

VEOLIA WASTE SERVICES ALBERTA INC.

Human Health Risk Assessment Through Consumption of Fish near Swan Hills Treatment Centre

Based on 2024 Fish Monitoring Data

Document no. Rev 0: 217085-56230-EN-REP-00002



27 March 2025

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PROJECT 217085-56230-EN-REP-00002: Human Health Risk Assessment Through Consumption of Fish near Swan Hills Treatment Centre - Based on 2024 Fish Monitoring Data

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0	Issued for Use	 G. Young	 G. Ramesh/ C. Mushens	 G. Ramesh	27 March 2024

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Executive Summary

The Swan Hills Treatment Centre (the facility) is approximately 13.5 km northeast from the Town of Swan Hills, Alberta (AB) in W½ 6-67-8 W5M, and is operated by Veolia Waste Services Alberta Inc. (Veolia). The SHTC was constructed for the safe disposal of polychlorinated biphenyls (PCBs) and is one of the only facilities in Canada capable of disposing of these persistent contaminants. The facility is operated under Environmental Protection and Enhancement Act (EPEA) Approval No. 1744-03-00, as amended. The facility's operating approval requires that an annual environmental monitoring program (EMP) be executed to ensure the area surrounding the facility is not negatively influenced.

Brook trout are collected annually from Chrystina Lake (study lake) and Edith Lake (reference lake) as part of the EMP to measure concentrations of contaminants of concern in edible tissue. Polychlorinated biphenyl (PCB) concentrations are measured given that these compounds are the main contaminants of concern based on historical monitoring data. Polychlorinated dibenzo-p-dioxin (dioxin) and polychlorinated dibenzofuran (furan) concentrations are also measured in edible brook trout tissue given that these contaminants can be produced when PCBs are heated. Historically, dioxin and furan concentrations in fish tissue have been below analytical detection limits in both lakes but they continue to be monitored to ensure the monitoring program captures these potential effects on the surrounding environment.

Tissue concentrations measured in brook trout from Chrystina Lake and Edith Lake are used to inform the annual human health risk assessment (HHRA) component of the EMP. The objectives of the HHRA in 2024 include:

- Comparing measured Contaminant of Concern (COC) concentrations in edible brook trout tissue from Chrystina Lake and Edith Lake in 2024 with historical concentrations; and
- Determining potential risk to human health posed by consumption of brook trout captured from Chrystina Lake and Edith Lake based on Health Canada's current exposure limits.

The scope of the EMP is expanded for all monitoring components every five years to identify potential data gaps and ensure the level of effort and methods used are appropriate to fulfill program objectives. The 2024 monitoring program represents an expanded monitoring year and additional scope for the HHRA includes:

- A review of currently used exposure factors (e.g. background exposure estimates, consumption rates, and body weights) and their reliability to assure the accuracy of risk estimates calculated during the HHRA.
- A review of current tolerable daily intakes (TDIs) for COCs and their supporting derivation information, including consultation with Alberta Health to investigate the most appropriate TDIs for the HHRA.
- Review historical trends associated with maximum tissue concentrations to investigate maximum worst-case risk estimates over time.

- Assessment of current program triggers and development of new triggers if required following review of exposure factors (e.g. consumption rates, body weights, background exposure estimates), and TDIs used for the HHRA in 2024 and beyond.

Refinement of the HHRA since its inception has identified consumption of wild-caught fish as the main exposure pathway to PCBs and this is the only exposure pathway assessed as part of the HHRA. The current version of the HHRA characterizes risk to adult, adolescent, child, and toddlers through the fish consumption pathway and associated risk factors for these groups are also considered.

Contaminant Concentration Analysis

The HHRA is based on analysis of fish tissue samples using congener-specific PCB analysis (based on EPA method 1668C), which includes concentrations of all 209 PCB congeners. Brook trout tissue concentrations for each dioxin, furan, and dioxin-like PCBs including PCB 77, 81, 126, and 169 are also measured using EPA method 1613B.

Tissue concentrations measured in brook trout from each lake are divided into three categories for the HHRA including the maximum concentration, weighted average, and average of 'keeper' fish. Maximum concentrations provide an overly conservative estimate of risk but is included to provide a worst-case scenario for comparison with exposure limits. Since 2019, the weighted average of brook trout 2+ years old and up has been included in the HHRA given that these fish are generally targeted by recreational fishers based on size. These brook trout are generally referred to as 'keeper' fish. Notably, large brook trout with unknown ages have been incorporated into the 'keeper' category since 2022 given that they would be targeted by recreational fishers.

Exposure estimates calculated for the 2024 HHRA are based on contaminant concentrations including:

- the annual weighted average of all brook trout sampled from each lake since 2002;
- the weighted average of 'keeper' brook trout from each lake since 2019;
- the maximum concentration measured in brook trout from each lake in 2024; and
- the maximum concentration measured in brook trout from each lake since 2006 (as part of the expanded program).

Risk Characterization

In the context of HHRA, risk characterization is the final step in the risk assessment process that combines information from the toxicity and exposure assessments to determine estimated risk to consumers. The toxicity assessment includes a scientific evaluation of the potential harm from COCs to human health and involves the development of exposure limits for various exposure routes. The Swan Hills HHRA assesses risks from the consumption of wild-caught fish, therefore exposure limits are based on tolerable daily intakes (TDIs) established by Health Canada. These TDIs set the safe consumption limits for COCs based on available toxicological data. The exposure assessment is the process of quantifying the following:

1. Magnitude, frequency and duration aims to quantify how much, how often and how long humans (e.g. daily intake or dose) are exposed to a COC.

2. Population characteristics - Adults, adolescents, children, and toddlers were identified as receptors exposed to PCBs through ingestion of fish tissue collected near the SHTC.
3. Routes and pathways – This HHRA is aimed only at the fish consumption pathway in this instance (see Section 3).

Population characteristics are a key component of the exposure assessment given that exposure estimates are based on assumed exposure factors including consumption rates, body weights, and background exposures based on available information. Consumption rates, body weights, and background exposures are based on food consumption surveys, ideally within the region of the specific HHRA. Health Canada and Alberta Health have developed guidance documents to help determine the most reliable exposure factor values based on meta-analysis of previous food consumption surveys throughout Alberta/Canada. Exposure factors traditionally used for the SHTC HHRA are adopted from the 1997 diet and activity study by Alberta Health. These exposure factors, along with COC concentrations, are used to calculate daily intakes (exposure estimates) for each consumer group (Equation 1). Exposure factors currently used for each consumer group assessed during the SHTC HHRA are summarized in Table E-1.

Equation 1

$$\text{Estimated Exposure} = \frac{\text{COC Concentration} * \text{Consumption Rate}}{\text{body weight}} + \text{Background Exposure}$$

Table E-1: Exposure factors used to quantify exposure for the SHTC HHRA

Life Stage	Age Group	Average Consumption Rate (grams/day)	Average Body Weight (kg)	Background Exposure
Adult	>19 years	High consumer = 167 Medium consumer = 47 Low consumer = 13 Very low consumer = 2 Advisory level = 22	73 (propose change to 80 kg following 2024)	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.5 pg TEQ/kg/day
Adolescent	12 – 19 years	40	65.2	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.63 pg TEQ/kg/day
Child	5 – 11 years	33	35.2	Total PCBs = 0.0035 µg/kg/day Total TEQ = 0.99 pg TEQ/kg/day
Toddler	7 month – 4 years	20	15.3	Total PCBs = 0.0068 µg/kg/day Total TEQ = 1.89 pg TEQ/kg/day
Notes: Bold text denotes that the medium consumer group more accurately reflects current maximum consumption rates of traditional foods in the Swan Hills region based on literature review and discussions with Alberta Health				

Risk is characterized for each consumer group by comparing the estimated exposure from the exposure assessment with Health Canada TDIs from the toxicity assessment to calculate an exposure ratio (ER) using Equation 2.

