APPENDIX C

ESTIMATES OF DAILY INTAKES OF DIOXINS AND HCB FOR THE CANADIAN POPULATION

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C1-1.0 CANADIAN POPULATION DIOXIN ESTIMATED DAILY INTAKE

Estimated daily intake (EDI) rates of PCDDs, PCDFs and dioxin-like PCBs (DLCs; dioxin-like compounds) for the Canadian population were estimated for both current and historical conditions. The estimation of current EDIs followed methods outlined previously (Cantox Environmental Inc., 2006). The objectives of this report were as follows:

- The identification and collection of appropriate background information concerning current and historical ambient levels of DLCs in the Canadian environment (*e.g.*, air, soil, water, food, *etc.*); and,

- The derivation of EDI rates of DLCs for five (5) specific age classes within the Canadian population as well as a lifetime average EDI.

EDI rates of DLCs (expressed as pg TEQ/kg body weight) were derived for five different age groups in the Canadian population including: infants (age 0 to 6 month.); toddlers (age 7 month. to 4 years); children (age 5 to 11 years); adolescents (age 12 to 19 years); and, adults (>20 years of age). EDI rates were derived by combining media- and age-specific intake rates (Table C1-1) with background concentrations of DLCs in various Canadian environmental media (*e.g.*, food, air, water, soil, *etc.*) (see following sections). A life-time averaged EDI was also calculated.

Table C1-1 Receptor Characteristics Provided by Health Canada (2004a)

Receptor Characteristics	Infant	Toddler	Child	Teen	Adult	Source[a]
Age	0 to 6 mo.	7 mo. to 4 yrs	5 to 11 yrs	12 to 19yrs	>20 yrs	Health Canada, 1994
Body Weight (kg)	8.2	16.5	32.9	59.7	70.7	Richardson, 1997
Soil Ingestion Rate (g/d)	0.02	0.08	0.02	0.02	0.02	CCME, 1996; MADEP, 2004
Inhalation Rate (m^3/day)	2.1	9.3	14.5	15.8	15.8	Richardson, 1997
Water Ingestion Rate (L/day)	0.3	0.6	0.8	1.0	1.5	Richardson, 1997
Area of Exposed Skin - Hands (cm^2)	320	430	590	800	890	Richardson, 1997
Area of Exposed Skin – Arms & Legs (g/cm^2/event)	1460	2580	7200	8220	8220	Richardson, 1997
Soil loading to exposed skin – Hands/Other (g/cm^2/event)	1.0×10^{-4}/ 1.0×10^{-5}	1.0×10^{-4}/ 1.0×10^{-5}	1.0×10^{-4}/ 1.0×10^{-5}	1.0×10^{-4}/ 1.0×10^{-5}	1.0×10^{-4}/ 1.0×10^{-5}	Kissel *et al.*, 1996; 1998

[a] Source of information cited by Health Canada (2004a)

Calculating the EDI rates involved characterizing the average daily intake of specific age groups as a result of ingesting food, water, soil and consumer products containing background levels of DLCs. The EDI rates also considered the average daily intake of individuals due to the inhalation of ambient air.

EDIs were estimated to represent both current and historical exposures to DLCs, since the objective of this study involves the consideration of exposures that occurred in the 1960s.

C1-2.0 FOOD

Average food intake rates for the Canadian population were provided by Health Canada (*via* Petrovic, 2005 pers. comm.) by way of an unpublished draft report (Health Canada, 1998) (Table C1-2). PCDD, PCDF and dioxin-like PCB (DLC) concentrations in food have been collected for the period of 1992 to 1995 from five cities across Canada (Health Canada, 2004b) (Table C1-3). Food was collected from: Halifax (1994), Montreal (1993), Toronto (1992); Winnipeg (1994); and, Vancouver (1995).

Table C1-2 Average Daily Food Intake Rates (g/day) Provided by Health Canada (1998)

Food Item	Infants	Toddlers	Children	Teens	Adults
Whole Milk	186.81	296.09	332.78	250.08	144.80
Milk 2%	199.98	189.96	185.51	192.27	73.02
Skim Milk	21.42	61.11	55.36	64.86	32.08
Evaporated Milk	67.66	20.62	6.52	7.08	9.66
Cream 10 to 12% Butterfat	0.00	1.68	2.83	2.64	8.93
Ice Cream	3.38	15.74	25.57	25.61	13.65
Yogurt	0.00	0.80	0.49	0.89	1.82
Cheese Natural	0.01	2.59	3.18	5.68	8.83
Cheese Cottage	0.00	1.69	1.33	1.76	3.85
Cheese Processed	0.16	3.64	4.93	6.39	4.74
Baby Food Formulae	96.25	6.65	0.01	0.00	0.16
Beef Steak	0.27	2.95	7.04	10.59	19.40
Beef Roast	0.10	5.81	8.19	17.47	21.36
Beef Hamburger	1.29	12.16	19.24	31.01	24.83
Pork Fresh	0.01	7.39	11.11	21.83	25.31
Pork Cured	0.17	1.20	1.78	2.41	3.57
Veal	0.00	0.52	0.31	1.78	2.19
Lamb	0.00	0.03	1.80	1.18	0.56
Poultry	0.39	6.71	8.98	10.38	13.79
Organ Meat	0.00	0.94	1.73	2.24	3.37
Cold Cuts	0.00	5.69	7.57	9.61	9.63
Wieners Fresh	0.11	2.27	6.31	5.51	2.92
Luncheon Meat Canned	0.00	0.94	0.97	2.22	2.39
Baby Food Meat, Poultry or Eggs	14.62	2.32	0.00	0.00	0.00
Luncheon Meat, Ham	0.00	0.24	0.24	1.33	0.38
Wieners Canned	0.00	0.01	0.05	0.01	0.01
Eggs (Medium)	11.84	24.64	20.89	21.69	32.40

Table C1-2 Average Daily Food Intake Rates (g/day) Provided by Health Canada (1998)

Food Item	Infants	Toddlers	Children	Teens	Adults
Fish Marine	0.00	1.59	4.74	5.09	7.67
Fish Fresh	0.00	1.16	1.08	1.09	1.28
Fish Canned	0.14	0.45	1.91	3.91	4.76
Shellfish	0.00	0.27	0.27	0.15	0.70
Soups Meat, Canned	5.36	41.64	41.76	35.12	55.29
Soups Dehydrated	0.33	10.43	7.98	7.91	8.33
Pizza	0.01	0.12	3.09	5.13	2.55
Margarine	0.10	2.66	6.10	8.25	5.11
Butter	0.91	7.32	12.93	16.35	15.19
Cooking Fats, Animal	0.00	0.03	0.18	0.07	0.22
French Fried Potatoes	2.28	18.46	22.73	32.89	24.07

Table C1-3 PCDD, PCDF and Dioxin-Like PCB Concentrations (pg I-TEQ/g whole wt) in Different Food Types Collected from Five Canadian Cities[a]

Food Type	Mean (n= 5)	Std. Dev.	95% UCL	Comment
Whole milk	0.044	0.021	0.063	Student's t 95% UCL recommended
2% milk	0.046	0.023	0.063	Student's t 95% UCL recommended
Skim milk	0.011	0.003	0.015	Student's t 95% UCL recommended
Evaporated milk	0.053	0.012	0.065	Student's t 95% UCL recommended; exceeded maximum value
Cream	0.109	0.051	0.158	Student's t 95%UCL recommended; exceeded maximum value
Ice cream	0.110	0.065	0.157	Student's t 95%UCL recommended
Yogurt	0.028	0.008	0.035	Student's t 95%UCL recommended
Cheddar cheese	0.332	0.118	0.421	Student's t 95%UCL recommended
Cottage cheese	0.054	0.016	0.070	Student's t 95%UCL recommended
Processed cheese	0.201	0.039	0.239	Student's t 95%UCL recommended; exceeded maximum value
Butter	0.807	0.254	0.993	Student's t 95%UCL recommended
Beef steak	0.141	0.064	0.202	Student's t 95%UCL recommended; exceeded maximum value
Beef roast	0.110	0.032	0.140	Student's t 95% UCL recommended
Pork, fresh	0.027	0.010	0.036	Student's t 95% UCL recommended
Pork, cured	0.064	0.035	0.097	Student's t 95% UCL recommended
Veal	0.044	0.023	0.060	Student's t 95% UCL recommended
Lamb	0.060	0.023	0.082	Student's t 95% UCL recommended
Cold cuts	0.099	0.024	0.122	Student's t 95% UCL recommended
Lunch meat, canned	0.107	0.052	0.156	Student's t 95% UCL recommended
Organ meat	0.324	0.085	0.405	Student's t 95% UCL recommended
Wieners	0.268	0.058	0.312	Student's t 95% UCL recommended
Eggs	0.216	0.330	0.859	Chebyshev 95% UCL method recommended; maximum value exceeded
Poultry	0.055	0.025	0.089	Student's t 95% UCL recommended
Marine fish	0.154	0.114	0.263	Student's t 95% UCL recommended
Freshwater fish	0.466	0.190	0.647	Student's t 95%UCL recommended; exceeded maximum value
Fish, canned	0.177	0.067	0.240	Student's t 95% UCL recommended

Table C1-3 PCDD, PCDF and Dioxin-Like PCB Concentrations (pg I-TEQ/g whole wt) in Different Food Types Collected from Five Canadian Cities[a]

Food Type	Mean (n= 5)	Std. Dev.	95% UCL	Comment
Shell fish	0.148	0.171	0.488	Approximate Gamma 95% UCL recommended; exceeded maximum value
Meat soup	0.015	0.007	0.021	Student's t 95% UCL recommended
Dehydrated soup	0.008	0.001	0.010	Student's t 95% UCL recommended
Cooking fat	0.388	0.152	0.533	Student's t 95% UCL recommended
Margarine	0.146	0.067	0.394	Student's t 95% UCL recommended
Formula milk	0.028	0.025	0.069	Chebyshev 95% UCL method recommended; maximum value exceeded
Baby food, meat	0.065	0.025	0.083	Student's t 95% UCL recommended
Pizza	0.104	0.023	0.126	Student's t 95% UCL recommended
French fries	0.086	0.045	0.128	Student's t 95% UCL recommended
Hamburger	0.131	0.050	0.178	Student's t 95% UCL recommended

[a] These data also include dioxin-like PCBs
ND= Not documented

The data collected between 1992 and 1995 can be used to estimate historical food related exposures for the Canadian population (Table C1-4) for the early 1990s. For all ages of Canadians, the average dietary intake of DLCs was 1.74 pg TEQ/kg bw/day (Cao *et al*., 2005).

