Sound	HU 5840 9932	06/06/01	8928	WPC/N/61857 (00)	800
Boatsroom Voe, cage	Boatsroom Voe	HU 4948 7100	15/06/01	8929	WPC/N/62056 (01)	800
Setterness West - Poseidon Site, cage	Off Lunnaness	HU 4729 7064	14/06/01	8930	WPC/N/62059 (01)	3150
Setterness East - Bomlo, cage	Off Lunnaness	HU 4807 7121	14/06/01	8931	WPC/N/62058 (02)	3500
Swinnister Voe, cage	Swinnister Voe	HU 4531 7268	18/06/01	8932	WPC/N/62034 (01)	990
Collafirth, Delting Site 1 (S), cage	Colla Firth	HU 4320 6899	15/06/01	8933	WPC/N/62095 (01)	625
Collafirth, Delting Site 2 (N), cage	Colla Firth	HU 4410 6950	15/06/01	8934	WPC/N/62094 (01)	600
East of Hildasay, cage	Hildasay	HU 3630 4039	22/06/01	8935	WPC/N/62242	400
East of Hildasay, reference		HU 3630 4039	22/06/01	8936		
East of Bruna Ness, cage	Lang Sound	HU 3871 3756	23/06/01	8937	WPC/N/61646 (00)	1154
Brei Geo Offshore, cage	Sandsound Voe	HU 3571 4647	23/06/01	8938	WPC/N/61405 (01)	2635
Brei Geo Offshore, reference		HU 3571 4647	23/06/01	8939		

Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
North of Papa, W of Scalloway, cage	The Deeps	HU 3662 3837	22/06/01	8940	WPC/N/60784 (00)	40
North of Papa, W of Scalloway, reference		HU 3662 3837	22/06/01	8941		
Slocka (Site C), cage	Ronas Voe	HU 2853 8267	20/06/01	8942	WPC/N/61926 (00)	1000
Slocka (Site C), reference		HU 2853 8267	20/06/01	8943		
Pobie Sukka (Site A), cage	Ronas Voe	HU 3103 8075	21/06/01	8944	WPC/N/61925 (00)	400
Ronas Voe, cage	Ronas Voe	HU 3253 8075	20/06/01	8945	WPC/N/62304	600
Ronas Voe, reference		HU 3253 8075	20/06/01	8946		
Site 3, Collafirth Ness, cage	Swinning Voe	HU 4550 7039	21/06/01	8947	WPC/N/59542 (01)	1920
Loch a Laip (Inner), Site 1, Benbecula, cage	Loch a Laip	NF 6153 4738	16/08/01	17927	T/B19/81/98 (00)	750
Loch Skipport (Outer), Ornish, S. Uist, cage	Loch Skipport,	NF 5276 3850	16/08/01	17928	T/B19/080/98 (00)	1250
Loch Maddy (Rubha Nan Gall), N. Uist, cage	Loch Maddy	NF 2657 6884	17/08/01	17929	RP2/6B/93/017	550
Eilean nam Mult, N. Uist, cage	Loch Euphort	NF 7900 6364	17/08/01	17930	RP2/C6D/93/040	60
Eilean Trannay, cage	Loch Euphort	NF 9378 6373	17/08/01	17931	RP2/6D/93/041	60
Pecam Bay, Lewis, cage	Loch Erisort	NB 3941 2180	20/08/01	17932	T/B19/079/98 (00)	600
Sgeir Bhuidhe, Pecam Bay 3, cage	Loch Erisort	NB 4015 2207	20/08/01	17933	T/B19/090/98 (00)	800

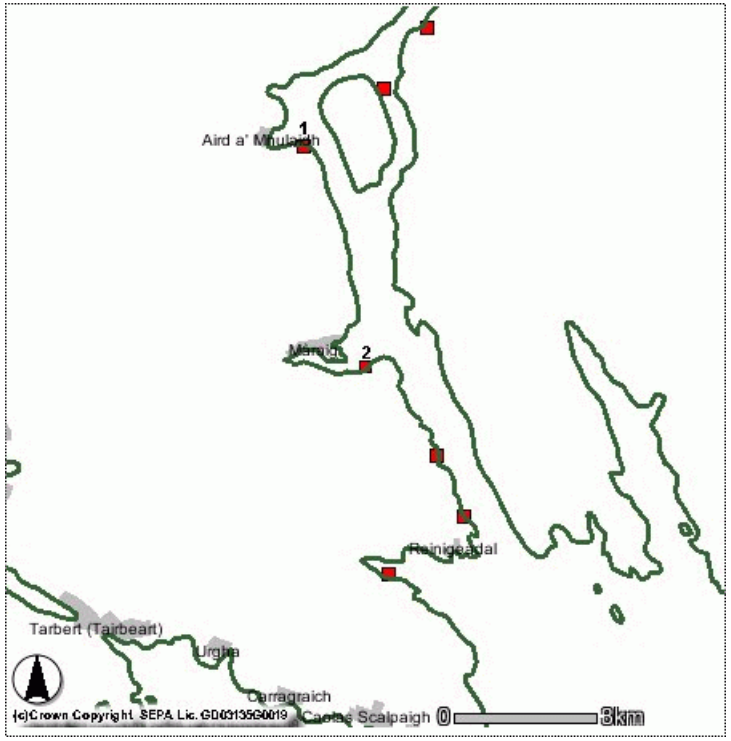
Table 3 - Site details continued

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Loch Grimshader, Lewis, cage	Loch Grimshader	NB 3976 1432	22/08/01	17934	WPC/N/60983 (00)	622
Loch Shell (mid) Shell Pairc East, Lewis, cage	Loch Shell	NB 3549 1026	22/08/01	17935	WPC/N/60813 (00)	1700
Loch Shell (mid) Shell Pairc West, Lewis, cage		NB 3452 1031	22/08/01	17936		
Ardvourlie, Harris, cage	Loch Seaforth	NB 1958 1050	23/08/01	17937	WPC/N/62139 (00)	540
Maaruig, Harris, cage	Loch Seaforth	NB 2096 0577	23/08/01	17938	WPC/N/62138 (00)	540
Ardvourlie, Harris, cage west	Loch Seaforth	NB 1958 1050	23/08/01	17939	WPC/N/62139 (00)	540
Ardvourlie, Harris, 25m off west		NB 1956 1050	23/08/01	17940		
Ardvourlie, Harris, 50m off west		NB 1953 1050	23/08/01	17941		
Ardvourlie, Harris, 75m off west		NB 1951 1049	23/08/01	17942		
Ardvourlie, Harris, cage east		NB 1976 1049	23/08/01	17943		
Ardvourlie, Harris, 25m off east		NB 1978 1049	23/08/01	17944		
Ardvourlie, Harris, 50m off east		NB 1981 1048	23/08/01	17945		
Ardvourlie, Harris, 75m off east		NB 1984 1049	23/08/01	17946		
Ardvourlie, Harris, 100m off east		NB 1986 1050	23/08/01	17947		
Ardvourlie, Harris, 25m off north		NB 1960 1056	23/08/01	17948		

Table 3 - Site details continued

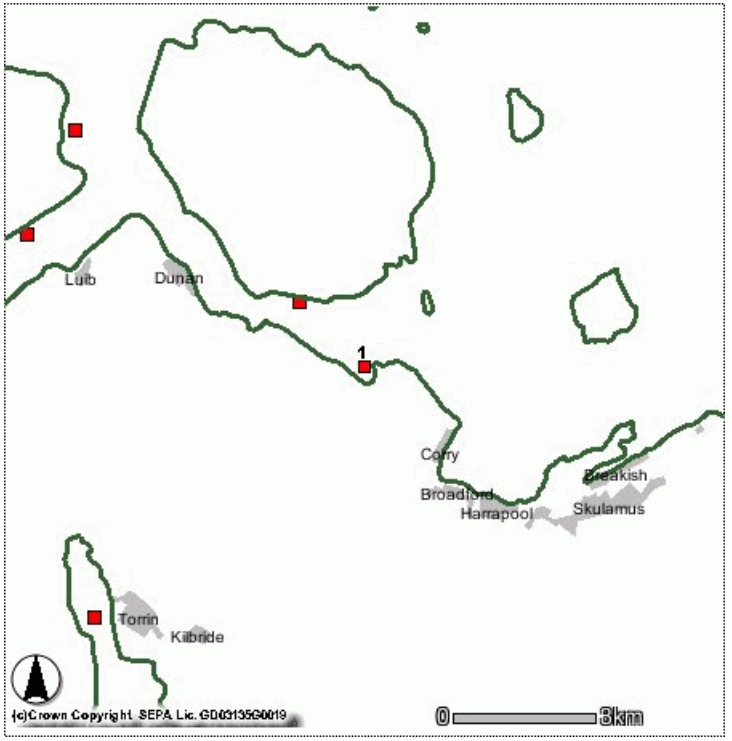
Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Ardvourlie, Harris, 50m off north	Loch Seaforth	NB 1961 1059	23/08/01	17949	WPC/N/62139 (00)	540
Ardvourlie, Harris, 75m off north		NB 1961 1062	23/08/01	17950		
Ardvourlie, Harris, 100m off north		NB 1961 1064	23/08/01	17951		

Figure 1 - Map of Loch Seaforth



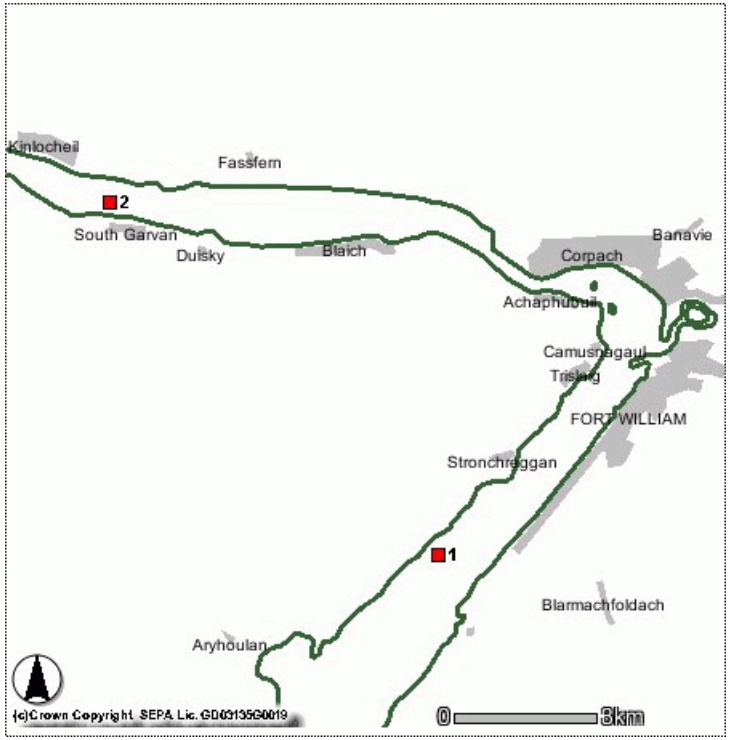
[1] - Ardvourlie
[2] - Maaruig

Figure 2 - Map of Sound of Raasay



[1] - Camas Na Sgainadin

Figure 3 - Map of Loch Linnhe

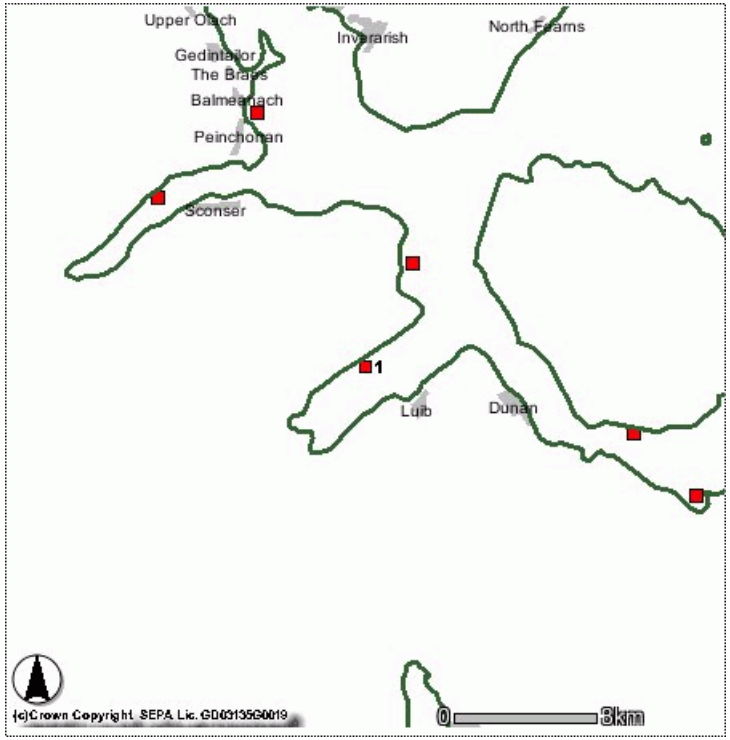


[1] – Gorsten, Ardgour
[2] – Garven, Loch Eil

Figure 4 - Map of Loch Laxford

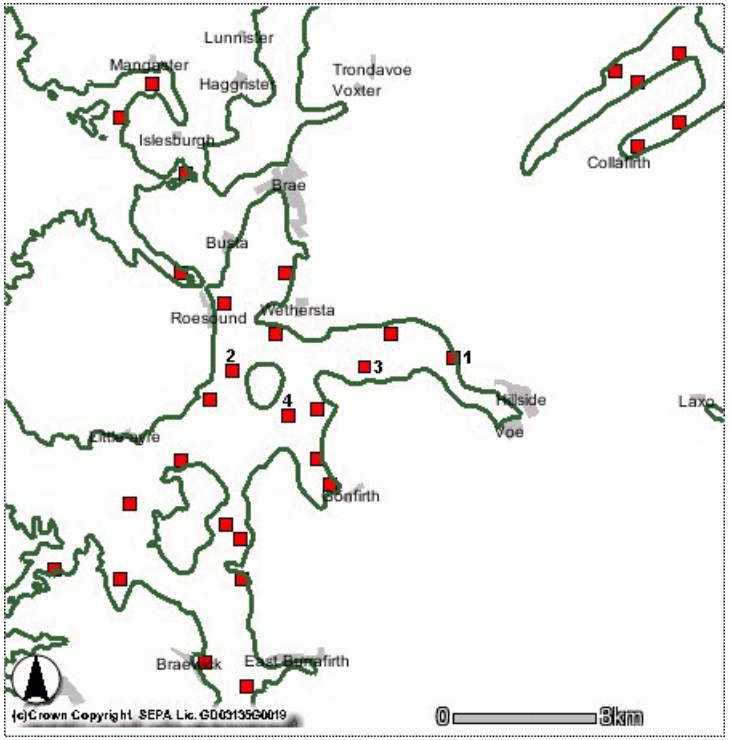
[1] – Eilean Ard

Figure 5 - Map of Loch Ainort



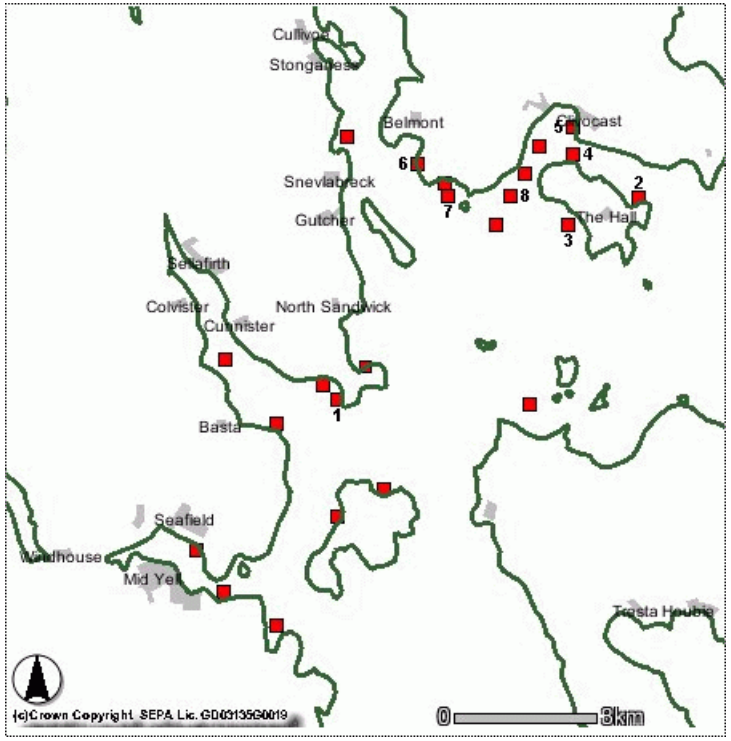
[1] - Cairidh

Figure 6 - Map of Busta Voe, Cole Deep and Olna Firth



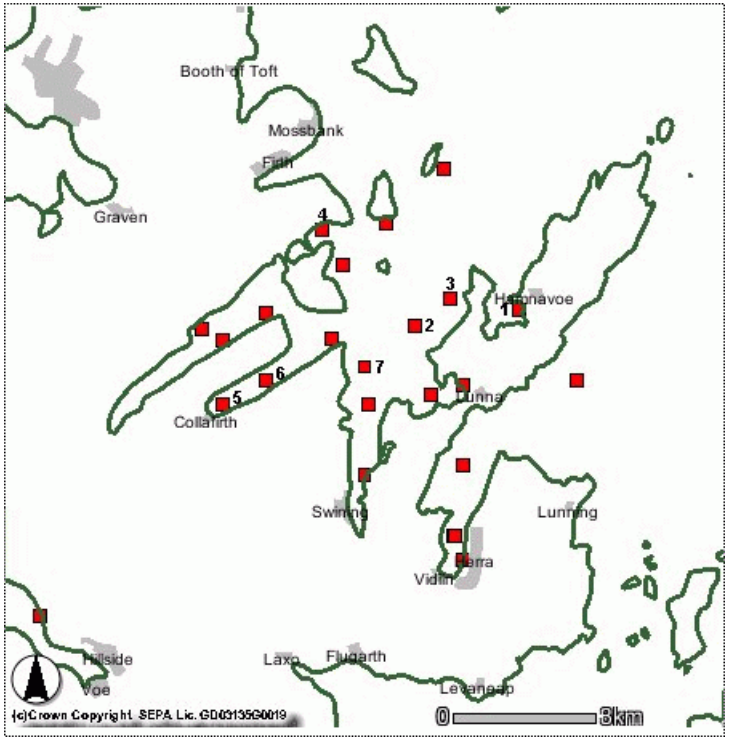
[1] - Bight of Cliffs
[2] - North Knowe, Greetaing
[3] - Olnafirth South
[4] - Cole Deep

Figure 7 - Map of Basta Voe, Blue Mull Sound, Uyea Sound and Winnaness



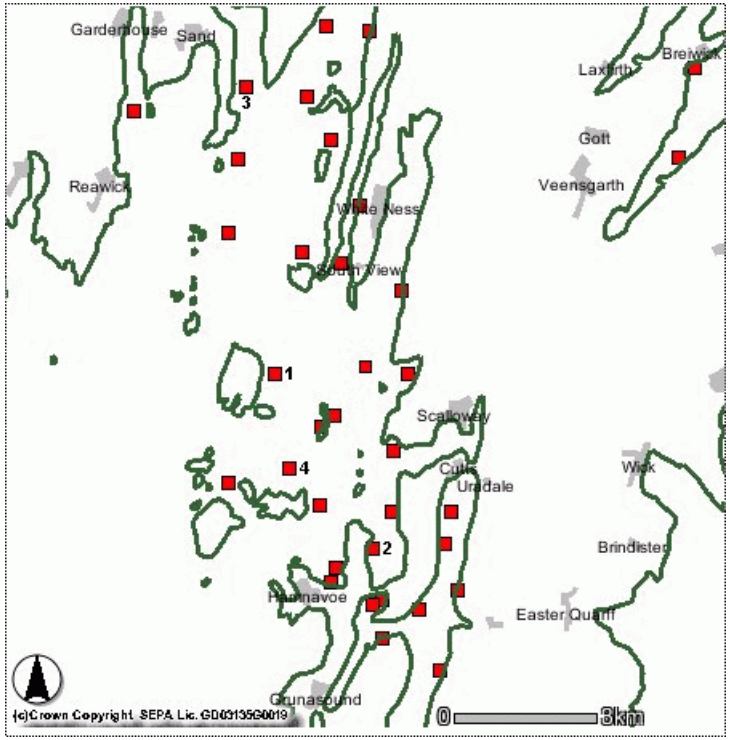
[1] – Basta Voe East Site
[2] - NW of Turraness
[3] - NW of Winnaness
[4] - Uyeasound Site 1
[5] - Uyeasound Site 2
[6] - Wick of Belmont North
[7] - South Head of Mula
[8] - Point of Burkwell

Figure 8 - Map of Boatsroom Voe, Colla Firth, Swinning Voe and Swinnister Voe



[1] - Boatsroom Voe
[2] - Setterness West - Poseidon Site
[3] - Setterness East - Bomlo
[4] - Swinnister Voe
[5] - Collafirth Delting Site 1 (South)
[6] - Collafirth Delting Site 2 (North)
[7] - Collafirth Ness

Figure 9 - Map of the Deeps, Hildasay, Lang Sound and Sandsound Voe

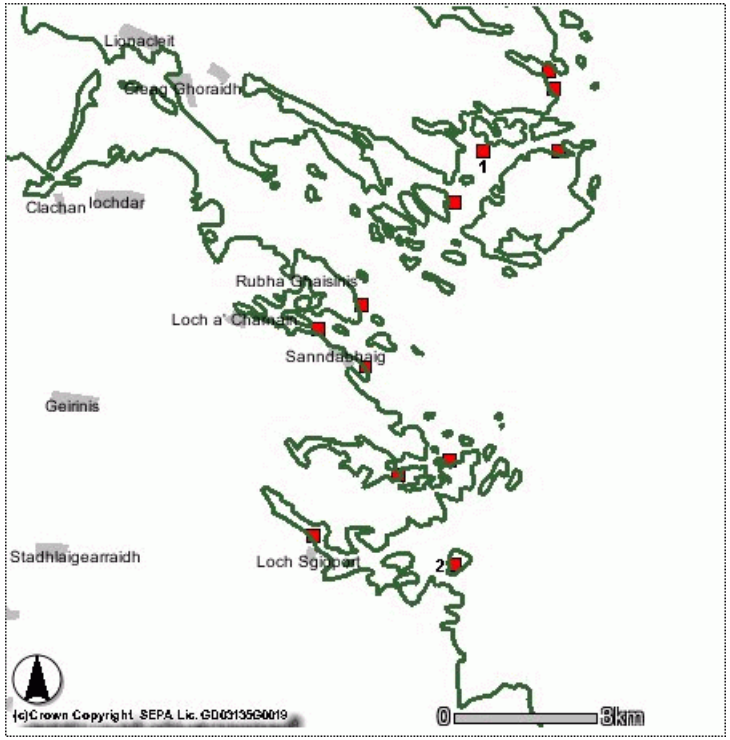


[1] - East of Hildasay
[2] - East of Bruna Ness
[3] - Brei Geo Offshore
[4] - North of Papa, W of Scalloway

Figure 10 - Map Figure of Ronas Voe

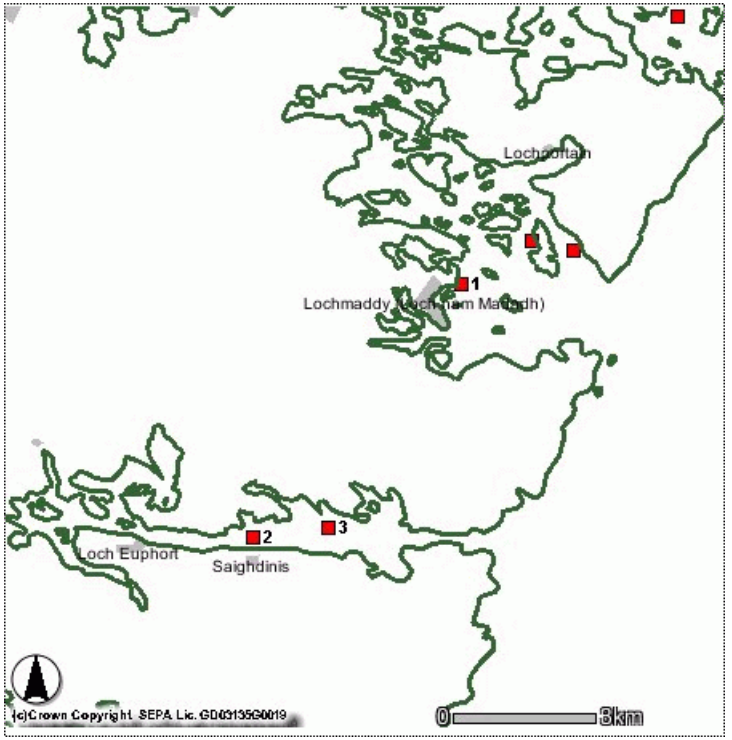
[1] - Slocka
[2] - Pobie Sukka
[3] - Ronas Voe

