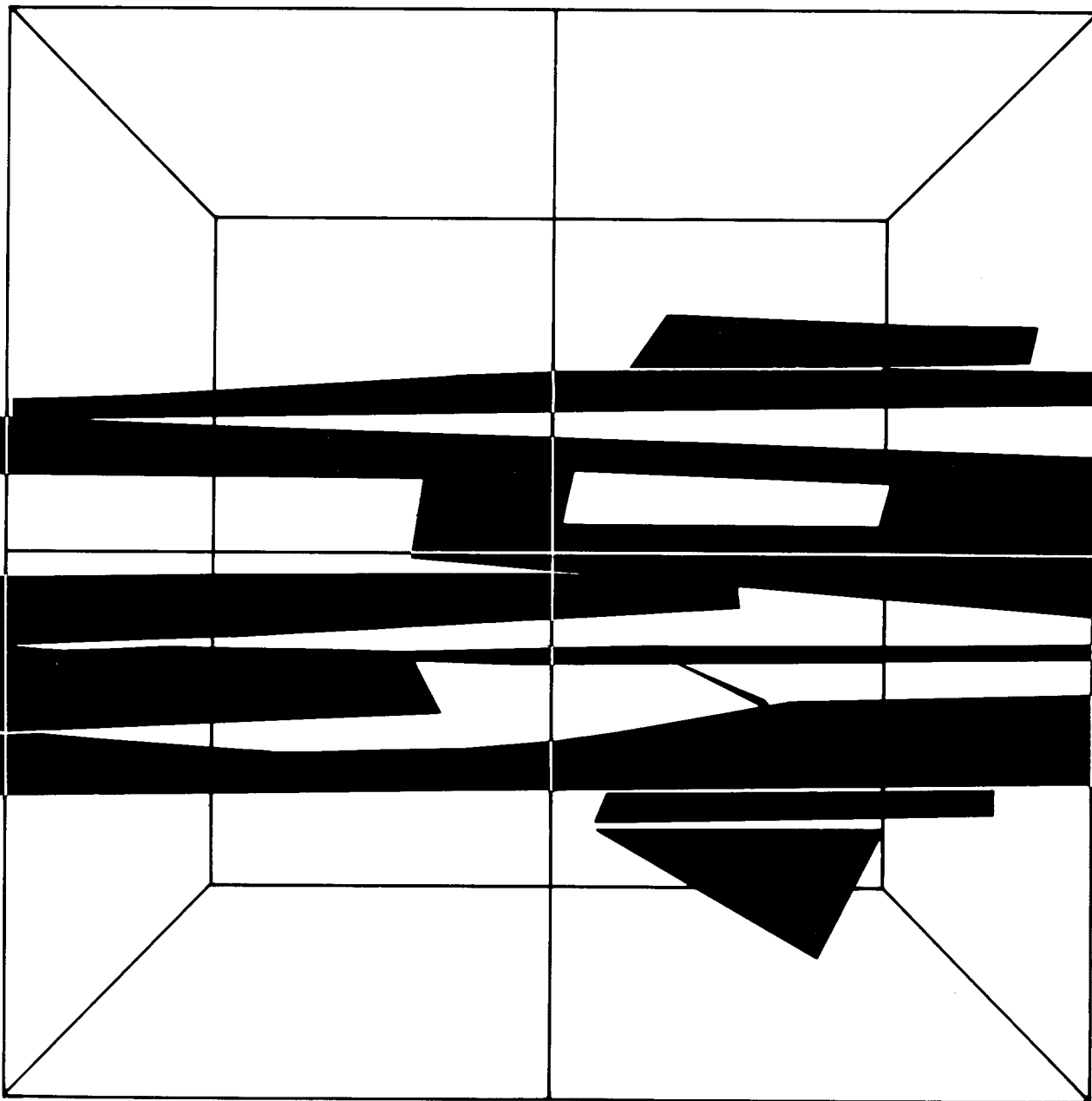


Summary of Environmental Criteria for Polychlorinated Biphenyls (PCBs)

Report EPS 4/HA/1
Revised Version
October 1987



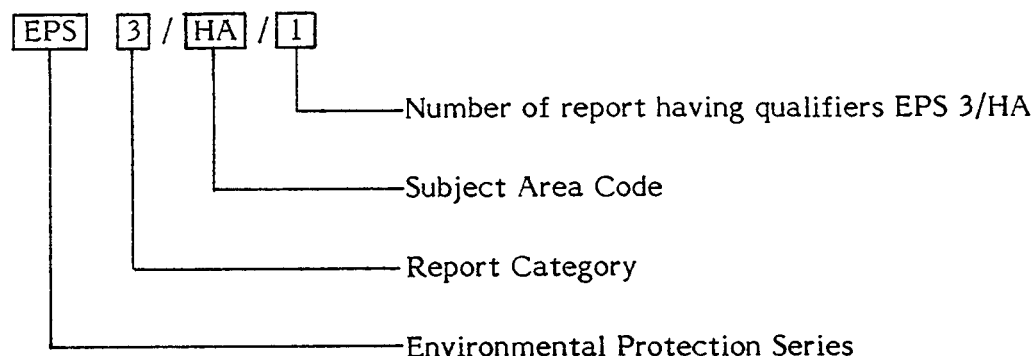
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**SUMMARY OF ENVIRONMENTAL CRITERIA FOR
POLYCHLORINATED BIPHENYLS (PCBs)**

Environmental Analysis Branch
Environmental Protection
Conservation and Protection
Environment Canada

Report EPS 4/HA/1
Revised Version
October 1987

READER COMMENTS

Readers who wish to comment on the content of this report should address their comments to:

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ABSTRACT

The tables in this report summarize the criteria for PCBs in various environmental media. The information was obtained from Canadian federal and provincial agencies, and from international agencies (i.e., USA, Netherlands, Japan). This information is by no means complete but has been gathered to provide government and industry personnel (and the public) with a basis for comparison of PCB levels reported and criteria employed in Canada.