Equation 2

$$\text{Exposure Ratio (ER)} = \frac{\text{Estimated exposure}}{\text{Exposure Limit (TDI)}}$$

The toxicity and exposure assessments maintain a conservative approach to ensure that potential risks to human consumers are not underestimated. The SHTC HHRA maintains this conservatism by incorporating the following:

1. Dioxin, furan, and PCB concentrations below the detection limit are replaced with half the detection limit value to account for potential exposure to these COCs.
2. Risk estimates are based on the highest consumption rate from the 1997 Swan Hills survey to ensure ERs are protective of people consuming the highest tissue quantities.
3. Risks are characterized based on maximum concentrations reported in fish tissue to account for a worst-case scenario for human consumers of wild-caught fish.
4. The lowest regional background exposure rates available have not been incorporated into the HHRA given that some other available diet surveys report higher background exposure rates.
5. Risks are characterized based on tissue concentrations of edible tissue with the skin on to account for higher COC concentrations of lipophilic COCs such as PCBs, dioxins, and furans.
6. Risks reported do not account for cooking prior to eating, which can remove up to 50% of the tissue residues present in edible tissue.

Given the steps to ensure the HHRA maintains a conservative approach, the risks associated with ERs below 1 are considered negligible to be acceptable by Health Canada where background exposure is considered (Health Canada 2021). In this Project, the ER's relevance to levels of risk used during the HHRA include:

- **ER ≤ 1.0** – estimated exposure from fish consumption are below the respective exposure limit and **no risk** of adverse health effects are expected.
- **1 < ER ≤ 10** – estimated exposure from fish consumption presents a **low risk** of potential adverse human health effects given the conservatism built into the HHRA.
- **10 < ER** – **medium risk** of potential adverse health effects, indicating that risk management and/or adaptive monitoring measures should be considered.

The Health Canada TDI for non-dioxin-like PCBs before 2021 was 0.13 µg/kg/day but was lowered in 2021, causing the ERs calculated during the HHRA to increase substantially. This increase in risk estimates did not reflect a change in tissue concentrations in brook trout captured from Chrystina Lake or Edith Lake. Rather the increased risk estimates caused by the more stringent TDI prompted a review of available TDIs for PCBs in recent years. Currently the Health Canada TDIs for organic COCs, including total PCBs and dioxins/dioxin-like compounds, near the SHTC are:

- Total (non-dioxin-like) PCBs = 0.01 µg/kg/day; and
- Total TEQ (dioxin-like PCBs, dioxins and furans) = 2.3 pg TEQ/kg/day.

The derivation of the 2021 non-dioxin-like PCB TDI was reviewed in detail as part of the expanded program in 2024. A key finding of this review was that the current TDI used in the HHRA has to be corrected (reduced) to account for the proportion of the total PCB concentration that consist of a subset of seven marker PCBs. Comparison with total PCB concentrations from Chrystina Lake and Edith Lake potentially overestimate risk given that the tissue concentrations are based on the sum of all 209 PCB congeners rather than being limited to the seven marker PCBs discussed in the report.

Current versus Proposed Exposure Factors for Risk Characterization

In 2024, risk was characterized based on the exposure factors and PCB concentrations currently used for the HHRA to provide consistency with previous reports and comparison with newly proposed methods. Risk estimates using these methods are referred to as the current HHRA case throughout the report. Risk estimates calculated using the proposed changes to the exposure estimation methods are presented as part of the proposed HHRA case. The current HHRA case overestimates risk based on the findings of the review of exposure factors and limits in 2024. The proposed HHRA case recommends changes including the following:

- Increasing the assumed adult body weight from 73 kg to 80 kg.
- High consumption rate from the 1997 Swan Hills diet and activity study potentially overestimates current consumption rates based on more recent survey data in the Swan Hills region and the medium consumption rate from the 1997 survey aligns more closely with these more recent consumption rates for determining risk.
- Total PCB concentrations (for non-dioxin-like PCBs) currently overestimates risk by comparing tissue concentrations based on the sum of all 209 PCB congeners with the current Health Canada TDI that accounts for only seven marker PCBs.

Health Risks Associated with Consuming Brook Trout from the Swan Hills Area

Tissue concentrations measured in brook trout from Chrystina Lake and Edith Lake in 2024 are summarized in Table E-2. The weighted average concentrations measured in 2024 are compared with historical concentrations since 2002 in Figure E-1.

Table E-2: Weighted averages for total PCB concentrations and TEQs measured in brook trout sampled for the 2024 HHRA

Age Group	Station	Total PCB (µg/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
2024 Maximum	Chrystina Lake	0.0366	1.56	0.22	1.78
	Edith Lake	0.0086	0.64	0.21	0.85
All ages (weighted average)	Chrystina Lake	0.0143	0.68	0.17	0.84
	Edith Lake	0.0042	0.36	0.17	0.53

Age Group	Station	Total PCB (µg/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
>2+ years old ("Keeper")	Chrystina Lake	0.0174	0.83	0.16	1.00
	Edith Lake	0.0048	0.50	0.15	0.65

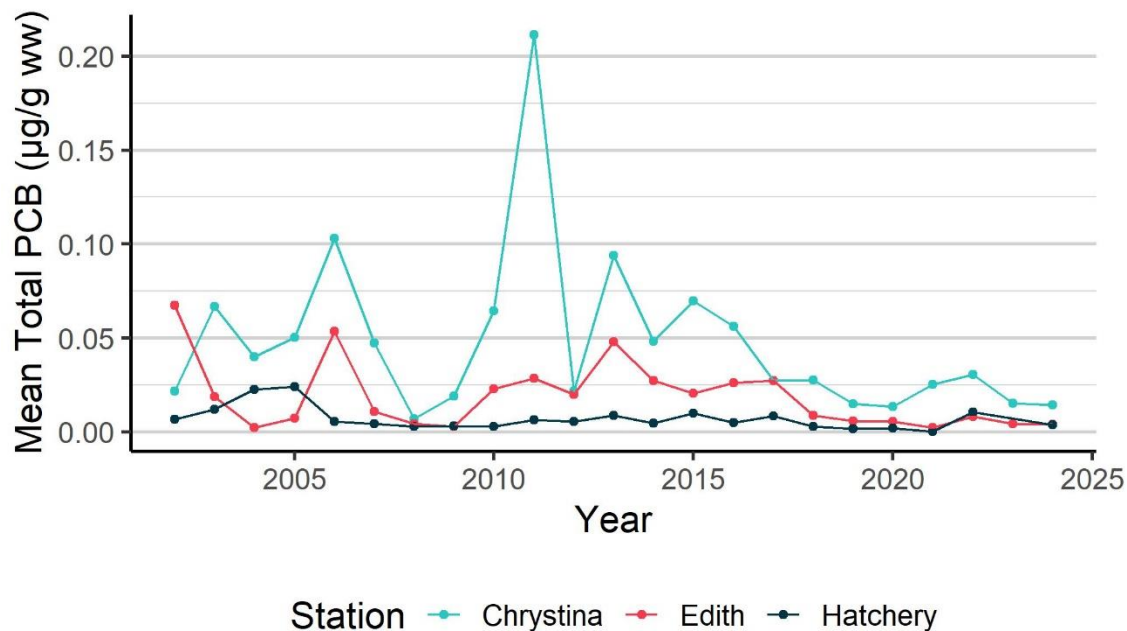


Figure E-1: Weighted Average of Total PCBs in Brook Trout Sampled from Chrystina Lake, Edith Lake and the Hatchery (2002 to 2024)

Adult Fish Consumers

The ERs calculated for adult consumer groups based on the maximum, weighted average, and 'keeper' average PCB concentrations in Chrystina Lake, Edith Lake, and hatchery brook trout in 2024 (Table E-3). The ERs for low and very low consumer groups were all below 1, therefore these groups are not included in Table E-3. There are no ERs exceeding 10 in 2024. High consumers have ERs over one suggesting there is a low potential risk to high consumers of Chrystina lake brook trout. Three of the five tissue samples from Edith Lake reported total PCB concentrations equal to or below concentrations in trout taken directly from the hatchery, leading to similar ERs between Edith Lake (based on weighted average) and hatchery brook trout in 2024 (Table E-3).