Table C1-4 Historical Canadian Food Related Exposures for PCDD/PCDFs and Dioxin-Like PCBs (pg TEQ/kg bw/day)

Environmental Media	ESTIMATED DAILY INTAKE (pg I-TEQ/kg bw/day)[A]					
	Infant (0 to 6 mo.)	Toddler (7 mo. to 4 yrs)	Child (5 to 11 yrs)	Teen (12 to 19 yrs)	Adult (>20 yrs)	Lifetime Receptor
Food	5.90	4.67	2.71	1.64	1.31	1.74

In addition to the DLC concentrations in food collected between the period of 1992 to 1995, Health Canada collected additional food samples from four Canadian cities between 1995 and 1999 as part of the Total Diet Study (Cao *et al*., 2005). Data collection occurred in Ottawa, Toronto, Whitehorse and Calgary in 1995, 1996, 1998 and 1999, respectively. This provided a comprehensive database of concentrations of DLCs in food across Canada from 1992 to 1999. For all ages of Canadians, the average dietary intake of DLCs was 0.88 pg TEQ/kg bw/day. This average dietary intake value (Table C1-5) can be used to determine an EDI (pg TEQ/kg bw/day) for a lifetime receptor (Cao *et al*., 2005) reflective of current conditions.

Table C1-5 The Average Daily Food Intake of PCDD, PCDFs and Dioxin-like PCBs for the All Ages of Canadians for the Total Diet Study Conducted from 1992 to 1999

Food category	Canada (average)	
	pg TEQ@-WHO_{98}/kg bw/ day	%
Dairy	0.43	48
Meat	0.25	28
Poultry & egg	0.11	12
Fish	0.02	2
Fats & oils	0.05	5
Average total intake	0.88	

There is a notable downward temporal trend in the concentration of dioxin-like compounds in environmental media, even within the last decade. For instance, the TEQ concentration in food items sampled across Canada decreased during the eight year period over which the Total Diet Study occurred (Cao *et al*., 2005) (Figure C-1). This trend can also be observed in PCDD and PCDF concentrations in historical and recent meat samples (Winters *et al*., 1998) (Figure C-2).

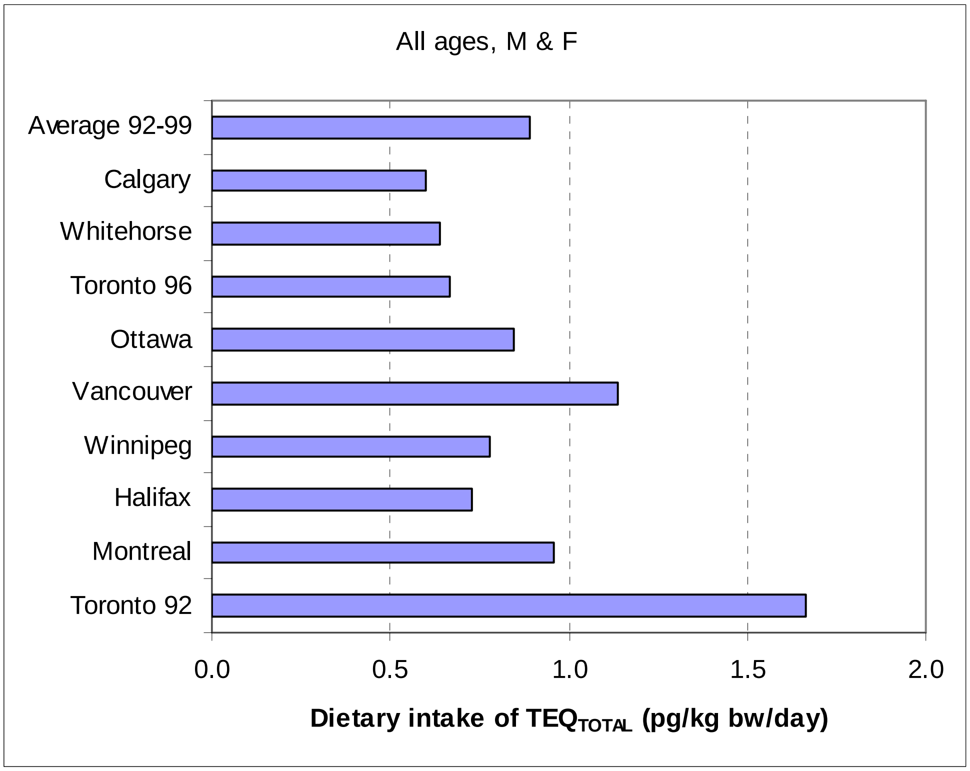

Figure C1-1 Dietary Intakes (pg TEQ/kg body weight/day) for all ages of Canadians from 1992 to 1999 in each city sampled (Cao *et al*., 2005)

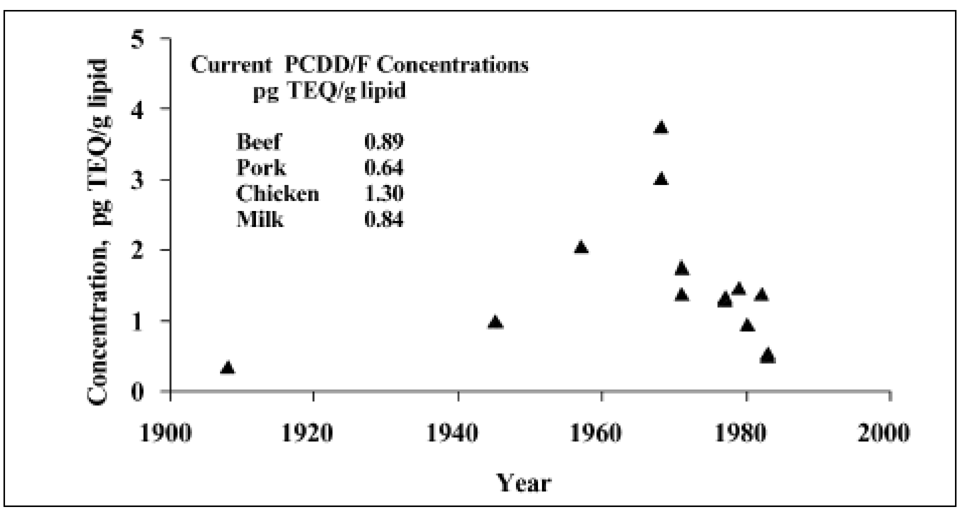

Figure C1-2 Dioxin and PCB concentrations (pg TEQ/g lipid) in historical meat samples (Winters *et al*., 1998)

This downward trend would tend to indicted that exposures in the 1960s may have been substantially greater than those estimated based on the data collected from the 1990s. As discussed in Section C1-6.0, other studies have attempted to quantify this trend. Birmingham *et al*. (1989) estimated food related exposures in the range of 0.56 to 2.1 pg TEQ/kg bw/day for adult Canadian based on data collected in the early to mid-1980s. U.S. EPA (2003) has indicated that current EDI estimates fall in the range of 0.61 TEQ_{DF}/kg bw/day, which is dramatically less than those previously estimated (1.7 TEQ_{DF}/kg bw/day). Lorber (2002) has estimated that EDIs in the 1960s and 1970s may have been as much as 10-fold higher than those currently estimated. In all of these studies, food is the primary media contributing to the EDI esitmates.

C1-3.0 OTHER ENVIRONMENTAL MEDIA

The following data evaluate environmental concentrations of dioxins, furans and dioxin-like PCBs.

C1-3.1 Soil

The soil background level of 4 pg TEQ/g (dry wt) was considered representative of the mean background concentration of PCDD/Fs in Canadian soils by CCME (2002) (Table C1-6). This value is based on the highest mean background concentration for Canadian soils (5.0 pg TEQ/g soil (dry weight)) (Table C1-6). The data from Quebec was not included as high detection limits for each congener may have resulted in an overestimation of actual background concentrations. The soil background level of 4 pg TEQ/g (dry weight) is consistent with the 98th percentile of Ontario's typical range. However, the background of 4 pg TEQ/g soil (dry weight) was determined using a limited number of studies (soil samples were obtained from Ontario, British Columbia, and Quebec) and may not accurately reflect the ambient background concentration of PCDD/Fs in soils elsewhere in Canada (CCME, 2002). The U.S. EPA (2003) determined rural background concentration in North American soil for dioxins and furans and dioxin-like PCBs of 9.3 and 2.3 pg TEQ/g soil, respectively.