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1 **STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT**

Information concerning such topics as regulations and guidelines for PCBs in the environment (air, water, soil, food, waste) has been gathered from the available literature, legislation, federal government departments, provincial offices, and Environment Canada Regional Offices. Information was sought on existing guidelines and regulations, and on guidelines and criteria which were being considered, developed, or used as internal "rules of thumb" for management decision-making.

The terms criterion, objective, guideline and standard have different meanings for different agencies. This was recognized early on in Canada's effort to compile and evaluate these for the purpose of establishing national water quality guidelines. Some examples of different definitions used in Canada are listed in the Appendix. In this report, no attempt has been made to standardize the terminology used by different agencies and some confusion may arise from direct comparison of the numerical values listed in Table 1. Therefore, it is recommended that the values in this document be used for general comparison only and that source documents be consulted before values are used for analytical or technical purposes.

Many of the provinces did not have their own specific guidelines, but had implemented, or were moving to implement federal guidelines and regulations (e.g., Chlorobiphenyl Regulations Nos. 2 and 3). The information obtained is summarized in Table 1, which also includes limited information from other countries for comparison.

The author hopes that readers will contact him to convey any additional information they may have to offer. In this way, revised versions may be distributed to inform the audience of progress in this area.

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Air - ambient	Ontario	35 ng/m ³ (1-yr av.) 150 ng/m ³ (24-h av.) 450 ng/m ³ (0.5-h av.)	1 (1984)	- ambient air quality criteria
	NY State	1.0 µg/m ³ (short-term max.)	2a (1984)	- recommended standard
Water - ambient	Manitoba	0.002 µg/L	13 (1979)	- ambient water quality objective
		0.014 µg/L	52 (1983)	- surface water quality objective to protect aquatic life and wildlife
	Ontario	0.001 µg/L	14 (1984) ^g	- ambient water quality objective for unfiltered sample
	Quebec	0.001 µg/L	2a (1984)	- ambient water quality objective
	IJC- Great Lakes	0.001 µg/L	15 (1977)	- water quality objective estimated to meet the recommended level in fish and aquatic life of 0.1 µg/g wet weight
	Canada - CCREM	0.001 µg/L	53 (1987)	- water quality guideline to protect freshwater aquatic life
	U.S. EPA	0.79 x 10 ⁻³ µg/L	16 (1980)	- water quality criteria for protection of human health (cancer risk 1:10 ⁵);
		0.079 x 10 ⁻³ µg/L	16 (1980)	- water quality criteria for protection of human health (cancer risk 1:10 ⁶);
		0.0079 x 10 ⁻³ µg/L	16 (1980)	- water quality criteria for protection of human health (cancer risk 1:10 ⁷)
	U.S. EPA	0.014 µg/L	16 (1980)	- water quality criteria for protection of freshwater aquatic life
	U.S. EPA	0.03 µg/L	16 (1980)	- saltwater quality criteria for protection of saltwater aquatic life
	Indiana	0.001 µg/L	50 (1985)	- water quality criteria for protection of aquatic life
	Ohio	0.001 µg/L	50 (1985)	- water quality criteria for protection of aquatic life
	Pennsylvania	0.001 µg/L	50 (1985)	- water quality criteria for protection of aquatic life
Water - recreational	Quebec	0.1 µg/L	2a (1984)	- recommended standard
	Indiana	0.001 µg/L	50 (1985)	
Water - drinking	Saskatchewan	undetectable	23	- desirable objective
		3 µg/L	23	- recommended maximum concentration
	Ontario	3 µg/L	18 (1983)	- recommended maximum concentration
	Quebec	0.1 µg/L	2a (1984)	- recommended standard
	Nova Scotia	3 µg/L	17a (1985)	- recommended maximum concentration
	U.S. EPA ^b	125 µg/L	19 (1981)	- 1-day EPA Suggested No Adverse Response Level (SNARL) for a child
		12.5 µg/L	19 (1981)	- 10-day EPA-SNARL for a child
	U.S. NAS	350 µg/L	19a (1981)	- 1-day NAS-SNARL for an adult
		50 µg/L	19a (1981)	- 7-day NAS-SNARL for an adult