Table E-3: Exposure Ratios based on total PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	8.57	3.48	4.17
	Medium (47 g/day)	2.56	1.12	1.32
	Advisory (22 g/day)	1.30	0.63	0.72
Edith Lake	High (167 g/day)	2.17	1.17	1.31
	Medium (47 g/day)	0.76	0.47	0.51
	Advisory (22 g/day)	0.46	0.33	0.35
Hatchery	High (167 g/day)	1.06		
	Medium (47 g/day)	0.44		
	Advisory (22 g/day)	0.31		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs calculated for potential exposure to dioxin-like PCBs, dioxins, and furans (as total TEQ) from adult consumption of brook trout from Chrystina Lake, Edith Lake, and the hatchery in 2024 are presented in Table E-4. All the ERs for low and very low consumers were well below 1 and indicate no risk to these consumer groups. The ERs for consumers of Chrystina Lake brook trout were slightly above 1 based on the highest consumption rate. Based on the total TEQ concentrations reported in 2024, there is no risk to most adult consumer groups eating brook trout from both lakes. The low potential risk to high consumers of Chrystina Lake brook trout may overestimate risk based on more recent consumption rate estimates.

Table E-4: Exposure Ratios for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	1.98	1.05	1.21
	Medium (47 g/day)	0.71	0.45	0.50
	Advisory (22 g/day)	0.45	0.33	0.35
Edith Lake	High (167 g/day)	1.06	0.74	0.86
	Medium (47 g/day)	0.46	0.37	0.40
	Advisory (22 g/day)	0.33	0.29	0.30
Hatchery	High (167 g/day)	0.49		
	Medium (47 g/day)	0.29		
	Advisory (22 g/day)	0.25		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs for high consumers based on concentrations of dioxin-like PCBs, dioxins, and furans from 2002 to 2024 are presented in Figure E-2. These ERs suggest there is no risk to consumers of Edith Lake brook trout and low potential risk to adult consumers of Chrystina Lake brook trout since 2017. In addition, Edith Lake brook trout pose a similar risk to brook trout taken directly from the hatchery since 2017.

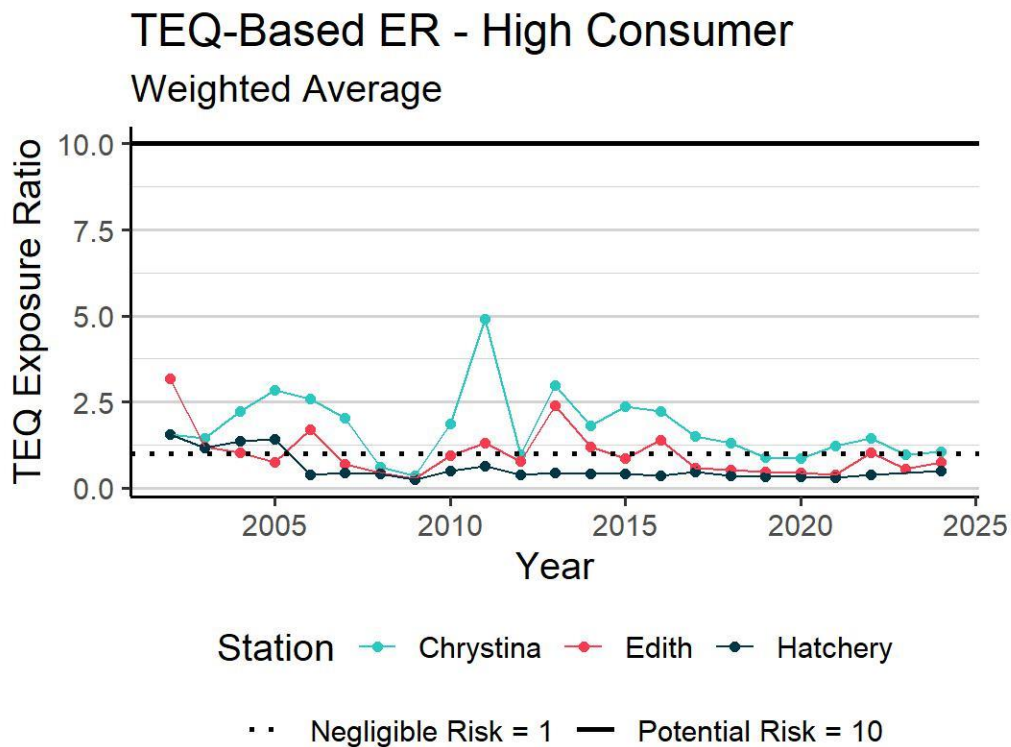


Figure E-2: Exposure ratios for adult high consumers of Chrystina Lake, Edith Lake, and hatchery brook trout based on the weighted average TEQ for dioxin-like PCBs, dioxins, and furans

Adolescent/Juvenile Fish Consumers

The ERs for adolescent, child, and toddler consumers of brook trout from Chrystina Lake, Edith Lake, and the hatchery based on the current HHRA case methods are provided in Table E-5. Based on the concentrations measured in 2024 in Chrystina Lake there is a low potential risk to toddler, child, and adolescent consumers. Alternatively, there is no risk to child and adolescent consumers, and low potential risk for toddler consumers of Edith Lake brook trout based on concentrations measured in 2024. Similarly to adult consumers, the ERs calculated for Edith Lake brook trout consumers (based on weighted average) were comparable to those calculated for the hatchery brook trout.

Table E-5: Adolescent/Juvenile Exposure Ratios for total PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	Adolescent	2.45	1.08	1.27
	Child	3.78	1.69	1.98
	Toddler	5.46	2.55	2.95
Edith Lake	Adolescent	0.73	0.46	0.50
	Child	1.16	0.75	0.80
	Toddler	1.81	1.23	1.31
Hatchery	Adolescent	0.43		
	Child	0.70		
	Toddler	1.17		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs for adolescent, child and toddler consumers of 'keeper' brook trout from Chrystina Lake and Edith Lake for dioxin-like PCBs, dioxins, and furans (as total TEQ) from 2019 to 2024 are provided in Figure E-3. These ERs suggest that there is no risk to adolescent and child consumers of brook trout from either lake since 2019, however toddler consumers may have low potential risk from brook trout consumption. Notably, the ERs for toddler consumers is highly conservative given that the background exposure estimate for this consumer group represents 82% of the TDI. Consequently, the ER for brook trout taken directly from the hatchery is nearly 1 (ER=0.98).