Table C1-6 Dioxin/furan Ambient Background Soil Concentrations in Canada (TEQ equivalents, dry weight) (CCME, 2002)

Location	Mean (pg TEQ/g)	Range (pg TEQ/g)	Sample Size	Site Description	Reference
Ontario	1.7[a]	--	74	Rural parkland	OMOEE, 1993
British Columbia	5.0[b]	0.0-57.0	53	Background	Van OOstdam and Ward, 1995
Quebec	10[c] ± 16.5	0.0-99[d]	57	Background for semi-rural	Trepanier, 1992

[a] The OTR98 (98th percentile of the Ontario typical range) is equal to 4.8 pg TEQ/g.
[b] Dwernychuk *et al*. (1991) reported a background mean value of 11.1 ng TEQ·kg-1, n=14; results were included in Van Oostdam and Ward (1995).
[c] Geometric mean = 4.4 pg TEQ/g
[d] Detection limits were often high, non-detected values of each congener was set equal to half the detection limit. This could result in an overestimate of actual background concentrations.

The Ministry of Environment in British Columbia conducted a 2-year monitoring study from 1990 to 1992 in order to measure background concentrations of PCDD/PCDFs in soil (BC Environment, 1995). Soil samples also were collected from sites close to point sources. For the

53 background samples, 2,3,7,8-TCDD was not detected, and 2,3,7,8-TCDF concentrations ranged from non-detects to 3.2 pg/g. The mean soil concentration was 5.0 pg/g TEQ (non-detects set at zero; range 0.0 to 57.0 pg TEQ/g). Table C1-7 provides a summary of the PCDD/PCDF concentrations observed in British Columbia soils (U.S. EPA, 2003).

Table C1-7 PCDD/PCDF Concentration in British Columbia Soils (U.S. EPA, 2003)

Sample Type[a]	PCDD/PCDF TEQ (pg/g)		
	Range	Mean[b]	N
Background Soils	0.0 to 57.0	5.0	53
Primary Soils (all sources)	0.0 to 2580.0	252.3	31
Primary Soils (chemical sources)	0.0 to 2580.0	418.5	18
Primary Soils (combustion sources)	0.0 to 125.7	22.3	13
Secondary Soils (all sources)	0.0 to 18721.8	241.7	137
Secondary Soils (chemical sources)	0.0 to 18721.8	668.6	47
Secondary Soils (combustion sources)	0.0 to 472.6	18.7	90

[a] Primary sources were soil samples collected immediately adjacent to the suspected source of contamination. Secondary sources were soil samples collected in the nearby receiving environment which was believed to have been impacted from the primary source.
[b] Non-detect samples were set to zero.
Source: U.S. EPA (2003)

In 1997, soil samples (n=63) were taken from Nova Scotia, Ontario, Alberta, Vancouver Island, the Yukon and Northwest Territories at remote (*i.e.*, away from populated/industrialized/ agrochemical application areas) locations ranging from the U.S./Canada border to the Arctic circle (Wagrowski and Hites, 2000). The total PCDD/PCDF concentrations ranged from 6.2 pg/g dry weight (dw) (Dempster Highway, Yukon Territory) to 1,891 pg/g dw (Sooke, Vancouver Island, B.C.) (Table C1-8).

Table C1-8 Total PCDD/PCDF Concentrations in Soil (pg/g dw) for Various Remote Canadian Sites (Wagrowski and Hites, 2000)

Location	Province/Territory	Total dioxins/furans (pg/g dw)
Dempster Highway	Yukon Territory	6.2
Eagle Plain	Yukon Territory	13
Eagle Plain	Yukon Territory	28
Pelly Crossing	Yukon Territory	246
Rock River	Yukon Territory	21
Teslin	Yukon Territory	249
Dease Lake	British Columbia	93
Seeley Lake	British Columbia	209
Sooke, Vancouver Island	British Columbia	1,891
Prophet River	British Columbia	33
Pine Pass	British Columbia	101
Marble Canyon	British Columbia	55
Marble Canyon	British Columbia	49
Wilcox Pass	Alberta	51
Wilcox Pass	Alberta	60
Waterton National Park	Alberta	29
Waterton National Park	Alberta	51
Yellowknife	Northwest Territories	39
Burnt Island	Ontario	593
Kejimkujik National Park	Nova Scotia	1,859
Mt. Thom	Nova Scotia	843

Archived soil samples (0 to 23 cm) from Brandon and Winnipeg, Manitoba, sampled in the 1880s and stored in the Rothamsted Experimental Station in the United Kingdom, were analyzed for dioxins/furans (pg/g dw) (Green *et al*., 2004). Contemporary soil samples (0 to 5 cm) were also taken in 1998 in remote Canadian locations (Southern Alberta, Southern Manitoba, Southern Ontario). The archived soils had total PCDD/PCDF concentrations (pg/g dw) of 5 and 83 for Brandon and Winnipeg, respectively (Green *et al*., 2004). The contemporary remote Canadian soils were all below the limit of detection (15 pg/g dw) (Green *et al*., 2004). The authors hypothesized that the PCDD/PCDF concentrations in archived soils point to natural source(s) of PCDD/PCDF of geochemical or biological origin (Green *et al*., 2004). The authors speculated that the prevalence of the OCDD and HpCDD congener groups in environmental samples may be due to their resistance to degradation relative to other homologue groups rather than their relative prevalence of formation/emissions.

Soil samples collected from rural and urban sites in Ontario, Canada in 1987 were analyzed by Pearson *et al*. (1990). Rural woodlot samples contained OCDD at a mean concentration of 30 pg/g. Samples obtained from an undisturbed urban parkland setting had TCDFs present at the highest mean concentration of 29 pg/g. A mean estimated concentration for soil sampled from urban backyards, public use areas and parkland in Ontario and Midwestern U.S in the early to mid-1980s was 49 pg TEQ/g (Birmingham *et al*., 1989a).

There is a notable downward temporal trend in the concentration of dioxin-like compounds in environmental media within the past century. For instance, concentrations of total dioxins and furans in dated sediment cores from Beaver Lake in Washington illustrate the changing temporal trend between the late 1880s and early 1970s (Cleverly *et al*., 1966) (Figure C1-3). Furthermore, Aylward and Hays (2002) indicate, based on sediment coring analyses, that PCDD/F levels began to increase in the 1930s, peaked in the 1960s or early 1970s and have been declining since the 1970s.

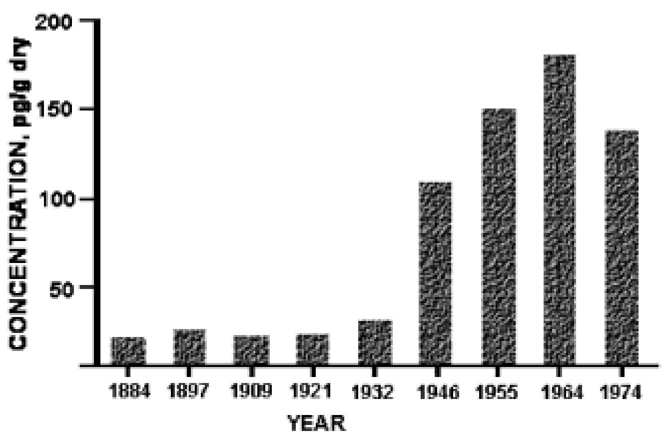

Figure C1-3 Concentrations of Total Dioxins and Furans in Dated Sediment Cores from Beaver Lake in Washington (Lorber, 2002)

C1-3.2 Air

Air samples are taken across Canada as part of the National Air Pollutant Surveillance (NAPS) program. For the period of 1995 to 2004 the mean PCDD/PCDF air concentration was 35.41 fg/m^3 I-TEQ and ranged from 1.61 (Saint John) to 827 .36 (Toronto) fg/m^3 I-TEQ (Dann, 2005 pers. comm.). Summary statistics for the national averages are provided.

Air data for PCDD/PCDFs were collected at the downtown air monitoring station in Winnipeg from April 3, 1995 to August 24, 2002 (Van Dusen, 2005 pers. comm.). For the period from 1995 to 1999, 57 air samples were taken. The mean air concentration was 0.04 pg/m^3 TEQ (0.067 SD), with a minimum and maximum of 0.007 and 0.43 pg/m^3 TEQ, respectively. The data are also published in Krawchuk (2002). For the period of January 1, 2000 to August 24, 2002, 28 air samples were taken. The mean air concentration for this period was 0.019 pg/m^3 TEQ (SD of 0.014), with a minimum and maximum of 0.004 and 0.058 pg/m^3 TEQ, respectively (Van Dusen, 2005 pers. comm.).