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Sediment - dredge spoil	Ontario Great Lakes	0.05 mg/kg	49 ^a (1976)	- recommended criteria for disposal in open water of the Great Lakes
	Quebec	0.1 mg/kg	20 ^a (1982)	- recommended criteria for disposal in open water
	Canada	1 mg/kg	21	- administrative guideline for disposal in open marine waters
	Holland, Norway, Sweden	1 mg/kg	22 (1984)	- administrative guideline used by "Contracting Parties to Oslo Convention" for disposal in open marine waters
Sediment - quality objectives	British Columbia	0.03 mg/kg (dry wt. max.)	44 (1985)	- provisional quality objective for the Fraser River sub-basin from Kanaka Creek to mouth
Soil	Quebec	>5 mg/kg	37	- level considered to be contaminated
	Quebec	≤ 1 mg/kg	24 (1984)	- recommended target level for cleanup
	Saskatchewan	<5 mg/kg	23	- target level for cleanup
	U.S. EPA	<1 mg/kg	45 (1987)	- TSCA regulation for cleanup of low-concentration spills of <1 lb PCBs
		≤ 25 ppm or ≤ 50 ppm + notice	45 (1987)	- TSCA regulation for cleanup of high-concentration spill or low-concentration spill of 1 lb or more PCBs in outdoor electrical substation
		≤ 25 ppm		- TSCA regulation for cleanup of high-concentration spill or low-concentration spill of 1 lb or more PCBs in restricted access areas
		≤ 10 ppm + excavation of top 10 inches; ≤ 1 ppm for replacement soil	45 (1987)	- TSCA regulation for cleanup of high-concentration spill or spill of 1 lb or more PCBs in non-restricted access areas
	Holland	1 mg/kg	46 (1983)	- guideline for further investigation of contamination
		10 mg/kg 1 to 5 mg/kg	46 (1983) 47	- guideline for urgent remediation target level for cleanup of residential areas
	France	1 mg/kg	47	- guideline for further investigation
		5 mg/kg	47	- guideline for remediation
		10 mg/kg	47	- guideline for urgent remediation
Solid surface contamination - levels for cleanup	Quebec	2.5 mg/m ² (Askarel 1242) 1.25 mg/m ² (Askarel 1254, 1260)	36 (1985)	- to be regulated under the Dangerous Waste Regulations
	U.S. EPA	≤ 10 µg/100 cm	45(1987)	- TSCA regulation after low-concentration spill of <1 lb PCBs
		≤ 100 µg/100 cm	45(1987)	- TSCA regulation for outdoor electrical substation after high-concentration spill or low-concentration spill of 1 lb or more of PCBs

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Solid surface contamination - levels for cleanup	U.S. EPA (cont'd)	$\leq 10 \mu\text{g}/100 \text{ cm}$	45 (1987)	- TSCA regulation for high contact surface in restricted access area after high-concentration spill or low-concentration spill of 1 lb or more of PCBs
		$\leq 10 \mu\text{g}/100 \text{ cm}$	45 (1987)	- TSCA regulation for low contact indoor impervious surface in restricted access area after high-concentration spill or low-concentration spill of 1 lb or more of PCBs
		$\leq 10 \mu\text{g}/100 \text{ cm}$ or $\leq 100 \mu\text{g}/100 \text{ cm}$ + encapsulation	45 (1987)	- TSCA regulation for low contact indoor nonimpervious surface in restricted access area after high-concentration spill or low-concentration spill of 1 lb or more of PCBs
		$\leq 100 \mu\text{g}/100 \text{ cm}$	45 (1987)	- TSCA regulation for low contact outdoor surface in restricted access area after high-concentration spill or low concentration spill of 1 lb or more of PCBs
		$< 10 \mu\text{g}/100 \text{ cm}$	45 (1987)	- TSCA regulation for indoor or high-access outdoor surface in non-restricted area after high-concentration spill or low-concentration spill of 1 lb or more of PCBs
		$< 10 \mu\text{g}/100 \text{ cm}$ or $\leq 100 \mu\text{g}/100 \text{ cm}$ + encapsulation	45 (1987)	- TSCA regulation for indoor vault area or outdoor low-contact impervious surface after high-concentration spill or low-concentration spill of 1 lb or more of PCBs
Solid waste - sludge	U.S. FDA	$> 10 \text{ mg/kg}$ (dry wt.)	25 (1983)	- Resource Conservation and Recovery Act regulated restrictions for application to agricultural land
Solid waste - considered hazardous	Canada	$\geq 50 \text{ mg/kg}$	26 (1982)	- guideline for management of PCB wastes
	Quebec	$> 50 \text{ mg/kg}$ (or leachate $> 10 \mu\text{g/L}$)	36 (1985)	- considered hazardous and must be decontaminated or destroyed
		$< 15 \text{ mg/kg}$ (or leachate $< 5 \mu\text{g/L}$)	36 (1985)	- disposal permitted in sanitary landfill
		15 to 50 mg/kg (or leachate 5 to 10 $\mu\text{g/L}$)	36 (1985)	- disposal in secure landfill
	Alberta	$\geq 50 \text{ mg/kg}$	43 (1985)	- regulated under the Alberta Hazardous Waste Regulations
Liquid waste - considered hazardous	Canada	$\geq 50 \text{ mg/kg}$	26 (1982)	- guideline for management of PCB wastes
	Quebec	$\geq 0.3 \text{ mg/kg}$	36 (1985)	- considered dangerous waste under Quebec's Dangerous Waste Regulations
	Alberta	$\geq 50 \text{ mg/kg}$	43 (1985)	- regulated under the Alberta Hazardous Waste Regulations
Liquid waste - maximum concentration of PCBs in effluents	Canada	50 mg/kg	27 (1985)	- regulated under the ECA
	Ontario	5 $\mu\text{g/L}$	10 (1985)	- recommended by commission as standard for effluents from mobile destruction facilities