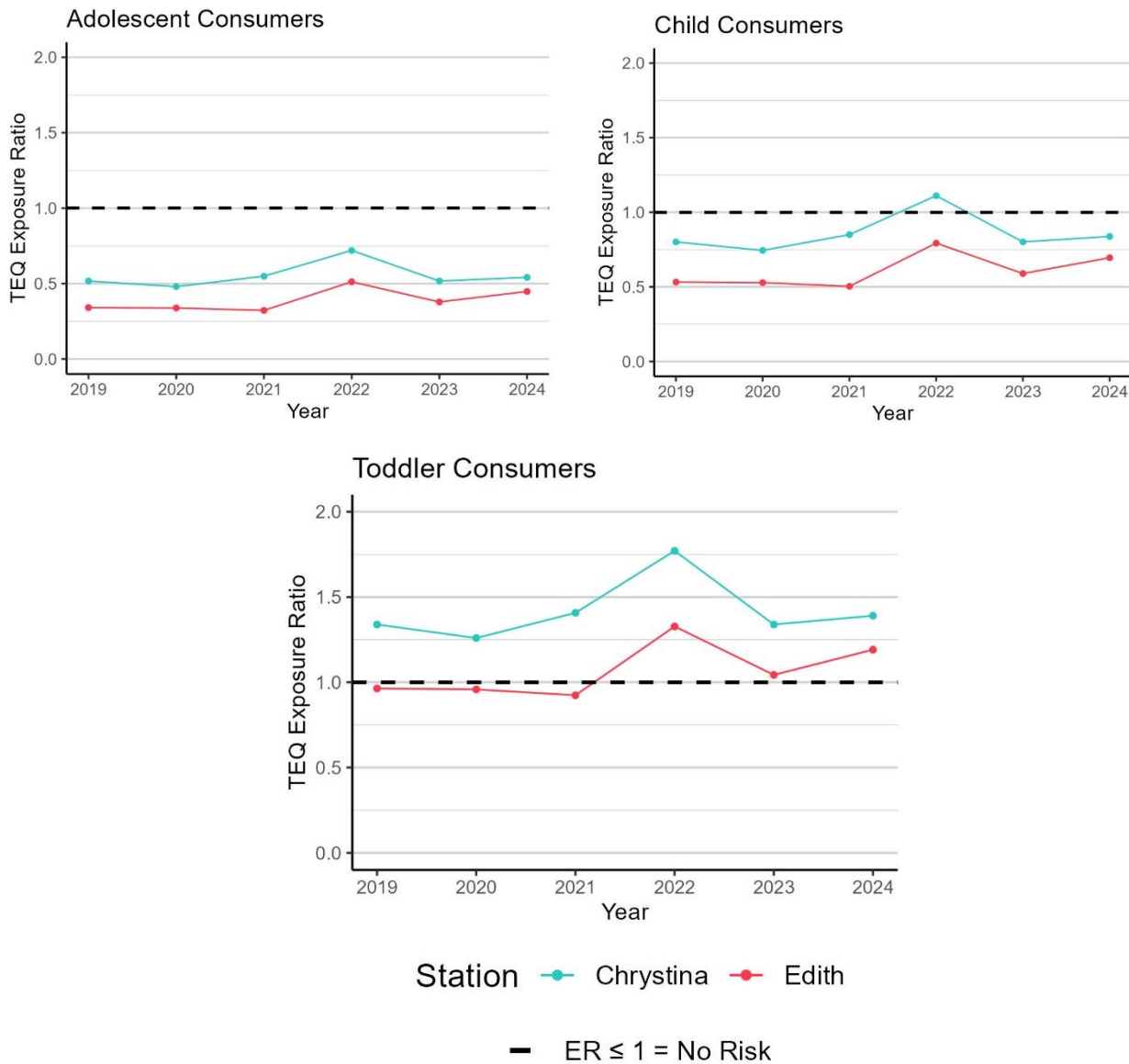


Figure E-3: Exposure ratios for adolescent (top left), child (top right), and toddler (bottom) consumers of brook trout from Chrystina Lake and Edith Lake from 2019 to 2024, based on average concentrations of dioxin-like PCBs, dioxins, and furans in 'keeper' fish

A common theme observed throughout the HHRA in 2024 is that risk estimates for consumers of Edith Lake brook trout based on weighted averages are similar to risk estimates for brook trout taken directly from the hatchery. This is in part a reflection of the conservatism built into the HHRA and similar PCB concentrations in Edith Lake brook trout and control brook trout from the hatchery. Although risk potential is elevated for consumers of Chrystina Lake brook trout compared with Edith Lake brook trout consumers, the potential for risk remains low for Chrystina Lake.

Recommendations for 2025 HHRA

In 2024, apart from using historical ERs to calculate risk to all three levels of fish consumers, we also applied changes to exposure factors that were informed by more recent surveys and guidance documents. Risk estimates calculated with these changes was called the proposed HHRA as we propose to use this new methodology moving forward. Details and support for these changes are provided in the report in Section 3.

The risk assessment results based on currently used methods suggest that there is little to no risk to consumers of Edith Lake brook trout, whereas non-dioxin-like PCBs pose a low potential risk to people consuming brook trout from Chrystina Lake at a high consumption rate. Risk potential and COC concentrations in Edith Lake brook trout has been consistently low, and most risk estimates based on weighted average concentrations since 2017 have been similar to brook trout directly from the hatchery. Therefore, it is recommended that:

- Sampling and the risk assessment to humans through the ingestion pathway via consumption of fish be continued for Chrystina Lake.
- Sampling effort in Edith Lake be reduced to biannual sampling so that monitoring efforts can focus on better characterizing PCB variability in Chrystina Lake brook trout tissue.
- A review of the fish consumption advisory by Alberta Health to determine its applicability for Edith Lake and other lakes within 20 km of Swan Hills. Meanwhile, consumers should remain aware of the current Alberta fish consumption advisory of 150 g/week (22 g/day) of fish from lakes within 20 km of Swan Hills (including Chrystina Lake and Edith Lake).
- Consumers should remove fish skin from edible tissue and cook tissue before eating, as this will remove fatty tissue that contains higher proportions of COCs and will help in degradation of COCs before consumption.

The literature review of exposure factors and limits used for the HHRA identified that currently assumed body weight for adult consumers may underestimate average body weight in Central Alberta, the high consumption rate from the 1997 Swan Hills diet and activity study is high compared to more recent consumption estimates for traditional foods. In addition, PCB concentrations based on the seven marker PCBs used in the derivation of the 2021 Health Canada TDI for non-dioxin-like PCBs provides a more accurate comparison with this TDI. Therefore, it is recommended that:

- The proposed revisions to the risk classification methods implemented in 2024 should be used for future monitoring years and temporal risk trends should be based on the medium consumer group to prevent over-estimating risk.
- The seven marker PCBs discussed in the report is used as an indicator of overall PCB concentrations, while concentrations of the 12 dioxin-like PCBs is also measured to determine TEQ for assessing risk. Analytical methods providing these analytes is available from ALS in addition to the currently used congener-specific analysis allowing for a defensible transition to subset analysis.