Table C1-9 Summary of TEQ Concentrations and Summary Statistics (fg/m^3 I-TEQ) at Canadian Sites (Dann, 2005 pers. comm.)[a]

City	n	Min.	Percentiles					Max.	Mean	Std. Dev.
			10	50	70	95	99			
National Summary	**1615**	**1.61**	**7.81**	**21.59**	**33.38**	**97.93**	**290.12**	**827.36**	**35.41**	**56.39**
Charlottetown	3	13.83	13.83	16.51	43.85	43.85	43.85	43.85	24.73	16.61
Halifax	2	15.24						90.94	53.09	
Kejimkujik National Park	95	2.34	3.91	13.04	16.38	24.75	30.22	30.22	12.93	6.75
St. Andrews	67	3.60	6.68	10.33	13.17	28.57	81.93	81.93	13.51	10.88
Saint John	12	1.61	3.48	5.47	7.57	46.94	46.94	46.94	10.62	13.22
Jonquiere	100	3.58	9.62	37.88	45.55	129.09	487.01	487.01	44.91	60.01
Montreal	113	9.75	14.07	25.73	36.09	85.64	121.07	210.43	34.57	28.16
Montreal	63	7.94	13.61	25.16	45.05	125.20	253.72	253.72	44.17	43.47
Point Petre	95	3.38	6.46	13.69	17.40	28.82	131.78	131.78	15.85	14.32
Toronto	92	11.02	17.48	36.90	51.15	190.47	827.36	827.36	61.09	99.12
Toronto	35	12.98	17.28	26.03	32.76	54.55	61.60	61.60	28.38	11.86
Toronto	49	8.69	10.31	20.41	32.18	61.53	102.25	102.25	26.56	17.84
Toronto	33	9.87	11.34	18.20	25.93	65.99	71.61	71.61	24.08	15.55
Egbert	66	2.18	4.09	12.31	16.83	41.53	58.18	58.18	14.64	11.22
Hamilton	92	12.04	20.32	43.76	67.39	112.42	589.80	589.80	61.64	76.39
Hamilton	66	4.74	12.96	25.27	39.30	99.68	203.62	203.62	37.58	36.70
Hamilton	84	2.38	17.20	41.86	65.20	337.85	764.71	764.71	84.62	134.41
Simcoe	91	3.36	7.93	15.34	21.84	46.06	154.31	154.31	20.76	19.37
Windsor	4	37.86	37.86	68.31	68.31	89.69	89.69	89.69	61.47	22.60
Windsor	102	12.26	21.21	40.85	65.51	128.40	160.92	178.50	54.15	35.96
Walpole	3	25.57	25.57	32.15	32.64	32.64	32.64	32.64	30.12	3.95
Burnt Island	5	2.52	2.52	5.18	6.02	6.17	6.17	6.17	4.82	1.51
Winnipeg	93	7.01	10.26	20.61	26.30	93.35	425.94	425.94	33.47	53.90
Winnipeg	3	7.94	7.94	13.68	23.36	23.36	23.36	23.36	14.99	7.79
Regina	2	24.61						28.28	26.45	
Regina	2	15.80						72.33	44.06	
Prince Albert	5	19.89	19.89	22.74	27.68	31.63	31.63	31.63	24.43	5.09

Table C1-9 Summary of TEQ Concentrations and Summary Statistics (fg/m^3 I-TEQ) at Canadian Sites (Dann, 2005 pers. comm.)[a]

City	n	Min.	Percentiles					Max.	Mean	Std. Dev.
			10	50	70	95	99			
Estevan	2	18.15						38.87	28.51	
Gray	4	11.53	11.53	21.59	21.59	32.04	32.04	32.04	19.78	9.23
Edmonton	91	4.84	9.16	17.20	26.80	65.51	439.91	439.91	31.57	60.67
Edmonton	2	45.95						49.65	47.80	
Fort Saskatchewan	3	26.55	26.55	39.31	88.56	88.56	88.56	88.56	51.47	32.75
Fort McMurray	2	68.95						83.84	76.39	
Trail	1	44.21						44.21	44.21	
Trail	18	5.65	5.86	8.86	11.17	286.35	286.35	286.35	29.17	65.78
Whitehorse	2	30.01						31.96	30.99	
Vancouver	4	12.68	12.68	32.34	32.34	44.80	44.80	44.80	29.26	13.29
Vancouver	24	10.10	15.03	21.45	25.53	37.37	37.55	37.55	22.88	7.93
Vancouver	2	43.85						46.43	45.14	
Vancouver	3	18.48	18.48	60.48	84.55	84.55	84.55	84.55	54.50	33.44
Chilliwack	2	18.41						30.03	24.22	
Powell River	20	9.13	12.77	23.14	24.92	67.15	67.15	67.15	24.15	13.14
Victoria	1	22.08						22.08	22.08	

[a] The air data was not screened for proximity to potential point sources

Air samples were taken in Alert, Nunavut from 2000 to 2001 (Hung *et al*., 2002). The samples were collected during an "Arctic Haze" event, which typically occurs from December to April of each year. Air particulate concentrations during this time are much higher than the rest of the year; thus, these concentrations may represent maximum Arctic PCDD/PCDF air concentrations (Hung *et al*., 2002). The concentrations ranged from 1.3 to 13 fg/m^3 for total PCDD and 2.9 to 46 fg/m^3 total PCDF, respectively (n=15; 1/week).

Hoff *et al*. (1992) evaluated PCBs in ambient Canadian air. Samples (n=143) were taken from Egbert, Ontario, Canada between 1988 and 1989 and analyzed for various vapor-phase PCB congeners. The toxic PCB congeners examined were PCB 105, 114, 118, 118, 170, 180 and 189. Annual mean concentrations were calculated with the assumption that non-detectable concentrations were zero. Based on the mean concentrations for each PCB congener the total TEQ concentration is 0.88 fg/m^3. As this value is significantly lower than the national average concentration of dioxins and furans in Canadian air, it was not included in the background air concentration.

C1-3.3 Consumer Products

Ryan *et al*. (1991, 1992) investigated the potential for bleached paper boards in milk cartons to transfer PCDD/PCDF to milk. Ryan *et al* (1992) estimated that bleached paper boards, produced pre-1989, resulted in a percent migration from the bleached paper boards to the milk products of

between 3 to 25%. They concluded that milk stored for up to 14 days in milk cartons produced after mid-1989 would contain undetectable amounts of PCDD/PCDFs (Ryan *et al*., 1992). DeVito and Schecter (2002) investigated the potential human exposures to PCDDs resulting from the use of tampons and diapers relative to PCDD exposure *via* dietary sources. Results of the exposure analysis indicated that PCDD exposures as a result of using tampons were approximately 13,000 to 240,000 fold less than dietary exposures. For nursing infants, estimated PCDD exposures resulting from the use diapers were 30,000 to 2.2 million fold lower than expected dietary exposures.

No recent data describing levels of PCDD/PCDFs in various Canadian "consumer products" were identified. The term "consumer product" could encompass a wide array of items. The term "consumer product" has not well defined and therefore could include products that might be inhaled, ingested and/or applied to the skin. As a result, a significant amount of data would be required to predict age-specific EDI rates as a result of day-to-day use of various "consumer products".

The "consumer products" medium is one of five environmental media with which the CCME 2005, (Draft – Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines) assumes receptors could come into contact. In order to provide quantitative EDI rates, one would require concentration data for each "consumer product" and quantitative data describing a receptor's contact or intake rate with each "consumer product".

According to the U.S. EPA *Dioxin Reassessment Document* (U.S. EPA, 2003), Gilman *et al*. (1991) suggested that "consumer products" may contribute < 0.7 pg I-TEQ/day. For a lifetime receptor weighing 61.7 kg, the EDI (as a result of using consumer products) would be approximately 0.011 pg I-TEQ/kg bw/day. Since the Gilman *et al*. (1991) data represent the average daily lifetime exposure rate, a composite (or lifetime) body weight of 61.71 kg was calculated using the reported life-stage body weights and time frames. The estimated lifetime daily exposure intake of 0.7 pg I-TEQ/day reported by Gilman *et al*. (1991) accounts for < 1% of the total EDI of a "lifetime receptor". It is noted that the CCME (2000) also cites Gilman *et al*. (1991); however, the estimated lifetime daily exposure rate from using "consumer products" was not reported.

C1-3.4 Drinking Water

There are no updates available for PCDD/PCDF concentrations in water. However, it is noted that the Ontario Ministry of Environment (MOE), in its Drinking Water Surveillance Program (DWSP) Summary Report for 2000, 2001 and 2002, indicated that all 47 drinking water samples analyzed for PCDDs were less than the limit of detection (1.0 pg/L). It should be noted that PCDD/PCDFs are not routinely monitored by DWSP.

The U.S. EPA (2003) did not find any literature on dioxin-like PCB congener concentrations in water. All of the background studies they reviewed contained data for OCDD and OCDF only. The background condition in North America of TEQ_{DF}-WHO 0.00056 pg/L was determined using samples obtained from Ontario and New York in 1988 and 1986/88, respectively (Meyer *et al*., 1989; Jobb *et al*., 1990). A mean dioxin and furan concentration in Canadian drinking water of 0.07 pg TEQ/L was determined by the MOE (1984, 1986).

Information from the CCME (2000) was used to select a PCDD/PCDF drinking water concentration for the purpose of approximating EDI rates. The only PCDD/PCDF TEQ data presented by CCME (2000) were six (6) samples taken from the St-Maurice River in Quebec during 1998. The variability observed within these samples was considerable. The sample size was considered too small to conduct any statistical analyses and it is unclear if these data could be considered representative of background concentrations in Canadian drinking water since industrial activity is present along the St-Maurice watershed (CCME, 2000). Given the lack of any other published Canadian drinking water data for PCDD/PCDFs, the mean concentration from these six (6) samples taken from St-Maurice River was used during the development of EDI rates. It is noted that drinking water, relative to food and soil intake is not expected to significantly contribute to the overall EDI rates.

C1-3.5 Summary

For the purposes of approximating age-specific EDI rates, chronic (*i.e.*, long term) exposures of individuals are of primary concern. As a result, it is important that the exposure point concentration (for any environmental medium) reflect the average concentration to which an individual would be expected to come into contact over his or her entire exposure duration (*e.g.*, 25, 50, and 70 years, *etc.*).