Figure 11 - Map of Loch a Laip and Loch Skipport



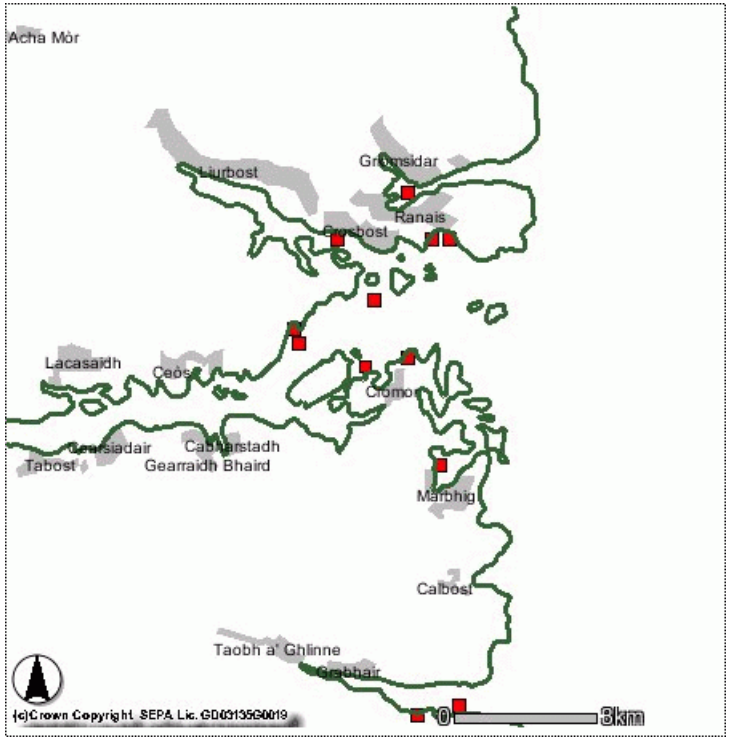
[1] - Loch a Laip (Inner)
[2] - Loch Skipport (Outer)

Figure 12 - Map of Loch Euphort and Loch Maddy



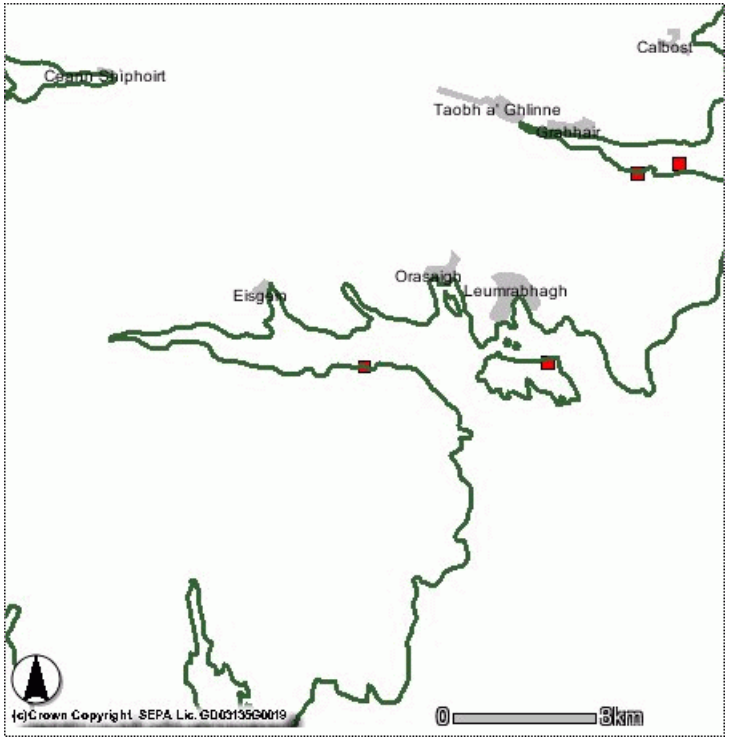
[1] - Loch Maddy (Rubha Nan Gall)
[2] - Eilean nam Mult
[3] - Eilean Trannay

Figure 13 - Map of Loch Erisort and Loch Grimshasder



[1] - Pecam Bay
[2] - Sgeir Bhuidhe
[3] - Loch Grimshader

Figure 14 - Map of Loch Shell



[1] – Loch Shell (mid) Shell Pairc East
[2] – Loch Shell (mid) Shell Pairc West

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content)

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Fish food sample	-	0.39	0.79	1.09	0.85	2.51	1.62	0.53	7.78	19.45	-	-
Camas Na Sgainadin, Perpendicular, 100m	4419	ND	ND	ND	ND	ND	ND	ND	ND	ND[a]	N/A	N/A
Gorsten, Ardgour, cage	4426	ND	**0.06**	**0.13**	**0.13**	**0.32**	**0.28**	**0.08**	**1.05**	**2.63[a]**	N/A	N/A
Garven, Loch Eil, cage	4427	**0.08**	**0.08**	**0.23**	**0.21**	**0.48**	**0.50**	**0.11**	**1.69**	**4.23[a]**	N/A	N/A
Cairidh, cage	4428	**0.27**	**0.60**	**0.70**	**0.53**	**1.10**	**0.89**	**0.21**	**4.30**	**10.75[a]**	N/A	N/A
Eilean Ard (Site 3), cage	4429	**0.03**	**0.03**	**0.10**	**0.11**	**0.23**	**0.20**	**0.05**	**0.75**	**1.88[a]**	N/A	N/A
Bight of Cliffs, cage	8916	**0.18**	**0.24**	**0.20**	**0.18**	**0.30**	**0.24**	**0.08**	**1.42**	**3.55**	**5.84**	**0.24**
North Knowe, Greetaing, cage	8917	ND	ND	**0.18**	**0.23**	**0.39**	**0.38**	**0.11**	**1.29**	**3.23**	**9.25**	**0.34**
Basta Voe, East Site, cage	8918	**0.40**	**0.15**	**0.18**	**0.16**	**0.21**	**0.19**	**0.07**	**1.36**	**3.40**	**3.86**	**0.88**
Olnafirth South, cage	8919	**0.13**	ND	**0.15**	**0.10**	**0.17**	**0.13**	**0.06**	**0.74**	**1.85**	**8.81**	**0.11**
Cole Deep, cage	8920	**0.13**	ND	**0.26**	**0.24**	**0.47**	**0.38**	**0.12**	**1.60**	**4.00**	**7.56**	**0.53**
Cole Deep, fallow	8921	**0.07**	**0.11**	**0.07**	**0.08**	**0.10**	**0.10**	**0.03**	**0.56**	**1.40**	**6.72**	**0.21**
NW of Turraness, cage	8922	**0.05**	ND	**0.17**	**0.16**	**0.32**	**0.24**	**0.18**	**1.12**	**2.80**	**6.47**	**0.43**
NW of Winnaness, cage	8923	**0.54**	**0.14**	**0.14**	**0.12**	**0.24**	**0.20**	**0.07**	**1.45**	**3.63**	**7.78**	**0.47**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; [a] – not corrected for %moisture; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Uyeasound, Site 1, cage	8924	**0.68**	**0.17**	**0.18**	**0.14**	**0.20**	**0.19**	**0.09**	**1.65**	**4.13**	**7.73**	**0.53**
Uyeasound, Site 2, cage	8925	1.40	0.21	0.19	0.16	0.20	0.20	0.07	2.43	6.08	1.23	4.94
Site 2, Wick of Belmont North, cage	8926	0.67	0.15	0.15	0.15	0.17	0.14	0.14	1.57	3.93	3.77	1.04
Site 3, South Head of Mula, cage	8927	**0.22**	ND	**0.07**	**0.05**	**0.06**	**0.04**	ND	**0.44**	**1.10**	**2.89**	**0.38**
Site 5, Point of Burkwell, cage	8928	**0.07**	ND	**0.17**	**0.11**	**0.17**	**0.15**	**0.05**	**0.65**	**1.63**	**8.64**	**0.19**
Boatsroom Voe, cage	8929	**0.07**	ND	**0.18**	**0.18**	**0.28**	**0.21**	**0.08**	**1.00**	**2.50**	**6.53**	**0.38**
Setterness West - Poseidon Site, cage	8930	**0.08**	ND	ND	**0.14**	**0.32**	**0.08**	ND	**0.94**	**2.35**	**7.32**	**0.32**
Setterness East - Bomlo, cage	8931	**0.06**	ND	**0.05**	**0.03**	**0.23**	**0.19**	ND	**0.89**	**2.23**	**7.18**	**0.31**
Swinnister Voe, cage	8932	**0.10**	**0.08**	**0.11**	ND	**0.09**	**0.08**	**0.03**	**0.49**	**1.23**	**6.79**	**0.18**
Collafirth, Delting Site 1 (S), cage	8933	**0.08**	**0.12**	**0.36**	**0.36**	**0.43**	**0.35**	**0.14**	**1.84**	**4.60**	**7.79**	**0.59**
Collafirth, Delting Site 2 (N), cage	8934	ND	ND	**0.09**	**0.22**	**0.34**	**0.35**	ND	**1.18**	**2.95**	**11.34**	**0.26**
East of Hildasay, cage	8935	**0.14**	**0.38**	**0.97**	**1.64**	**1.84**	**1.62**	**0.57**	**7.16**	**17.90**	**7.65**	**2.33**
East of Hildasay, reference	8936	**0.31**	**0.17**	**0.21**	ND	**0.16**	**0.17**	**0.05**	**1.07**	**2.68**	**7.51**	**0.35**
East of Bruna Ness, cage	8937	**0.43**	**0.98**	**2.40**	**0.37**	**1.86**	**2.34**	**0.43**	**8.81**	**22.03**	**6.87**	**3.21**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Brei Geo Offshore, cage	8938	**0.34**	**0.46**	**1.08**	**2.55**	**1.65**	**1.30**	**0.58**	**7.96**	**19.90**	**12.19**	**1.63**
Brei Geo Offshore, reference	8939	**0.15**	**0.21**	**0.18**	**0.05**	**0.22**	**0.25**	**0.08**	**1.14**	**2.85**	**6.28**	**0.45**
North of Papa, cage	8940	**0.37**	**0.19**	**0.24**	**0.15**	**0.26**	**0.22**	**0.09**	**1.52**	**3.80**	**8.80**	**0.43**
North of Papa, reference	8941	**0.73**	**0.40**	**0.27**	ND	**0.18**	**0.23**	**0.16**	**1.97**	**4.93**	**7.59**	**0.65**
Slocka (Site C), cage	8942	**0.12**	**0.15**	**0.26**	**0.04**	**0.07**	**0.06**	**0.02**	**0.72**	**1.80**	**4.76**	**0.38**
Slocka (Site C), reference	8943	**0.52**	**0.27**	ND	ND	**0.11**	**0.09**	**0.04**	**1.03**	**2.58**	**3.88**	**0.66**
Pobie Sukka (Site A), cage	8944	**0.06**	ND	**0.05**	**0.05**	**0.09**	**0.08**	**0.03**	**0.36**	**0.90**	**6.47**	**0.14**
Ronas Voe, cage	8945	**0.48**	**0.23**	**0.27**	**0.29**	**0.43**	**0.33**	**0.10**	**2.13**	**5.33**	**7.77**	**0.69**
Ronas Voe, reference	8946	**0.40**	**0.31**	**0.10**	**0.08**	**0.20**	**0.16**	**0.10**	**1.45**	**3.63**	**6.15**	**0.59**
Site 3, Collafirth Ness, cage	8947	**0.42**	**0.59**	**1.18**	**0.96**	**1.91**	**1.54**	**0.52**	**7.12**	**17.80**	**12.95**	**1.37**
Uyeasound, Site 2, cage	9186	0.58	ND	ND	ND	0.08	0.06	ND	0.72	1.80	2.69	0.67
Loch a Laip(Inner), Site1, cage	17927	0.25	1.08	1.01	1.03	1.47	1.41	0.39	6.64	16.60	10.64	1.56
Loch Skipport (Outer), cage	17928	**0.09**	**0.06**	**0.19**	**0.18**	**0.38**	**0.32**	**0.08**	**1.30**	**3.25**	**9.19**	**0.35**
Loch Maddy (Rubha Nan Gall), cage	17929	**0.13**	**0.30**	**0.38**	**0.36**	**0.74**	**0.62**	**0.17**	**2.70**	**6.75**	**6.37**	**1.06**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Eilean nam Mult, cage	17930	**0.07**	**0.16**	**0.16**	**0.18**	**0.24**	**0.24**	**0.07**	**1.12**	**2.80**	**4.99**	**0.56**
Eilean Trannay, cage	17931	**0.05**	ND	**0.10**	**0.09**	**0.15**	**0.14**	**0.03**	**0.56**	**1.40**	**6.04**	**0.23**
Pecam Bay, cage	17932	**0.04**	ND	ND	**0.15**	**0.27**	**0.24**	**0.07**	**0.77**	**1.93**	**6.30**	**0.31**
Sgeir Bhuidhe, Pecam Bay 3, cage	17933	**0.12**	**0.17**	**0.33**	**0.36**	**0.51**	**0.53**	**0.16**	**2.18**	**5.45**	**6.60**	**0.83**
Loch Grimshader, cage	17934	**0.06**	**0.03**	**0.07**	**0.06**	**0.11**	**0.09**	**0.02**	**0.44**	**1.10**	**6.88**	**0.15**
Loch Shell (mid) Shell Pairc East, cage	17935	**0.11**	**0.19**	**0.54**	**0.55**	**0.85**	**0.82**	**0.25**	**3.31**	**8.23**	**7.26**	**1.11**
Loch Shell (mid) Shell Pairc West, cage	17936	**0.21**	**0.34**	**0.62**	**0.53**	**1.21**	**1.05**	**0.30**	**4.26**	**10.65**	**7.18**	**1.48**
Ardvourlie, cage	17937	**0.09**	**0.08**	**0.13**	**0.13**	**0.26**	**0.23**	**0.06**	**0.98**	**2.45**	**6.95**	**0.35**
Maaruig, cage	17938	**0.15**	**0.18**	**0.24**	**0.34**	**0.38**	**0.41**	**0.67**	**2.37**	**5.93**	**5.26**	**1.13**
Ardvourlie, cage west	17939	ND	ND	**0.17**	**0.19**	**0.31**	**0.28**	**0.28**	**1.23**	**3.08**	N/A	N/A
Ardvourlie, 25m off west	17940	**0.06**	**0.05**	**0.09**	**0.13**	**0.12**	**0.16**	**0.04**	**0.65**	**1.63**	N/A	N/A
Ardvourlie, 50m off west	17941	**0.03**	**0.03**	**0.07**	**0.09**	**0.09**	**0.11**	**0.02**	**0.44**	**1.10**	N/A	N/A
Ardvourlie, 75m off west	17942	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, cage east	17943	**0.12**	**0.12**	**0.17**	**0.32**	**0.55**	**0.54**	ND	**1.82**	**4.55**	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 4 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Ardvourlie, 25m off east	17944	**0.04**	**0.01**	**0.03**	**0.04**	**0.06**	**0.05**	**0.02**	**0.25**	**0.63**	N/A	N/A
Ardvourlie, 50m off east	17945	**0.05**	ND	ND	**0.03**	**0.04**	**0.03**	**0.03**	**0.18**	**0.45**	N/A	N/A
Ardvourlie, 75m off east	17946	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 100m off east	17947	ND	ND	ND	ND	ND	ND	**0.35**	ND	ND	N/A	N/A
Ardvourlie, 25m off north	17948	**0.03**	**0.03**	**0.04**	**0.05**	**0.05**	**0.05**	**0.02**	**0.27**	**0.68**	N/A	N/A
Ardvourlie, 50m off north	17949	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 75m off north	17950	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ardvourlie, 100m off north	17951	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 5 – PCB congeners normalised to PCB-180

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Camas Na Sgainadin, Perpendicular, 100m	4419	Not determined since all results below LOD						
Ardvourlie, cage	17937	1.50	1.33	2.17	2.17	4.33	3.83	1.00
Ardvourlie, cage west	17939	ND	ND	0.61	0.68	1.11	1.00	1.00
Ardvourlie, 25m off west	17940	1.50	1.25	2.25	3.25	3.00	4.00	1.00
Ardvourlie, 50m off west	17941	1.50	1.50	3.50	4.50	4.50	5.50	1.00
Ardvourlie, 75m off west	17942	Not determined since all results below LOD						
Ardvourlie, cage east	17943	2.40	2.40	3.40	6.40	11.00	10.80	1.00
Ardvourlie, 25m off east	17944	2.00	0.50	1.50	2.00	3.00	2.50	1.00
Ardvourlie, 50m off east	17945	1.67	ND	ND	1.00	1.33	1.00	1.00
Ardvourlie, 75m off east	17946	Not determined since all results below LOD						
Ardvourlie, 100m off east	17947	Not determined since all results below LOD						
Ardvourlie, 25m off north	17948	1.50	1.50	2.00	2.50	2.50	2.50	1.00
Ardvourlie, 50m off north	17949	Not determined since all results below LOD						
Ardvourlie, 75m off north	17950	Not determined since all results below LOD						
Ardvourlie, 100m off north	17951	Not determined since all results below LOD						
Gorsten, Ardgour, cage	4426	ND	**0.75**	**1.63**	**1.63**	**4.00**	**3.50**	**1.00**
Garven, Loch Eil, cage	4427	**0.73**	**0.73**	**2.09**	**1.91**	**4.30**	**4.50**	**1.00**
Cairidh, cage	4428	1.28	2.80	3.30	2.50	5.24	4.24	1.00
Eilean Ard (Site 3), cage	4429	0.60	0.60	2.00	2.20	4.60	4.00	1.00
Bight of Cliffs, cage	8916	2.25	3.00	2.50	2.25	3.75	3.00	1.00
North Knowe, Greetaing, cage	8917	ND	ND	1.64	2.09	3.50	3.45	1.00
Basta Voe, East Site, cage	8918	5.21	2.14	2.57	2.29	3.00	2.71	1.00
Olnafirth South, cage	8919	2.17	ND	2.50	1.67	2.83	2.17	1.00
Cole Deep, cage	8920	1.08	ND	2.17	2.00	3.92	3.17	1.00
Cole Deep, fallow	8921	2.30	3.67	2.33	2.67	3.33	3.33	1.00
NW of Turraness, cage	8922	0.28	ND	0.94	0.88	1.78	1.33	1.00
NW of Winnaness, cage	8923	7.71	2.00	2.00	1.71	3.43	2.86	1.00

Table 5 – PCB congeners normalised to PCB-180 (continued)

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Uyeasound, Site 1, cage	8924	7.55	1.89	2.00	1.56	2.22	2.11	1.00
Uyeasound, Site 2, cage	8925	20.00	3.00	2.71	2.29	2.86	2.86	1.00
Site 2, Wick of Belmont North, cage	8926	4.78	1.07	1.07	1.07	1.21	1.00	1.00
Site 3, South Head of Mula, cage	8927	Not determined since PCB-180 below LOD						
Site 5, Point of Burkwell, cage	8928	1.40	ND	3.40	2.20	3.40	3.00	1.00
Boatsroom Voe, cage	8929	1.40	ND	2.25	2.25	3.50	2.64	1.00
Setterness West - Poseidon Site, cage	8930	Not determined since PCB-180 below LOD						
Setterness East - Bomlo, cage	8931	Not determined since PCB-180 below LOD						
Swinnister Voe, cage	8932	3.33	2.67	3.67	ND	3.00	2.67	1.00
Collafirth, Delting Site 1 (S), cage	8933	0.57	0.86	2.57	2.57	3.07	2.50	1.00
Collafirth, Delting Site 2 (N), cage	8934	Not determined since PCB-180 below LOD						
East of Hildasay, cage	8935	0.25	0.66	1.70	2.88	3.23	2.84	1.00
East of Hildasay, reference	8936	6.20	3.40	4.20	ND	3.20	3.40	1.00
East of Bruna Ness, cage	8937	1.00	2.28	5.58	0.86	4.33	5.44	1.00
Brei Geo Offshore, cage	8938	0.59	0.79	1.86	4.40	2.84	2.24	1.00
Brei Geo Offshore, reference	8939	1.88	2.62	2.25	0.63	2.75	3.13	1.00
North of Papa, cage	8940	4.11	2.11	2.66	1.66	2.88	2.44	1.00
North of Papa, reference	8941	4.56	2.50	1.69	ND	1.13	1.44	1.00
Slocka (Site C), cage	8942	6.00	7.50	13.00	2.00	3.50	3.00	1.00
Slocka (Site C), reference	8943	13.00	6.75	ND	ND	2.75	2.25	1.00
Pobie Sukka (Site A), cage	8944	2.00	ND	1.67	1.67	3.00	2.67	1.00
Ronas Voe, cage	8945	4.80	2.30	2.70	2.90	4.30	3.30	1.00
Ronas Voe, reference	8946	4.00	3.10	1.00	0.80	2.00	1.60	1.00
Site 3, Collafirth Ness, cage	8947	0.80	1.13	2.27	1.85	3.67	2.96	1.00
Uyeasound, Site 2, cage	9186	Not determined since PCB-180 below LOD						
Loch a Laip(Inner), Site1, cage	17927	0.64	2.77	2.59	2.64	3.77	3.62	1.00
Loch Skipport (Outer), cage	17928	1.13	0.75	2.38	2.25	4.75	4.00	1.00
Loch Maddy (Rubha Nan Gall), cage	17929	**0.76**	**1.76**	**2.24**	**2.12**	**4.35**	**3.65**	**1.00**

Table 5 – PCB congeners normalised to PCB-180 (continued)

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Eilean nam Mult, cage	17930	1.00	2.29	2.29	2.57	3.43	3.43	1.00
Eilean Trannay, cage	17931	1.66	ND	3.33	3.00	5.00	4.67	1.00
Pecam Bay, cage	17932	0.57	ND	ND	2.14	3.86	3.43	1.00
Sgeir Bhuidhe, Pecam Bay 3, cage	17933	**0.75**	**1.06**	**2.06**	**2.25**	**3.19**	**3.31**	**1.00**
Loch Grimshader, cage	17934	3.00	1.50	3.50	3.00	5.50	4.50	1.00
Loch Shell (mid) Shell Pairc East, cage	17935	0.44	0.76	2.16	2.20	3.40	3.28	1.00
Loch Shell (mid) Shell Pairc West, cage	17936	**0.70**	**1.13**	**2.07**	**1.77**	**4.03**	**3.50**	**1.00**
Maaruig, cage	17938	0.22	0.26	0.35	0.51	0.56	0.61	1.00

ANNEX 2 – RESULTS 2002

Table 6 - Site details

BreiGeo Fish Farm sampled on 21/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Sandsound Voe	HU 357 465 SE	22052	WPC/N/61405 (01)	2635
Parallel transect to head of loch 25m		HU 357 465 SE	22053		
Parallel transect to head of loch 100m		HU 357 466 SE	22054		
Offshore transect at cage edge		HU 357 463 SE	22055		
Offshore transect 25m		HU 357 463 SE	22056		
Offshore transect 100m		HU 357 463 SE	22057		
Inshore transect at cage edge		HU 356 464 SE	22058		
Inshore transect 25m		HU 356 464 SE	22059		
Inshore transect 100m		HU 355 464 SE	22060		
Parallel transect to mouth of loch at cage edge		HU 356 461 SE	22061		
Parallel transect to mouth of loch 25m		HU 356 461 SE	22062		
Parallel transect to mouth of loch 100m		HU 356 460 SE	22063		
Reference		HU 352 482 SW	22064		

Table 6 - Site details continued

Bight of Cliffs Fish Farm sampled on 22/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Olna Firth	HU 392 644 NW	22068	WPC/62086 (01)	500
Parallel transect to head of loch 25m		HU 393 644 NW	22069		
Parallel transect to head of loch 100m		HU 393 643 NW	22070		
Offshore transect at cage edge		HU 392 645 NW	22081		
Offshore transect 25m		HU 391 645 NW	22082		
Offshore transect 100m		HU 391 645 NW	22083		
Inshore transect at cage edge		HU 392 645 NW	22065		
Inshore transect 25m		HU 392 645 NW	22066		
Inshore transect 100m		HU 392 646 NW	22067		
Parallel transect to mouth of loch at cage edge		HU 391 646 NW	22071		
Parallel transect to mouth of loch 25m		HU 391 646 NW	22072		
Parallel transect to mouth of loch 100m		HU 390 647 NW	22073		
Reference		HU 391 642 SW	22085		