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Liquid waste - maximum level in oil applied to roads	Canada	5 mg/kg	27 (1985)	- regulated under the ECA
	Quebec	0 mg/kg	37	- road oiling to be discontinued; to be regulated under Dangerous Waste Regulations
	Ontario	5 mg/kg	42	- adopted federal guidelines
Liquid waste - permitted loss during storage	Canada	1 g/d per piece of equipment	27 (1985)	- regulated under the ECA
Food - (max.) tolerance levels				
- fish	IJC	0.1 µg/g (whole body)	15 (1977)	- recommendation for the protection of fish-eating birds and animals
- fish	Ontario	2 µg/g (edible portion)	28 (1985)	- adopted federal guideline for commercial fishing and as a guideline for sport fish
- fish	British Columbia	0.5 µg/g (wet weight) (max. in fish muscle)	44 (1985)	- provisional objective for PCBs in fish muscle for the Fraser River sub-basin from Kanaka Creek to the mouth.
- fish	Canada	2 µg/g (edible portion)	51 (1975)	- NHW/DFO/provincial fisheries - commercial fishing restriction in regions where guideline is expected to be exceeded based on fish monitoring data
- fish/shellfish	U.S. FDA	2 µg/g (edible portion)	32 (1984)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- fish	NY State	3.0 µg/g	38	- average contamination level for a collection of sport fish - used as a guideline to assess the need for a health advisory
- fish	Japan	3 µg/g 0.5 µg/g	40	- guideline for inshore fish - guideline for offshore fish
- fish meal, and other animal-produced feeds	Japan	5.0 µg/g	40	
- fish (and fish products)	Switzerland	1 µg/g (edible portion)	41 (1983)	- provisional as of Jan. 1/81
- fish, crustaceans molluscs and parts thereof (unprocessed)	Sweden	2.0 µg/g	41 (1983)	- in force since July, 1980
- fish liver, salmon	Sweden	5.0 µg/g	41 (1983)	- in force since July, 1980
- milk/dairy products	Canada	0.2 mg/kg (fat basis)	29a (1983)	- administrative guideline established by Health and Welfare Canada
- milk/dairy products	U.S. FDA	1.5 mg/kg (fat basis)	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Food - (max.) tolerance levels (cont'd)				
- milk	Japan	0.1 mg/kg	40	
- dairy products	Japan	1.0 mg/kg	40	
- powdered milk for infants	Japan	0.2 mg/kg	40	
- human milk	Japan	0.033 mg/kg (mean)	40	
- eggs	Canada	0.1 mg/kg (whole less shell)	29a (1983)	- administrative guideline established by Health and Welfare Canada
- poultry	Canada	0.5 mg/kg (fat basis)	29a (1983)	- administrative guideline established by Health and Welfare Canada
- eggs	U.S. FDA	0.3 mg/kg	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- poultry	U.S. FDA	3.0 mg/kg (fat basis)	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- eggs	Japan	0.2 mg/kg	40	
- beef	Canada	0.2 mg/kg (fat basis)	29a (1983)	- administrative guideline established by Health and Welfare Canada
- red meat	U.S. FDA	3.0 mg/kg	31 (1981)	- action level set under the Federal Food, Drug and Cosmetic Act
- meat	Japan	0.5 mg/kg	40	
- infant/junior foods	U.S. FDA	0.2 mg/kg	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- animal feed component	Canada	2.0 mg/kg (fish oil)	29a (1983)	- administrative guideline established by Agriculture Canada for PCBs in fish oil destined for animal feed
- animal feed components	U.S. FDA	2.0 mg/kg	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- finished animal feed	U.S. FDA	0.2 mg/kg	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- compound feeds	Japan	0.5 mg/kg	40	
- paper food packaging material	U.S. FDA	10 mg/kg	30 (1981)	- tolerance level set under the Federal Food, Drug and Cosmetic Act
- containers and wrapping	Japan	5.0 mg/kg	40	