Table C1-10 Background Levels of PCDD/PCDFs in Environmental Media used to Derive EDI Rates for the Canadian Population

Media	Concentration	Units[a]	Reference
Soil	4	pg WHO_{98}-TEQ/g	CCME, 2002
Air	0.0384	pg I-TEQ/m^3	Dann, 2005 pers. comm.
Water	0.0573	pg TEQ/L	CCME, 2000
Consumer Products	ND		

[a] Note: the TEQ type for water was not reported by CCME, (2000).
ND – Not Determined

C1-4.0 EQUATIONS AND ASSUMPTIONS USED TO PREDICT AGE-SPECIFIC CANADIAN EDI RATES

Age-specific EDI rates for the Canadian population were calculated using the data presented above in combination with general exposure equations and assumptions. For reporting purposes, the following Exhibits have used intake rate data for the toddler (7 months to 4 yrs) to illustrate the detailed exposure equations and assumptions used to characterize daily exposure rates. With the exception of age-specific receptor characteristics (*e.g.,* body weight, inhalation rates, food intake rates, *etc.*), the general equations and assumptions presented below were applied to all age-classes to produce age-specific EDI rates.

For the purpose of this report, dioxin-like compounds were assumed to exhibit a threshold dose-response mechanism. As a result, time activity patterns (*i.e.,* exposure frequency (EF) and exposure duration (ED)) were excluded from all exposure equations, since the ratio of EF/ED would result in unity under a threshold dose-response assumption.

C1-4.1 Exposure *via* Incidental Soil Ingestion

Equation C1 provides the equation and assumptions used to determine the average daily dose received by an individual *via* incidental soil ingestion.

Equation C1 **Incidental Ingestion of Soil**

$$EXP_{SOIL} = \frac{SI \times RAF_{ORAL} \times C_{SOIL}}{BW(kg)}$$

Where:

EXP_{SOIL}	=	Exposure to PCDD/PCDFs *via* incidental ingestion of soil (pg TEQ/kg bw/day)
SI	=	Soil/dust ingested per day (0.08 g/day)
RAF_{ORAL}	=	Relative absorption factor for ingestion (1.0; unitless)
C_{SOIL}	=	Concentration of chemical in soil (pg/g soil)
BW	=	Body weight (16.5 kg)

C1-4.2 Exposure *via* Direct Air Inhalation

Equation C2 provides the equation and assumptions used to determine the average daily dose received by an individual *via* direct air inhalation.

Equation C2 **Direct Air Inhalation**

$$EXP_{AIR} = \frac{AI \times RAF_{INH} \times C_{AIR}}{BW}$$

Where:

EXP_{AIR}	=	Exposure to PCDD/PCDFs *via* inhalation (pg TEQ/kg bw/day)
AI	=	Amount of air inhaled (9.3 m^3/day)
RAF_{INH}	=	Relative absorption factor for inhalation of chemical (1.0; unitless)
C_{AIR}	=	Concentration of chemical in air (pg/m^3)
BW	=	Body weight (16.5 kg)

C1-4.3 Exposure via Drinking Water Ingestion

Equation C3 provides the equation and assumptions used to determine the average daily dose of PCDD/PCDFs received *via* drinking water.

Equation C3 **Ingestion of Drinking Water**

$$EXP_{DW} = \frac{AO_{DW} \times RAF_{ORAL} \times C_{DW}}{BW}$$

Where:

EXP_{DW}	=	Daily exposure to PCDD/PCDFs *via* ingestion of drinking water (pg TEQ/kg bw/day)
AO_{DW}	=	Amount of drinking water consumed per day (0.6 L/day)
RAF_{ORAL}	=	Relative absorption (1.0; unitless)
C_{DW}	=	Concentration of chemical in drinking water (pg/L)
BW	=	Body weight (16.5 kg)

C1-4.4 Exposure *via* Food Consumption

The equation presented in Equation C4 and previously EDI rates were used to derive the estimated daily exposure of individuals to dioxin-like compounds (expressed as pg TEQ/kg bw/day) *via* food ingestion.

Equation C4 Ingestion of Food

$$EXP_{FOOD} = \sum_{N}^{N+1} \frac{FIR_N \times RAF_{ORAL} \times C_N}{BW}$$

Where:

EXP_{FOOD}	=	Daily exposure to PCDD/PCDFs and dioxin-like PCBs *via* food ingestion (pg TEQ/kg bw/day)
FIR_N	=	Amount of food item, "n" consumed per day (g/day)
RAF_{ORAL}	=	Relative absorption factor for ingestion (1.0; unitless)
C_N	=	Concentration of PCDD/PCDFs in food item "n" (pg TEQ/g)
BW	=	Body weight (16.5 kg)

C1-5.0 CANADIAN EDI RATES

The Canadian EDI rates are based on an averaged lifetime receptor. This value was selected since it captures exposure during different life stages, and accounts for elevated exposure levels on younger age groups.

C1-5.1 Historical Canadian EDI

Historical EDI rates for the Canadian population are difficult to estimate for years prior to the 1980s due to a paucity of data. Lorber (2002) has estimated that EDIs in the 1960s and 1970s were as high as 6.0 pg TEQ/kg bw/day. This value has been utilized to represent EDIs reflective of exposures in the 1960s and 1970s.

Age specific EDI rates representing exposures in the late 1980s and early 1990s have been estimated using the data presented above with general exposure equations and assumptions. The 1980s-1990s historical Canadian EDI rate for dioxin-like compounds was estimated to be 1.76 pg TEQ/kg bw/day for a lifetime receptor (Table C1-11). This value was utilized as the historical lifetime EDI rate for this time period.

Table C1-11 Historical Canadian EDI Rates for PCDD/PCDFs and Dioxin-Like PCBs (pg TEQ/kg bw/day)

Environmental Media	ESTIMATED DAILY INTAKE (pg TEQ/kg bw/day)[a]					
	Infant (0 to 6 mo.)	Toddler (7 mo. to 4 yrs)	Child (5 to 11 yrs)	Teen (12 to 19 yrs)	Adult (>20 yrs)	Lifetime Receptor
Soil [b]	0.010	0.019	0.002	0.001	0.001	0.003
Air[b]	0.010	0.022	0.017	0.010	0.009	0.010
Water[b]	0.002	0.002	0.001	0.001	0.001	0.001

Table C1-11 Historical Canadian EDI Rates for PCDD/PCDFs and Dioxin-Like PCBs (pg TEQ/kg bw/day)

Environmental Media	ESTIMATED DAILY INTAKE (pg TEQ/kg bw/day)[a]					
	Infant (0 to 6 mo.)	Toddler (7 mo. to 4 yrs)	Child (5 to 11 yrs)	Teen (12 to 19 yrs)	Adult (>20 yrs)	Lifetime Receptor
Consumer Products[b]	ND	ND	ND	ND	ND	0.011
Food[c]	5.90	4.67	2.71	1.64	1.31	1.74
TOTAL	**5.92**	**4.71**	**2.73**	**1.65**	**1.32**	**1.76**

[a] As previously noted, food and soil PCDD/PCDFs concentrations are expressed as (pg. TEQ – WHO/g soil or food) while air concentration data were expressed using international TEQ (I-TEQ). The TEQ type for water was not reported by CCME, (2000).
[b] The EDI (pg TEQ/kg bw/day) for the other environmental media (soil, air, water and consumer products) is for dioxins and furans only.
[c] The EDI (pg TEQ/kg bw/day) for food includes dioxins, furans and dioxin like PCBs
ND – Not Determined

The studies used to estimate historical levels of dioxins, furans and dioxin-like PCBs in Canadian environmental media were conducted between 1990 and the present day. This is partially due to the low detection limits required to detect these particular contaminants. In air for instance, the detection limits (pg/m^3) required to detect dioxin-like compounds were not achieved until the mid 1980s. Therefore, the background PCDD/PCDF concentrations in environmental media (air, water, soil and consumer products) utilized to establish the Canadian current and historical EDI rates are representative of concentrations in environmental media between 1990 and present day. However, the historical EDI rates for dioxin-like compounds determined above (Table C1-11) are considered representative of historical exposures as in several instances, historical data from the early 1980s are consistent with the selected background environmental media concentrations. However, the majority (~95 to 97%) of exposure to Dixon-like chemicals for Canadians occurs through food consumption. Therefore, even large changes (ten-fold) in environmental media dioxin, furan or dioxin-like PCB concentrations will not have a significant effect on the Canadian EDI rate.

A comparison to other exposure studies conducted for Canadian populations support the selection of the historical EDI value (see Section 6.1).

C1-5.2 Current Canadian EDI

A current average lifetime daily intake rate of dioxin-like compounds of 0.905 pg TEQ/kg bw/day was approximated as presented in Table C1-12. This value was utilized as the current lifetime EDI rate in this report for risk assessment purposes.

Table C1-12 Current Canadian EDI Rates for PCDD/PCDFs and Dioxin-like PCBs (pg TEQ/kg bw/day)

Environmental Media	Estimated Average Daily Intake (pg TEQ/kg bw/day)[a]
Soil [b]	0.003
Air [b]	0.010
Water [b]	0.001
Consumer Products [b]	0.011
Food [c]	**0.88**
TOTAL	**0.905**

[a] As previously noted, food and soil PCDD/PCDFs concentrations are expressed as (pg. TEQ – WHO/g soil or food) while air concentration data were expressed using international TEQ (I-TEQ). The TEQ type for water was not reported by CCME, (2000).
[b] The EDI (pg TEQ/kg bw/day) for the other environmental media (soil, air, water and consumer products) is for dioxins and furans only.
[c] The EDI (pg TEQ/kg bw/day) for food includes dioxins, furans and dioxin like PCBS

The EDI rates provided in Tables C1-12 and 13 appear to be similar to other studies presented by the CCME (2000) and Schaum *et al*. (1994). Schaum *et al*. (1994) reported an average daily background exposure to PCDD/PCDFs in the U.S population of 1.7 pg/kg bw/day for a 70 kg adult. This value has since been updated to a much lower EDI of 0.94 pg/kg bw/day (U.S. EPA, 2003).