Table 6 - Site details continued

North Nestings 2 Fish Farm sampled on 20/6/02

Site Name	Water	Grid Reference	Sample No.	Consent No.	Maximum Biomass
Parallel transect to head of loch at cage edge	Dury Voe	HU 462 621 SW	22095	WPC/N/61956 (00)	995
Parallel transect to head of loch 25m		HU 462 621 SW	22096		
Parallel transect to head of loch 100m		HU 462 620 SW	22097		
Offshore transect at cage edge		HU 463 623 SW	22089		
Offshore transect 25m		HU 463 623 SW	22090		
Offshore transect 100m		HU 464 623 SW	22091		
Inshore transect at cage edge		HU 462 623 SW	22086		
Inshore transect 25m		HU 462 623 SW	22087		
Inshore transect 100m		HU 461 624 SW	22088		
Parallel transect to mouth of loch at cage edge		HU 462 624 SW	22092		
Parallel transect to mouth of loch 25m		HU 462 625 SW	22093		
Parallel transect to mouth of loch 100m		HU 463 625 SW	22094		
Reference		HU 479 629 NE			

Table 6 - Site details continued

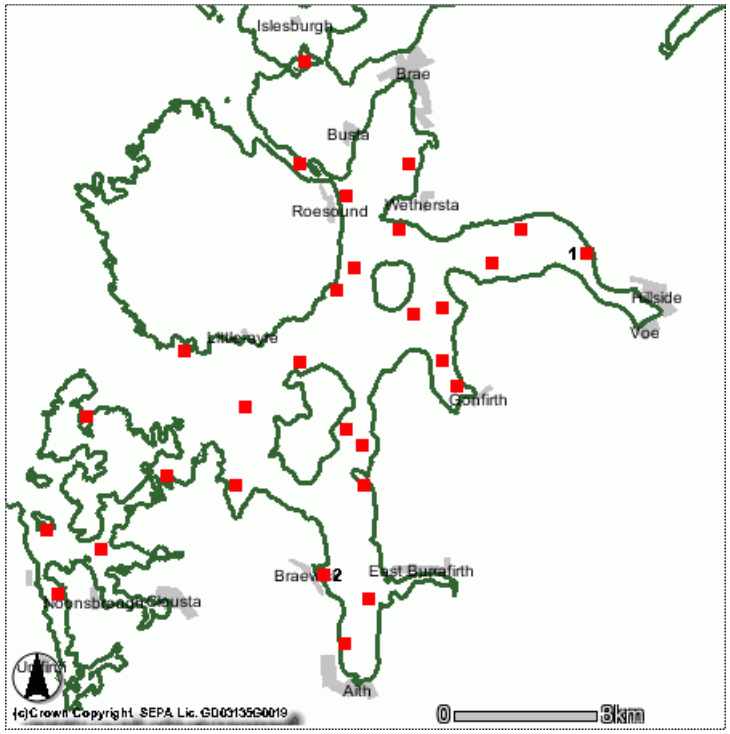
Other Fish Farm Sites

Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No.	Maximum Biomass
Basta Voe North	Basta Voe	HU 522 961 SW	13/6/02	32375	WPC/N/61625 (00)	600
Basta Voe North West		HU 544 952 SW	13/6/02	22103	WPC/N/61979 (01)	500
Basta Voe East		HU 546 950 NE	13/6/02	22104	WPC/N/61978 (01)	500
Basta Voe East Inner Rep 2			13/6/02	22105	WPC/N/61978 (01)	500
Basta Voe South		HU 531 949 NW	13/6/02	22079	WPC/N/61966 (02)	950
Bight of Braewick	Aith Voe	HU 343 579 NW	22/6/02	22106	WPC/N/62074 (02)	990
Hildasay	Hildasay	HU 363 402 SW	21/6/02	22107	WPC/N/62077 (01)	400
Kallee Ness	Clift Sound	HU 393 352 SW	16/6/02	22108	WPC/N/59549 (01)	300
Lippie Geo	Clift Sound	HU 393 324 SW	15/6/02	22109	WPC/N/60952 (01)	407
Vatsetter	South Sound Yell	HU 535 902 SW		22110	WPC/N/61968 (01)	950
Holms Geo	Clift Sound	HU 388 310 SE	15/6/02	22111	WPC/N/60953 (00)	509 1999
Djuba Wick cage	Hascosay	HU 558 934 SE		22112	WPC/N/61973 (02)	
Bunya Sand	Mid Yell Voe	HU 524 909 NW		22113	WPC/N/60720 (00)	425

Table 6 - Site details continued

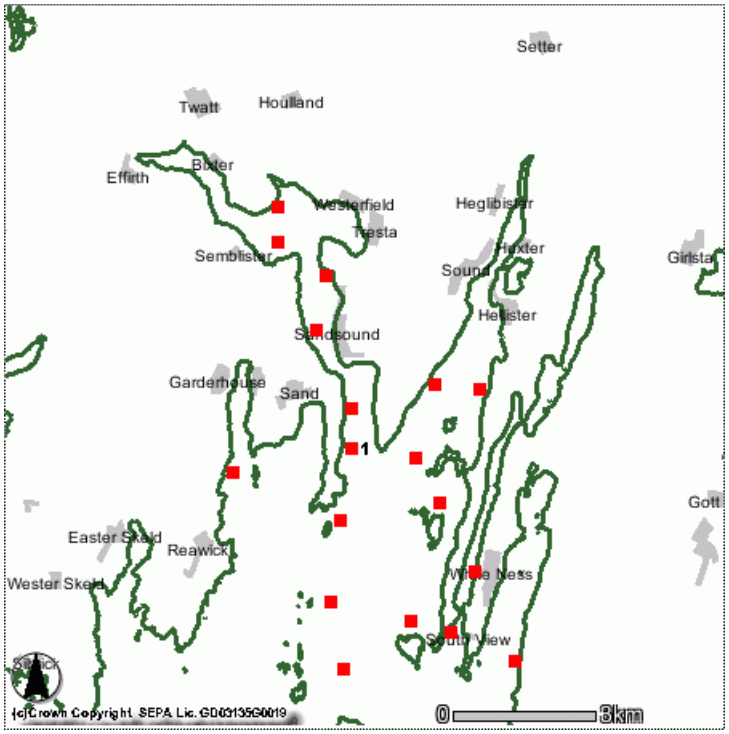
Site Name	Water	Grid Reference	Date Sampled	Sample No.	Consent No	Maximum Biomass
Trondra	Clift Sound	HU 400 369 NE	16/6/02	22114	WPC/N/62085 (01)	257
Louva Voe site 3	Dury Voe	HU 473 620 NW		22115	WPC/N/61957 (01)	995
Wester Quarff	Clift Sound	HU 400 358 NW	16/6/02	22080	WPC/N/62084 (02)	500
Cloudin	Valia Sound	HU 233 476 NW	29/6/02	29428	WPC/N/62049 (01)	1995
Burraston	Valia Sound	HU 227 477 NE	29/6/02	29429	WPC/N/62052 (01)	600
Foraness	Dales Voe	HU 455 470 NE	26/6/02	29430	WPC/N/62214 (01)	800
Hogan	Gruting Voe	HU 273 477 NW	28/6/02	29431	WPC/N/62036 (01)	1500
Aith Voe	Bressay	HU 507 437 NE	25/6/02	29432	WPC/N/62080 (01)	400
Dales Voe	Dales Voe	HU 450 452 SE	26/6/02	29433	WPC/N/62078 (01)	800
White Ness	Valia Sound	HU 233 476 NW	29/6/02	29434	WPC/N/62011 (01)	600
Mid Taing	Gruting Voe	HU 259 472 SE		29435	WPC/N/62440 (00)	500
East Loch Seaforth	Loch Seaforth	NB 212 117 NW	19/8/02	29436	WPC/N/61845 (00)	871
Scotasay	East Loch Tarbet	NG 190 977 NW	16/8/02	29437	WPC/N/62387 (00)	750
Miavaig	East Loch Tarbet	NG 168 968 NE	16/8/02	29438	WPC/N/62392 (00)	500

Figure 15 - Map of Olna Firth and Aith Voe



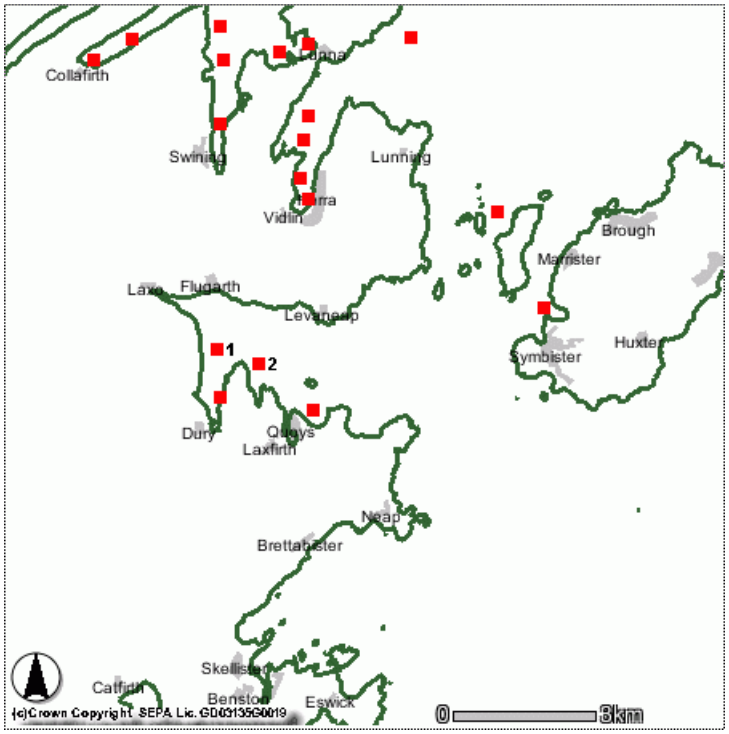
[1] – Bight of Cliffs
[2] – Bight of Braewick

Figure 16 - Map of Sandsound Voe



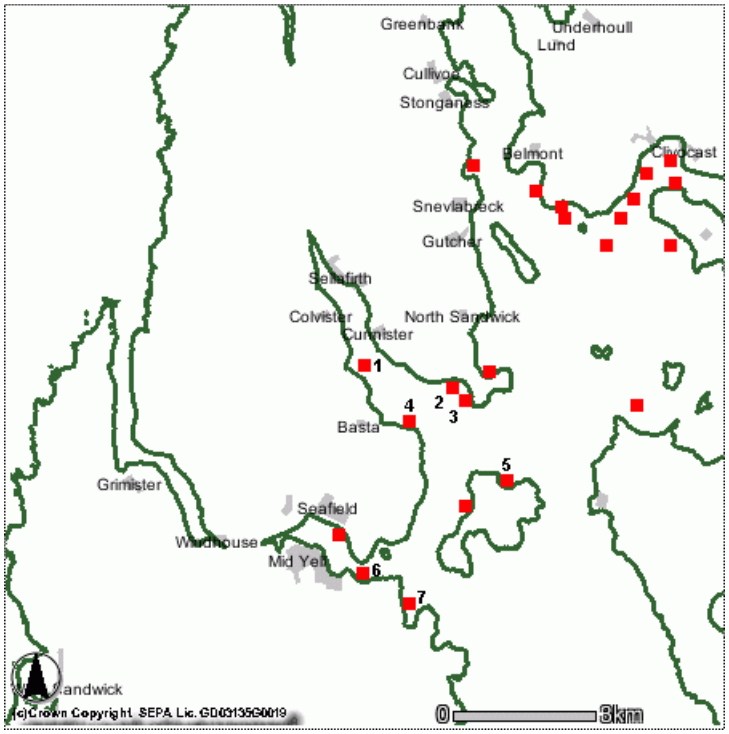
[1] – Brei Geo

Figure 17 - Map of Dury Voe



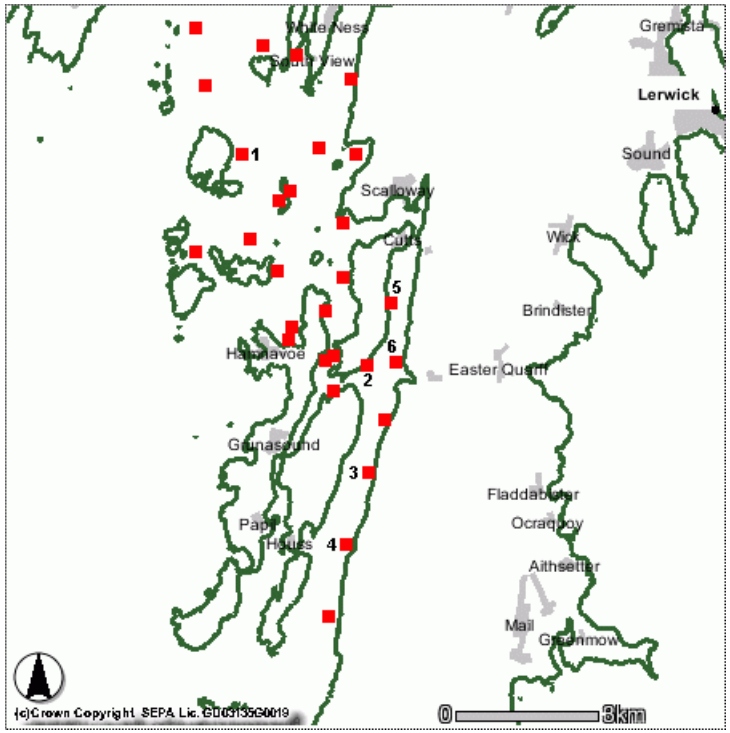
[1] – North Nestings Site 2
[2] – Loura Voe Site 3

Figure 18 - Map of Basta Voe, Hascosay and Yell Voe



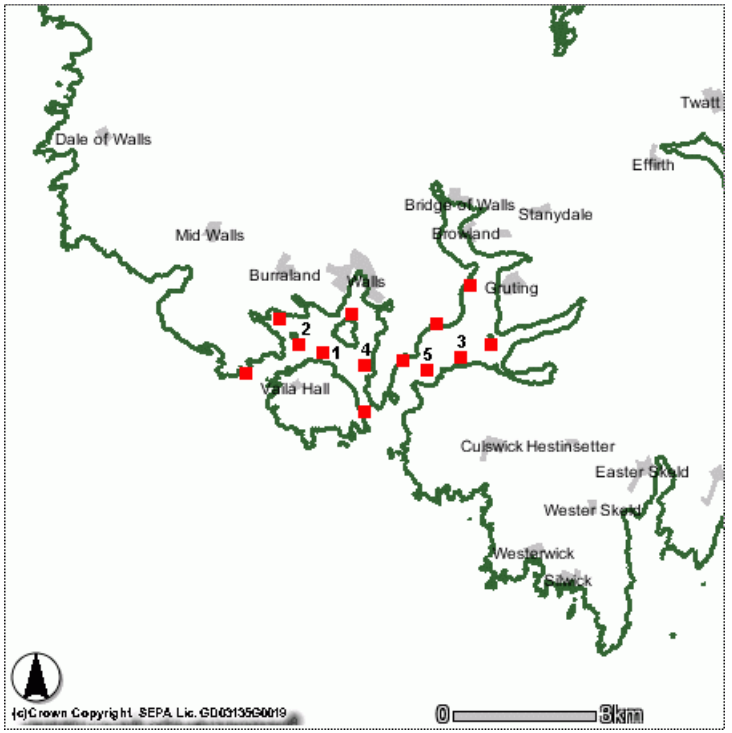
[1] – Basta Voe North
[2] – Basta Voe North West
[3] – Basta Voe East
[4] – Basta Voe South
[5] – Djuba Wick
[6] – Bunya Sand
[7] – Vatsetter

Figure 19 - Map of Hildasay and Clift Sounds



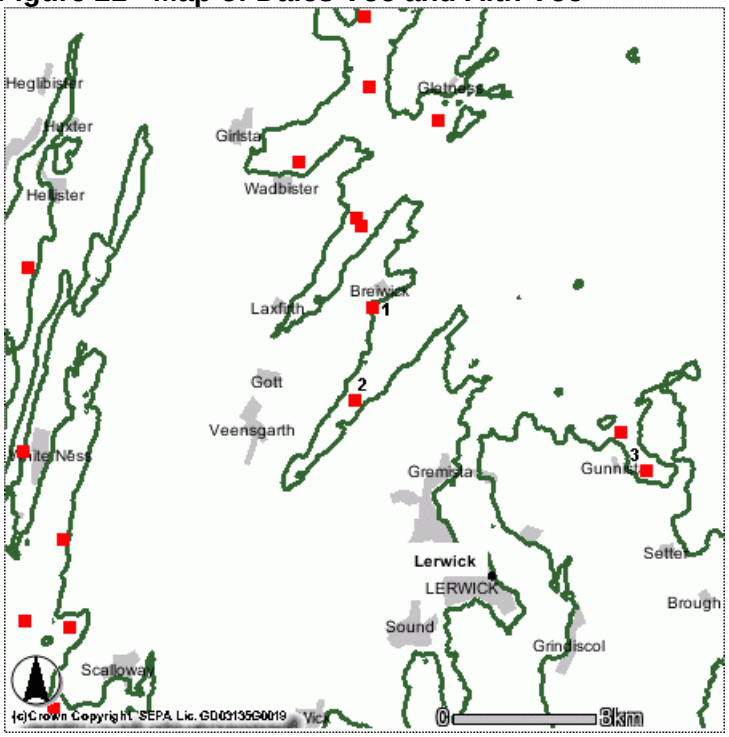
[1] – East of Hildasay
[2] – Killee Ness
[3] – Lippie Geo Site 2
[4] – Holms Geo
[5] – Lea Trondra
[6] – Wester Quarff

Figure 20 - Map of Valia Sound and Gruting Voe



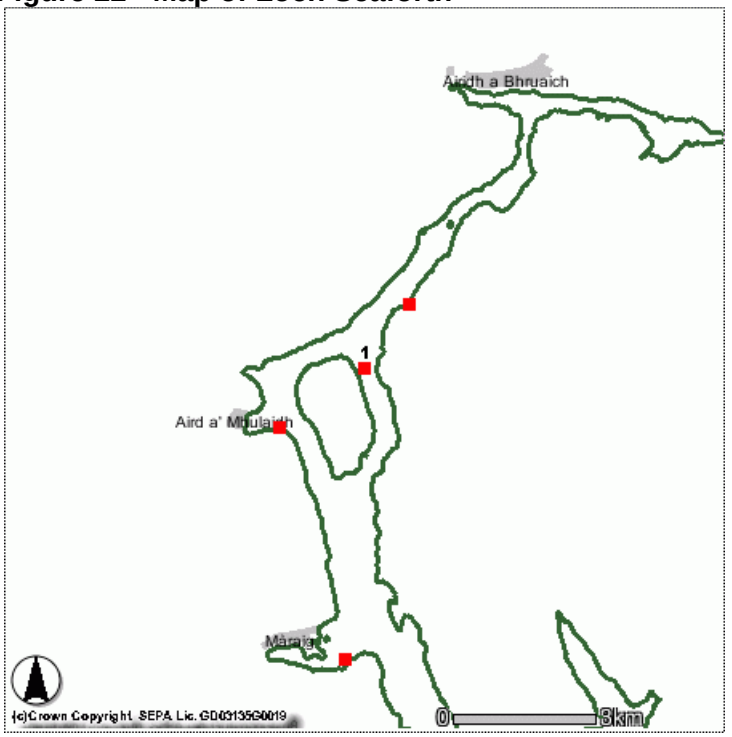
[1] – Cloudin
[2] – Burrastow
[3] – Hogan
[4] – Whitesness
[5] – Mid Taing

Figure 21 - Map of Dales Voe and Aith Voe



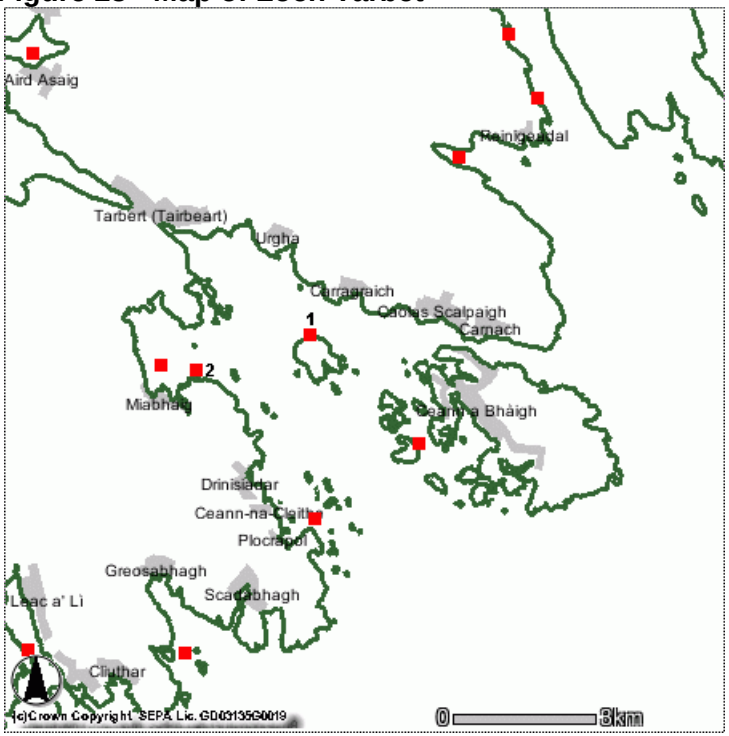
[1] – Fora Ness
[2] – Dales Voe
[3] – Aith Voe

Figure 22 - Map of Loch Seaforth



[1] - East Loch Seaforth

Figure 23 - Map of Loch Tarbet



[1] - Scotasay
[2] - Miavaig

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content)

Brei Geo Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22052	**0.63**	**0.57**	**0.48**	**0.34**	**0.52**	**0.51**	**0.14**	**3.2**	**8.0**	N/A	N/A
Parallel to head 25m	22053	ND	**0.15**	**0.22**	**0.09**	**0.21**	**0.2**	ND	ND	ND	N/A	N/A
Parallel to head 100m	22054	ND	**0.11**	**0.32**	**0.08**	**0.22**	**0.21**	ND	ND	ND	N/A	N/A
Offshore at cage	22055	**0.17**	**0.21**	**0.37**	**0.2**	**0.42**	**0.38**	**0.12**	**1.87**	**4.68**	N/A	N/A
Offshore 25m	22056	**0.13**	**0.36**	**0.42**	**0.23**	**0.45**	**0.41**	**0.09**	**2.09**	**5.23**	N/A	N/A
Offshore 100m	22057	**0.17**	**0.22**	**0.3**	**0.14**	**0.29**	**0.28**	**0.11**	**1.51**	**3.77**	N/A	N/A
Inshore at cage	22058	**1.28**	**0.6**	**1.46**	**0.97**	**1.81**	**1.58**	**0.6**	**8.32**	**20.8**	N/A	N/A
Inshore 25m	22059	**0.11**	**0.09**	**0.14**	**0.06**	**0.18**	**0.18**	**0.07**	**0.82**	**2.04**	N/A	N/A
Inshore 100m	22060	**0.27**	**0.23**	**0.12**	**0.04**	**0.09**	**0.05**	**0.02**	**0.81**	**2.02**	N/A	N/A
Parallel to mouth at cage	22061	**1.49**	**1.03**	**1.73**	**1.31**	**2.26**	**2.04**	**0.61**	**10.45**	**26.1**	N/A	N/A
Parallel to mouth 25m	22062	**0.18**	**0.23**	**0.36**	**0.25**	**0.52**	**0.49**	**0.16**	**2.18**	**5.45**	N/A	N/A
Parallel to mouth 100m	22063	**0.57**	**0.22**	**0.19**	**0.13**	**0.26**	**0.19**	**0.06**	**1.62**	**4.05**	N/A	N/A
Reference	22064	**0.44**	**0.16**	**0.13**	**0.05**	**0.08**	**0.06**	**0.01**	**0.94**	**2.36**	N/A	N/A