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Tolerable daily intake (TDI)	Canada	1 µg/kg body wt. per day	29a (1983)	- estimated daily "tolerable" exposure based on studies using Rhesus monkeys
	U.S. EPAC	3.0 µg/kg body wt. per day	33 (1983)	- estimated TDI - based on rat studies - safety factor of 100
		0.3 µg/kg body wt. per day	34 (1983)	- estimated TDI - based on rat studies - safety factor of 1000
	U.S. FDA	3.0 µg/kg body wt. per day	35 (1983)	- estimated TDI - based on rat studies
		2.5 µg/kg body wt. per day	35 (1983)	- estimated TDI - based on dog studies
		20 µg/kg body wt. per day ^d	35 (1983)	- estimated 50 day TDI - based on Yusho
		1.0 µg/kg body wt. per day ^d	35 (1983)	- estimated 22 month TDI - based on Yusho
Air - occupational	Canada	1 mg/m ³ over 8 h - 42% C1 ^e	3 (1980)	- regulated under the Canada Labour Code (adoption of ACGIH standard)
		2 mg/m ³ over 15 min. - 42% C1 ^e		
		0.5 mg/m ³ over 8 h - 54% C1 ^e		
		1 mg/m ³ over 15 min. - 54% C1 ^e		
	British Columbia	1 mg/m ³ over 8 h - 42% C1 ^e	4 (1982)	- adoption of ACGIH standard
		2 mg/m ³ over 15 min.		
		0.5 mg/m ³ over 8 h		
		1 mg/m ³ over 15 min. - 54% C1 ^e		
	Alberta	1 mg/m ³ over 8 h - 42% C1 ^e	5 (1983)	- adoption of ACGIH standard
		2 mg/m ³ over 15 min.		
		0.5 mg/m ³ over 8 h		
		1 mg/m ³ over 15 min. - 54% C1 ^e		
	Quebec	1 mg/m ³ over 8 h - 42% C1 ^e	6 (1982)	- adoption of ACGIH standard
		2 mg/m ³ over 15 min.		
		0.5 mg/m ³ over 8 h		
		1 mg/m ³ over 15 min. - 54% C1 ^e		
	New Brunswick	1 mg/m ³ over 8 h - 42% C1 ^e	7 (1980)	- adoption of ACGIH standard
		2 mg/m ³ over 15 min.		
		0.5 mg/m ³ over 8 h		
		1 mg/m ³ over 15 min. - 54% C1 ^e		

TABLE 1 SUMMARY OF STANDARDS, RECOMMENDATIONS, GUIDELINES, AND CRITERIA FOR PCBs IN THE ENVIRONMENT (Cont'd)

Environmental Medium	Region	Concentration	Reference	Notes/Comments
Air - occupational (cont'd)	Newfoundland	1 mg/m ³ over 8 h - 42% Cl ^e 2 mg/m ³ over 15 min. 0.5 mg/m ³ over 8 h 1 mg/m ³ over 15 min. - 54% Cl ^e	8 (1983)	- adoption of ACGIH standard
	Ontario	0.05 mg/m ³ (av. for 40-h work wk.)	9a (1984)	- recommended - Ministry of Labour;
		450 ng/m ³ (0.5 hour max.)	10 (1985)	- max. 1/2-h av. air concentration recommended by commission as standard for area surrounding mobile destruction facility
	U.S. ACGIH	1 mg/m ³ over 8 h - 42% Cl ^e 2 mg/m ³ over 15 min. 0.5 mg/m ³ over 8 h 1 mg/m ³ over 15 min. - 54% Cl ^e	11 (1984)	- regulated under the Occupational Safety and Health Act
	U.S. NIOSH	1 µg/m ³ (average over 40-h work week)	12 (1977)	- recommended by NIOSH for amendment of the Occ. Safety and Health Act
	West Germany	1.0 mg/m ³ (8-h av.) ^f - 42% Cl ^e 0.5 mg/m ³ (8-h av.) ^f - 54% Cl ^e	2a (1984)	
	East Germany	1.0 mg/m ³ (8-h av.) ^f	2a (1984)	
	Sweden	0.5 mg/m ³ (8-h av.) ^f	2a (1984)	
	Australia	1.0 mg/m ³ (8-h av.) ^f	2a (1984)	
	Czechoslovakia	1.0 mg/m ³ (8-h av.) ^f - 42% Cl ^e	2a (1984)	
		0.5 mg/m ³ (8-h av.) ^f - 54% Cl ^e		
	Romania	1.0 mg/m ³ (8-h av.) ^f - 42% Cl ^e 0.5 mg/m ³ (8-h av.) ^f - 54% Cl ^e	2a (1984)	
Air - occupational (cont'd)	Finland	1.0 mg/m ³ (8-h av.) ^f - 42% Cl ^e 0.5 mg/m ³ (8-h av.) ^f - 54% Cl ^e	2a (1984)	
	Japan	1.0 mg/m ³ at 25°C and 1 atm. (8-h av.) ^f	2a (1984)	

a These secondary references are cited because primary references were unavailable or unobtainable;

b The U.S. EPA has recently (1985) revised its assessment of PCBs and concluded that suitable data were not available upon which to estimate Suggested No Adverse Response Level (SNARL) (48);

c The U.S. EPA has recently revised its assessment of PCBs and concluded that suitable data were not available upon which to estimate a Tolerable Daily Intake (TDI) (U.S. EPA - pers. com.).

d Tolerable Daily Intake (TDI) values based on "Yusho" incident were calculated using an average total exposure level of 2000 mg/adult. This was later reduced to about 1/2 this value due to contamination of the PCB liquid with polychlorinated quaterphenyls and furans. The TDI values listed should be reduced by about 1/2 to reflect the intake of PCBs. Since furans and quaterphenyls were also present, estimate of a "no observed effect" level due solely to PCBs is impossible from this data.

e Weight percent of chlorine present in the PCB molecule.

f Duration of occupational exposure assumed by author based on similarity to ACGIH guidelines.

g The Ontario Ministry of Environment has designated PCBs as substances with a "zero tolerance limit", they are hazardous if released at any concentration (14).