Acronyms and Abbreviations

Acronyms/abbreviation	Definition
µg/kg/day	Micrograms per kilogram per day
AB	Alberta
AEPA	Alberta Environment and Protected Areas
ALS	ALS Laboratories Ltd
COCs	contaminants of concern
CFIA	Canadian Food Inspection Agency
dioxins	polychlorinated dibenzo-p-dioxins
EMP	Environmental Monitoring Program
EPEA	Environmental Protection and Enhancement Act
ER	Exposure Ratio
FTMP	fish tissue monitoring program
furans	polychlorinated dibenzofurans
FNFNES	First Nations Food, Nutrition, and Environment Study
GOA	Government of Alberta
GOC	Government of Canada
HHRA	human health risk assessment
ICES-7	International Council for the Exploration of the Sea marker PCBs consisting of PCB #28, 52, 101, 118, 138, 153, and 180
LOAEL	lowest observable adverse effect level
ML	maximum levels
NOAEL	no observable adverse effect level
PCBs	polychlorinated biphenyls
Pg TEQ/kg/day	Toxic equivalence quotient in Picograms per kilogram per day
PMRA	Pest Management Regulatory Agency
SHTC	Swan Hills Treatment Centre
TCDD	2,3,7,8- tetrachlorodibenzo-p-dioxin
TDI	Tolerable Daily Intake
TEF	toxic equivalency factor
TEQ	toxic equivalency quotients
TRV	Toxicological Reference Values
Veolia Waste Services Alberta Inc.	Veolia
WHO	World Health Organization

1. Introduction

The Swan Hills Treatment Centre (SHTC) is approximately 13.5 km northeast of the Town of Swan Hills, Alberta (AB) in W½ 6-67-8 W5M and is operated by Veolia Waste Services Alberta Inc. (Veolia). The SHTC was constructed for the safe disposal of polychlorinated biphenyls (PCBs) and is one of the only facilities in Canada capable of disposing of these persistent contaminants. The facility is operated under *Environmental Protection and Enhancement Act* (EPEA) Approval No. 1744-03-00, as amended. Section 4.10 of the EPEA approval requires that an annual Environmental Monitoring Program (EMP) reviews the potential effects of the facility's operation on the surrounding environment.

1.1 Project Description

The EMP requirement of the EPEA approval is fulfilled by a detailed annual EMP initiated in 1985 for the SHTC and surrounding area. As of 2024, key components of the EMP include groundwater, surface water, sediment, fish, air, soil, vegetation, animal tissue, and wildlife. Each year, fish tissue near the facility is collected, and edible tissue is analyzed for contaminants of concern (COCs), including metals, PCBs, polychlorinated dibenzo-p-dioxins (dioxins), and polychlorinated dibenzofurans (furans).

Chrystina Lake is approximately 1.5 km downwind from the SHTC and is the main study lake, whereas Edith Lake is upwind and approximately 15 km from the SHTC and acts as a local reference. Both lakes are stocked annually with triploid brook trout (*Salvelinus fontinalis*) during Alberta Environment and Protected Area's (AEPA) annual stocking program, are open to recreational fishing year-round, and are easily accessible by high-grade gravel roads. Limnological and biological characteristics are well-documented through the surface water quality, sediment quality, and fish tissue quality components of the EMP. A detailed description of both lakes is provided with the fish tissue monitoring program (FTMP) annual reports (WorleyParsons 2015).

1.2 Approach and Methodology

The FTMP is a component of the EMP and provides COC tissue residues in edible brook trout tissue to support a human health risk assessment (HHRA). This HHRA is a separate component of the EMP designed to determine health risks associated with consuming fish near the facility. The HHRA has been completed annually as part of the EMP since 1995 and has been refined over-time to focus on fish consumption as the most relevant exposure pathway (see Section 3 – Problem Formulation).

The HHRA uses direct measurements of edible tissue (with skin on) from brook trout samples collected from each lake to characterize risk and does not account for the effects of cooking on exposure to fish consumers. Analyzing COC concentrations with skin on is based on feedback from local/indigenous stakeholders who eat fish with its skin on.

Notably, removing skin and fatty tissue before cooking (using methods that allow melted fat to drip away) can reduce lipophilic contaminant intake by up to 50% (Great Lakes Sportfish Consumption Advisory Task Force [GLSFATF] 1993).

Tissues from Chrystina Lake and Edith Lake brook trout are analyzed annually alongside fish taken directly from the hatchery to control for potential contamination during hatchery rearing. A detailed explanation of risk characterization methods used for the HHRA is provided in Section 3.

1.3 Scope of Risk Assessment

Consumption of wild-caught fish is an important aspect of subsistence and recreational fisheries and is an important exposure pathway to humans when food is collected from in and around contaminated sites (Health Canada 2010a; Health Canada 2023). The scope of the SHTC HHRA in 2024 includes:

- Comparing measured concentrations in edible brook trout tissue from Chrystina Lake and Edith Lake in 2024 with historical concentrations.
- Determining potential risks to human health posed by consumption of brook trout captured from Chrystina Lake and Edith Lake based on Health Canada's current exposure limits.

The scope of the EMP is expanded for all monitoring components every five years to identify potential data gaps and ensure the level of effort and methods used are appropriate to fulfill program objectives. The 2024 monitoring program represents an expanded monitoring year, and additional scope for the HHRA includes:

- A review of currently used exposure factors (e.g. background exposure estimates, consumption rates, and body weights) and their reliability to assure the accuracy of risk estimates calculated during the HHRA (see Section 3.2).
- A review of current tolerable daily intakes (TDIs; see Section 4.2) for COCs and their supporting derivation information, including consultation with Alberta Health to investigate the most appropriate TDIs for the HHRA.
- Review historical trends associated with maximum tissue concentrations to investigate maximum worst-case scenario risk estimates over time.
- Assessment of current program triggers and development of new triggers if required following review of exposure factors (e.g. consumption rates, body weights, background exposure estimates) and TDIs used for the HHRA in 2024 and onwards.

2. Background Information

2.1 Regional Health Conditions

A key consideration for the HHRA is that there is currently an Alberta Health advisory recommending that consumption of brook trout captured within 20 km of Swan Hills be kept to two servings (75 g/serving) per week (Government of Alberta [GOA] 2024). This advisory encompasses both Chrystina Lake and Edith Lake, which have been in place since 1997 (GOA 2013) and equates to a daily recommended intake limit of 22 g/day.

The consumption advisory currently in place was established in response to a release that occurred from the SHTC in 1997. Following this release, Alberta Health initiated a human health impact assessment to quantify potential risk of consuming wild game and fish from the areas surrounding the SHTC (Alberta Health 1997). Follow up HHRAs were published by Alberta Health in 2009 (GOA 2009) and again in 2013 (GOA 2013). Although a decrease in dioxins and furans was documented by these studies, the PCB concentrations in Chrystina Lake brook trout remained high and the applicability of the fish consumption advisory was reaffirmed.

The Alberta Health risk assessments used exposure factors developed through a diet and activity study completed during the 1997 Alberta Health assessment, including body weights and fish consumption rates of adults (19+ year-olds) in and around the Swan Hills area. Currently, the annual SHTC HHRA has also adopted these body weights and consumption rates for adults given that it maintained consistency within the HHRA methods for assessing temporal trends and provided local estimates for these exposure factors. The accuracy and potential limitations of the consumption rates and body weights from the 1997 Alberta Health survey are discussed alongside other exposure factor resources in Alberta in the *Inventory and Analysis of Exposure Factors for Alberta* (GOA 2018).

The First Nations Food, Nutrition and Environment Study (FNFNES) is a Canada-wide program intended to characterize the health of adult First Nations living on reserve in Canada. The survey was completed in Alberta in 2013, and the closest community to the SHTC surveyed as part of the study was the Driftpile First Nation near Slave Lake. A detailed summary of this study provides additional background health information for First Nations in Alberta, as well as estimated consumption rates of traditional foods and estimated daily intakes for nutrients and contaminants of potential concern (Chan et al. 2016).

2.2 Background Environmental Conditions

Swan Hills and the SHTC are in a remote area of Alberta primarily used for oil and gas development since the 1960s, recreational activities (e.g. hunting, fishing, camping, boating), and forestry. Detailed descriptions of the environmental conditions around the SHTC are provided in previous annual reports for the EMP (WorleyParsons 2015; Worley 2024).