C1-6.0 OTHER STUDIES

C1-6.1 Previous Canadian Exposure Assessments

A Federal-Ontario study estimated the total exposure of Canadians to dioxin and furans from all environmental pathways (Birmingham *et al*., 1989a). This study determined an EDI for adults of 0.56 to 2.1 pg TEQ/kg bw/day (Table C1-13). All of the data utilized to establish background dioxin and furan concentrations in environmental media were from the early to mid-1980s.

Table C1-13 Estimates of Canadian Intake of Dioxins and Furans (Birmingham *et al*., 1989a)

Substrate/Medium	Estimated Intake (pg TEQ/kg bw/day)			
	Adult[a]	Child[b]	Infant[c]	Neonate[d]
Food	0.49[e] to 2.0[f]	1.18[e] to 4.78[f]	2.6[e] to 10.7[f]	165
Air	0.04	0.07	0.1	0.04
Soil	0.01	0.027 to 0.03	0.34 to 0.038	-
Water	<0.01 to 0.05	<0.01 to 0.07	<0.002 to 0.11	-
Consumer Products[g]	<0.01	<0.01	<0.01	<0.01
Total Estimated Intake	0.56 to 2.1	1.3 to 5.0	3.1 to 11.0	165

[a] Adult differ, slightly from quoted reference due to small difference, in calculations and an assumed body weight of 70 kilograms.
[b] Child: Weighs 33 kilograms; Breathes 15m3 air: Intake 1 litre water, 0.02 gm soil, 113% of adult food.
[c] Infant: Weighs 13 kilograms; Breathes l0 m3 air: Intake 0.6 litre water, 0.1 gm soil, 100% of adult food.
[d] Neonate: Weighs 5 kilograms; Breathes l m3 air: Intake 750 millilitres, 3% fat breast milk containing 36.5 picograms toxic equivalents per gram of fat
[e] Lower end of all ranges assumes a reported Not Detectable = 0.
[f] Upper end of all ranges assumes a reported Not Detectable = Limit of Detection.
[g] Does not include intake from cigarette smoking.

A second study by Birmingham *et al*. (1989b) investigated the dietary intake of PCDD and PCDF from food in Ontario, Canada. Twenty-five (25) composite samples were analyzed from ten food classes including meats, eggs, mil, fruit and vegetables including both local and imported goods. The majority of samples were analyzed using low resolution mass spectrometry (LRMS) analysis; however, some samples were pooled and analyzed by high resolution mass spectrometry (HRMS) at the Ontario Dioxin Facility to confirm the LRMS results (Birmingham *et al*., 1989b). The calculated daily intake of PCDD and PCDF through residues in food was 1.31 pg/TEQ_{DF}-WHO/kg bw/day (Table C1-14). It was concluded that food intake is the largest human exposure pathway for PCDD and PCDF, accounting for 95% of total exposure.

Table C1-14 Calculated Daily Intakes of PCDDs and PCDFs in Ontario, *via* Residues in Food[a]

Food Group	Daily Consumption (g/person/day) whole weight[b]	Daily Intake (pg TEQ/kg bw/day)[c]
Beef	55.8	0.23
Pork	19	0.009
Poultry	20	0.11
Eggs	29	0.24
Milk Products	444	0.70
Fruit	190	0.011
Vegtables	220	0.006
Wheat Based Products	125	0.001
Total		**1.31**

[a] Modified from Birmingham *et al.*, 1989b
[b] Nutrition Canada, 1977
[c] Daily intakes were determined using a body weight of 70 kg.

C1-6.2 U.S. EPA

The National Center for Environmental Assessment (U.S. EPA, 2003) estimated background exposures to PCDD/PCDFs and dioxin-like PCBs in North America using (1) the arithmetic mean TEQ-WHO_{98} levels in environmental media and food (Table C1-15); (2) the standard contact rates for ingestion of soil, water, and food, and inhalation of ambient air; and (3) the appropriate unit conversion factors. The general equation used to estimate background exposures is as follows:

$$\text{Intake (pg WHO98} - \text{TEQ/kg} - \text{day)} = \frac{\text{Daily Contact Rate x Concentration x Unit Conversion Factors}}{\text{Body Weight}}$$

Adult daily intakes of PCDD/PCDFs and dioxin-like PCBs are estimated to average 0.61 and 0.33 pg TEQ-WHO_{98} /kg bw/day, respectively, for a total intake of 0.94 pg/ TEQ/kg bw/day . For PCDD/PCDFs alone, daily intakes are estimated to be 0.61 pg TEQ/kg bw/day. Daily intake is estimated by combining exposure media concentrations (food, soil, and air) with contact rates (ingestion, inhalation). Media concentrations, contact rates and resulting intake estimates are summarized in Table C1-15. This value has dramatically decreased, as the previously reported EDI for dioxins and furans was 1.7 pg TEQ/kg bw/day (U.S. EPA, 2003).

The intake estimate is supported by an extensive database on food consumption rates and estimates of dioxin-like compounds in food (U.S. EPA, 2003). Pharmacokinetic modeling provides further support for the intake estimates. Applying a simple steady-state pharmacokinetic model to an adult with an average blood level of 25 ppt $TEQ\text{-}WHO_{98}$ (on a lipid basis) yields a daily intake of 2.09 pg TEQ/kg bw/day) (assumes TEQ has an effective half-life of 7.1 years, 80% of ingested dioxin is absorbed into the body, and lipid weight is 25% of the adult assumed body weight of 70 kg, or 17.5 kg). This modeled PCDD/PCDF/PCB intake estimate is 2.2 times higher than the direct intake estimate of 0.94 pg $TEQ\text{-}WHO_{98}$/kg bw/day. This difference is to be expected with this application of a simple steady-state pharmacokinetic model to current average adipose tissue concentrations. Current adult tissue levels reflect intakes from past exposure levels, which are thought to be higher than current levels. Because the direction and magnitude of the difference in intake estimates between the two approaches are understood, the pharmacokinetic derived value is judged supportive of the pathway-derived estimate. It should be recognized, however, that the pathway-derived value will underestimate exposure if it has failed to capture all the significant exposure pathways (U.S. EPA, 2003).

Table C1-15 Adult Contact Rates and Background Intake of Dioxin-like Compounds (from U.S. EPA, 2003)

Exposure Rate	Contact Rate	Dioxin and Furans		Dioxin-like PCBs		Total Intake (pg $TEQ_{DEP\text{-}}$ WHO_{98}/kg-d
		Concentration $TEQ_{DF}\text{-}WHO_{98}$	Intake (pg TEQ_{DF}- WHO_{98}/kg-d	Concentration $TEQ_{DF}\text{-}WHO_{98}$	Intake (pg $TEQ_{p\text{-}}$ WHO_{98}/kg-d	
Soil ingestion	50 mg/d	9.3 p/g	0.0066	2.3 ppt	0.0016	0.0082
Soil dermal	12 g/d	9.3 pg/g	0.0016	2.3 ppt	0.00039	0.002
Freshwater fish and shellfish[a]	5.9 g/d	1.0 pg/g	0.084	1.2 pg/g	0.1	0.18
Marine fish and shellfish[a]	9.6 g/d	0.26 pg/g	0.036	0.25 pg/g	0.034	0.07
Inhalation	13.3 m^3/d	0.12 pg/m^3	0.023	NA	NA	0.023
Milk	175 g/d	0.018 pg/g	0.045	0.0088 pg/g	0.022	0.067
Dairy	55 g/d	0.12	0.094	0.058 pg/g	0.046	0.14
Eggs	0.024 g/kg-d	0.081 pg/g	0.019	0.10 pg/g	0.024	0.043
Beef	0.67 g/kg-d	0.18 pg/g	0.13	0.084 pg/g	0.06	0.19
Pork	0.22 g/kg-d	0.28 pg/g	0.062	0.012 pg/g	0.0026	0.065
Poultry	0.5 g/kg-d	0.068 pg/g	0.034	0.026 pg/g	0.013	0.047
Other meats	0.35 g/kg-d	0.18 ppt	0.062	0.041 pg/g	0.014	0.076
Vegetable fat	17 g/d	0.056 pg/g	0.014	0.037	0.009	0.023
Water	1.4 L/d	0.0005 pg/L	0.000011	NA	NA	0.000011
Total			**0.61 (43 pg/d)**		**0.33 (23 pg/d)**	**0.94 (6 pg/d)**

[a] The TEQ_{DF} fish concentrations reported here are species-specific ingestion rate weighted averages.

Table C1-16 Variability in Average Daily Toxic Equivalent (TEQ) Intake as a Function of age (from U.S. EPA, 2003)

Age range	Intake, mass basis pg TEQ_{DEF}-WHO_{98}/d	Body Weight (kg)	Intake, body weight basis pg TEQ_{DEF}- WHO_{98}/kgd
1-5 years	50	15	3.3
6-11 years	54	30	1.8
12-19 years	61	55	1.1
Adult	66	70	0.9

The historical estimated dioxin and furan daily intake (pg TEQ/kg bw/day) for the North American population estimated by the U.S. EPA in 1994 is significantly greater than the current EDI (Table C1-17).