2 RATIONALE FOR ESTABLISHMENT OF CRITERIA

Rationales used to develop or arrive at some of the more important environmental guidelines, criteria, and tolerances, are described in the following sections. Only a small number of the values given in Table 1 are discussed here. Different agencies use similar approaches in developing their guidelines, so that many of the following discussions can be considered general in nature.

2.1 Air - Ambient

The Ontario Ministry of the Environment has established an ambient air quality guideline for PCBs. In establishing this guideline, the carcinogenic potential (as demonstrated in feeding studies with rats and mice), and reproductive effects (studies with rhesus monkeys) were taken into consideration. An exposure criterion of 35 ng/m³ as an annual average ambient concentration, with a maximum 24-hour average of 150 ng/m³, and a maximum half hour average concentration of 450 ng/m³, was determined to represent a risk of 0.84 additional cancers per million individuals.

If the guidelines were calculated using the usual "no observable effect level - safety factor" approach, then these guidelines would probably be larger. It is assumed, therefore, that the guidelines for Ontario are conservative in terms of the estimate of protection of human and animal health in the environment (9).

2.2 Water - Ambient

2.2.1 Ontario. The Ontario Ministry of the Environment has established a desirable objective for PCBs of 1 ng/L in unfiltered water samples. This level is thought to be sufficient to prevent the biomagnification of PCBs in fish exceeding the 2 µg/g (ppm) wet weight, edible portion level (9) which was established by Health and Welfare Canada as an action level for the sale and export of fish for human consumption (51).

2.2.2 International Joint Commission (IJC). In 1974, the IJC recommended a concentration of total PCBs in fish tissue (whole fish, calculated on a wet weight basis) not exceeding 0.1 µg/g in order to protect fish-consuming birds and animals. This value was derived, in part, from studies on commercial ranch mink where the lowest dietary concentration observed to cause a deleterious biological effect (in this case interference with reproduction) was 0.64 µg/g (Aroclor 1254). Applying a safety factor of five gave the recommended level for fish (0.1 µg/g). This recommendation was designed to protect all consumers of aquatic life, including man. Using an estimated bioconcentration factor

of 1×10^5 , it was calculated that a water concentration of $<0.001 \mu\text{g/L}$ would be required to reach the recommended tissue level. This water concentration, however, was not put forth as a formal recommendation because it would be beyond the detection sensitivity of present routine analytical procedures and the bioconcentration factor used was only an estimate (15).

2.2.3 U.S. Environmental Protection Agency (EPA). The U.S. EPA has developed ambient water quality criteria for the protection of freshwater aquatic life, saltwater aquatic life, and human health (at specified increased incidences of cancer). For fresh- and saltwater aquatic life, the criteria are based on bioconcentration factors measured in laboratory studies. The criteria document suggests that these bioconcentration factors may underestimate those in the field by as much as ten times and, therefore, the criteria are "probably too high". It is recognized, however, that these criteria will likely protect aquatic life from acute effects. The criteria for fresh- and saltwater are $0.014 \mu\text{g/L}$ and $0.03 \mu\text{g/L}$, respectively.

For human health, an ambient water concentration of zero would provide maximum protection based on a non-threshold assumption for effects (cancer) of PCBs. This level may be unattainable; therefore, the EPA has determined the ambient water concentrations which would produce a specified increase in cancers. For consumption of 2 L/d of contaminated water and 6.5 g/d of fish taken from the contaminated water (a bioaccumulation factor of 31 200 was used), water quality criteria were 0.79 ng/L, 0.079 ng/L, and 0.0079 ng/L for increased cancer risks of $1:10^5$, $1:10^6$, and $1:10^7$, respectively (16).

2.3 Water - Drinking

2.3.1 U.S. Environmental Protection Agency (EPA). The EPA's "Office of Drinking Water" published a draft "Advisory Opinion for Polychlorinated Biphenyls" in 1981. This advisory, known as a Suggested No Adverse Response Level (SNARL), was developed to indicate the level of PCBs in drinking water at which adverse effects would not be anticipated. A margin of safety is used in order to protect the most sensitive group of the general public, which, in this case, the EPA considers to be children.

The EPA-SNARL was based on reproductive effects in rabbits as an end-point of minimal toxicity. A level of 12.5 mg/kg body weight per day PCBs in the mother's diet for the first 28 days of gestation produced an array of effects in the progeny. Using this value, and a safety factor of 1000 (since the data are from animal studies on only one species), a 24-hour SNARL for a 10-kg child consuming 1 L/d of water was determined to

be 0.125 mg/L. A 10-day SNARL was derived simply by dividing the one-day SNARL by 10 giving a value of 0.0125 mg/L. A longer term EPA-SNARL was not calculated because of the carcinogenic potential of PCBs (19).

It should be noted that the Office of Drinking Water has subsequently revised its PCB assessment and concluded that "suitable data were not available to estimate a One-day...(or)...a Ten-day Health Advisory." (48)

2.3.2 U.S. National Academy of Sciences (NAS). The NAS also calculates a Suggested No Adverse Response Level (SNARL). The NAS, however, developed its SNARL for a 70-kg adult rather than a 10-kg child. For PCBs, the NAS used the induction of hepatic MFO activity as the index of minimal toxicity, and the 70-kg adult was assumed to consume 2 L/d of water. The resulting calculations produced a one-day NAS-SNARL for PCBs of 0.35 mg/L and a seven-day NAS-SNARL of 0.05 mg/L (19).