3. Problem Formulation

3.1 Site Characterization, Contaminant Screening, and Exposure Pathway Identification

The SHTC EMP has included an HHRA component for nearly 30 years, and the EMP has been adapted to address changing environmental conditions and technical capabilities over that time. Other factors contributing to monitoring changes over time include reduced PCB waste processing volumes (Figure 3-1) and a review of monitoring results for all components of the EMP. Previous analyses of metals, dioxins, and furans have indicated that these compounds contribute little to the potential risk from fish consumption. In addition, annual air and vegetation monitoring has shown a decrease in the release of PCBs, and PCB deposition is low in the areas surrounding Chrystina Lake. Consequently, PCB exposure through inhalation and dermal exposure are considered negligible for the HHRA. Lastly, PCB concentrations in the water column were investigated using passive samplers in 2012, resulting in low concentrations below detection (WorleyParsons 2013). Therefore, ingestion of water from the lakes is not considered a potential exposure pathway. Given that PCBs are the main COC, metals are not assessed during the HHRA, and discussion of dioxins and furans is limited to toxic equivalency quotients (TEQ) used to quantify risk of dioxin-like compounds (see Section 4.1). Although dioxins and furans are typically below detection in fish from both lakes assessed, the potential risk from these compounds is considered in the HHRA to provide a conservative risk estimate.

PCB Processing vs Ambient PCB Levels (1992 - 2024)

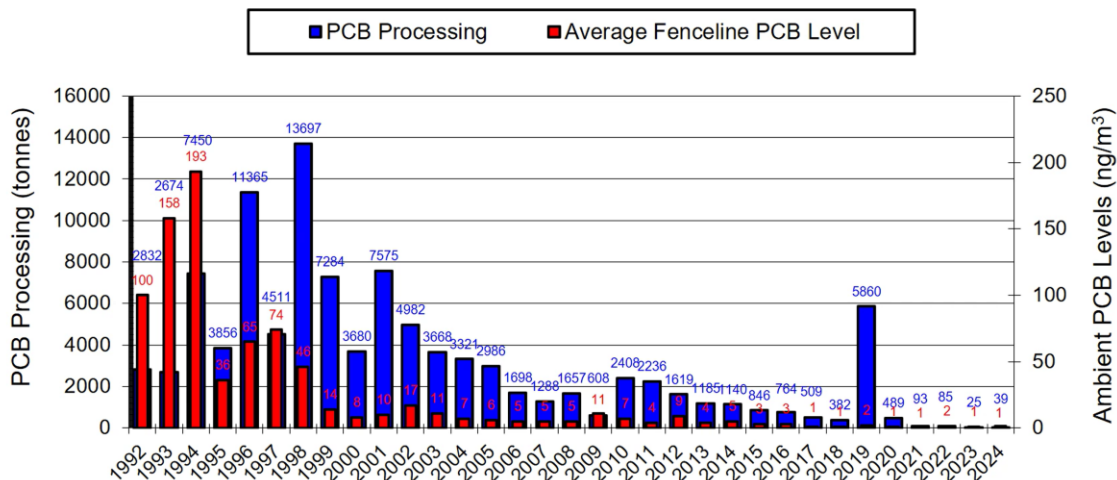


Figure 3-1: Volumes of wastes containing PCBs processed by the SHTC and PCB concentrations measured in air at the SHTC fence line from 1992 to 2024 (provided by Veolia at 2024 technical review meeting)

Results from each component of the EMP, including the HHRA, are discussed at an annual technical meeting with the provincial government regulators, technical specialists, and stakeholders. This approach has allowed the HHRA and other elements of the EMP to extensively characterize potential exposure pathways, receptors of concern, and identify the most relevant COCs. Through these discussions, PCBs have been reaffirmed as the main COC, and the ingestion of traditional foods as the main exposure pathway. Notably, indigenous-led studies of game meat quality have been completed in the past, separately from this HHRA. Consequently, the current study focuses only on potential exposure to PCBs from consumption of wild-caught fish.

3.2 Receptor Identification and Characterization

The current version of the HHRA characterizes risk to adult, adolescent, child, and toddler fish consumers, given the different risk factors for these groups. Younger age classes were incorporated into the HHRA more recently based on recommendations from local Indigenous peoples representatives that expressed concerns regarding the health of younger individuals in their community ingesting fish from Chrystina Lake. As per Health Canada, exposure factors are crucial for estimating human exposure to chemical substances, encompassing characteristics like body weight, inhalation rates, and ingestion rates, with values representative of the Canadian general population and adjusted for age groups (Health Canada 2023). The exposure factors currently used during the HHRA are summarized in Table 3-1. As part of the expanded program in 2024, these assumptions were compared with currently available information through a literature review and discussions with Alberta Health. The potential risk using the current assumptions are provided alongside results based on updated exposure factors and the most recent Health Canada exposure limits. This ensures comparability with previous monitoring years, while ensuring assumptions used are based on the most reliable information. The goal of this review is to quantify potential risk based on a maximum exposure that is not overly conservative but does not underestimate risk to fish consumers.

Table 3-1: Exposure factors used to quantify exposure currently for the SHTC HHRA

Life Stage	Age Group	Average Consumption Rate (grams/day)	Average Body Weight (kg)	Background Exposure
Adult	>19 years	High consumer = 167 Medium consumer = 47 Low consumer = 13 Very low consumer = 2 Advisory level = 22	73	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.5 pg TEQ/kg/day
Adolescent	12 – 19 years	40	65.2	Total PCBs = 0.002 µg/kg/day Total TEQ = 0.63 pg TEQ/kg/day
Child	5 – 11 years	33	35.2	Total PCBs = 0.0035 µg/kg/day Total TEQ = 0.99 pg TEQ/kg/day
Toddler	7 month – 4 years	20	15.3	Total PCBs = 0.0068 µg/kg/day Total TEQ = 1.89 pg TEQ/kg/day

3.3 Literature Review

The review of exposure factors and recent exposure limits released is intended to ensure that appropriate TDIs, background exposure estimates, and consumption rate measurements are incorporated into the HHRA as new information becomes available. Although updated consumption rate and body weight estimates were assessed, the focus of the literature review was to confirm an accurate background exposure for each age group and establish which TDI will be applied after the TDI for non-dioxin-like PCBs was updated by Health Canada in 2021 (Health Canada 2021). Scientific journal articles and the most recent guidance documents from Health Canada and Alberta Health were reviewed for pertinent information. Alberta Health was consulted to discuss the most relevant assumptions and how they should be applied to the HHRA. In addition, the literature review incorporated searches of several knowledge bases, including:

- Google scholar;
- PubMed; and
- JSTOR.

Literature cited within materials obtained through these resources was also reviewed for further information when these were thought to provide pertinent information. Key resources and exposure estimates reviewed during the literature review are summarized in Table 3-2. Key points relevant to the execution of the SHTC HHRA are discussed further in the relevant toxicity and exposure assessment sections.