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Bight of Cliffs Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22065	**0.53**	**0.41**	**0.39**	**0.2**	**0.4**	**0.33**	**0.11**	**2.36**	**5.91**	N/A	N/A
Parallel to head 25m	22066	**0.09**	**0.13**	**0.3**	**0.13**	**0.23**	**0.24**	**0.07**	**1.18**	**2.95**	N/A	N/A
Parallel to head 100m	22067	**0.14**	**0.17**	**0.24**	**0.14**	**0.3**	**0.25**	**0.06**	**1.31**	**3.27**	N/A	N/A
Offshore at cage	22081	**0.66**	**0.59**	**0.15**	**0.22**	**0.45**	**0.37**	**0.11**	**2.54**	**6.36**	N/A	N/A
Offshore 25m	22082	**0.1**	**0.09**	**0.32**	**0.09**	**0.36**	**0.35**	**0.1**	**1.41**	**3.53**	N/A	N/A
Offshore 100m	22083	**0.15**	**0.18**	**0.26**	**0.14**	**0.27**	**0.23**	**0.04**	**1.25**	**3.12**	N/A	N/A
Inshore at cage	22068	**0.39**	**0.26**	**0.44**	**0.25**	**0.54**	**0.4**	**0.15**	**2.42**	**6.05**	N/A	N/A
Inshore 25m	22069	**0.49**	**0.26**	**0.06**	**0.14**	**0.3**	**0.21**	**0.09**	**1.56**	**3.9**	N/A	N/A
Inshore 100m	22070	**0.06**	**0.27**	**0.19**	**0.1**	**0.17**	**0.2**	**0.06**	**1.04**	**2.61**	N/A	N/A
Parallel to mouth at cage	22071	**0.1**	**0.19**	**0.23**	**0.19**	**0.41**	**0.39**	**0.04**	**1.55**	**3.87**	N/A	N/A
Parallel to mouth 25m	22072	**0.66**	**0.65**	**0.02**	**0.11**	**0.28**	**0.14**	ND	ND	ND	N/A	N/A
Parallel to mouth 100m	22073	**0.43**	**0.6**	**0.48**	**0.19**	**0.43**	**0.36**	**0.14**	**2.62**	**6.56**	N/A	N/A
Reference	22085	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.98**	ND

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

North Nestings 2 Fish Farm

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Parallel to head at cage	22095	**0.71**	**0.32**	**0.34**	**0.18**	**0.28**	**0.24**	**0.09**	**2.16**	**5.41**	N/A	N/A
Parallel to head 25m	22078	**0.08**	**0.13**	**0.24**	**0.11**	**0.26**	**0.26**	**0.08**	**1.16**	**2.9**	N/A	N/A
Parallel to head 100m	22075	**0.07**	**0.06**	**0.17**	**0.07**	**0.13**	**0.16**	**0.1**	**0.76**	**1.9**	N/A	N/A
Offshore at cage	22077	**0.08**	**0.17**	**0.24**	**0.07**	**0.12**	**0.22**	**0.02**	**0.93**	**2.33**	N/A	N/A
Offshore 25m	22090	**0.05**	**0.05**	**0.25**	**0.12**	**0.19**	**0.21**	**0.05**	**0.94**	**2.35**	N/A	N/A
Offshore 100m	22091	**0.37**	**0.34**	**0.39**	**0.13**	**0.23**	**0.18**	**0.1**	**1.76**	**4.32**	N/A	N/A
Inshore at cage	22086	**0.08**	**0.04**	**0.14**	**0.04**	**0.13**	**0.2**	**0.04**	**0.68**	**1.69**	N/A	N/A
Inshore 25m	22087	**0.13**	**0.03**	**0.19**	**0.05**	**0.11**	**0.15**	**0.07**	**0.73**	**1.83**	N/A	N/A
Inshore 100m	22088	**0.1**	**0.15**	**0.18**	**0.05**	**0.11**	**0.17**	**0.16**	**0.93**	**2.32**	N/A	N/A
Parallel to mouth at cage	22092	**0.16**	**0.07**	**0.18**	**0.08**	**0.13**	**0.17**	**0.08**	**0.85**	**2.13**	N/A	N/A
Parallel to mouth 25m	22093	**0.18**	**0.08**	**0.17**	**0.07**	**0.1**	**0.18**	**0.04**	**0.82**	**2.05**	N/A	N/A
Parallel to mouth 100m	22094	**0.13**	**0.1**	**0.2**	**0.07**	**0.13**	**0.17**	**0.15**	**0.96**	**2.4**	N/A	N/A
Reference	22098	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.98**	ND

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Other Fish Farm Sites

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Basta Voe North	32375	**0.22**	**0.19**	**0.34**	**0.22**	**0.37**	**0.35**	**0.1**	**1.8**	**4.5**	**7.3**	**0.62**
Basta Voe North West	22103	**0.06**	**0.08**	**0.05**	**0.03**	**0.06**	**0.04**	ND	ND	ND	**3.42**	ND
Basta Voe East	22104	**0.05**	**0.17**	**0.02**	**0.03**	**0.02**	**0.01**	ND	ND	ND	**7.25**	ND
Basta Voe East Inner Rep 2	22105	**0.09**	**0.22**	**0.2**	**0.14**	**0.21**	**0.19**	**0.06**	**1.11**	**2.78**	**0.4**	**6.95**
Basta Voe South	22079	**0.22**	**0.29**	**0.29**	**0.25**	**0.46**	**0.4**	**0.16**	**2.07**	**5.18**	**2.34**	**2.21**
Bight of Braewick	22106	**0.22**	**0.36**	**0.07**	**0.08**	**0.13**	**0.12**	**0.05**	**1.02**	**2.56**	**6.63**	**0.39**
Hildasay	22107	**0.33**	**0.28**	**0.2**	**0.28**	**0.55**	**0.65**	**0.2**	**2.48**	**6.21**	**8.27**	**0.75**
Kallee Ness	22108	**1.11**	**1.1**	**0.3**	**0.4**	**0.84**	**1.2**	**0.2**	**5.15**	**12.9**	**6.51**	**1.98**
Lippie Geo	22109	**0.09**	**0.36**	**0.86**	**0.28**	**0.55**	**0.56**	**0.14**	**2.84**	**7.1**	**6.48**	**1.1**
Vatsetter	22110	**0.11**	**0.33**	**0.94**	**0.34**	**0.8**	**0.66**	**0.25**	**3.43**	**8.58**	**3.17**	**2.71**
Holms Geo	22111	**0.1**	**0.49**	**1.29**	**0.47**	**0.78**	**0.7**	**0.21**	**4.04**	**10.1**	**5.76**	**1.75**
Djuba Wick cage	22112	**0.05**	**0.2**	**0.07**	**0.04**	**0.06**	**0.04**	**0.04**	**0.5**	**1.25**	**0.46**	**2.72**
Bunya Sand	22113	**0.03**	**0.17**	**0.07**	**0.06**	**0.11**	**0.09**	**0.03**	**0.55**	**1.38**	**1.42**	**0.97**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 7 - Concentration of total PCBs found in sediments (corrected for %moisture content) continued

Sample Name	Sample No.	PCB 28 µg/kg	PCB 52 µg/kg	PCB 101 µg/kg	PCB 118 µg/kg	PCB 153 µg/kg	PCB 138 µg/kg	PCB 180 µg/kg	Sum ICES 7 µg/kg	Total PCB[1] µg/kg	Organic Carbon %	Total PCB[2] µg/kg
Trondra	2214	**0.16**	**1.51**	**3.36**	**2.28**	**2.23**	**3.72**	**0.43**	**13.7**	**34.3**	**8.84**	**3.88**
Louva Voe site 3	22115	**0.17**	**0.17**	**0.16**	**0.1**	**0.24**	**0.21**	**0.06**	**1.1**	**2.75**	**2.6**	**1.06**
Wester Quarff	22080	**0.14**	**0.3**	**0.66**	**0.48**	**0.57**	**0.72**	**0.14**	**3.01**	**7.53**	**6.63**	**1.14**
Cloudin	29428	**0.64**	**0.61**	**0.33**	**0.13**	**0.27**	**0.59**	**0.2**	**2.77**	**6.93**	**8.81**	**0.79**
Burraston	29429	**0.12**	**0.2**	**0.15**	**0.09**	**0.18**	**0.16**	**0.05**	**0.95**	**2.38**	**2.78**	**0.86**
Foraness	29430	**0.39**	**0.21**	**0.3**	**0.15**	**0.32**	**0.29**	**0.12**	**1.77**	**4.43**	**2.4**	**1.85**
Hogan	29431	**0.16**	**0.11**	**0.24**	**0.12**	**0.23**	**0.22**	**0.07**	**1.15**	**2.88**	**12.28**	**0.23**
Aith Voe	29432	**0.13**	**0.27**	**0.15**	**0.06**	**0.12**	**0.08**	**0.03**	**0.85**	**2.13**	**0.56**	**3.8**
Dales Voe	29433	**0.07**	**0.09**	**0.25**	**0.04**	**0.09**	**0.07**	**0.03**	**0.64**	**1.6**	**2.65**	**0.6**
White Ness	29434	**0.21**	**0.23**	**0.38**	**0.27**	**0.45**	**0.47**	**0.17**	**2.18**	**5.45**	**8.5**	**0.64**
Mid Taing	29435	**0.8**	**0.61**	**0.5**	**0.34**	**0.48**	**0.54**	**0.16**	**3.44**	**8.6**	**11.11**	**0.77**
East Loch Seaforth	29436	**0.28**	**0.36**	**0.32**	**0.18**	**0.31**	**0.3**	**0.13**	**1.89**	**4.73**	**5.16**	**0.92**
Scotasay	29437	**0.06**	**0.21**	**0.17**	**0.07**	**0.13**	**0.13**	**0.03**	**0.81**	**2.03**	**8.83**	**0.23**
Miavaig	29438	**0.13**	**0.14**	**0.26**	**0.14**	**0.23**	**0.24**	**0.08**	**1.22**	**3.05**	**5.89**	**0.52**

[1] – estimated total PCBs; [2] – nominal to 1 % organic carbon; positive results in bold

Table 8 – PCB congeners normalised to PCB-180

Brei Geo Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22052	4.43	4.03	3.38	2.4	3.67	3.57	1.0
Parallel to head 25m	22053	0.59	Not determined since all results below LOD					1.0
Parallel to head 100m	22054	1.28	Not determined since all results below LOD					1.0
Offshore at cage	22055	1.4	1.73	3.06	1.7	3.48	3.15	1.0
Offshore 25m	22056	1.35	3.87	4.44	2.44	4.81	4.36	1.0
Offshore 100m	22057	1.52	1.93	2.62	1.21	2.52	2.51	1.0
Inshore at cage	22058	2.15	1.01	2.44	1.63	3.04	2.65	1.0
Inshore 25m	22059	1.61	1.34	2.08	0.94	2.7	2.72	1.0
Inshore 100m	22060	12.0	10.4	5.16	1.68	3.82	2.14	1.0
Parallel to mouth at cage	22061	2.44	1.68	2.84	2.14	3.7	3.34	1.0
Parallel to mouth 25m	22062	1.16	1.44	2.24	1.54	3.25	3.07	1.0
Parallel to mouth 100m	22063	10.0	3.85	3.31	2.36	4.52	3.33	1.0
Reference	22064	32.47	11.6	9.73	3.75	6.1	4.36	1.0

Table 8 – PCB congeners normalised to PCB-180

Bight of Cliffs Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22065	4.83	3.76	3.61	1.85	3.67	3.05	1.0
Parallel to head 25m	22066	1.21	1.80	4.24	1.9	3.21	3.37	1.0
Parallel to head 100m	22067	2.4	2.96	4.17	2.39	5.05	4.3	1.0
Offshore at cage	22081	5.89	5.26	1.38	1.94	4.04	3.29	1.0
Offshore 25m	22082	1.05	0.93	3.21	0.89	3.61	3.49	1.0
Offshore 100m	22083	4.13	5.14	7.39	3.88	7.55	6.51	1.0
Inshore at cage	22068	2.65	1.77	3.04	1.72	3.67	2.75	1.0
Inshore 25m	22069	5.21	2.8	0.66	1.46	3.17	2.21	1.0
Inshore 100m	22070	1.01	4.74	3.22	1.68	3.02	3.42	1.0
Parallel to mouth at cage	22071	2.63	5.02	5.96	4.9	10.7	10.0	1.0
Parallel to mouth 25m	22072	Not determined since PCB 180 result below LOD						
Parallel to mouth 100m	22073	3.13	4.44	3.55	1.4	3.15	2.64	1.0
Reference	22085	1.35	1.37	1.29	1.25	0.2	0.25	1.0

Table 8 – PCB congeners normalised to PCB-180

North Nestings 2 Fish Farm

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Parallel to head at cage	22095	7.87	3.48	3.72	1.95	3.11	2.68	1.0
Parallel to head 25m	22078	1.01	1.71	3.06	1.47	3.29	3.29	1.0
Parallel to head 100m	22075	0.67	0.56	1.73	0.74	1.25	1.58	1.0
Offshore at cage	22077	3.68	7.72	11.0	3.17	5.38	9.92	1.0
Offshore 25m	22090	1.0	1.0	4.73	2.17	3.64	3.97	1.0
Offshore 100m	22091	3.77	3.41	3.9	1.31	2.31	1.82	1.0
Inshore at cage	22086	1.75	1.02	3.3	0.85	3.04	4.46	1.0
Inshore 25m	22087	1.74	0.44	2.5	0.65	1.52	2.0	1.0
Inshore 100m	22088	0.67	0.97	1.17	0.32	0.8	1.06	1.0
Parallel to mouth at cage	22092	2.11	0.87	2.37	0.99	1.65	2.15	1.0
Parallel to mouth 25m	22093	4.04	1.72	3.92	1.56	2.2	4.0	1.0
Parallel to mouth 100m	22094	0.89	0.65	1.36	0.46	0.9	1.15	1.0
Reference	22098	Not determined since all results below LOD						

Table 8 – PCB congeners normalised to PCB-180

Other Fish Farm Sites

Sample Name	Sample#	28/180	52/180	101/180	118/180	153/180	138/180	180/180
Fish Food Sample	**-**	**0.74**	**1.49**	**2.06**	**1.60**	**4.74**	**3.06**	**1.00**
Basta Voe North	32375	2.19	1.88	3.33	2.18	3.63	3.4	1.0
Basta Voe North West	22103	Not determined since PCB 180 result below LOD						
Basta Voe East	22104	Not determined since PCB 180 result below LOD						
Basta Voe East Inner Rep 2	22105	1.58	3.65	3.29	2.34	3.57	3.11	1.0
Basta Voe South	22079	1.4	1.82	1.79	1.54	2.89	2.47	1.0
Bight of Braewick	22106	4.56	7.5	1.52	1.63	2.77	2.42	1.0
Hildasay	22107	1.65	1.37	0.99	1.38	2.71	3.24	1.0
Kallee Ness	22108	5.68	5.62	1.55	2.02	4.28	6.14	1.0
Lippie Geo	22109	0.63	2.33	6.08	1.99	3.85	3.98	1.0
Vatsetter	22110	0.42	1.3	3.7	1.35	3.15	2.58	1.0
Holms Geo	22111	0.49	2.33	6.19	2.27	3.73	3.34	1.0
Djuba Wick cage	22112	1.31	5.28	1.84	0.94	1.67	1.01	1.0
Bunya Sand	22113	1.01	6.56	2.7	2.34	4.1	3.38	1.0
Trondra	2214	0.38	3.49	7.77	5.27	5.16	8.6	1.0
Louva Voe site 3	22115	2.95	2.84	2.7	1.67	4.12	3.53	1.0
Wester Quarff	22080	1.0	2.13	4.62	3.38	3.97	5.03	1.0
Cloudin	29428	3.16	3.02	1.64	0.62	1.33	2.93	1.0
Burraston	29429	2.35	3.95	2.84	1.72	3.58	3.05	1.0
Foraness	29430	3.2	1.71	2.45	1.25	2.66	2.35	1.0
Hogan	29431	2.18	1.56	3.28	1.62	3.07	2.95	1.0
Aith Voe	29432	4.06	8.17	4.7	1.89	3.53	2.6	1.0
Dales Voe	29433	2.28	3.25	8.72	1.51	2.98	2.6	1.0
White Ness	29434	1.22	1.36	2.24	1.58	2.66	2.79	1.0
Mid Taing	29435	4.89	3.73	3.08	2.11	2.94	3.34	1.0
East Loch Seaforth	29436	2.1	2.71	2.38	1.34	2.28	2.23	1.0
Scotasay	29437	1.89	7.05	5.71	2.46	4.26	4.23	1.0
Miavaig	29438	1.67	1.82	3.44	1.82	3.04	3.17	1.0

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Organochlorines and breast cancer risk by receptor status, tumor size, and grade (Canada)

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Abstract

Objective: We evaluated the association between organochlorines and breast cancer subtype defined by the tumor characteristics: estrogen receptor status, progesterone receptor status, tumor size, and grade.
Methods: A case–control study was conducted from 1995 to 1997 in Kingston and Toronto, Canada. Breast adipose tissue, taken from 217 cases and 213 biopsy controls frequency-matched on age, was analysed for 14 polychlorinated biphenyl (PCB) congeners and 10 pesticides.
Results: Adjusting for age, geometric means of several organochlorines differed by estrogen receptor status and tumor grade ($p < 0.05$). Odds ratios (ORs) for each organochlorine relative to the common control group for breast cancers of differing subtype were compared using polytomous logistic regression. Although the ORs did not differ significantly by subtype, the ORs of PCBs and p, p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (DDE) were higher with risk of estrogen receptor-negative breast cancer than estrogen receptor-positive breast cancer. One of the most extreme differences was with DDE, where the OR for the association with risk of estrogen receptor-negative breast cancer was 2.4 (95% confidence interval (CI) 1.0–5.4) in the uppermost tertile relative to the lowest, whereas the corresponding OR for risk of estrogen receptor-positive breast cancer was 1.1 (95% CI 0.6–1.9). PCBs also tended to be more strongly positively associated with risk of larger and higher-grade tumors.
Conclusions: The association between organochlorines and breast cancer risk did not significantly differ by subtype, but many PCBs were more strongly associated with tumors of poor prognosis.

Introduction

Persistent organochlorines, including the pesticide, 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane (DDT), and the industrial chemicals, polychlorinated biphenyls (PCBs), have been widely used in the past and are now ubiquitous in the environment. Organochlorines have been studied extensively in relation to breast cancer since the general population is exposed to them through their diet, and many organochlorines accumulate in fatty tissues of the breast and can mimic the action of estrogen. In some studies, compared with controls, women with breast cancer had higher levels of some chlorinated compounds including PCBs and pesticides [1–7], but in others, the cases had lower or similar levels [8–16]. The inconsistencies in the results of these studies may be due to the study populations and their different susceptibilities.

Many studies have found different risk factor profiles for breast cancer with different characteristics. The most

studied characteristic has been estrogen receptor (ER) status, where the supposition is that hormonal risk factors are more strongly related with ER-positive cancer, which is more sensitive to hormonal treatments. Differences in risks by ER status have been found with reproductive factors [17–20]. With respect to organochlorines specifically, one study has found that p,p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene (DDE), a metabolite of the pesticide, DDT, was associated with ER-positive breast cancer, but not with ER-negative cancer [21].

We have conducted a hospital-based case–control study in which we observed that breast cancer risk was associated with breast adipose tissue concentrations of PCBs 105 and 118 [22]. The objective of the present report was to determine the associations between organochlorines measured in breast adipose tissue and different subtypes of breast cancer, and to investigate whether the associations differed by subtype. Subtypes of breast cancer were defined according to the tumor characteristics: hormone receptors (estrogen and progesterone), tumor size, and grade.

Materials and methods

The methods of this hospital biopsy case–control study have been reported in detail elsewhere [22] and will be described briefly here. The protocol was approved by the ethics committees at Women's College Hospital and Queen's University/Kingston General Hospital and all subjects provided informed consent.

Subjects

In order to obtain a sample of breast adipose tissue in which to measure organochlorines, subjects were women who had a diagnostic breast biopsy at Women's College Hospital in Toronto and Kingston General Hospital in Kingston. Before biopsy, the study was presented by the surgeons to women who did not have previous cancer or breast implants and were under the age of 80. Of the 824 eligible women, 663 (80.5%) completed a questionnaire.

The questionnaire collected information about known and suspected risk factors that were considered as potential confounders in the analyses. Important variables derived from the questionnaire included age (continuous), site (Toronto/Kingston), menopausal status (pre/post), parity (no/yes), lactation duration (continuous), age last breast-fed (never/<30/≥ 30 years), ethnicity (British/Canadian/other), family history (no/breast cancer in first or second-degree relative), body mass index (continuous), fat intake (continuous), alcohol intake ($<1/\geq 1$ drink per week), current smoking (no/yes), and cumulative smoking (continuous). Subjects who reported that their menstrual periods had stopped permanently were classified as postmenopausal. However, six subjects who had a hysterectomy in the absence of bilateral oophorectomy, and were under the mean age of menopause of subjects having a natural menopause (49 years), were classified as premenopausal.

Approximately 0.2–1 g of benign breast tissue were frozen and sent to the laboratory for analysis of organochlorines. After the biopsy, pathology records were reviewed to determine which subjects were cases (*in situ* or invasive breast cancer) and which were controls (biopsy negative for malignancy). Organochlorines were determined in the 217 cases for whom enough breast adipose tissue was available and in 213 controls frequency-matched to the cases by age in 5-year groups and study site.

Organochlorine analysis

The organochlorines measured were: 14 PCB congeners (International Union of Pure and Applied Chemists no. 28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, and 187), p,p′-DDT, p,p′-DDE, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, hexachlorobenzene (HCB), Mirex, and β-hexachlorocyclohexane (β-HCH), α-chlordane, and γ-chlordane. Total PCB was calculated as the sum of PCBs 138 and 153, multiplied by 5.2 to approximate the level of the commercial PCB mixture, Arochlor 1260.

Samples were analyzed at Le Centre de Toxicologie du Québec blind to case–control status. Le Centre de Toxicologie du Québec is accredited by the Canadian Association for Environmental Analytical Laboratories, and participates in many quality assurance/quality control programs including the Great Lakes Research Program's QA/QC Project of the Community Public Health Agency in Michigan, and Environment Canada's Arctic Environment Strategy's QA/QC Program.

Organochlorines were determined using a Hewlett Packard 5890 series II gas chromatograph with dual capillary columns and dual Ni-63 electron-capture detectors. The percentage of lipids in each sample was determined and the concentrations of the organochlorines were expressed as the concentration in lipid. The instrument detection limits were set at three times the average standard deviation of background and were, on a wet-weight basis, 3 μg/kg for total PCBs, 0.6 μg/kg for p,p′-DDT and β-HCH, and 0.3 μg/kg for the rest of the organochlorines determined. The detection limits on a lipid basis depend on the sample weight and the percentage of lipids in the sample, and therefore vary by subject.

Tumor characteristics

Levels of ER and PR in the tumors of the cases were determined by one or both of immunohistochemistry or enzyme immunoassay. The enzyme immunoassay, although considered a more sensitive indicator of receptor status, was missing in several cases due to the lack of tissue for the assay. Using the immunohistochemical assay, tumors were classified as receptor-positive if more than 10% of the cells stained for the receptor. Using the enzyme immunoassay, tumors were classified as receptor-positive if the concentration of receptor was greater than 10 fmol/mg cytosolic protein. Cases who were positive by at least one assay were considered to have positive receptor status.

Tumor size and grade were abstracted from the pathology reports, or were reported separately to us by the pathologist at the hospital. Tumors were graded at both hospitals according to the Scarff–Bloom–Richardson (SBR) system which classifies tumors into three grades: I (well differentiated), II (moderately differentiated), and III (poorly differentiated), according to the tumor architecture, nuclear pleomorphism, and the number of mitotic figures. Only invasive ductal carcinomas were graded. Where pathology reports were missing grade information, or had grade reported by a different grading system, the pathologist (S.K.S.) reviewed the report or the slide.

Statistical analyses

More than 30% of subjects had undetectable levels of PCBs 28, 52, 101, and 128, α-chlordane, and γ-chlordane, and these organochlorines were not considered further. The distributions of organochlorines were positively skewed; therefore geometric means were used to describe the central tendency in controls and cases stratified by the pathology variables. Differences in the concentration of each organochlorine (log-transformed) between cases with different pathology characteristics while controlling for age were tested using two-way analysis of variance.

ORs were calculated as estimates of the relative risk for each subtype of breast cancer associated with exposure to organochlorines. For these analyses, exposure to organochlorines was examined in tertiles based on the distribution in controls. Subjects with undetected levels were included in the lowermost category if the detection limit of the organochlorine was below the first tertile. The remaining subjects with undetected levels were excluded because they could not be placed reliably in any category; if a subject's detection limit was above the first tertile cutpoint, it would be unclear whether the true concentration of that organochlorine in her breast adipose tissue was in the first tertile or the second tertile. Thus, at most six subjects were excluded from the analyses of PCB 105, PCB 183, *cis*-nonachlor, and Mirex.

All ORs were adjusted for age, site, and menopausal status. A confounder model was then built for each individual organochlorine based on a logistic model in which all cases were combined and compared to controls. Additional covariates were included in the model if their deletion caused any organochlorine OR to change more than 10% from the model saturated with all covariates. Polytomous logistic regression was used to estimate risk of breast cancer subtypes relative to the control group associated with exposure to each organochlorine using the SAS CATMOD procedure (SAS Institute, Cary, NC, USA). Each polytomous model was fit with the outcomes being defined by one pathology variable at a time. For example, one model would have three outcomes: ER-positive, ER-negative, and controls. A likelihood ratio test was performed to evaluate the significance of the organochlorine variable in a logistic model comparing one case subgroup with another case subgroup. The significance of this test indicated if heterogeneity existed in the associations between organochlorines and risk of different subtypes of breast cancer.