2.4 Sediment - Dredge Spoil

An administrative guideline for disposal of contaminated dredge spoil at sea was established by Canada and a number of "Contracting Parties to the Oslo Convention". This guideline is set as 1 ppm (dry weight) PCBs in the dredged material. Although not binding, it has been used as a screening limit to help reduce the chemical contamination of the North Atlantic and Pacific oceans. In Canada's Ocean Dumping Control Act (ODCA) the value was determined, as for other toxic chemicals, as 1% of a sediment level of PCBs known to be toxic to marine organisms (21,22).

2.5 Food - Tolerance Limits

Health and Welfare Canada has established administrative guidelines for the PCB content of dairy products, meat, poultry, eggs and fish. Fish, however, are the only food which has had to have control measures applied since they are a common source of ingested PCBs. The maximum residue levels (MRLs) in all foods except fish were obtained by compiling all available Canadian residue data for the various foods and then selecting a MRL which covered the great majority of the food samples. For fish (MRL = 2 mg/kg), consideration was given to such factors as the available data, the remaining tolerable exposure after consideration of other dietary sources (estimated to be 40 µg/person-day), economic impact to the fishing industry, and the potential decrease of food supply to the consumer. The estimated dietary intake of PCBs from specific foods based on data from the 1970s are listed in Table 2 (29).

TABLE 2 ESTIMATED DIETARY INTAKE OF PCBs IN CANADA

Food	Food Intake ^a (g/person·day)	MRL (µg/g)	PCB Intake (µg/person·day)
dairy ^b	32.8	0.2 ^c	6.6
meat	48	0.2 ^c	9.6
poultry	3.6	0.5 ^c	1.8
eggs	34	0.1 ^d	3.4
fish	20	2 ^e	<u>40</u>
TOTAL			61.4

a based on Statistics Canada figures for disappearance of foods from the marketplace

b includes milk, cheese, and butter

c fat basis

d whole weight minus shell

e edible portion

Assuming an average adult weight of 60 kg, the estimated total daily exposure would amount to 1.0 µg/kg body weight per day, which is the recommended "tolerable daily intake" for PCBs in Canada (29).

2.6 Tolerable Daily Intake

Health and Welfare Canada has identified a tolerable exposure level (tolerable daily intake) for PCBs of 1 µg/kg body weight per day. This value was derived from research using rhesus monkeys in which a dietary exposure of 100 µg/kg body weight per day caused reproductive disfunction. A 100-fold safety factor was applied to arrive at the tolerable exposure level (29).

2.7 Air - Occupational

2.7.1 American Conference of Governmental Industrial Hygienists (ACGIH). The most widely accepted standards for occupational exposure to PCBs are those recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). Nine nations (not specified) have accepted these limits which are expressed as Threshold Limit Values (TLVs) and Short-term Exposure Limits (STELs) (39). TLVs are recommended as the time-weighted average exposure level for an 8-hour working day, while the STEL is the recommended maximum exposure level for no more than a

15-minute duration, no more than four times per day. The ACGIH recommendations for occupational exposure to PCBs are:

- 42% CI: 1 mg/m³ over 8 h (TLV)
- 2 mg/m³ over 15 min. (STEL)
- 54% CI: 0.5 mg/m³ over 8 h (TLV)
- 1 mg/m³ over 15 min. (STEL)

These values have been based on animal studies performed in the 1930s and information on the effects of PCBs on humans during occupational exposure. These values are believed to "offer reasonable good protection against systemic intoxication, but may not guarantee complete freedom from chloracne." (39)

2.7.2 The National Institute for Occupational Safety and Health (NIOSH). This institute has performed a review of the pertinent literature and arrived at a recommended time weighted average exposure level for all PCBs of $\leq 1 \mu\text{g}/\text{m}^3$ for up to a 10-hour day, 40-hour work week (12). This value was based on:

- the reproductive effects in animals and humans (Yusho patients) (effects on animals included teratogenesis);
- NIOSH's conclusion that PCBs are carcinogenic (liver and pituitary cancers occurred in PCB-fed rats and mice, and there are preliminary reports of increased incidence of certain cancers in workers exposed to PCBs);
- no evidence of an exposure level low enough to prevent liver injury;
- the minimum detectable level of PCBs in workroom air as measured by the methodology recommended in the document (the minimum detectable level is $1 \mu\text{g}/\text{m}^3$).

According to NIOSH, occupational exposures at or below the minimum detectable level of $1 \mu\text{g}/\text{m}^3$ "should reduce risks of reproductive and carcinogenic effects, and protect the employees from metabolic dysfunction, hepatic injury, and dermal effects due to PCB exposures during their working lifetimes" (12).

2.7.3 Ontario. The Ontario Ministry of Labour has adopted a time-weighted average exposure criteria (TWAEC) of $50 \mu\text{g}/\text{m}^3$ (9). This guideline was established through a quasi-judicial hearing which resulted from an appeal of a Director's Order regarding air concentrations in a workplace. The Ministry of Labour adopted this guideline following its acceptance at that hearing. This is the time-weighted average exposure concentration for a 40-hour work week to which it is believed nearly all workers may be exposed day after day without experiencing adverse effects (10).