Table C1-17 Comparison of Adult Contact Rates, TEQ_{DF} Concentrations, and background Exposure Estimates from the 1994 Draft and Current Version of the U.S. EPA (2003) Dioxin Assessment Document

Media	Previous I-TEQ_{DF} Concentration	Current TEQ_{DF} - WHO_{98} Concentration	Previous Contact Rate	Current Contact Rate	Previous Daily Intake Rate (pg/kg-day)	Current Daily Intake Rate (pg/kg-day)
Soil Ingestion	8.0 ppt[a]	9.3 ppt[b]	100 mg/day	50 mg/day	$1.1x10^{-2}$	$6.6x10^{-3}$
Soil Dermal Contact	--	9.3 ppt	--	12 mg/day	--	$1.6x10^{-3}$
Freshwater Fish and Shellfish Ingestion	1.2 ppt	1.0 ppt[c]	6.4 g/day	5.9 g/day	$1.1x10^{-1}$	$8.4x10^{-2}$
Marine Fish and Shellfish Ingestion	--	0.26 ppt[c]	--	9.6 g/day	--	$3.6x10^{-2}$
Inhalation	0.095 pg/m^2	0.12 pg/m^3	23 m^2/day	13.3 m^3/day	$3.1x10^{-2}$	$2.3x10^{-2}$
Water Ingestion	0.0056 ppq	0.00056 ppq	1.4 L/day	1.4 L/day	$1.1x10^{-1}$	$1.1x10^{-5}$
Milk Ingestion	0.7 ppt	0.016 ppt	251 g/day	175 g/day	$2.5x10^{-1}$	$4.5x10^{-2}$
Dairy Ingestion	0.36 ppt	0.12 ppt	67 g/day	55 g/day	$3.4x10^{-1}$	$9.4x10^{-2}$
Eggs Ingestion	0.14 ppt	0.081 ppt	29 g/day	0.24 g/kg/day	$5.8x10^{-2}$	$1.9x10^{-2}$
Beef Ingestion	0.48 ppt	0.18 ppt	77 g/day	0.71 g/kg/day	$5.3x10^{-1}$	$1.3x10^{-1}$
Pork Ingestion	0.26 ppt	0.28 ppt	47 g/day	0.22 g/kg/day	$1.7x10^{-1}$	$6.2x10^{-2}$
Poultry Ingestion	0.19 ppt	0.068 ppt	68 g/day	0.50 g/kg/day	$1.8x10^{-1}$	$3.4x10^{-2}$
Other Meat Ingestion	--	0.18 ppt	--	0.35 g/kg/day	--	$6.2x10^{-2}$
Vegetable Ingestion	--	0.056 ppt	--	17 g/day	--	$1.4x10^{-2}$
TOTAL	**--**	**--**	**--**	**--**	**$1.7x10^{0}$ (119 pg/day)**	**$6.1x10^{-1}$ (43 pg/day)**

Adapted from U.S. EPA, 2003

[a] Rural/pristine background sites

[b] Urban background sites

[c] This concentration is a species-specific ingestion-weighted average value

From the analysis of historical samples of environmental media and foods, it appears that the levels of dioxin-like compounds have increased in the environment starting from the 1930s through to the 1960s (U.S. EPA, 2003). Loadings began to decline starting in the 1970s and have continued to the present. Body burden data and recent evidence on animal food products in the U.S. provide evidence that human exposures to dioxins may have followed the same trends.

C1-6.3 European EDI Estimates

For Europe, total TEQ_{DF} exposure estimates range from 1.13 pg/kg bw/day to 2.26 pg/kg bw/day (U.S. EPA, 2003). In 1997 estimated exposures from the UK Total Diet Study resulted in an average intake value of 1.8 and 4.6 TEQ/kg bw/day for adults and toddlers, respectively (Food Standards Agency, 2000).

C1-6.4 Other Studies

Lorber (2002) indicates, based on dioxin analysis of carbon-dated sediment cores of lakes and rivers, preserved meat samples and limited body burden measurements of dioxin-like chemicals that exposure of Americans to dioxin-like compounds increased during the 1940s and 1950s, reached a peak in the 1960s and 1970s and decreased to lower levels in the 1980s and 1990s. Lorber (2002) modeled TEQs concentration as PCDDs and PCDFs only, as dioxin-like PCBs are not included in body burden concentrations. Unlike early modeling efforts by Pinsky and Lorber (1998) this model calibrated the temporally varying dose and the rate of dissipation of TEQs from the body, and modeled TEQs as through it were a single compound. The calibrated TEQ intake dose over the past century was determined using an established early and late century TEQ dose of 0.50 pg TEQ/kg bw/day (Figure C1-4). The model suggests that peak TEQ doses in the 1960s and 1970s were above 6.0 pg TEQ/kg bw/day, which is 10 times higher than the current North American exposure estimate of 0.61 pg TEQ/kg bw/day (U.S. EPA, 2003). Lorber (2002) also predicted adult population body concentrations of TEQs (Figure C1-5). Modeled values match measured population body concentrations.

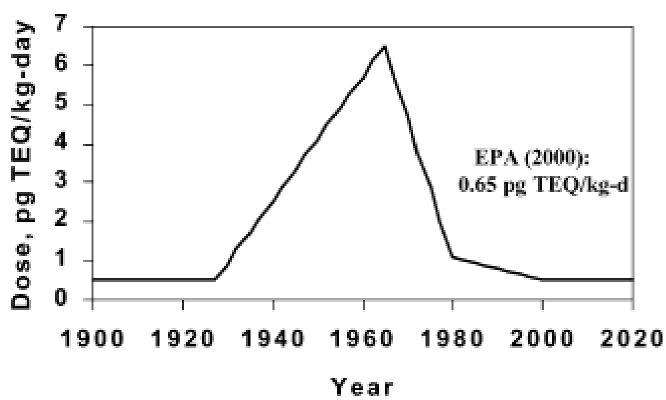

Figure C1-4 Calibrated TEQ intake dose function (Lorber, 2002)

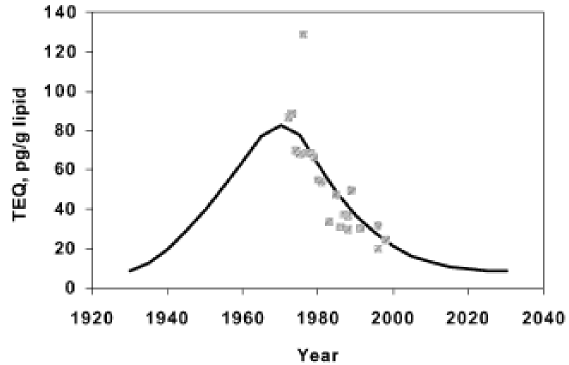

Figure C1-5 Predicted adult population body concentrations of TEQs pg/g lipid (solid lines) compared against measured population body concentrations of TEQs, pg/g lipid (squares) (Lorber, 2002)

Aylward and Hays (2002) utilized a simple one-compartment pharmacokinetic model to develop a range of TCDD doses for historical, current and future exposures. A simple first-order elimination process was utilized, with a half-life of 7.5 years. The initial body-burden in 1972 was set to correspond to a lipid-adjusted level of 20 ppt in a 70 kg person based on historical data collected from the 1970s. The initial intake rate of 1.3 pg TCDD/kg bw/day was utilized in order to achieve the desired serum lipid level (20 ppt) after an extended period of intake. Modeling indicates that the observed temporal decreases in TCDD lipid levels are consistent with intake functions that rapidly decrease to less than 5% of the 1970 intake levels before 1980, with continuing low-level exposure (Figure C1-6). The model predicts an average daily intake of 0.04 pg TCDD/kg bw/day or less for the year 2000. If TCDD accounts for 10% of the TEQ intake of dioxins and furans, as if often the case, this estimate of 0.04 pg TCDD,kg bw/day is less than the U.S. EPA (2003) and above derived Canadian EDI rate of 0.061 and 0.090 pg TCDD/kg bw/day.

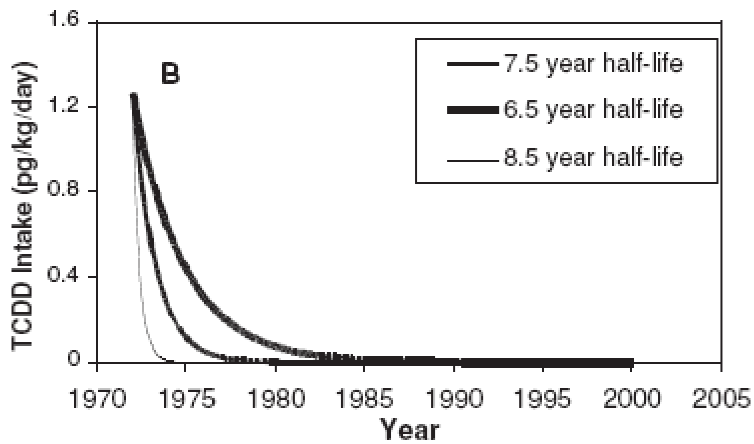

Figure C1-6 Exponential decline function for intake producing the best fit of predicted lipid-adjusted TCDD levels *versus* measured lipid-adjusted TCDD levels for elimination half lives of 6.5, 7.5 and 8.5 years (Aylward and Hays, 2002)

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C2: ESTIMATED DAILY INTAKE - HEXACHLOROBENZENE

C2-1.0 HEXACHLOROBENZENE (HCB) EDI

Health Canada Total Diet Study

The Total Diet study conducted by Health Canada collected food samples from eights cities over a period of 8 years (1992 to 1999)(Cao *et al*., 2005). This provided a comprehensive database of concentrations of HCB in food across Canada. Dietary intakes of HCB residues were calculated for different age-sex groups based on the food intake from the National Food Survey (Table C2-1).