Results

ER assays were available for 201 cases. Of these, 111 cases had ER status determined by both the immunohistochemical assay and the enzyme immunoassay, and the concordance between the two assays was 94%. Overall, 51 (25%) were ER-negative and 150 (75%) were ER-positive. PR assays were available for 202 cases. Of these, 111 had PR status determined by both the immunohistochemical assay and the enzyme immunoassay, and the concordance between the two assays was 83%. Overall, 72 (36%) were PR-negative and 130 (64%) were PR-positive. The majority (75%) with missing receptor status had carcinoma *in situ*.

Histologic grade was available only for 169 cases with invasive ductal carcinomas since invasive lobular carcinomas and carcinoma *in situ* are not given an overall SBR grade. Of these, 27 (16%) were SBR grade I, 79 cases (47%) were SBR grade II, and 63 (37%) were SBR grade III. Grades I and II were combined for the analyses to ensure a sufficient sample size in each category of organochlorine exposure. Tumor size was available from the pathology reports of 198 (91%). Of these, 49 (25%) had tumors less than 1 cm in diameter,

83 (42%) had tumors between 1 and 1.9 cm, and 66 (33%) had tumors 2 cm or larger. The first two categories of size were combined to ensure a sufficient sample size in categories of exposure and for comparability to another study of the same issue [23]. All of the associations between ER status, PR status, tumor size, and tumor grade were significant ($p < 0.001$), except PR status and tumor size ($p = 0.5$).

A description of the controls and cases by the pathology variables with respect to selected covariates is shown in Table 1. The greatest differences by ER status were that, compared with ER-positive cases, ER-negative cases were younger, had a higher body mass index, and more were from Toronto, had ethnic background other than British or Canadian, and a negative family history. Large differences in the covariates by PR status were not evident, and thus are not shown. More cases with tumors 2 cm or larger in diameter were from Toronto than cases with smaller tumors. When cases were examined by tumor grade, cases with tumors of high grade were younger and more were from Toronto, had ethnicity other than British or Canadian, and had a negative family history than cases with low or medium grade tumors.

In general, the control group had lower breast adipose tissue concentrations of all organochlorines (Table 2) [22]. While adjusting for age, the concentration of PCBs 99, 138, 153, and 183, total PCBs, DDE, and β-HCH was higher in ER-negative than ER-positive cases ($p < 0.05$). The concentrations of organochlorines did not differ significantly between PR-negative and PR-positive cases, and thus are not shown. The concentration of *cis*-nonachlor and β-HCH was significantly higher in cases with larger tumors than cases with smaller tumors ($p < 0.05$). The concentration of PCBs 153 and 183, DDE, DDT, HCB, and β-HCH was higher

Table 1. Characteristics of controls and cases by tumor characteristics with respect to covariates

Covariate	Controls	ER		Size		Grade	
		Negative	Positive	<2 cm	≥2 cm	I/II	III
Continuous	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (years)	53.9 (10.9)	54.2 (11.0)	58.8 (11.6)	59.1 (11.5)	56.5 (11.7)	58.6 (11.4)	55.3 (11.5)
Lactation (months)	6.0 (12.9)	5.5 (9.2)	6.0 (8.9)	5.4 (8.3)	6.5 (10.0)	5.7 (9.0)	6.6 (9.7)
Body mass index (kg/m^2)	25.2 (4.3)	25.9 (4.7)	24.9 (4.4)	24.9 (4.4)	26.0 (4.8)	25.0 (4.6)	25.4 (4.3)
Fat intake (g/day)	34.8 (19.0)	39.0 (16.5)	39.4 (16.2)	39.9 (16.7)	38.3 (15.3)	40.0 (16.3)	38.1 (17.6)
Categorical	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Site							
Toronto	104 (48.8)	29 (56.9)	67 (44.7)	57 (43.2)	41 (62.1)	35 (33.0)	29 (54.7)
Kingston	109 (51.2)	22 (43.1)	83 (55.3)	75 (56.8)	25 (37.9)	71 (67.0)	24 (45.3)
Menopausal status							
Premenopausal	94 (44.1)	18 (35.3)	48 (32.0)	40 (30.3)	22 (33.3)	33 (31.1)	24 (38.1)
Postmenopausal	119 (55.9)	33 (64.7)	102 (68.0)	92 (69.7)	44 (66.7)	73 (68.9)	39 (61.9)
Ever pregnant							
No	33 (15.5)	9 (17.6)	27 (18.0)	21 (15.9)	14 (21.2)	21 (19.8)	9 (14.3)
Yes	180 (84.5)	42 (82.4)	123 (82.0)	111 (84.1)	52 (78.8)	85 (80.2)	54 (85.7)
Age last breast-fed							
Never	112 (52.6)	24 (47.1)	66 (44.0)	61 (46.2)	29 (43.9)	51 (48.1)	28 (44.4)
<30 years	56 (26.3)	10 (11.8)	40 (26.7)	38 (28.8)	13 (19.7)	29 (27.4)	11 (17.5)
≥30	45 (21.1)	17 (41.2)	44 (29.3)	33 (25.0)	24 (36.4)	26 (24.5)	24 (38.1)
Current use of hormone replacement therapy							
No	174 (81.7)	48 (94.1)	136 (90.7)	119 (90.2)	62 (93.9)	95 (89.6)	60 (95.2)
Yes	39 (18.3)	3 (5.9)	14 (9.3)	13 (9.8)	4 (6.1)	11 (10.4)	3 (4.8)
Ethnicity							
British	113 (53.6)	24 (47.1)	90 (60.4)	77 (58.8)	36 (54.5)	66 (62.9)	29 (46.0)
Canadian	14 (6.6)	6 (11.8)	16 (10.7)	18 (13.7)	4 (6.1)	12 (11.4)	8 (12.7)
Other	84 (39.8)	21 (41.2)	43 (28.9)	36 (27.5)	26 (39.4)	27 (25.7)	26 (41.3)
Family history							
No	142 (66.7)	38 (74.5)	81 (54.0)	77 (58.3)	42 (63.6)	58 (54.7)	44 (69.8)
Yes	71 (33.3)	13 (25.5)	69 (46.0)	55 (41.7)	24 (36.4)	48 (45.3)	19 (30.2)
Alcohol intake							
<1 drinks/week	107 (50.7)	31 (62.0)	86 (57.7)	74 (56.1)	43 (67.2)	63 (60.0)	39 (61.9)
≥1	104 (49.3)	19 (38.0)	63 (42.3)	58 (43.9)	21 (32.8)	42 (40.0)	24 (38.1)

Table 2. Geometric means of organochlorines with 95% confidence intervals for controls and cases by tumor characteristics

Organochlorine	Controls	Cases, by ER status		Cases, by tumor size		Cases, by grade	
		Negative	Positive	<2 cm	>2 cm	I or II	III
PCB 99 (μg/kg)	17.7 (16.2–19.3)	21.9 (18.2–26.4)	18.9 (17.1–21.0)	19.7 (17.7–21.9)	20.5 (17.5–24.1)	19.7 (17.7–21.9)	20.5 (17.6–23.9)
PCB 138 (μg/kg)	66.8 (62.1–71.9)	81.8 (68.6–97.4)	71.7 (66.2–77.7)	73.7 (67.8–80.1)	77.2 (67.4–88.5)	73.7 (67.8–80.1)	78.0 (67.1–90.7)
PCB 153 (μg/kg)	98.3 (91.8–105.3)	114.6 (96.9–135.5)	102.8 (95.4–110.9)	104.6 (96.6–113.3)	110.6 (97.3–125.9)	104.6 (96.6–113.3)	113.8 (98.2–131.9)
PCB 156 (μg/kg)	17.2 (16.0–18.5)	20.1 (17.1–23.6)	18.3 (17.0–19.8)	18.9 (17.6–20.3)	19.1 (16.7–22.0)	18.9 (17.6–20.3)	19.7 (17.0–22.9)
PCB 170 (μg/kg)	32.0 (29.7–34.4)	36.1 (30.4–42.8)	33.8 (31.4–36.4)	33.9 (31.4–36.5)	37.0 (32.2–42.5)	33.9 (31.4–36.5)	36.2 (31.2–42.1)
PCB 180 (μg/kg)	65.7 (61.5–70.2)	75.0 (63.9–88.1)	71.4 (66.5–76.7)	71.7 (66.6–77.2)	76.0 (66.6–86.8)	71.7 (66.6–77.2)	75.8 (65.8–87.4)
PCB 183 (μg/kg)	9.5 (8.8–10.2)	11.8 (9.9–14.0)	9.9 (9.1–10.8)	10.1 (9.2–11.0)	11.4 (10.0–13.2)	10.1 (9.2–11.0)	11.2 (9.6–13.0)
PCB 187 (μg/kg)	24.2 (22.6–26.0)	27.1 (22.6–32.5)	25.3 (23.3–27.6)	25.1 (22.8–27.5)	27.5 (23.8–31.8)	25.1 (22.8–27.5)	27.2 (23.3–31.9)
Total PCB (mg/kg)	0.87 (0.81–0.92)	1.02 (0.86–1.21)	0.92 (0.85–0.99)	0.94 (0.86–1.02)	0.98 (0.86–1.12)	0.94 (0.86–1.02)	1.00 (0.86–1.16)
DDE (μg/kg)	596 (530–670)	906 (682–1203)	638 (557–730)	693 (597–804)	768 (616–958)	693 (597–804)	781 (618–988)
DDT (μg/kg)	19.3 (17.3–21.6)	23.5 (17.3–32.0)	21.3 (18.8–24.1)	20.9 (18.3–24.0)	25.3 (19.7–32.5)	20.9 (18.3–24.0)	24.5 (18.7–32.0)
cis-Nonachlor (μg/kg)	6.0 (5.6–6.5)	6.2 (5.1–7.6)	5.9 (5.3–6.5)	5.6 (5.1–6.3)	6.8 (5.8–8.0)	5.6 (5.1–6.3)	6.2 (5.2–7.5)
trans-Nonachlor (μg/kg)	41.1 (38.7–43.6)	43.3 (36.5–51.3)	39.1 (35.6–43.0)	39.8 (35.6–44.4)	43.5 (38.8–48.8)	39.8 (35.6–44.4)	41.6 (36.6–47.2)
HCB (μg/kg)	30.1 (27.8–32.5)	34.9 (27.3–44.7)	31.0 (28.3–33.9)	31.0 (28.1–34.4)	35.2 (29.4–42.3)	31.0 (28.1–34.3)	35.8 (29.2–43.7)
β-HCH (μg/kg)	41.5 (36.1–47.6)	56.2 (38.3–82.3)	39.3 (34.7–44.5)	39.8 (34.8–45.6)	54.9 (40.9–73.7)	39.8 (34.8–45.6)	54.9 (40.1–75.2)

among cases with more poorly differentiated tumors than cases with moderately or well differentiated tumors ($p < 0.05$).

Risk estimates for the associations between organochlorines and breast cancer risk by the pathology variables are shown in Tables 3–6. Results are shown always for total PCBs and DDE, to facilitate comparison with other studies. The results for other organochlorines are also shown where heterogeneity existed in the associations with the risk of breast cancer between the subtypes at a liberal $p \leq 0.30$. That is, although none of the ORs differed significantly by subtype at $p < 0.05$, the results in which the ORs are most different by subtype are shown. Therefore, the risk estimates that are not shown were similar to those for the whole case group as previously reported [22].

Breast adipose tissue concentrations of all the PCBs and DDE were more strongly positively associated with risk of ER-negative breast cancer (Table 3). The OR for risk of ER-negative breast cancer in the uppermost tertile, compared with the lowest tertile, was elevated for DDE (OR 2.4; CI 1.0–5.4) and the *p*-value for the test of linear trend was 0.03. Breast adipose tissue concentrations of *trans*-nonachlor and β-HCH were more strongly negatively associated with risk of ER-positive breast cancer. The OR for ER-positive breast cancer in the uppermost tertile of *trans*-nonachlor was 0.5 (CI 0.3–0.9).

Risk estimates for the associations between organochlorines and PR-negative breast cancer risk and PR-positive breast cancer risk are shown in Table 4. The association between PCB 180 and PR-negative breast cancer risk was stronger than that with PR-positive breast cancer risk, but the OR for PR-negative breast cancer was highest in the second tertile.

Breast adipose tissue concentrations of the PCB congeners tended to be more strongly positively associated with risk of breast tumors of greater size than of lesser size (Table 5). Conversely, breast adipose tissue concentrations of DDE were only weakly associated with risk of tumors less than 2 cm in diameter, but were not associated at all with tumors 2 cm or larger.

Table 3. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to estrogen receptor status

Organochlorine	Controls	ER-negative		ER-positive	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 99[a]					
≤12 μg/kg	63	12	1.0	29	1.0
13–22	74	13	0.9 (0.4–2.3)	59	1.7 (0.9–3.2)
≥23	71	26	2.1 (0.9–5.0)	59	1.8 (0.9–3.6)
PCB 153[b]					
≤80 μg/kg	69	14	1.0	40	1.0
81–122	69	14	1.0 (0.4–2.3)	61	1.1 (0.6–2.0)
≥123	71	23	1.7 (0.7–3.9)	47	1.0 (0.5–1.8)
PCB 156[c]					
≤13 μg/kg	63	7	1.0	32	1.0
14–21	70	25	3.9 (1.5–10.2)	65	1.7 (0.9–3.1)
≥22	76	19	2.5 (0.9–6.7)	51	1.2 (0.6–2.2)
PCB 170[d]					
≤25 μg/kg	68	14	1.0	33	1.0
26–39	70	16	1.4 (0.6–3.1)	69	1.7 (1.0–3.0)
≥40	74	21	1.5 (0.7–3.3)	47	0.9 (0.5–1.6)
Total PCB[e]					
≤0.70 mg/kg	69	14	1.0	38	1.0
0.71–1.0	68	14	1.1 (0.5–2.7)	56	1.3 (0.8–2.4)
≥1.1	72	23	1.7 (0.8–3.9)	54	1.3 (0.7–2.3)
DDE[f]					
≤432 μg/kg	69	13	1.0	46	1.0
433–869	70	11	0.8 (0.3–2.1)	49	0.9 (0.5–1.6)
≥870	69	27	2.4 (1.0–5.4)	52	1.1 (0.6–1.9)
cis-Nonachlor[g]					
≤4.5 μg/kg	67	22	1.0	46	1.0
4.6–7.3	72	13	0.5 (0.2–1.1)	58	0.9 (0.5–1.7)
≥7.4	68	16	0.5 (0.2–1.2)	43	0.7 (0.4–1.2)
trans-Nonachlor[h]					
≤33 μg/kg	70	16	1.0	51	1.0
34–49	69	16	1.0 (0.5–2.3)	54	0.8 (0.5–1.4)
≥50	70	19	1.1 (0.5–2.4)	43	0.5 (0.3–0.9)
β-HCH[i]					
≤27 μg/kg	69	15	1.0	51	1.0
28–44	71	13	0.8 (0.3–1.9)	52	0.8 (0.4–1.4)
≥45	68	23	1.4 (0.6–3.2)	44	0.7 (0.4–1.3)

[a] ORs adjusted for age, site, menopausal status, lactation duration, age last breast-fed, current use of hormone replacement therapy, ethnicity, family history, body mass index, and intake of fat and alcohol.

[b] ORs adjusted for age, site, menopausal status, lactation duration, age last breast-fed, current use of hormone replacement therapy, ethnicity, and intake of fat and alcohol.

[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, family history, and intake of fat.

[d] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and body mass index.

[e] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.

[f] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

[g] ORs adjusted for age, site, menopausal status, age last breast-fed, ethnicity, and intake of fat.

[h] ORs adjusted for age, site, menopausal status, ethnicity, and intake of fat.

[i] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, family history, body mass index, and intake of fat and alcohol.

Table 4. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to progesterone receptor status

Organochlorine	Controls	PR-negative		PR-positive	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 180[a]					
≤0.54 μg/kg	70	11	1.0	33	1.0
0.55–81	69	31	2.6 (1.2–5.9)	50	1.4 (0.8–2.6)
≥82	73	30	1.9 (0.9–4.4)	46	1.1 (0.6–2.0)
Total PCB[b]					
≤0.70 mg/kg	69	17	1.0	35	1.0
0.71–1.0	68	27	1.4 (0.7–3.0)	44	1.2 (0.7–2.2)
≥1.1	72	28	1.4 (0.6–2.9)	49	1.4 (0.8–2.6)
DDE[c]					
432 μg/kg	69	21	1.0	38	1.0
433–869	70	18	0.7 (0.3–1.5)	43	1.0 (0.6–1.8)
≥870	69	33	1.5 (0.7–3.1)	46	1.3 (0.7–2.3)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and body mass index.
[b] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.
[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

Table 5. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to tumor size

Organochlorine	Controls	Size < 2 cm		Size ≥ 2 cm	
		Cases	OR (95% CI)	Cases	OR (95% CI)
PCB 187[a]					
≤17 μg/kg	63	34	1.0	14	1.0
18–29	75	51	1.1 (0.6–2.0)	22	1.4 (0.6–2.9)
≥30	73	46	0.9 (0.5–1.6)	30	1.6 (0.7–3.5)
Total PCB[b]					
≤0.70 mg/kg	69	30	1.0	17	1.0
0.71–1.0	68	51	1.6 (0.9–2.9)	21	1.2 (0.6–2.7)
≥1.1	72	50	1.5 (0.8–2.8)	26	1.5 (0.7–3.1)
DDE[c]					
≤432 μg/kg	69	35	1.0	20	1.0
433–869	70	43	1.1 (0.6–2.0)	19	0.9 (0.4–1.8)
≥870	69	53	1.6 (0.9–2.9)	25	1.1 (0.5–2.4)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, and ethnicity.
[b] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.
[c] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

Risk estimates for the association between organochlorines and breast cancer risk by grade are shown in Table 6. The ORs for all the PCBs and DDE were only slightly higher with risk of breast cancer of a higher grade than the risk of breast cancer of a low or medium grade.

Discussion

Concentrations of organochlorines were almost always higher in cases with tumors of poorer prognosis (ER-negative, PR-negative, size ≥ 2 cm, grade III) than in cases with tumors of better prognosis (ER-positive, PR-positive, size < 2 cm, grade I/II). Geometric means differed significantly by ER status and tumor grade for several organochlorines while adjusting for age. However, when all confounders were taken into account, associations between the organochlorines and breast cancer did not differ significantly by subtype of breast cancer as defined by either ER, PR, tumor size, or tumor grade. The risk estimates for ER-negative breast cancer with PCBs and DDE remained nonsignificantly higher

Table 6. Association of adipose tissue concentrations of organochlorines with breast cancer risk, according to tumor grade

Organochlorine	Controls	Grade I or II		Grade III	
		Cases	OR (95% CI)	Cases	OR (95% CI)
Total PCB[a]					
≤0.70 mg/kg	69	29	1.0	17	1.0
0.71–1.0	68	37	1.2 (0.7–2.3)	19	1.2 (0.5–2.5)
≥1.1	72	38	1.2 (0.6–2.4)	27	1.5 (0.7–3.2)
DDE[b]					
≤432 μg/kg	69	34	1.0	18	1.0
433–869	70	31	0.7 (0.4–1.4)	20	1.1 (0.5–2.2)
≥870	69	38	1.1 (0.6–2.1)	25	1.4 (0.6–3.1)

[a] ORs adjusted for age, site, menopausal status, current use of hormone replacement therapy, ethnicity, family history, and intake of fat and alcohol.

[b] ORs adjusted for age, site, menopausal status, present use of hormone replacement therapy, ethnicity, body mass index, and intake of fat.

than for ER-positive breast cancer. PCBs also tended to be more strongly positively associated with risk of larger and higher grade tumors.

Only some studies of organochlorines and breast cancer risk have included analyses by hormone receptor status. Of these, some have found no significant difference between ER-positive and ER-negative cases in mean levels for the array of contaminants measured in our study [23], total PCBs and DDE [16, 24], β-HCH [25], or HCB [26]. We also observed no difference between age-adjusted mean levels of total PCBs and HCB, but mean levels of β-HCH and some specific PCB congeners did differ. Others have also reported no difference in risk estimates either between ER-negative and ER-positive breast cancer, or excluding ER-negative cases from the analysis, for total PCBs [9, 10, 27], noncoplanar PCBs [6], and DDE [6, 9, 10, 13, 27]; these observations are similar to our study in that no statistically significant difference was found. However, higher risk among ER-positive cases was reported for DDE in one study [21], and for coplanar PCBs (PCBs 77, 126, 169) [6].

Some factors may help explain the discrepancies between studies. In some studies it is not clear whether age and other covariates were taken into account. Many publications did not present data, and only noted in the text that organochlorine levels did not differ by ER status. It is not clear if levels were nonsignificantly different between cases by ER status and if these differences were in a consistent direction for all the contaminants.

The rationale for investigating risk by hormone receptor status is that receptor-positive tumors are responsive to hormones and, therefore, to agents such as organochlorines that are hypothesized to act as hormone mimics. The natural history of breast cancer may involve a progression from ER-positive disease to ER-negative disease [28]. Therefore, receptor-negative disease may have been ER-positive at the critical time in cancer induction. However, in our study this is not supported by the observation that subjects with ER-negative tumors were younger than subjects with ER-positive tumors. The PCBs that were found to be higher in ER-negative cases were those that are dioxin-like and potentially antiestrogenic [29].

One possible explanation for the slightly higher risk estimates seen for ER-negative breast cancer in our study is that tumors that are receptor-negative when diagnosed may have a faster rate of progression than tumors that are receptor-positive when diagnosed. Demers and colleagues [23] observed that, among cases, the risk of having a tumor that was aggressive as defined by higher stage and size was associated with some organochlorines. Similarly, cases with high levels of an organochlorine pesticide, dieldrin, had poorer survival than cases with lower levels in a Danish study [30]. Therefore, higher levels of organochlorines may increase the aggressiveness of the tumor. Alternatively, the risk associated with organochlorines and ER-negative disease is truly the same as the risk associated with ER-positive disease, but the risk appears to be stronger for ER-negative disease because the critical time period for exposure for this more aggressive tumor is closer to the time of diagnosis than that for ER-positive tumors. The apparent difference in risk may appear because exposure would be misclassified less for subjects with ER-negative disease than subjects with ER-positive disease.

In this study, women with ER-negative tumors, larger tumor size and grade were more likely to be from Toronto than from Kingston. This raises the possibility that, in Toronto, tumors were rated more highly in

terms of these factors than they may have been rated in Kingston. A central review of the slides was not done; previous collaborative work between these two centers found good between-center comparability of steroid receptor assays (unpublished observations). However, it is also possible that the tumors in Kingston were diagnosed earlier because an active screening program existed there. Also, analyses stratified by study site tended to support the results of the combined group although they were slightly unstable due to small sample sizes.

This study was one of the largest to date to report the associations between breast cancer risk by several tumor characteristics and a broad range of organochlorines measured in breast adipose tissue. Measures made in adipose tissue have the advantage over measures made in blood because they provide a good measure of cumulative internal exposure at the target site for breast cancer [31, 32]. Also, since the concentrations of organochlorines are 200–1000 times higher in adipose tissue than in blood, even small samples have detectable levels. Another advantage of this study was the virtually complete information about the tumor characteristics. Although this study had a large sample size compared to other studies of organochlorines and breast cancer risk, it had insufficient precision to detect differences in risk by the tumor characteristics presented in this paper, and also had too little statistical power to examine risk by joint ER/PR status. Differences in other studies have been found within the ER-positive cases by PR status [20, 33, 34].

In summary, these data suggest that organochlorines may be more strongly related to breast tumors that have poorer prognosis, but larger studies are needed to confirm this finding. Further research is needed to investigate the natural history of breast tumors that have different pathological characteristics as defined by extent of disease and various tumor markers. Research is also needed to investigate the possibility that hormone receptor levels in benign tissue are associated with breast cancer risk and may influence the susceptibility to other risk factors. To date, only one study has been published on this issue [35], and our group is also presently examining this as an extension to this study.