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APPENDIX

DEFINITIONS OF CRITERION, OBJECTIVE, GUIDELINE AND STANDARD AS USED BY DIFFERENT AGENCIES IN CANADA

APPENDIX: DEFINITIONS OF CRITERION, OBJECTIVE, GUIDELINE AND STANDARD AS USED BY DIFFERENT AGENCIES IN CANADA (extracted from reference 54, unless otherwise stated)

Alberta	-	see Prairie Provinces Water Board
British Columbia	-	<p>Criterion: A maximum or minimum physical, chemical or biological characteristic of water, biota or sediment, which must not be exceeded to prevent specified detrimental effects from occurring to a water use or aquatic life, under specified environmental conditions.</p> <p>Objective: A maximum or minimum physical, chemical or biological characteristic of water, biota or sediment, which will protect the most sensitive designated water use at a specific location with an adequate degree of safety, taking local circumstances into account.</p>
Manitoba 1979	-	<p>Criteria: Are based on scientific data which relate the quality or health of the aquatic environment to properties, conditions and chemical constituents of the water.</p> <p>Objectives: Differ from the criteria in that they incorporate the notion of a desirable goal. They normally take risk and uncertainty into account by including a margin of safety. Water quality objectives are basically of a scientific nature.</p> <p>Standard: The stream standard is used to designate the quality objectives for a given stream in terms of specific limits to contaminants and conditions related to quality. The stream standard is not a law that is being enforced; it remains an objective. It is an objective which relates to a specific situation and is based on specified uses and observed qualities of the stream.</p>
Manitoba 1983	-	<p>Objective: Surface water quality objectives are designated concentrations of constituents that, when not exceeded will protect an organism, a community of organisms, a prescribed water use, or a designated multiple purpose water use with an adequate degree of safety.</p>
Ontario	-	<p>Criterion: A designated concentration of a constituent, based on scientific judgements, that, when not exceeded will protect an organism, a</p>

Ontario (cont'd)

community of organisms, or a prescribed water use with an adequate degree of safety.

Guideline: Any suggestion, rule, etc., that guides or directs objectives.

Objectives: Are a set of narrative and numerical criteria designed for the protection of aquatic life and other uses of water; they represent a desirable level of water quality that the Ministry of the Environment strives to maintain in surface waters of Ontario.

International Joint Commission

-

General objectives: Are broad descriptions of water quality conditions consistent with the protection of the beneficial uses and the level of environmental quality which the Parties desire to secure and which will provide overall water management guidance.

Specific objectives: Means the concentration or quality of a substance or level of effect that the Parties agree, after investigation, to recognize as a maximum or minimum desired limit for a defined body of water or portion thereof, taking into account the beneficial uses or level of environmental quality which the Parties desire to secure and protect.

Prairie Provinces Water Board

-

Criterion: Designates a means by which anything is tried in forming a correct judgement respecting it. From criteria, which detail cause and effect, the management agency can develop water quality objectives or standards.

Objective: Represents an aim or a goal toward which to strive. The establishment of an objective must be done with discretion because it may represent an ideal that is difficult to attain because of natural conditions. Objectives do not imply strict adherence nor rigid enforcement by control agencies. The use of objectives for water quality avoids the rigidity and authoritativeness of standards.

Standard: Applies to any definite rule, principle or measure established by authority. The adoption of standards for surface water quality may be administratively desirable as a crutch to facilitate action and enforcement but there is a tendency to take such an approach without sound scientific justification.

Environment Canada 1979 "Preamble"	-	Objective:	A designated concentration of a constituent that when not exceeded, will protect an organism, a community of organisms, a prescribed water use, or a designated multiple-purpose water use with an adequate degree of safety.
		Criteria:	Are the results of scientific investigations which are used to determine the suitability of water quality to support and protect a prescribed water use.
		Standard:	Is a legally described concentration of a constituent established under statutory authority.
Health & Welfare Canada	-	Criteria:	The scientific data evaluated to derive the recommended limits for potable water.
		Objective:	The level of physical, chemical and microbiological characteristics interpreted as the ultimate quality goal for both health and aesthetic purposes.
Environment Canada (1983 - 1984) *	-	Criteria:	Represent the basic scientific information from which the suitability of water quality will be assessed for a particular use.
		Guideline:	A limiting characteristic of water, sediment or biota, derived from the use of criteria and the application of safety factors, to avoid specific detrimental environmental effects from occurring to a particular water use. The limiting characteristics may be of a physical, chemical or biological nature.
		Objective:	A limiting characteristic of water, sediment or biota, which has been negotiated to support and/or protect the designated uses of water within a specified location. The limiting characteristic may be of a physical, chemical or biological nature.
		Standard:	A guideline or objective value, determined for a particular reach of a waterway, that is recognized in enforceable environmental control laws of a level of government.

* See draft Water Quality Objectives Division Program document.

Canadian Council of Resource and Environment Ministers (1987) (from ref. 53)

1. Criteria: scientific data evaluated to derive the recommended limits for water uses.
2. Water quality guideline: numerical concentration or narrative statement recommended to support and maintain a designated water use.
3. Water quality objective: a numerical concentration or narrative statement which has been established to support and protect the designated uses of water at a specified site.
4. Water quality standard: an objective that is recognized in enforceable environmental control laws of a level of government.