Table C2-1 The Cities Examined in the Total Diet Study Between 1992 and 1999 (Cao *et al*., 2005)

City	Sample period
Toronto	1992 and 1996
Montreal	1993
Halifax	1994
Winnipeg	1994
Vancouver	1995
Ottawa	1995
Whitehorse	1998
Calgary	1999

The lifetime average dietary intake of HCB for all ages and sexes of Canadians is 0.10 ng/kg bw/day. The arithmetic mean for individual receptor groups were calculated based on data provided by Cao *et al*. (2005) (Table C2-2).

Table C2-2 Estimated Dietary Intakes of Hexachlorobenzene (ng/kg bw/day) for the Canadian General Population (Adapted from Cao *et al*., 2005)

Medium	Infant	Toddler	Child	Teen	Adult	Lifetime Receptor[c]
	0-6 mo	7 mo-4 yrs	5-11 yrs	12-19 yrs	20+ yrs	
Food	0.05[a]	0.11[a]	0.22	0.14[b]	0.08[a,b]	0.10

[a] Airthmetic mean calculated using data provided by Cao *et al.* (2005)
[b] Arithmetic mean of male and female intake rates provided by Cao *et al*. (2005)
[c] Lifetime Receptor is a weighted average of individual receptor groups

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The mean daily intakes of HCB were determined using the most representative concentrations of HCB in air, water, food and soil, along with standard values for body weights and intakes of these environmental media.

Table C2-3 Estimated Intakes of Hexachlorobenzene (ng/kg bw/day) for the Canadian General Population (verbatim from CEPA, 1993)

Medium	Infant 0-6 mo	Toddler 7 mo-4 yrs	Child 5-11 yrs	Teen 12-19 yrs	Adult 20+ yrs	Lifetime Receptor
Air[a]	0.04	0.06	0.07	0.06	0.05	--
Drinking water[b]	0	0.006	0.003	0.002	0.002	--
Soil[c]	0.004	0.003	0.001	0.0003	0.0002	--
Food[e]	214.3[d]	17.7	9.8	4.8	2.7	--
TOTAL[f]	214.3	17.8	9.9	4.8	2.8	6.2

[a] Intakes *via* air based on mean airborne concentrations (0.15 ng/m^3) reported by Environment Canada (1990; 1991) for both Walpole Island and Windsor sites; in absence of data on indoor air, assumed equal to ambient

[b] Intakes *via* drinking water based on mean concentration (0.1 ng/L) for three Lake Ontario cities reported by Oliver and Nicol (1982)

[c] Intakes *via* soil based on levels in B.C. agricultural soils treated 10-15 years prior with HCB cereal seed treatments (Wilson and Wan, 1982). Estimated mean soil concentration is 0.8 ng/g (assume mean concentration in soils with detectable HCB (6/24) is as midpoint of reported range (1.75 ng/g), and sites with no detectable HCB had mean concentration of one-half of the EOD of 1 ng/g, or 0.5 ng/g)

[d] Assumed that infant is exclusively breast-.fed for first six months. Drinking water intake is assumed to be zero. as "exclusively breast-fed infants do not require supplementary liquids". Estimated intake *via* breast milk based on mean HCB concentration from 1982 Health and Welfare Canada survey (2 ppb, whole milk basis; Mes *et al*., 1986), breast milk consumption of 750 ml per day and body weight of 7 kg

[e] Intakes *via* food estimated based on the concentrations of HCB reported by Davies (1988) for 2% milk (0.16 ng/g), fresh meat and eggs (0.17 ng/g), leafy above-ground vegetables (0.02 ng/g), root vegetables (0.04 ng/g), and fruit (0.005 ng/g = one-half LOD); by Gunderson (undated) for cheese (0.90 ng/g), cottage cheese (0.10 ng/g), processed cheddar (0.70 ng/g), butter (2.40), marine fish (0.20 ng/g), peanuts and peanut butter (3.10 ng/g), canned fish, shellfish, soups, grain-based foods, foods primarily sugar, fats and oils (all ND, use 0.05 ng/g = one-half LOD); data for freshwater fish (1.10 ng/g) are average for all species monitored by Sport Fish Contaminant Monitoring Program (Cox, pers. comm.) from Crest Lakes other than Lake Ontario, and from several other major recreational Ontario lakes, assuming that ND are 0.5 ng/g (= one-half LOD). The concentration of HCB in each food has been multiplied by its consumption in the Nutrition Canada Survey (1977) for each age class (EHD, 1992).

[f] Total may not equal sum of medium-specific intakes, because of rounding off

Table C2-4 Receptor Characteristics

	0-6 month	7 mo-4 yrs	5 – 11yrs	12-19 yrs	20+ yrs	Reference
Body weight (kg)	7	13	27	57	70	EHD, 1992
Air intake (m^3 air)	2	5	12	21	23	EHD, 1992
Water intake (L)	0	0.8	0.9	1.3	1.5	EHD, 1992
Soil ingestion rate (mg/day)	35	50	35	20	20	EHD, 1992

Virtually the entire daily estimated intake of HCB by the Canadian general population is through food. Primarily through such dairy products as milk, butter and ice cream, and fresh meat, eggs, and peanuts to a lesser extent (CEPA, 1993). However, it must be noted that the monitoring data on which the estimated intakes are based upon are relatively limited. In particular, the intakes through most dairy products have been derived from levels of HCB in milk from a single study, and data on the remaining dairy products are from the U.S. Total Diet Study. Despite this, the adult dietary intake rate established by Environment Canada using Canadian data is similar to the mean dietary intake reported for Japan, UK and USA (2 to 4 ng/kg bw/day) by WHO (1985) during the review of 1980 to 1983 data from the WHO/FAO Collaborating Centres for Food Monitoring (FAO, 1985). The estimated dietary intake for HCB utilized by CEPA (1993) to establish the EDIs in 1993 are significantly greater than those values reported by the Total Diet Study conducted by Health Canada between 1992 to 1999.

Historical and Current Hexachlorobenzene EDI

Historical

The estimated intake rates of hexachlorobenzene (Table C2-5) calculated by CEPA (1993) were selected as the historical EDI rates to be utilized for historical reconstruction.

Current

Based on the EDI rates for HCB derived by CEPA (1993), exposure *via* the diet accounts for 96-100% of Canadian's daily HCB intake. Furthermore, according to the Environmental Health Criteria for HCB, the principal route of HCB exposure is through the diet (92%) (WHO, 1997). Air and water are estimated to contribute 7% and 1%, respectively, to daily intake rates (WHO, 1997). Therefore, in order to determine a current daily intake of HCB for the general population, dietary intake values determined by Health Canada from the Total Diet Study (1992 to 1999) were utilized (Cao *et al*., 2005) (Table C2-6).

Environmental media data provided by CEPA (1993) were used to calculate the current EDI rates based upon the low apportionment of HCB intake to environmental media by WHO (1997) and in the historical EDIs derived by CEPA (1993) (Table C2-5). A weighted average was calculated to determine the lifetime receptor exposure to HCB through soil, drinking water and soil. These values were selected as current EDI rates to be utilized for risk assessment purposes.

Table C2-5 Current Estimated Intakes of Hexachlorobenzene (ng/kg bw/day) for the Canadian General Population

Medium	Infant 0-6 mo	Toddler 7 mo-4 yrs	Child 5-11 yrs	Teen 12-19 yrs	Adult 20+ yrs	Lifetime Receptor
Air[a]	0.04	0.06	0.07	0.06	0.05	0.05[g]
Drinking water[b]	0	0.006	0.003	0.002	0.002	0.002[g]
Soil[c]	0.004	0.003	0.001	0.0003	0.0002	0.0005[g]
Food	0.05[e]	0.11[e]	0.22	0.14[e,f]	0.08[e,f]	0.10
TOTAL[d]	**0.09**	**0.18**	**0.29**	**0.20**	**0.13**	**0.16**

[a] Intakes *via* air based on mean airborne concentrations (0.15 ng/m3) reported by Environment Canada (1990; 1991) for both Walpole Island and Windsor sites; in absence of data on indoor air, assumed equal to ambient

[b] Intakes *via* drinking water based on mean concentration (0.1 ng/L) for three Lake Ontario cities reported by Oliver and Nicol (1982)

[c] Intakes *via* soil based on levels in B.C. agricultural soils treated 10-15 years prior with HCB cereal seed treatments (Wilson and Wan, 1982). Estimated mean soil concentration is 0.8 ng/g (assume mean concentration in soils with detectable HCB (6/24) is as midpoint of reported range (1.75 ng/g), and sites with no detectable HCB had mean concentration of one-half of the EOD of 1 ng/g, or 0.5 ng/g)

[d] Total may not equal sum of medium-specific intakes, because of rounding off

[e] Arithmetic means calculated from data provided by Cao *et al*. (2005)

[f] Arithmetic mean of male and female intake rates provided by Cao *et al*. (2005)

[g] Weighted averages calculated from data provided by CEPA (1993)

Based on the significant decrease in dietary intake rates, it is likely that HCB concentrations in the environmental media have also significantly decreased within the past decade. Therefore, the current EDIs may be an overestimate of the actual daily intake experienced by the Canadian population. For instance, according to the apportionment of HCB intake as indicated by WHO (1997) or CEPA (1993), the current EDI for an adult receptor based on current dietary intake rates are 0.087 and 0.083 ng/kg bw/day, respectively, which is lower than that current estimate of 0.13 ng/kg bw/day).

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