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Breast Adipose Tissue Concentrations of Polychlorinated Biphenyls and Other Organochlorines and Breast Cancer Risk[1]

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Abstract

Numerous studies have examined the relationship between organochlorines and breast cancer, but the results are not consistent. In most studies, organochlorines were measured in serum, but levels in breast adipose tissue are higher and represent cumulative internal exposure at the target site for breast cancer. Therefore, a hospital-based case-control study was conducted in Ontario, Canada to evaluate the association between breast cancer risk and breast adipose tissue concentrations of several organochlorines. Women scheduled for excision biopsy of the breast were enrolled and completed a questionnaire. The biopsy tissue of 217 cases and 213 benign controls frequency matched by study site and age in 5-year groups was analyzed for 14 polychlorinated biphenyl (PCB) congeners, total PCBs, and 10 other organochlorines, including p,p′-1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene. Multiple logistic regression was used to assess the magnitude of risk. While adjusting for age, menopausal status, and other factors, odds ratios (ORs) were above 1.0 for almost all organochlorines except five pesticide residues. The ORs were above two in the highest concentration categories of PCB congeners 105 and 118, and the ORs for these PCBs increased linearly across categories (*P*s for trend ≤0.01). Differences by menopausal status are noted especially for PCBs 105 and 118, with risks higher among premenopausal women, and for PCBs 170 and 180, with risks higher among postmenopausal women. Clear associations with breast cancer risk were demonstrated in this study for some PCBs measured in breast adipose tissue.

Introduction

Organochlorines, a class of 15,000 chlorine-containing organic chemicals, including DDT[3] and 209 PCB congeners, have been widely used in the past in industrial applications and as pesticides. Some are resistant to degradation and are very lipid soluble and therefore, have persisted in the environment and have biomagnified up the food chain to humans (1). The general population is exposed to organochlorines through many commonly eaten foods but also through water, ambient and indoor air, dust, and soil (2, 3). As a result, several organochlorines are now detectable in most human serum, adipose tissue, and breast milk.

Studies in animals have lead to a consensus that DDT, its metabolite DDE, and other related pesticides and chemicals are known animal and suspected human carcinogens (4, 5). PCBs have produced liver cancer in rats and are classified as probable human carcinogens (4, 6). Organochlorines have been studied with respect to breast cancer due to the potential to act as direct carcinogens or as indirect carcinogens by mimicking the action of estrogen, interfering with intercellular communication, inducing cytochrome p450 enzymes in humans, and disrupting immune function (7–10). Because known risk factors for breast cancer do not account for all cases, it is reasonable to investigate as potential risk factors chemicals that persist in the environment, accumulate in humans, and for which a plausible biological mechanism of action exists.

Nineteen epidemiological studies have been published examining breast cancer risk in relation to organochlorines (11–31). In some, compared with controls, women with breast cancer had higher levels of some chlorinated compounds, including total PCBs, some PCB congeners, DDE, and the pesticides, β-HCH, HCB, and dieldrin (11, 13, 20, 22–25, 28). In others, compared with controls, cases had lower concentrations or similar levels of DDE (11, 12, 14–16, 18, 19, 26, 27, 31), β-HCH (11, 29), and HCB (30). Some researchers also have found increased risks associated with some PCBs, DDE, and the pesticide, Mirex, in subgroups defined by estrogen receptor status of cases, lactation status, or CYP1A1 polymorphisms (17, 21, 32). Considered together, the relationship between the

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[3] The abbreviations used are: DDT, 2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane; DDE, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)-ethylene; BBD, benign breast disease; BMI, body mass index; CI, confidence interval; GM, geometric mean; HCB, hexachlorobenzene; β-HCH, β-hexachlorocyclohexane; OR, odds ratio; PCB, polychlorinated biphenyl; HRT, hormone replacement therapy.

organochlorines investigated and breast cancer risk is not consistent (for review, see Refs. 33 and 34).

In most studies, organochlorines were measured in serum (11–20), whereas only small studies and one recent larger study have measured these chemicals in breast adipose tissue (21–26, 28–31). In humans, adipose tissue levels are 200-1000 times higher than levels in serum (35–38). Therefore, even small samples of adipose tissue have organochlorine compounds in the detectable range and are more suitable for congener-specific analyses (39). Congener-specific analyses are important because individual congeners have been shown to have different biological activity (40). Finally, organochlorines measured in breast adipose tissue provide a good measure of cumulative internal exposure at the target site for breast cancer, accounting for all routes and sources of exposure (41, 42). To evaluate the association between breast cancer risk and breast adipose tissue concentrations of several persistent organochlorines, a hospital-based case-control study was conducted in the province of Ontario, Canada between July 1995 and June 1997.

Materials and Methods

Subjects. Women under the age of 80 were enrolled by their surgeons at Women's College Hospital in Toronto and Kingston General Hospital in Kingston when they were being scheduled for excision biopsy of suspected breast cancer. Women were excluded if they had a previous diagnosis of any cancer except nonmelanoma skin cancer, had breast implants, were participating in a Tamoxifen trial, or were too ill. Of the 824 eligible women, 735 (89%) agreed to participate and signed informed consent. Following biopsy, pathology records were reviewed. Cases were subjects diagnosed with *in situ* or invasive breast cancer. Controls were subjects with biopsies negative for malignancy, but most were diagnosed with some form of BBD.

A questionnaire providing information about known and suspected risk factors for breast cancer was completed by 663 women (80.5% of those eligible) by telephone interview or by mail. Seventy-two women who had originally agreed to participate were unreachable after at least eight attempts made at different times of the day and different days, had phone numbers that were not in service and were not listed in the telephone directory, or found they were too anxious about their biopsy to complete the questionnaire. Because no information was obtained from these women, it is unknown if they were different from the women who completed a questionnaire except that more were from Toronto (90%), a large metropolitan area. Answers to the questionnaire were recorded by a trained interviewer (91%) or the questionnaires were received by mail (9%); most (60%) were received before the subject's biopsy date. The majority of questionnaires were received before participants knew their diagnosis.

The questionnaire included demographics, menopausal status, weight at age 25 and two years prior to interview, height, reproductive history variables, use of exogenous hormones, physical activity and diet variables, and family history of breast cancer. Subjects who reported that their menstrual periods had stopped permanently were classified as postmenopausal except those who had a hysterectomy in the absence of bilateral oophorectomy and were under the mean age of menopause of the subjects having a natural menopause (49 years); these six subjects were classified as premenopausal. Those who reported that a first or second degree relative had breast cancer were classified as having a family history of breast cancer. Ethnicity was coded to Statistics Canada groupings used for the census of the population (43), where British referred to those with British, Scottish, Irish, or Welsh ancestry and Canadian referred to those with native or aboriginal ancestry. The rest of the ethnic groups were collapsed together into one category.

The food frequency section of the questionnaire, which was used to record the consumption of 67 foods two years before the interview, was used to create indices of intake of nutrients and foods within the major groups. The food frequency questionnaire was based on that developed by Jain *et al.* (44) for a similar population (*i.e.,* Ontario women undergoing mammography), but it was modified to take into account foods, especially those high in animal fat, that contribute significantly to organochlorine exposure (2). A standard table of nutritive contents based on the Canadian Nutrient File was used to assign nutrient values to the food on the questionnaire (45).

Organochlorines were determined in all cases for whom enough tissue was available ($n = 217$) as well as in a subset of controls frequency matched by age in 5-year groups and study site ($n = 213$). Those with organochlorine concentrations analyzed differed from those without this analysis in a few respects. Among the cases, the 50 women without enough breast tissue to analyze were younger (by a mean of about 4 years), had a lower BMI, and a higher proportion were premenopausal and from Toronto. Among the controls, the 183 not analyzed for organochlorines were much younger than those analyzed because this group was frequency matched by age to cases. The controls not analyzed also had a lower BMI, and a lower proportion were from Toronto, were ever pregnant, were of British ethnicity, and had a negative family history of breast cancer.

Tissue Analysis. Approximately 0.2–1 g of benign tissue taken during the breast biopsy was frozen in a glass vial at −70°C. Samples, labeled only with identification numbers to conceal case-control status, were shipped to Le Center de Toxicologie du Québec on ice and kept at −20°C. Levels of 14 PCB congeners (International Union of Pure and Applied Chemists nos. 28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, and 187) and total PCBs were determined. Total PCBs was calculated as the sum of PCBs 138 and 153 multiplied by 5.2 to approximate a level of the commercial PCB mixture, Aroclor 1260. This approximates the measurement of total PCBs using older analytic techniques. Levels of 10 organochlorinated pesticides were also determined (p,p′-DDT, p,p′-DDE, *cis*-nonachlor, *trans*-nonachlor, oxychlordane, HCB, Mirex, and β-HCH, α-chlordane, and γ-chlordane).

Samples were analyzed in batches of 5–10, each batch containing samples from both cases and controls randomly selected from the pool of subjects to be analyzed. Laboratory personnel were blind to case-control status. A polar extract of lipids was obtained. The sample was cleaned on Florosil columns, concentrated, and analyzed on a Hewlett Packard 5890 series II gas chromatograph with dual capillary columns and dual Ni-63 electron capture detectors. Peaks were identified by their relative retention times obtained from the two columns and quantified (46–48). The percentage of lipids in each sample was determined in a portion of the extracted samples, and the concentrations of the organochlorines were expressed in micrograms per kilogram of lipid. The instrument detection limits were set at three times the average SD of background and were, on a wet weight basis, 3 μg/kg for total PCBs, 0.6 μg/kg for p,p′-DDT and β-HCH, and 0.3 μg/kg for the rest of the organochlorines determined. The detection limits on a lipid basis depend on the sample weight and the percentage of lipids in the sample and therefore, vary by subject.

For each batch, two references were used. A nonextracted verification standard containing PCB congeners and organochlorines at concentrations of 10 μg/kg was run at the beginning of each batch to check the performance of the columns and the sensitivity of the detectors. An extracted verification standard was run to calculate the relative response factors. Le Centre de Toxicologie du Québec is accredited by the Canadian Association for Environmental Analytical Laboratories and participates in many quality assurance/quality control programs, including the Great Lakes Research Program's Quality Assurance/Quality Control Project of the Community Public Health Agency in Michigan and the Environment Canada's Arctic Environment Strategy's Quality Assurance/Quality Control Program.

Statistical Analyses. Because >30% of subjects had undetectable levels of PCBs 28, 52, 101, and 128, α-chlordane, and γ-chlordane, these organochlorines were not considered further. The distributions of organochlorines in adipose tissue were positively skewed and, therefore, were log-transformed to improve normality. The GMs and associated 95% CIs were calculated in cases and controls. Associations among organochlorines were investigated by calculating the Pearson correlation coefficient (r) on log-transformed organochlorine concentrations. Associations between age and the organochlorines were investigated by calculating the Spearman correlation coefficient (r_s).

Exposure to organochlorines was examined in four categories. To form a relatively extreme uppermost exposure category with an adequate number of subjects, the cutpoint for the upper category was at the 85th percentile. The first three categories were formed by dividing the distribution of controls with detectable levels into thirds below the 85th percentile (*i.e.*, cutpoints were at the 28th and 57th percentiles). Subjects with undetectable levels were included in the lowermost category if their detection limit of the organochlorine was below the 28th percentile. The remaining subjects with undetectable levels were excluded because their detection limits were above the cutpoint for the first category, and they could not be reliably placed in either the first or the second category. Eight subjects were excluded from the PCB 105 analysis, one from the PCB 183 analysis, three from the *cis*-nonachlor analysis, and three from the Mirex analysis.

To estimate breast cancer risk associated with exposure to each substance, unconditional logistic regression was used to calculate ORs and associated two-sided 95% CIs (49) using EGRET (Cytel Software, Cambridge, MA). All ORs were adjusted for age (continuous), site (Toronto/Kingston), and menopausal status (pre/post). Of the many covariates measured in the questionnaire, those that were included in a model built by a forward selection procedure and were associated with breast cancer risk at $P < 0.3$ were further tested as confounders. This model included the variables in Table 1 plus use of HRT (never/ever), age at menarche (<12/≥12 years), and duration of oral contraceptive use. To make an even more parsimonious confounder model for each organochlorine, these covariates were then modeled with the organochlorine exposure variable and kept in the confounder model if their deletion caused any organochlorine OR to change >10% from the model saturated with all of the additional covariates. The covariates that were confounders in the analyses of each organochlorine are shown in the "Appendix." Within the subset of 150 cases and 152 controls for whom digitized mammographic density was available, inclusion of this variable did not change ORs associated with the organochlorine variables and so was not included in confounder models.

Table 1 Characteristics of cases and controls with respect to covariates

Covariate	Mean (SD) or *n* (%)	
	Cases	Controls
Age (yr)	57.7 (11.6)[a]	53.9 (10.9)[a]
Site		
Toronto	102 (47.0%)	104 (48.8%)
Kingston	115 (53.0%)	109 (51.2%)
Menopausal status		
Premenopausal	74 (34.1%)	97 (45.5%)
Postmenopausal	143 (65.9%)	116 (54.5%)
Ever pregnant		
No	37 (17.1%)	33 (15.5%)
Yes	180 (82.9%)	180 (84.5%)
Lactation (mo)	5.8 (8.9)	6.0 (12.9)
Age last breast fed		
Never	98 (45.2%)	112 (52.6%)
<30 yr	54 (28.9%)	56 (26.3%)
≥30	65 (30.0%)	45 (21.1%)
Present use of hormone replacement therapy		
No	199 (91.7%)	174 (81.7%)
Yes	18 (8.3%)	39 (18.3%)
Ethnicity		
British	123 (56.9%)	113 (53.6%)
Canadian	24 (11.1%)	14 (6.6%)
Other	69 (31.9%)	84 (39.8%)
Family history		
No	129 (59.4%)	142 (66.7%)
Yes	88 (40.6%)	71 (33.3%)
BMI (kg/m^2)	25.2 (4.4)	25.2 (4.3)
Fat intake (g/day)	39.1 (16.0)	34.8 (19.0)
Alcohol intake (drinks/wk)		
<1	130 (60.5%)	107 (50.7%)
≥1	85 (39.5%)	104 (49.3%)
Present smoking		
No	182 (83.9%)	162 (76.1%)
Yes	35 (16.1%)	51 (23.9%)
Cumulative smoking (pack-yr)	11.3 (16.4)	10.0 (15.7)

[a] Mean age of premenopausal cases was 45.7 (5.5) and that of controls was 45.2 (5.3). Mean age of postmenopausal cases was 63.9 (8.5) and that of controls was 61.2 (8.8).

ORs were calculated for the whole sample and by menopausal status, the latter derived from one model with an interaction term between the organochlorine variable and menopausal status. ORs were calculated by menopausal status to improve comparability to other studies that have included only postmenopausal women (17, 27) and because it is hypothesized that premenopausal and postmenopausal breast cancer are distinct diseases and, therefore, risk factors may be related differently to each (50). To examine the modification of effects by other risk factors, interaction terms between organochlorine variables and the variables in the confounder models were examined. The hypothesis proposed by Moysich and colleagues (17), that breast cancer risk related to Mirex and some PCBs among postmenopausal parous women may differ by lactation, was also tested by including an interaction term between the organochlorine variable and lactation status (never/ever). To examine the effect of using only cases with invasive cancers and controls with nonproliferative BBD, ORs were also calculated among this subgroup while excluding cases with carcinoma *in situ* and controls with hyperplasia with or without atypia or papillomas.

Table 2 GMs of organochlorines with 95% CIs among those with detectable levels by case-control status

Organochlorine	GM (95% CI)	
	Cases	Controls
PCB 99 (μg/kg)	19.5 (17.9–21.2)	17.7 (16.2–19.3)
PCB 105 (μg/kg)	7.1 (6.4–7.8)	6.3 (5.7–7.0)
PCB 118 (μg/kg)	30.3 (27.7–33.2)	24.7 (22.4–27.3)
PCB 138 (μg/kg)	73.8 (68.9–79.1)	66.8 (62.1–71.9)
PCB 153 (μg/kg)	105.2 (98.5–112.3)	98.3 (91.8–105.3)
PCB 156 (μg/kg)	18.6 (17.5–19.9)	17.2 (16.0–18.5)
PCB 170 (μg/kg)	34.3 (32.1–36.6)	32.0 (29.7–34.4)
PCB 180 (μg/kg)	71.9 (67.5–76.5)	65.7 (61.5–70.2)
PCB 183 (μg/kg)	10.3 (9.6–11.1)	9.5 (8.8–10.2)
PCB 187 (μg/kg)	25.7 (23.9–27.7)	24.2 (22.6–26.0)
Aroclor 1260 (mg/kg)	0.94 (0.88–1.00)	0.87 (0.81–0.92)
p,p′-DDE (μg/kg)	693 (615–780)	596 (530–670)
p,p′-DDT (μg/kg)	22.0 (19.6–24.7)	19.3 (17.3–21.6)
cis-nonachlor (μg/kg)	6.0 (5.5–6.5)	6.0 (5.6–6.5)
trans-nonachlor (μg/kg)	40.4 (37.4–43.6)	41.1 (38.7–43.6)
oxychlordane (μg/kg)	30.4 (28.6–32.3)	30.5 (28.8–32.2)
HCB (μg/kg)	32.0 (29.3–34.8)	30.1 (27.8–32.5)
Mirex (μg/kg)	9.0 (8.1–10.0)	9.9 (8.8–11.2)
β-HCH (μg/kg)	43.1 (38.0–48.9)	41.5 (36.1–47.6)

Results

Table 1 provides summary descriptive information on study subjects with respect to covariates that were included in at least one confounder model. Cases are on average 4 years older than controls because not enough controls were in the older age groups to satisfy the frequency matching requirements. Related to this, a higher proportion of cases are postmenopausal. Fewer cases than controls presently use HRT, possibly because use of HRT increases the false-positive rate of mammography (51). More cases than controls have been pregnant, and although more have breast fed, cases breast fed for a shorter time, and more have last breast fed after 30 years of age. More cases are of British or Canadian ethnicity and have a family history of breast cancer in first or second degree relatives. Cases also have higher average dietary fat and BMI than controls, and more cases drink less than one alcoholic beverage per week and presently do not smoke.

The GMs of the organochlorine concentrations measured in breast adipose tissue are seen in Table 2. The more highly chlorinated PCBs, 138, 153, 156, 170, 180, 183, and 187, are very highly correlated with each other ($0.74 \leq r \leq 0.98$), but correlations with the less chlorinated PCBs, 99, 105, and 118, tend to be lower ($0.42 \leq r \leq 0.83$). Correlations between the PCBs and the organochlorinated pesticides, and among the organochlorinated pesticides, also tend to be lower ($0.03 \leq r \leq 0.80$). Cases have higher levels of almost all of the organochlorines measured, but organochlorines bioaccumulate and thus, their levels are associated with age ($0.10 \leq r_s \leq 0.48$; all Ps < 0.05). Therefore, all further analyses are controlled for age.

Risk estimates for the whole sample and by menopausal status for the association between breast cancer and PCBs adjusted for confounders are presented in Table 3, and those for the other organochlorines are presented in Table 4. The covariates that are confounders in the analyses of each organochlorine are shown in the "Appendix." For the whole sample, ORs are above 1.0 for almost all organochlorines except *cis*- and *trans*-nonachlor, oxychlordane, HCB, and β-HCH. Breast cancer risk is elevated most notably for PCBs 105 and 118, but risk is not elevated for most other substances. The magnitude of the risk is above two in the highest concentration categories of PCBs 105 and 118, and the ORs for these PCBs increase linearly across categories (Ps for trend ≤ 0.013). Differences by menopausal status are noted for many PCB congeners, with risks higher among postmenopausal women for PCBs 170 and 180 and higher among premenopausal women for PCBs 105 and 118. However, only the interaction term between menopausal status and PCB 170 is significant at the $\alpha = 0.05$ level.

Breast cancer risk associated with Mirex, but not other organochlorines, among postmenopausal parous women differs by lactation (P for interaction $= 0.050$; Table 5). Increases are clear among those who have never lactated, with the OR in the uppermost category above 4 (P for trend $= 0.08$). Risks among those who had lactated are reduced in the upper categories of Mirex.

Additional analyses investigating possible interactions between organochlorines and covariates in each of the confounder models indicate that estimated dietary fat and present HRT interact with some organochlorines. To explore this interaction with fat, intake was categorized by the median among controls (33.1 g/day). Differences in the association between organochlorines and breast cancer risk by dietary fat are not consistent across the organochlorines or across the levels of each organochlorine, but the ORs for PCBs 105 and 118 are higher among those with higher levels of fat intake (>33.1 g/day; data not shown).

Too few subjects presently use HRT to do a subgroup analysis. When present users are excluded, ORs are generally similar to those for the whole sample with some exceptions. ORs are increased in the upper categories for PCB 105 (third category: 2.6; 95% CI, 1.3–4.9; fourth category: 4.3; 95% CI, 1.9–9.8) and PCB 118 (third category: 2.1; 95% CI, 1.1–4.3; fourth category: 2.6; 95% CI, 1.2–5.8). The OR in the fourth category of p,p′-DDE is also increased (OR $= 2.0$; 95% CI, 1.0–4.2).

Dietary fat can be conceptualized as a confounder, independently related to the body burden of organochlorines and possibly to breast cancer risk. However, because dietary fat is a major source of persistent organochlorines, it could instead be hypothesized as part of the causal pathway between organochlorines and breast cancer. If so, it should not be included in confounder models. Reanalysis excluding fat from confounder models in which it had been included reveals no changes in ORs large enough to change conclusions from the results in Tables 3 and 4 (data not shown).

Results from additional analyses conducted to understand the effect of including only cases with invasive cancer and controls with nonproliferative BBD show that exclusion of the 27 carcinoma *in situ* cases consistently leads to very slightly reduced ORs compared to the whole sample. Excluding the 80 controls with proliferative BBD consistently results in slightly higher ORs for the uppermost category of chemical concentration and conclusions identical to those made for the whole sample. When excluding both *in situ* cases and proliferative BBD controls, most ORs increase slightly compared to those for the whole sample, and PCBs 105 and 118 remain associated with increased risk at the highest categories of concentration.

Discussion

This study demonstrates increased breast cancer risk associated with the breast adipose tissue concentrations of some specific PCB congeners, but inconsistent or null results for the other compounds that were measured. Among the total sample, PCBs 105 and 118 were associated consistently with breast cancer risk. Among premenopausal women, the risk estimates for PCBs 105 and 118 were even higher. Among postmenopausal women, risk estimates for PCBs 170 and 180 were elevated but

Table 3 Frequencies of breast cancer cases and controls by tissue concentration of PCBs and menopausal status and ORs with 95% CIs

Tissue concentration	Whole sample OR[a] (95% CI)	Premenopausal			Postmenopausal		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
PCB 99							
≤11 μg/kg	1.00	23	31	1.00	16	20	1.00
12–18	1.41 (0.77–2.60)	21	37	0.95 (0.42–2.16)	40	25	2.20 (0.87–5.52)
19–29	1.40 (0.75–2.62)	19	15		42	42	
≥30	1.92 (0.95–3.86)	9	11	1.63 (0.71–3.72)	43	27	1.70 (0.74–3.91)
PCB 105							
≤4.1 μg/kg	1.00	25	46	1.00	29	24	1.00
4.2–6.1	1.16 (0.62–2.14)	12	24	1.29 (0.52–3.20)	25	31	0.89 (0.38–2.06)
6.2–12	2.03 (1.12–3.68)	23	13		49	38	
≥13	3.17 (1.51–6.68)	7	6	3.91 (1.73–8.86)	37	21	1.49 (0.70–3.16)
PCB 118							
≤16 μg/kg	1.00	24	38	1.00	19	20	1.00
17–27	1.25 (0.68–2.29)	19	35	1.04 (0.46–2.35)	30	25	1.39 (0.57–3.41)
28–49	1.88 (1.00–3.55)	20	13		50	44	
≥50	2.31 (1.11–4.78)	8	7	2.85 (1.24–6.52)	41	25	1.58 (0.70–3.58)
PCB 138							
≤50 μg/kg	1.00	27	38	1.00	19	22	1.00
51–71	1.38 (0.79–2.42)	24	31	1.19 (0.56–2.54)	38	28	1.65 (0.71–3.83)
72–112	1.55 (0.86–2.80)	14	16		52	41	
≥113	1.56 (0.80–3.06)	8	10	1.52 (0.69–3.35)	32	23	1.69 (0.79–3.60)
PCB 153							
≤75 μg/kg	1.00	29	36	1.00	16	21	1.00
76–105	1.28 (0.71–2.30)	20	30	0.88 (0.40–1.93)	47	30	2.01 (0.84–4.79)
106–167	1.32 (0.72–2.40)	18	17		49	42	
≥168	1.04 (0.51–2.11)	6	12	1.06 (0.48–2.34)	29	21	1.61 (0.72–3.63)
PCB 156							
≤12 μg/kg	1.00	23	36	1.00	17	20	1.00
13–18	1.99 (1.12–3.53)	28	28	1.90 (0.87–4.13)	48	31	2.09 (0.90–4.86)
19–28	1.38 (0.76–2.49)	15	17		49	44	
≥29	1.35 (0.68–2.69)	7	14	1.35 (0.61–2.98)	27	19	1.41 (0.65–3.06)
PCB 170							
≤23 μg/kg	1.00	24	29	1.00	16	25	1.00
24–34	1.60 (0.92–2.78)	24	35	0.83 (0.39–1.78)	51	27	3.27 (1.44–7.44)
35–53	1.09 (0.61–1.96)	16	17		48	45	
≥54	1.15 (0.60–2.22)	9	15	0.89 (0.41–1.91)	28	19	1.63 (0.77–3.45)
PCB 180							
≤51 μg/kg	1.00	24	32	1.00	17	25	1.00
52–71	1.56 (0.90–2.70)	26	31	1.07 (0.51–2.27)	46	31	2.43 (1.09–5.43)
72–105	1.21 (0.68–2.14)	17	22		47	38	
≥106	1.27 (0.66–2.46)	6	11	0.89 (0.42–1.91)	33	22	1.77 (0.85–3.69)
PCB 183							
≤7.0 μg/kg	1.00	28	36	1.00	25	24	1.00
7.1–10	0.97 (0.55–1.71)	19	29	0.99 (0.44–2.22)	30	28	0.94 (0.42–2.10)
11–16	1.23 (0.71–2.14)	18	18		57	41	
≥17	1.27 (0.66–2.45)	8	11	1.37 (0.63–2.96)	29	21	1.16 (0.58–2.33)
PCB 187							
≤16 μg/kg	1.00	27	29	1.00	21	18	1.00
17–25	0.77 (0.44–1.36)	21	31	0.75 (0.35–1.64)	35	36	0.82 (0.36–1.85)
26–39	0.84 (0.48–1.48)	15	22		49	41	
≥40	1.26 (0.66–2.40)	11	14	0.86 (0.41–1.83)	37	20	1.08 (0.52–2.28)
Aroclor 1260							
≤0.67 mg/kg	1.00	31	38	1.00	19	21	1.00
0.68–0.92	1.13 (0.64–1.98)	19	29	0.86 (0.40–1.87)	42	31	1.52 (0.66–3.49)
0.93–1.4	1.41 (0.79–2.52)	18	17		48	37	
≥1.5	1.15 (0.58–2.25)	5	11	1.24 (0.58–2.66)	32	25	1.53 (0.71–3.30)

[a] Adjusted for age, study site, menopausal status, and confounders listed in the "Appendix."

did not follow a clear linear trend across categories. The only increased risk found for p,p′-DDE was among a subgroup excluding present HRT users. Among postmenopausal women who were parous but had never lactated, increased risk was apparent for Mirex.