Table 3-2: Literature sources reviewed and associated metrics provided during review of SHTC HHRA exposure quantification methods in 2024

Citation	Title	Survey Year/Period	Key Information
Ryan et al. 2013	Dioxins, furans and non-ortho-PCBs in Canadian total diet foods 1992–1999 and 1985–1988	1985 to 1999	Background exposure estimates from Market foods. 1999 background exposure to dioxins, furans, and non-dioxin-like PCBs = <0.5 pg TEQ/kg/day
Government of Canada (GOC) 2025a	Food Consumption Table derived from Statistics Canada's 2015 Canadian Community Health Survey, Nutrition, Share file. Ottawa.	1999 to 2016	Average Fish Consumption Rates: 1 to 3 years – 3.52 g/kg bw/day 4 to 8 years – 3.13 g/kg bw/day 9 to 13 years – 1.75 g/kg bw/day 14 to 18 years – 1.82 g/kg bw/day 19 to 30 years – 1.81 g/kg bw/day 31 to 50 years – 1.47 g/kg bw/day 51 to 70 years – 1.32 g/kg bw/day >71 years – 1.25 g/kg bw/day 1 to 18 years – 2.57 g/kg bw/day >19 years – 1.42 g/kg bw/day Average Body weights: 1 to 3 years – 13.89 kg 4 to 8 years – 23.49 kg 9 to 13 years – 43.41 kg 14 to 18 years – 66.8 kg 19 to 30 years – 73.79 kg 31 to 70 years – 79.21 kg 1 to 18 years – 39.94 kg >19 years – 77.64 kg PCB concentrations in freshwater fish bought at market across Canada from 1998 to 2016: 17 samples

Citation	Title	Survey Year/Period	Key Information
			Average = 0.0085 ng/g Range = 0.0002 ng/g to 0.0322 ng/g
GOC 2025a	Dietary intakes of dioxin-like chemicals (pg of TEQ/kg body weight/day) for different age-sex groups for Total Diet Study in Calgary, 1999 (Archived)	Updated 2006	Dietary intake of Dioxins, Furans, and dioxin-like PCBs 7 months to 4 years – 1.79 pg TEQ/kg/day 5 to 11 years – 1.32 pg TEQ/kg/day 12 to 19 years – 0.795 pg TEQ/kg/day All ages – 0.60 pg TEQ/kg/day
GOC 2025a	Dietary Intakes of Contaminants and Other Chemicals for Different Age-Sex Groups of Canadians - Canadian Total Diet Study - Health Canada	2002	Dietary intake of total PCBs 7 months to 4 years – 0.0061 µg/kg/day 5 to 11 years – 0.00465 µg/kg/day 12 to 19 years – 0.0027 µg/kg/day All ages – 0.0021 µg/kg/day
Chan et al. 2016	First Nations Food, Nutrition and Environment Study: Results from Alberta 2013	2013	First nations specific traditional food consumption rates, dietary intake rates for PCBs, dioxins, and dioxin-like compounds Consumption Rates: Average caught fish consumption = 7.8 g/day 95 th percentile caught fish consumption = 39.7 g/day Average traditional food consumption = 34.2 g/day 95 th percentile traditional food consumption = 156.0 g/day Contaminant concentrations and daily intake rates: Total PCBs in trout = 0.00271 µg/g ww mean and 0.00429 µg/g ww maximum Total PCB daily intake = 0.00002 µg/kg/day (average concentration and consumer) and 0.0002 µg/kg/day (maximum concentration and heavy consumers) Total dioxins and furans in trout = 0.03 pg TEQ/g ww mean and 0.07 pg TEQ/g ww maximum Dioxin and Furan daily intake = 0 µg/kg/day for all consumers in study

Citation	Title	Survey Year/Period	Key Information
Chan et al. 2021	Levels of metals and persistent organic pollutants in traditional foods consumed by First Nations living on-reserve in Canada	2008 to 2018	Meta-analysis of FNFNES data across Canada Total PCB concentrations in trout = 0.0181 µg/g Total PCB daily intake = 0.00308 µg/kg bw/day (95th percentile)
PMRA 2014	General Exposure Factor Inputs for Dietary, Occupational, and Residential Exposure Assessments	1999 to 2012	Average body weights 6 to 12 months – 9.2 kg 1 to 2 years – 11 kg 2 to 3 years – 14 kg 3 to 6 years – 19 kg 6 to 11 years – 32 kg 11 to 16 years – 57 kg 16 to <81 years – 80 kg
GOA 2018	Inventory and Analysis of Exposure Factors for Alberta	1997 to 2018	Literature review of exposure factors used for HHRA in Alberta including a semi-quantitative assessment of exposure factor quality for wild-caught fish consumption rates and body weights.
GOC 1999	Canadian exposure factors used in human health risk assessments	1999	Recommended body weights: 6 to 11 months – 9.1 kg 1 year – 11 kg 2 to 3 years – 15 kg 4 to 8 years – 23 kg 9 to 13 years – 42 kg 14 to 18 years – 62 kg ≥ 74 kg
Health Canada 2021	Federal Contaminated Site Risk Assessment in Canada, Part 1: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 3.0	---	Body weights based on Richardson (1997): 7 months to 4 years (Toddler) – 16.5 kg 5 to 11 years (Child) – 32.9 kg 12 to 19 years (Adolescent/Teen) – 59.7 kg ≥20 years (Adult) – 70.7 kg

Citation	Title	Survey Year/Period	Key Information
Richardson and Stantec 2013	2013 Canadian exposure factors handbook: Life expectancy, body dimensions, inhalation, time-activity, and soil ingestion	---	Recommended Body weights: 1 to 4 years (Toddler) – 15.3 kg 5 to 11 years (Child) – 35.2 kg 12 to 19 years (Adolescent/Teen) – 65.2 kg 20 to 65 years (Adult) – 76.5 kg ≥65 years (Senior) – 73.6 kg Currently used for risk characterization of adolescent, child, and toddler consumer groups during the SHTC HHRA.
Baars et al. 2001	Re-evaluation of human-toxicological maximum permissible risk levels	---	Supporting derivation of the 2021 Health Canada TDI for non-coplanar PCBs. Derivation based on toxicity test with PCB aroclor 1254 and TDI corrected to the concentration of indicator PCB congeners (PCB 28, 52, 101, 118, 138, 153, and 180). Background exposure to non-coplanar PCBs estimated at 0.01 µg/kg bw/day Recommended TDI for dioxins and dioxin-like compounds is based on range from 1 to 4 pg TEQ/kg bw/day and background exposure of 1.2 pg TEQ/kg bw/day.
CFIA 2014	Dioxins and Dioxin-Like Compounds in Selected Foods – April 1, 2012 to March 31, 2014: Food Chemistry – Targeted surveys – Final Report	2012 to 2014	Background exposure to dioxins and dioxin-like compounds in fats and oils sold at market. Average concentrations range from 0.023 pg TEQ/g lw in vegetable oils to 0.298 pg TEQ/g lw in cheese.
Health Canada 2007	Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption	1991	Eaters-Only recommended consumption rates for sport/subsistence fishers 20+ year-olds = 40 g/day 5 to 11 year-olds = 33 g/day 1 to 4 year-olds = 20 g/day Currently used for risk characterization of adolescent, child, and toddler consumer groups during the SHTC HHRA.

Citation	Title	Survey Year/Period	Key Information
Alberta Health and Wellness (2009)	Human Health Risk Assessment: Mercury in Fish in Central Alberta – Lac la Nonne and Lac Ste Anne	Various	Fish Consumption rates for Central Alberta are summarized: Subsistence Consumer from Lesser Slave Lake in 1999 Survey: High Consumer = 273 g/day (5% of population) Medium Consumer = 46 g/day (14% of population) Low Consumer = 13 g/day (38% of population) Very-low Consumer = 1.6 g/day (43% of population) Swan Hills local fish consumer: High Consumer = 167 g/day (2% of population) Medium Consumer = 47 g/day (13% of population) Low Consumer = 13 g/day (28% of population) Very-low Consumer = 2 g/day (57% of population) Athabasca River local fish consumer: High Consumer = 121 g/day (2% of population) Medium Consumer = 51 g/day (6% of population) Low Consumer = 15 g/day (26% of population) Very-low Consumer = 1 g/day (66% of population)

The FNFNES was initiated in 2008 to provide information for ensuring healthy environments and foods for First Nations throughout Canada. This comprehensive study characterizes the diet quality of Indigenous peoples living on reserves to support risk assessment. Adults (individuals older than 19 years) from Albertan Indigenous communities were surveyed in 2013 to establish consumption rates for various traditional foods, and traditional food samples were analyzed to characterize background exposure through the ingestion pathway (Chan et al. 2016). Consumption rates and estimated daily intakes for total PCBs, dioxins, and furans from this study suggest substantially lower background exposures and consumption rates than those currently used for the SHTC HHRA. The consumption rates and estimated daily intakes provided in Table 3-2 are based on respondents who were identified as consumers of traditional food from the Boreal Plains ecozone, given that the SHTC is within this ecozone. The Food, Environment, Health and Nutrition of First Nations Children and Youth is currently underway to provide additional information for risk assessment of children and youth living on reserves. Chan et al. (2021) provides a meta-analysis of the data collected during the FNFNES and found that the total PCB daily intake for the Boreal Plains ecozone across Canada was 0.00308 µg/kg bw/day (95th percentile). The total PCB daily intake in this ecozone ranged from below detection to 0.052 µg/kg bw/day based on the FNFNES (Chan et al. 2021).