Only a handful of studies can be directly compared with this study because they have used breast adipose tissue to quantify organochlorine levels (21–26, 28–31). Of the studies that examined the PCB congeners for which an association was found with breast cancer in this study, one found a higher risk for PCB 118 (23) and another found that PCB 118 was lower among estrogen receptor-negative cases compared with controls but no difference with PCB 105 (21). Also in agreement with this study, many have found a lack of a convincing

Table 4 Frequencies of breast cancer cases and controls by tissue concentrations of organochlorinated pesticides and menopausal status and ORs with 95% CIs

Tissue concentration	Whole sample OR[a] (95% CI)	Premenopausal			Postmenopausal		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
p,p′-DDE							
≤368 μg/kg	1.00	31	41	1.00	24	19	1.00
369–727	0.96 (0.55–1.68)	20	31	0.75 (0.34–1.62)	39	30	1.15 (0.50–2.63)
728–1389	0.92 (0.51–1.67)	10	17		44	42	
≥1390	1.62 (0.84–3.11)	13	8	1.52 (0.70–3.33)	36	25	1.05 (0.50–2.19)
p,p′-DDT							
≤12 μg/kg	1.00	26	31	1.00	32	27	1.00
13–20	0.82 (0.47–1.43)	19	36	0.54 (0.24–1.21)	37	26	1.20 (0.55–2.63)
21–37	0.93 (0.53–1.61)	20	18		40	41	
≥38	1.18 (0.61–2.29)	9	12	1.09 (0.49–2.40)	34	22	1.05 (0.53–2.06)
cis-nonachlor							
≤4.3 μg/kg	1.00	37	40	1.00	34	22	1.00
4.4–6.5	0.81 (0.47–1.39)	17	21	0.74 (0.33–1.70)	47	36	0.81 (0.39–1.68)
6.6–10	0.48 (0.27–0.86)	11	23		33	37	
≥11	0.80 (0.41–1.53)	8	11	0.67 (0.31–1.44)	29	21	0.54 (0.27–1.08)
trans-nonachlor							
≤31 μg/kg	1.00	33	38	1.00	25	18	1.00
32–43	0.93 (0.54–1.60)	24	33	0.93 (0.45–1.93)	39	31	0.93 (0.41–2.08)
44–64	0.69 (0.39–1.23)	13	18		46	41	
≥65	0.78 (0.40–1.53)	4	8	0.73 (0.33–1.63)	33	26	0.72 (0.34–1.49)
Oxychlordane							
≤24 μg/kg	1.00	38	40	1.00	23	16	1.00
25–32	0.68 (0.40–1.17)	16	33	0.46 (0.21–0.97)	44	29	1.00 (0.44–2.26)
33–46	0.61 (0.35–1.07)	16	16		44	46	
≥47	0.59 (0.31–1.16)	4	8	0.78 (0.37–1.67)	32	25	0.66 (0.31–1.40)
HCB							
≤21 μg/kg	1.00	31	42	1.00	24	16	1.00
22–31	0.97 (0.56–1.69)	27	32	1.27 (0.62–2.60)	31	29	0.62 (0.25–1.49)
32–51	0.75 (0.42–1.36)	9	18		52	43	
≥52	1.15 (0.57–2.34)	7	5	1.03 (0.45–2.37)	36	28	0.62 (0.28–1.40)
Mirex							
≤5.8 μg/kg	1.00	24	32	1.00	37	31	1.00
5.9–9.7	1.22 (0.71–2.09)	20	35	0.94 (0.42–2.10)	41	25	1.53 (0.73–3.20)
9.8–24	1.35 (0.79–2.30)	21	17		48	40	
≥25	1.18 (0.59–2.38)	8	12	1.72 (0.78–3.76)	17	19	1.13 (0.60–2.13)
β-HCH							
≤24 μg/kg	1.00	34	39	1.00	24	18	1.00
25–38	0.73 (0.42–1.29)	17	30	0.59 (0.27–1.30)	38	31	0.86 (0.37–1.99)
39–79	1.02 (0.57–1.83)	14	16		60	46	
≥80	0.69 (0.34–1.40)	9	12	1.01 (0.46–2.18)	21	21	0.89 (0.41–1.93)

[a] Adjusted for age, study site, menopausal status, and confounders listed in the "Appendix."

Table 5 ORs with 95% CIs for the association between tissue concentration of Mirex by lactation status among postmenopausal parous women

Mirex tissue concentration	All postmenopausal parous women OR[a] (95% CI)	Never lactators			Lactators		
		n_{cases}	$n_{controls}$	OR[a] (95% CI)	n_{cases}	$n_{controls}$	OR[a] (95% CI)
≤5.8 μg/kg	1.00	15	7	1.00	12	21	1.00
5.9–9.7	1.95 (0.86–4.44)	11	10	2.64 (0.65–10.8)	11	27	1.54 (0.53–4.45)
9.8–24	1.13 (0.54–2.39)	15	15	1.91 (0.53–6.88)	20	26	0.87 (0.33–2.31)
≥25	0.97 (0.37–2.50)	10	11	4.23 (1.01–17.8)	8	4	0.27 (0.06–1.15)

[a] Adjusted for age, study site, and confounders listed in the "Appendix" except age last breast fed.

association with total PCBs (21, 24–26), some PCB congeners (21, 23), DDE (22, 24–26, 31), and other organochlorinated pesticides, including HCB, β-HCH, and chlordane residues (21–25, 29, 30). However, some found that cases had higher levels than controls of some organochlorines, including total PCBs (22), DDE (21–23), or β-HCH (25). Adjustment for confounding in some of these studies was limited to only a few variables. One larger study using buttocks adipose tissue to measure DDE concentration in 265 cases and 341 controls found that DDE was associated with a reduced risk of breast cancer (27), a finding not replicated in this study.

The majority of studies investigating the association between organochlorines and breast cancer have used serum or plasma to quantify organochlorine levels and can be compared cautiously with this study. Many of these studies did not conduct congener-specific analyses due to limitations of using serum and older quantification techniques. Three of the studies with congener-specific analyses and with the congeners found

to be associated with breast cancer in this study either did not show the results but noted that no association existed (12, 13) or created indices based on the sum of PCBs in various classes based on the degree of chlorination (17). A fourth study, however, found no increased risk with either PCB 118 or PCB 138 (11). The difference by lactation status in the association between breast cancer risk and Mirex among parous postmenopausal women seen in this study was also found in one other study (17), but not a more recent study (12). Like this study, most other studies found no convincing association with total PCBs (11–15, 17), DDE (11–19), HCB (17), or β-HCH (11, 13). Only in one early nested case-control study measuring total PCBs and DDE were increased risks observed, but this study had a small sample size and did not adjust for serum lipids (20).

One of the main advantages of this study was that breast adipose tissue was chosen over serum in which to measure organochlorines. Because organochlorines theoretically will come to an equilibrium where the concentration is equal throughout the lipids in the body (52), most researchers have measured organochlorines in serum, and some have removed the variation introduced by fluctuating lipid levels in the blood either by using fasting samples or calculating concentrations on a lipid basis. However, more recent studies have shown that the ratio of adipose to serum levels is greater than one, even when adjusted for lipids (36, 53, 54). Not only do measurements made in serum or plasma not represent the concentration in adipose tissue on an absolute level, but they also do not represent concentrations closely on a relative level. Correlations between serum and adipose tissue concentrations in the general population are variable, with most reported correlation coefficients being above 0.8, but sometimes as low as 0.3–0.6, or even negative (36, 53–55). Therefore, measurements in adipose tissue may be more representative of exposure accumulated in breast tissue proximal to the epithelial cells, which give rise to breast tumors, and because this results in less misclassification, measurements in adipose tissue will be more powerful in an epidemiological study. Also, because adipose tissue is largely composed of lipid (>80%), concentrations on a wet weight basis will be much higher than in blood, which has much less lipid (<1%), and even small samples of adipose tissue will have organochlorine compounds in the detectable range and are more suitable for congener-specific analyses (39).

The use of breast adipose tissue in this study has necessitated the use of women who had a negative breast biopsy as controls. The use of this control group strengthened the design of this study by minimizing two important biases. First, cases and controls have come from the same hospital catchment areas and have undergone the same diagnostic tests. Therefore, the control group is drawn from the same population as the cases, and the absence of breast cancer in controls was histologically confirmed. Second, because subjects were enrolled before their biopsy, most of the questionnaire answers were received before the biopsy date and even more were completed before the participants' knowledge of their diagnosis. Therefore, differences in recall on the basis of case-control status were minimized. Because the main exposure, organochlorines, was measured as a biomarker, it cannot be subject to observation bias.

Women with biopsies negative for breast cancer generally have some form of BBD. Some exposures, including hormonal factors, are risk factors for both breast cancer and BBDs (56–58). If organochlorine exposure is positively related to both BBD and breast cancer, the risk estimates in this study would be underestimated. As well, some types of BBDs are thought to be part of the causal chain or risk factors for breast cancer (59) and could contaminate the control group by including subjects with precursor conditions. This was investigated by doing a sensitivity analysis excluding controls with diseases most strongly linked to breast cancer, and as expected, risk estimates associated with organochlorines were increased.

Differences between studies may be due to noncomparable levels of organochlorines in the subjects, although different measurement techniques, including use of different tissue compartments, analytical protocols and quantification techniques, especially of total PCBs, and inappropriate reporting of average levels (*i.e.*, using arithmetic means for positively skewed distributions) make the levels difficult to compare. However, the levels of organochlorines in this study can be compared generally to other studies using adipose tissue. The levels in this study are similar to another Canadian study (21), but DDT, DDE, and the higher PCB congeners seem to be in lower concentration in this study than studies conducted outside Canada (22–25, 27), and β-HCH and HCB seem to be at a higher concentration in this study than the one conducted in Connecticut (29, 30). Although the concentration of these organochlorines is low in this population, the compounds are detected in most of the subjects, and this study provides the opportunity to assess the association between organochlorines and breast cancer at a lower section of the dose-response curve.

Some older studies measured only DDE, DDT, and total PCBs. This study and several other recent studies have used high performance gas chromatography to quantify more organochlorinated pesticides and individual PCB congeners (13, 17, 21, 23, 24). Levels of individual organochlorines are correlated due to their common sources of exposure, particularly in the diet. This is especially true for the PCB congeners because they had been used as mixtures. However, the amounts and proportions of PCB congeners and other organochlorines do vary widely from individual to individual. Thus, the PCB congeners and other organochlorines were treated as separate entities in this study to help identify whether specific organochlorines are associated with breast cancer risk and to suggest groupings of organochlorines that may be relevant.

Examining each PCB congener and organochlorine individually leads to testing numerous associations, where even if true associations did not exist, some measured associations would appear significant by chance. However, the approach taken in the interpretation of this study was to look for patterns in the measured associations and consistency across the categories of compounds, not isolated occurrences of statistical significance. Of note in this study is that the PCBs found to be associated with breast cancer risk, PCBs 105, 118, and 156, are all mono-*ortho* substituted, a quality that makes them have some dioxin-like activity, but at a much lower level than dioxins or coplanar PCBs. However, because they are at higher concentrations than the dioxins or the PCB congeners that have greater dioxin-like activity, they, especially PCB 118, are the major contributors of dioxin-like activity in the body (60).

Even if environmental factors account for only a small percentage of breast cancer cases, given the tremendous number of women newly diagnosed each year, associations with some PCBs of the magnitude demonstrated in this study could translate into a large number of breast cancer cases if the association is truly causal. Further release of these compounds into the environment can be prevented with the careful disposal of existing stores and with public health education to prevent exposure through highly contaminated sources, such as fish in the Great Lakes. However, evidence for causality cannot be drawn on the basis of this study alone.

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Appendix

Table A1 Covariates included in the confounder models[a]

Organochlorine	Covariate										
	Ever pregnant	Lactation	Age last breast fed	Present use of HRT	Ethnicity	Family history	BMI	Fat intake	Alcohol intake	Present smoking	Cumulative smoking
PCB 99		•	•	•	•	•	•	•	•		
PCB 105	•	•	•	•	•	•	•	•	•		•
PCB 118				•	•	•	•	•	•	•	•
PCB 138				•	•	•		•	•		
PCB 153		•	•	•	•			•	•		
PCB 156				•	•	•		•			
PCB 170				•			•				
PCB 180				•			•				
PCB 183	•	•	•		•			•			
PCB 187				•	•						
Aroclor 1260				•	•	•		•	•		
p,p′-DDE				•	•		•	•			
p,p′-DDT			•		•		•	•	•		
cis-nonachlor			•		•			•			
trans-nonachlor					•			•			
oxychlordane									•		
HCB				•	•	•	•				
Mirex			•	•	•	•		•			
β-HCH				•	•	•	•	•	•		

[a] All confounder models included age, study site, and menopausal status plus the covariates indicated for each organochlorine in this table.

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PCB contamination in marine sediments from Golfo Dulce, Pacific coast of Costa Rica

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Abstract: Twenty-nine marine sediment samples collected from 1996 through 2002 from the Golfo Dulce embayment of Costa Rica were analyzed for PCB concentrations. The Esquinas River and Rincon Bay in the northern and western part of the gulf had relatively low overall concentrations of PCBs, with no samples having greater than 2.1 µg/g dw sediment. The Port of Golfito had the highest overall concentrations, ranging up to 15.7 µg/g dw sediment. These samples were also dominated by higher chlorinated congeners. Samples from the deeper (>100m) waters in the northern part of the gulf, as well as within the sediment plume from the Rio Coto Colorado had intermediate values. Within the Rio Coto Colorado sediment plume the concentrations did decrease with increasing depth and the congeners showed a shift towards less chlorinated congeners with depth. However, the deep northern basin had some of the highest PCB concentrations and the shift towards less chlorinated congeners was not apparent or significant. Whether the anoxic conditions that exist in the deep waters are capable of initiating dechlorination is still unknown. Overall, the data from Golfo Dulce show moderate PCB contamination, despite the pristine nature of the gulf and surrounding lands.

Keywords: Polychlorinated biphenyls (PCB), Golfo Dulce, organic contamination, marine pollution, Costa Rica.

PCBs are a class of man-made non-polar hydrocarbons with a biphenyl nucleus on which one to ten hydrogen atoms have been replaced by chlorines. Commercial PCBs were manufactured as complex mixtures of congeners from the 1930's through the 1960's. These commercial products were clear viscous liquids that were used widely in many industrial applications, especially in North America. They are soluble in most organic solvents, oils and fats and are very stable. Under certain conditions, however, they may be destroyed, either chemically, thermally, or biochemically. However, these degradation reactions are difficult and slow. After PCB contamination was recognized their use was restricted to a limited number of applications and production was banned since 1976 (Erickson 1997).

PCBs are one of several truly global environmental pollutants, including mercury, lead, and certain pesticides. They are highly lipophilic, and therefore, most PCB mass is found in soil and sediments and not in the water column. However, continued dissolution and volatilization from spills, *etc*. result in measurable aqueous and atmospheric emissions. Murphy *et al.* (1985) estimated that 0.9 x 10^9 g per year of PCBs cycle through the U.S. atmosphere. This is less that 1% of the total PCBs in the environment. Nevertheless, atmospheric transport is recognized as the primary mode of global PCB distribution. Eisenreich *et al.* (1981) estimated that the atmospheric pathway contributes 60-90% of PCB input into the Great Lakes. Therefore, their presence is recognizable in almost all

sediment and biological samples from around the world. However, practically no research has been done in tropical areas.

The presence of even low concentrations of PCB pollutants can be a continued and future source of in place contamination of the water column. Thus, they may continue to be an ecological threat, and possible human threat as well. This paper provides the detailed analyses of PCB congeners from various locations within the sediments of Golfo Dulce on the southwestern coast of Costa Rica. This is the first paper reporting their presence and concentrations in this area. A summary of previous PCB studies in other marine sediments in Costa Rica is included as an accompanying article for comparison (Spongberg 2004).

The gulf has become increasingly subjected to fishery, aquaculture, ecotourism, urbanization and port construction. Therefore, information on PCB concentrations in areas yet unaffected by extensive development is vital. As part of a larger project to evaluate the quality of Costa Rican waters, many samples/cores have been obtained from the coastal waters since 1997, including a more intensive investigation in Golfo Dulce. These sediment samples have been analyzed for many contaminants, including pesticides, heavy metals and polychlorinated biphenyls. The pesticide data were reported in Spongberg and Davis (1999). The PCB data for the complete sample set is presented as a companion to this paper (Spongberg, 2004). This paper presents a summary and details of the data collected from the Gulf of Dulce, as of 2003.

MATERIALS AND METHODS

Study area: Golfo Dulce is a deep fjord-like estuary at the southern end of the Pacific coast of Costa Rica. The depth exceeds 200 m in the inner basin and is sheltered against the open Pacific by a shallow sill (60 m) at the southern end. Water depths increase rapidly along fault scarp faces on the eastern side of the gulf (Hebbeln *et al.* 1996) and tidal ranges are as great as 6 m. Due to this morphology only a limited water exchange with the ocean takes place. Thus the deepest sediments are anoxic, at least temporarily, as compared to the shallow, well-oxygenated Golfo de Nicoya, further north along the Pacific coast (Richards *et al.* 1971). Thamdrup *et al.* (1996) re-investigated the geochemistry of the gulf and found steep gradients in both temperature and salinity to a depth of 60 m below a shallow mixed surface layer. The pycnocline is located about 10-20 m above the sill depth and rises about 10 m towards the head of the gulf. The photic zone extends to 30-40 m depth and surface water oxygen concentrations were 190-200 $\mu mol.L^{-1}$. A strong oxycline is associated with the pycnocline throughout the basin and no oxygen (<3 $\mu mol\ L^{-1}$) is detected below 100 m. Nitrate increases with depth to only 10 $\mu mol\ L^{-1}$ at the pycnocline and decreases below this depth to less than 1 $\mu mol\ L^{-1}$ at the basin floor.

Kuever *et al.* (1996) found that the number of microorganisms within the water column did not change with depth, despite the reduction in oxygen. The highest numbers of sulfate-reducing bacteria were found in or close to the sediment surface. The anoxic bottom water also contains sulfide-oxidizing bacteria of the *Thiovulum* and *Thiospira* genera. Dalsgaard *et al.* (2003) recently discovered that the anaerobic oxidation of ammonium with nitrite, or the 'anammox' reaction performed by bacteria, was responsible for 19–35% of the total N_2 formation in the deep water column in Golfo Dulce.

Analytical procedures: Details on the collection and analyses of the sediment samples is given in an adjoining paper (Spongberg 2004). Grab samples were prepared as follows. Estuary and shallow samples were collected by hand with a clean core barrel and immediately placed in either prewashed glass jars or plastic bags, depending on the subsequent analyses. Samples were sealed and frozen immediately after collection and transferred to the University of Toledo, Toledo, Ohio still frozen. Samples were dried

and re-frozen until analysis. Stations are indicated in Fig. 1.

The analysis of PCBs followed a modified version of EPA Methods 8081 and 3620 (USEPA, 1992). Approximately 10 to 20 g of dried, sieved sediment was extracted using a Soxtec Organic Extraction Unit, using methylene chloride or acetone:methylene chloride (1:1) as solvents. Separation and clean up were achieved by passing the extract through a florisil-filled glass column with diethylether in hexane (3:1) as the eluant.

Analyses were performed on a Hewlett Packard 6890 gas chromatograph equipped with a SPB-5 fused silica capillary column (30 m length, 0.25 mm ID, 0.25 µm film thickness, Supelco, Inc.) attached to either a ^{63}Ni electron capture detector (HP 5890 Series II) or a mass selective detector (HP 5972).

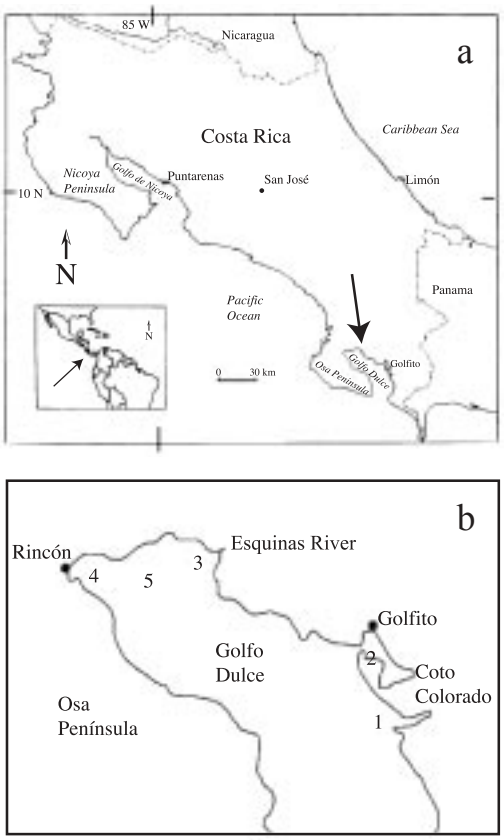

Fig. 1a, b. Location map of Golfo Dulce sediment samples. 1 = Rio Coto Colorado sediment plume emanating north-northwest from the mouth of the river. 2 = Golfito Port and bay, 3 = Rio Esquinas tidal flats, 4 = Río Rincón tidal flats and deforested shoreline, 5 = sediments within the deep northern basin (110-190 m).

Quality control included reagent blank determination, matrix spike (0.2 and 1.0 µg/g) recovery, and precision analyses. 2,3,5-trichlorobenzene was used as an internal standard. Calibration was checked routinely. Quantification of individual PCB congeners in samples was made by comparison to standard mixtures and confirmed using the extensive library of mass signatures of individual congeners. Recovery efficiencies varied between 65 and 95%. Detection limits were calculated using the area of the baseline noise over the elution time of each congener using low concentration standards. Limits of detection were three times the standard deviation of the baseline noise, and averaged 0.2 ng/g. Relative standard deviation of data from five consecutive duplicate runs was 3-5%. Data reported

TABLE 1
UPAC identification numbers, chlorine substitutions and classes of congeners used in the calculation of Total PCBs (after Vanier et al. 1996)

IUPAC number	Chlorine substitutions	Isomer Class
18*	2,2',5	3 Cl
31*	2,4',5	3 Cl
44*	2,2',3,5'	4 Cl
49*	2,2',4,5'	4 Cl
52*	2,2',5,5'	4 Cl
87*	2,2',3,4,5'	5 Cl
101*	2,2',4,5,5'	5 Cl
110*	2,3,3',4',6	5 Cl
118*	2,3',4,4',5	5 Cl
138*	2,2',3,4,4',5	6 Cl
151*	2,2',3,5,5',6	6 Cl
153*	2,2',4,4',5,5'	6 Cl
170*	2,2',3,3',4,4',5	7 Cl
180*	2,2',3,4,4',5,5'	7 Cl
194*	2,2',3,3',4,4',5,5'	8 Cl
195*	2,2',3,3',4,4',5,6	8 Cl
196*	2,2',3,3',4,4',5',6	8 Cl
199*	2,2',3,3',4,5,5',6'	8 Cl
209*	2,2',3,3',4,4',5,5',6,6'	10 Cl

* These 19 congeners are used in the calculation of Total PCBs.

TABLE 2

PCB congener data for Golfo Dulce, Costa Rican sediments taken from 1997 to 2002

	Internal ID	Sum (ng/g dw	Total* *1000)	15/17	18	31	40	44	49	52	60	87	101	110	118	121	138	151	153	170	180	183	194	195	196	199	209
				Percentages of sum																							
19D	Río Esquinas	1406	2059	7.47	3.01	4.43	8.38	6.64‡	2.06	3.32	0.00	12.97	**6.80†**	2.53	11.39	8.38	6.64	1.90	8.38	4.11	1.58	0.00	0.00	0.00	0.00	0.00	0.00
15C	Río Esquinas	1168	1783	4.54	6.30	6.62	6.09	7.37‡	5.13	5.55	3.63	1.71	**10.14**	2.88	6.51	5.98	6.19	5.02	6.62	5.13	2.78	0.53	1.28	0.00	0.00	0.00	0.00
20D	Río Esquinas	1162	1636	4.05	7.72	9.56	6.80‡	5.15	7.54	**11.40**	3.68	6.25	2.39	9.19	2.57	5.88	2.94	7.72	2.21	4.23	0.74	0.00	0.00	0.00	0.00	0.00	0.00
18D	Río Esquinas	995	1400	4.47	5.01	5.64	6.42	2.51	9.24‡	6.73	2.04	**9.71**	2.82	7.05	3.60	9.71	11.12	1.72	5.95	4.23	2.04	0.00	0.00	0.00	0.00	0.00	0.00
9D	Río Rincón	912	1334	6.08	5.28	6.94	4.95	5.84‡	3.96	7.82	4.95	**9.03**	7.27	4.73	9.03	6.17	1.54	5.73	6.94	2.64	1.10	0.00	0.00	0.00	0.00	0.00	0.00
8D	Río Rincón	526	764	5.35	11.83	6.40	7.24‡	9.88	3.62	0.56	2.92	**5.99**	3.62	8.21	6.54	3.62	8.21	1.95	7.80	5.15	1.11	0.00	0.00	0.00	0.00	0.00	0.00
6D	Deforested area	1301	1892	5.01	8.37	6.75	7.78‡	7.05	8.96	**10.57**	6.61	4.55	9.10	4.55	6.17	3.38	2.50	3.38	2.35	1.91	1.03	0.00	0.00	0.00	0.00	0.00	0.00
14D	Deforested area	1087	1462	5.90	7.99	4.66	9.32‡	13.98	5.10	**3.33**	9.32	11.32	2.89	3.11	4.22	5.10	6.88	2.22	1.11	0.89	2.66	0.00	0.00	0.00	0.00	0.00	0.00
23D	Río C. Colorado sediment plume,150 m	2703	3555	12.27	10.44	9.19	12.93	**7.64**	8.10	6.39	3.58	1.87	6.23	2.49	6.70	2.96	2.65	4.67	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22D	Río C. Colorado sediment plume, 95 m	3280	4703	7.42	9.59	8.37‡	5.95	7.04	11.28	**7.89**	5.58	9.95	5.70	4.37	6.31	4.97	3.15	0.00	1.46	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17D	Río C. Colorado sediment plume, 74 m	2563	3678	7.11	10.75	11.12‡	8.20	6.56	5.29	**10.39**	8.39	2.92	9.66	2.19	7.66	2.37	3.46	0.66	0.73	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21D	Río C. Colorado sediment plume, 60 m	3257	4604	8.53	10.71	9.73‡	6.03	10.96	**7.63**	5.54	7.51	5.29	6.40	2.09	2.22	5.17	2.83	1.97	5.17	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29D	Río C. Colorado sediment plume, 50 m	2347	2972	7.72	10.29	11.16‡	9.25	7.85	10.82	**2.79**	9.07	2.27	5.58	5.93	4.88	4.71	2.79	0.00	1.22	2.62	1.05	0.00	0.00	0.00	0.00	0.00	0.00
13D	Río C. Colorado sediment plume, 40 m	2361	3291	4.14	6.05	2.10	9.34	5.39‡	6.97	2.10	3.42	6.57	**8.94**	9.73	7.36	3.68	13.54	0.00	6.44	4.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4D	Río C. Colorado sediment plume, 4 m	3151	4487	2.37	4.96	3.44	6.33	11.43‡	9.91	8.40	**5.78**	4.27	0.69	5.92	7.16	8.40	5.78	1.51	5.78	7.30	0.55	0.00	0.00	0.00	0.00	0.00	0.00
3D	Río C. Colorado sediment plume, 2.5 m	2275	3471	1.74	3.01	4.71	5.50	1.70	3.40	7.33‡	6.28	9.68	**7.98**	3.27	8.37	6.93	10.60	8.24	5.89	4.06	1.31	0.00	0.00	0.00	0.00	0.00	0.00
26D	Río C. Colorado sediment plume, 10 m	473	612	2.93	7.18	2.26	10.67	2.67‡	8.62	2.46	6.57	**9.24**	8.62	12.52	10.67	2.67	1.64	2.87	5.75	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GD-XC	Port of Golfito, Frente UCR	3923	6429	0.00	10.32	5.16	3.87	7.74‡	8.39	11.61	2.58	0.00	**5.16**	11.61	5.16	0.00	7.74	0.00	6.45	0.00	14.19	0.00	0.00	0.00	0.00	0.00	0.00
GD-XA2	Port of Golfito, Frente Hong Kong	7631	10875	0.00	5.00	0.00	13.75	6.25‡	0.00	0.00	2.50	5.00	11.25	**8.75**	13.75	3.75	20.00	0.00	6.25	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GD-XA	Port of Golfito, Frente Hong Kong	4524	7437	0.00	8.38	4.19	6.28	6.28‡	6.81	14.66	2.09	1.05	**4.19**	9.42	7.33	0.00	6.28	2.09	8.38	0.00	12.57	0.00	0.00	0.00	0.00	0.00	0.00
25D	Port of Golfito	12271	15688	0.73	3.20	4.38	2.37	3.93	4.75	5.75‡	4.47	5.39	8.95	**11.42**	5.94	17.08	6.30	7.49	5.75	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15D	Golfito Bay, south islet, sandy	3083	3970	4.24	2.81	7.21	5.62	2.81	1.95	3.91‡	6.60	10.87	**8.31**	10.38	7.45	8.79	4.40	9.04	4.40	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24D	Golfito Bay, south islet	3221	4515	0.97	5.58	4.12	1.73	5.58	6.77	1.73‡	7.04	9.56	**8.50**	12.35	6.37	7.83	4.78	5.44	8.23	1.73	1.73	0.00	0.00	0.00	0.00	0.00	0.00
10D	Deep samples, 190 m	9151	9929	16.81	10.38‡	6.07	**17.03**	6.88	8.40	1.87	6.53	4.90	4.78	2.68	5.37	2.68	2.10	1.40	0.70	1.17	0.23	0.00	0.00	0.00	0.00	0.00	0.00
27D	Deep samples, 190 m	3994	5802	12.40	8.64	10.02‡	7.56	11.57	**7.56**	12.34	2.47	8.17	1.85	1.85	2.47	3.08	2.62	1.39	2.31	3.55	0.15	0.00	0.00	0.00	0.00	0.00	0.00
11D	Deep samples, 165 m	7883	10722	9.93	9.68	6.97‡	8.25	2.28	10.24	12.95	**6.55**	7.40	4.84	5.12	3.41	2.13	2.70	3.27	2.28	1.71	0.28	0.00	0.00	0.00	0.00	0.00	0.00
7D	Deep samples, 130 m	9300	12353	12.07	10.41	8.37‡	14.00	**10.07**	2.22	7.17	2.22	10.59	5.98	3.59	4.10	1.71	5.46	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12D	Deep samples, 110 m	5015	6539	11.69	9.98	6.57‡	14.91	**8.46**	6.82	6.70	2.65	5.05	3.16	2.91	3.28	2.65	5.31	2.27	2.65	4.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30D	Deep samples, 110 m	3830	5106	12.06	19.30	4.65‡	9.65	3.40	**12.87**	6.79	2.68	7.15	2.32	3.57	3.22	5.36	3.40	0.00	1.61	1.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* See text for calculation of Total PCB concentration.

† Represents congener at 50% cumulative total.

‡ Underscored figures represent congener at 25% cumulative total.

are not corrected for blank concentrations or recovery efficiencies.

RESULTS

The data on these congeners are expressed in two ways. The sum of the congeners identified in this study is presented as ∑PCBs. Table 1 lists those congeners. However, because different studies usually identify different congeners and different numbers of congeners, these studies can be difficult to compare. In this study, twenty five chromatographic peaks could be definitively assigned to PCB congeners. Although the utmost care was taken to assign the correct IUPAC number to that peak, there often unavoidably are other congeners that may co-elute. Due to their geochemical characteristics and mass selective signatures, it is likely that the co-eluting compounds have an equal number of chlorine atoms on the molecule, however, their placement on the biphenyl structure might vary. Therefore, the data are also presented as Total PCBs. As stated in Vanier *et al.* (1996), 19 congeners make up about 50% by weight of all congeners in Arochlor 1242, 1253, 1262, 1254, and 1260 (Table 1). Therefore, the concentrations of these 19 congeners are summed and multiplied by 2 and reported as Total PCBs. This value can, hopefully, be more useful for comparisons in future studies.

Table 2 lists the PCB data for the Golfo Dulce sediments. Data are divided by geographic location and include the ∑PCB and Total PCB concentrations, as well as the percentage of the sum attributed to the specific identified congeners (given as the IUPAC number). The congener in **bold type** represents the IUPAC number where 50% of the total sample lies below (fewer Cl) and 50% heavier (more Cl atoms). The underscored congener percentage represents the 25% cumulative value.

DISCUSSION

Figure 2 is a cross plot of the ∑PCB and Total PCB concentrations. The two calculated values correlate to each other positively with

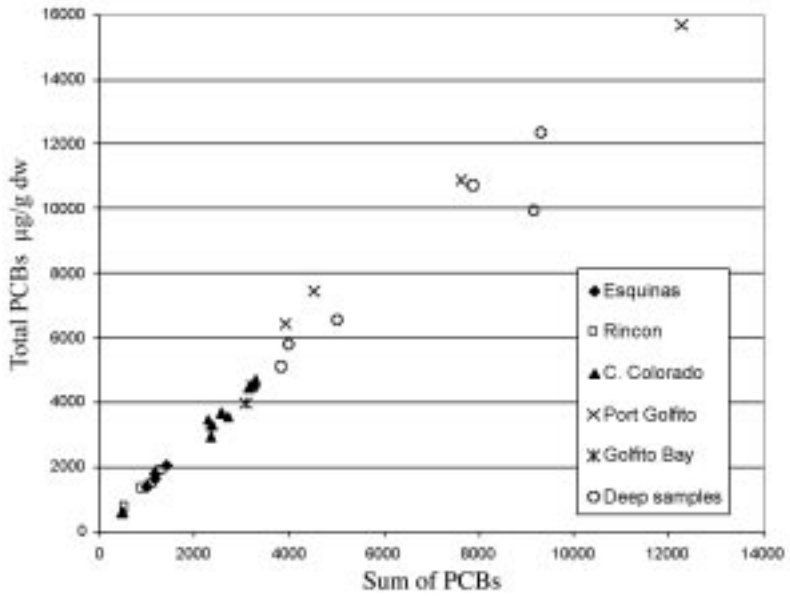

Fig. 2. Correlation between sum and Total PCB concentrations for the sediment samples from Golfo Dulce on the Pacific Coast of Costa Rica (1997-2003).

R-squared = 0.977. The sediments from the Port of Golfito stand out as having the highest concentrations (Average sum = 7.09 µg/g dw with S.E. = 1.91; Average total = 10.11 µg/g with S.E. 2.09). These samples consist of soupy black muds located within the port very near the large cargo boats. The presence of oils and other contaminants are visibly obvious. Within the Bay of Golfito, south of the port, the samples are sandier and show less than half the contamination of the port samples (Average sum = 2.15 µg/g , S.E. = 0.07; Average Total = 4.24 µg/g , S.E. = 0.03 µg/g dw). Evidently flow within the bay does not permit the transport of the contaminant-laden muds to this sheltered area of the bay.

The Río Rincón area, in the northwest part of Golfo Dulce is a pristine area, surrounded by National Parkland and little development, although the residents relied heavily on power generators and other less efficient or less environmentally-friendly power sources until very recently. Data on PCBs show some of the lowest values found in Costa Rica (Fig. 2), with average sum and total values of 0.96 and 1.05 (S.E. = 0.16 and 0.28) µg/g dw, respectively. These averages include samples from a deforested area only a few kilometers east of the mouth of the Río Rincón where erosion of the soils is fairly severe.

The Esquinas River in the Northeast of the Gulf and the Río Coto Colorado watersheds drain largely agricultural fields. The Esquinas River sediments were obtained on the tidal flats and among the mangrove roots and were fairly clay-rich. PCB contaminants had low overall concentrations averaging 1.18 and 1.72 (S.E. = 0.084 and 0.14 µg/g dw) for the sum and total, respectively (Fig. 2).

The Coto Colorado samples were obtained offshore within the sediment plume that extended from the river mouth to the north-northwest into the deeper waters of the gulf. These samples were also clay-rich, however, at a water depth of ~60 m the clays turned greenish, as compared to the usual dark grey clays found elsewhere. Figure 3 shows the trend of these data, normalized for organic matter, with depth. The two shallowest samples (2.5 and 4 m) had relatively high concentrations. These samples were actually closer to the outlet of Golfito Bay and may reflect an influence from the port's contaminants flowing from the bay into the main body of the gulf. The remaining plume samples showed an increase with depth, until the deepest samples where the values drop. In particular, when the data are normalized to organic matter content, the concentration seems to drop beneath a depth of 74 meters.

Also shown in Figure 3 are the data from the sediments retrieved from the deepest parts of the northern end of the gulf. These deep samples are centered between the Rios Esquinas and Rincon and would be expected to contain the fine-grained sediments from these watersheds. However, the concentrations in these sediments are some of the highest found in the entire Costa Rican study. The average sum and total concentrations were 6.53 and 8.41 (S.E. 1.04 and 1.22) µg/g dw respectively, while the average Total PCBs normalized for %OM was still 4.96 (S.E. = 0.93) µg/g dw. These sediments were found to contain relatively high concentrations of pesticides also (Spongberg and Davis 1999). Possibly these

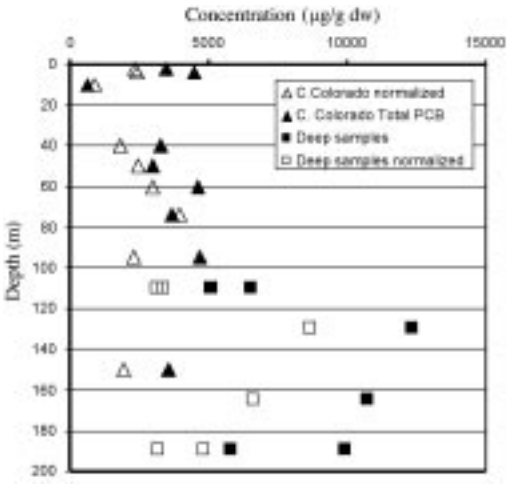

Fig. 3. Concentration (x 1000) of ∑PCBs and concentration normalized by percent organic matter for deep samples obtained within Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

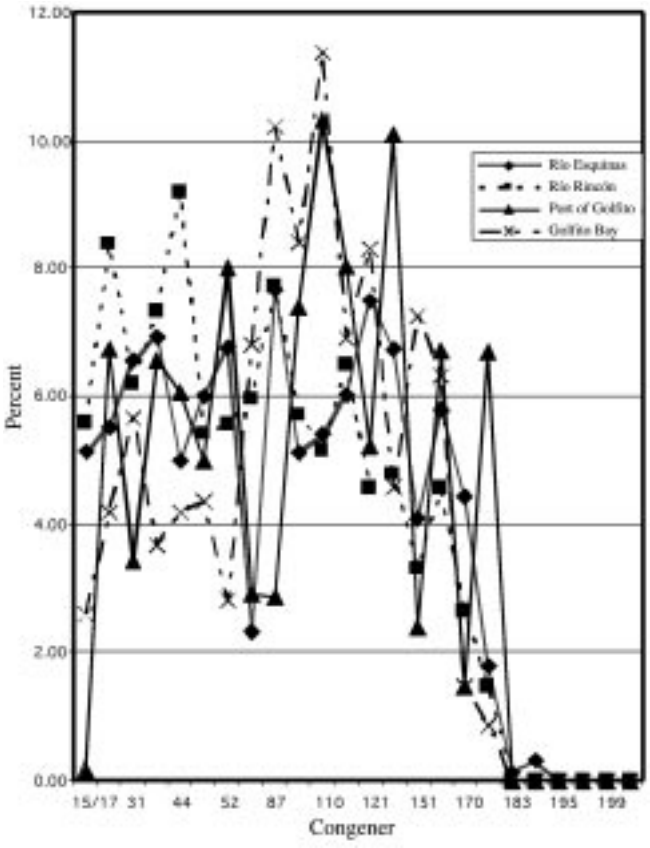

Fig. 4. Average percent of ∑PCB data for the four coastal areas sampled at Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

deeper sediments are a sink for many of the contaminants that move through the basin. However, the trend found in the Coto Colorado plume would indicate that the contaminants are either not moving into the deeper waters of the plume, or possibly that the deeper anoxic waters create conditions amenable to their degradation.

Figure 4 shows the average congener distribution for the four coastal areas sampled in Golfo Dulce. These data can also be evaluated in Table 2 by looking at the position of the 25th and 50th percentile groupings noted as the congener underscored and bold, respectively. None of the samples has a congener signature indicative of atmospheric deposition as was found in Golfo Papagayo (Spongberg 2004), or this signature is overwhelmed with congeners of higher chlorine numbers. Figure 5 illustrates the difference between the individual samples. The Rincon and Esquinas River samples show the distribution skewed somewhat to the lower chlorinated congeners. As degradation occurs the congeners lose their chlorines, however, these samples do not indicate extensive dechlorination. In fact, they may indicate that the contamination is recent, or that the compounds are not degrading in their present environment. However, the overall PCB concentrations of these samples were low. In comparison to this, the samples with the highest concentrations from the Port of Golfito show only a slightly higher degree of chlorination.

Table 2 shows the congener data for the deeper water samples both from sediment plume from the Coto Colorado River and the samples from the deep basin in the northern part of the gulf. Interestingly, the shallower samples have a preponderance of lower chlorinated congeners. However, in general the sediment plume shows an increase in congeners with lower chlorine atoms with increasing water depth. This trend is not apparent in the deep samples from the north part of the gulf. The Coto Colorado data is consistent with the lower concentrations found in the deeper samples and may indicate the capacity of the deep anoxic sediments in this area to degrade the compounds. This trend is not as apparent in the northern samples, however, these PCBs are more skewed towards the lower chlorinated congeners as compared to the PCBs within the Port of Golfito (Figure 5). However, if the deeper anoxic environment was indeed more amenable to dechlorination, the congeners would be expected to be more heavily skewed to the lighter congeners than is seen in these samples. Since the dechlorinated congeners have a higher water solubility, maybe they are being removed from the bottom sediments. We could be seeing concentrations more indicative

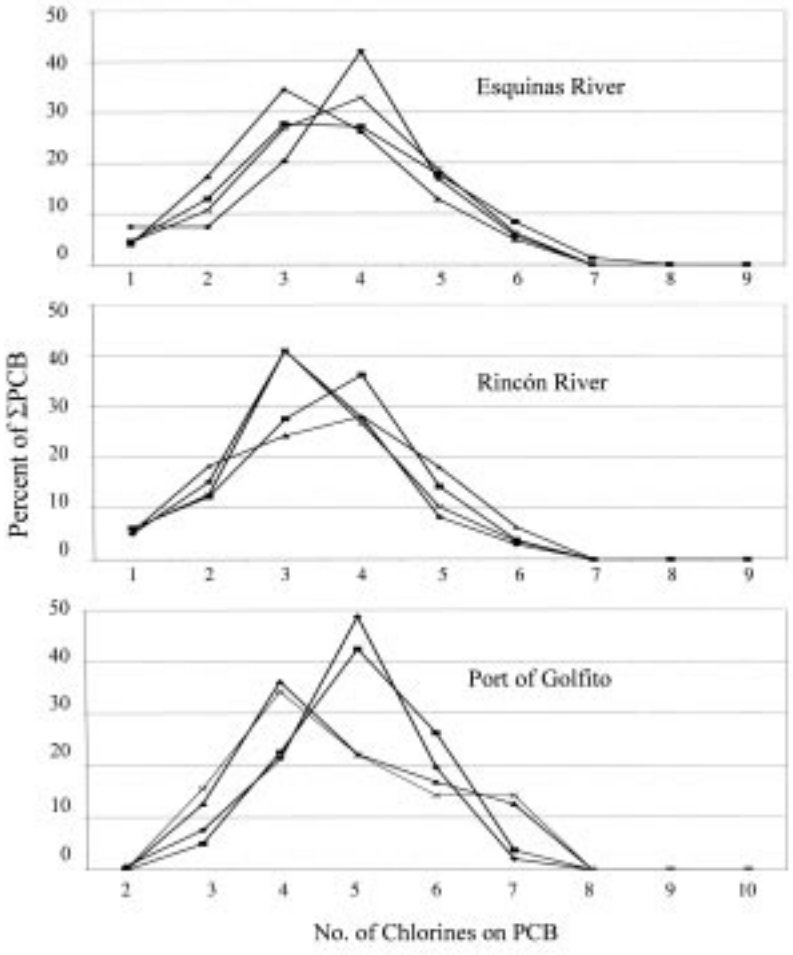

Fig. 5. Congener data for sediments from three coastal areas of Golfo Dulce, Pacific coast of Costa Rica (1997-2003).

of the lower K_{ow} values of the lower chlorinated congeners in comparison to the higher chlorinated species.

In contrast to data from the Golfo de Nicoya (Spongberg 2004), the Golfo Dulce samples show greater variability. This most likely is a result of the varying environments present within Golfo Dulce and the lack of thorough mixing of sediments throughout the gulf. Despite the pristine nature of the land surrounding the Golfo Dulce area and the anoxic conditions at depth, there were many sediments showing moderate PCB contamination. In comparison, many PCB contaminated sites within the temperate regions have concentrations in excess of 100 or even 1000 µg/g sediment (Erickson 1997). Unfortunately, this preliminary evaluation of PCB contamination within the coastal waters of coastal Costa Rica has presented more questions than answers, however, this database should provide a starting point for comparison as development of the coastal lands increases throughout the coming years.

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RESUMEN

Un total de 29 muestras de sedimentos recolectadas de 1996 a 2002 en el Golfo Dulce, Costa Rica fueron analizadas determinar las concentraciones de bifenilos policlorinados (PCBs). La Bahía de Rincón y el Río Esquinas en la parte noroeste del Golfo tienen concentraciones relativamente bajas de PCBs, con ninguna muestras superando los 2.1 ug/ dw (peso seco) de sedimento. El puerto de Golfito tuvo las mayores concentraciones hasta un máximo de 15.7 ug/g dw de sedimento. Estas muestras también estuvieron dominadas por los congéneres más clorinados. Las muestras de los sedimentos profundos (>100 m) de las aguas de la parte norte del Golfo, así como las de la estela del Río Coto Colorado, tienen concentraciones intermedias. Dentro de la estela de sedimentos del Río Colorado las concentraciones aumentaron con la profundidad y los congéneres variaron con la profundidad hacia los menos clorinados. Sin embargo, la región profunda tuvo una de las más altas concentraciones de PCBs, pero la tendencia hacia los menos clorinados no fue aparente o significativa. No se conoce si las condiciones anóxicas en las aguas profundas son capaces de iniciar la declorización. En general, las muestras analizadas muestran concentraciones moderadas de PCBs, no obstante las condiciones pristinas del Golfo y su cuenca.

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