3.4 Exposure Factor Assumptions

In the context of HHRA, the exposure assessment stage involves estimating the amount of a chemical coming into contact with or absorbed by human receptors per unit time (e.g. daily intake or dose). Exposure assessment is conducted for chemicals, human receptors/receptor age groups, and exposure pathways that were identified as being of concern, i.e. fish consumption pathway in this assessment.

3.4.1 Body Weights and Consumption Rates

The assumed adult body weight of 73 kg, currently used for the SHTC HHRA, is based on the results of the 1997 diet and activity survey for Swan Hills and its surrounding areas (Alberta Health 1997). Statistics from the Canadian Health Survey in 2014 indicate that the mean body weight for adults in the central region of Alberta is approximately 81 kg (GOA 2018). Adult body weights assumed by Health Canada as part of the total diet study and by the Pest management Regulatory Agency (PMRA) were similarly elevated compared with the assumed body weight for the Swan Hills area in 1997 (PMRA 2014; GOC 2025b). In addition, body weight of adults in the US EPA exposure factors handbook is assumed to be 80 kg. Consequently, the assumed body weight for adults during the 2025 SHTC HHRA was adjusted to 80 kg based on the mean body weight assumed/reported by Alberta Health (GOA 2018), the Health Canada PMRA (PMRA 2014) and US EPA exposure factors handbook (USEPA 2011). Age groupings for toddlers, children, and adolescents were kept consistent with the Canadian Exposure Factors Handbook, given that the inventory of exposure factors for Alberta provided limited information for children and toddlers less than six years old and the 2013 exposure factors more accurately reflect the division between infants and toddlers (i.e. when infants begin walking and stop breastfeeding; Richardson and Stantec Consulting 2013).

Assumed fish consumption rates for adults used in the HHRA previously are based on the diet and activity survey in Swan Hills as well (Alberta Health 1997) and are listed in Table 3-1. It is notable that in the 1997 diet and activity survey done by Alberta Health, high consumers represented 2% of the respondents surveyed, and 13% of the respondents were medium consumers. In addition, the study was based on a 12-month recall survey that could potentially lead to increased uncertainty for consumption rate estimates (GOA 2018). During the literature review in 2025, information from two additional diet studies in Central Alberta was obtained with similar consumption rates to that observed at Swan Hills in 1997 (Table 3-2; GOA 2009). Like the Swan Hills survey, the intake rate for high consumers was high (121 g/day and 273 g/day), and this consumer group represented a small proportion of the surveyed population (2% and 5%). A review of exposure factors for Alberta was completed by Alberta Health in 2018 and found that the consumption rates used for the Health Canada Mercury risk assessment in 2007 (Health Canada 2007) aligned with the upper percentile intake rates reported for first nations in the Boreal Plains region (Chan et al. 2016). Overall, the fish consumption rates reported for the Boreal Plains region during the FNFES were below both the high and medium consumers from the 1997 Swan Hills Study. Notably, the consumption rate estimates of combined traditional foods (including fish, game meat, game organs, birds and plants/berries) for boreal plains was 156.0 g/day (Chan et al. 2016), which is below the high consumer fish consumption rate currently used for the SHTC HHRA. This lower consumption rate in a more recent survey could reflect a trend towards less consumption of traditional foods by First Nations that has been previously reported (Chan et al. 2016).

Temporal analysis and annual risk characterization of adult consumers for the HHRA are currently based on the high consumption rate from the 1997 Swan Hills survey. Consumer exposure estimates calculated using the medium consumer rate (47 g/day) from the 1997 survey for Swan Hills more accurately reflect a reasonable worst-case scenario based on review of current intake estimates in Albertan and Canadian guidance documents and published literature. The medium consumption rate aligns with consumption rates recommended by Alberta Health (GOA 2018) and Health Canada (Health Canada 2007) better than the previously used high consumer rate (167 g/day), which may be overly conservative. Using the medium consumer rate from 1997, the HHRA provides a conservative risk estimate and takes into consideration locally obtained consumption data. Given that the medium and lower consumer groups accounted for 98% of the population in 1997 and traditional food intakes have decreased since then, it is thought that this approach will provide a 'reasonable' worst-case scenario for the risk assessment. Notably, risk potential for high consumers is presented and discussed for comparative purposes and to maintain consistency with historical HHRA for this site. It is recommended that risk potential for high consumers continue to be reported as part of the proposed changes to the HHRA to assess risk for subsistence fishers that consume high quantities, but trends and management decisions should be based on the medium consumer group to avoid over-estimating risk to the larger population.

The HHRA also characterizes risk for adolescents (12+ to 19+ year-olds), children (5 to 11 year-olds), and toddlers (7 month to 4 year-olds). The assumed consumption rates and average body weights for these age groups is summarized in Table 3-1.

The assumed consumption rates and body weights for these age groups are consistent with those previously used for the SHTC HHRA, as well as those recommended by the Human Health Risk Assessment of Mercury in Fish and Health Benefits of Consumption (Health Canada 2007), the Canadian Exposure Factors Handbook (Richardson and Stantec Consulting 2013), and the inventory and analysis of exposure factors for Alberta (GOA 2018).

3.4.2 Background Exposure

Background exposure concentrations to PCBs, dioxins, and furans are provided in Table 3-1 and were consistent with those used previously for the HHRA (G&P Resource Services Inc. 2021). These background levels are based on basket studies done in Calgary (1999) and Vancouver (2002) as part of Health Canada's total diet study (GOC 2025a). While results from the FNFNES suggest that background levels of these contaminants have decreased in the Boreal Plains region of Alberta (Chan et al. 2016), other background exposure estimates reported have been variable. For example, the FNFNES maximum background exposure estimated for Albertan First Nations in the Boreal Plains is 0.0002 µg/kg bw/day, an order of magnitude lower than the currently applied background exposure estimate for total PCBs (Chan et al. 2016). Alternatively, the estimated intake of PCBs (based on the 95% percentile) through consumption of traditional foods reported for the Boreal Plains across Canada is 0.00308 µg/kg bw/day (Chan et al. 2021), which is higher than the current background exposure estimate for the SHTC HHRA. Background estimates for dioxins, furans, and dioxin-like PCBs are similarly variable. Given the uncertainty associated with background exposure estimates, the previously used background exposure estimates used for the HHRA have been retained for the SHTC HHRA in 2024. It is notable that background exposures used for the HHRA represent a large proportion of the recommended TDI, particularly in younger age groups that are more susceptible. For example, the TEQ background is 82% of the TDI for toddlers (see Section 4.2).

4. Toxicity Assessment

In the context of Health Canada, a toxicity assessment (a.k.a. hazard assessment) is a scientific evaluation to determine the potential harm or danger a substance can cause to human health and the environment and the ways in which it can happen. Health Canada assesses the health risks posed to Canadians by environmental contaminants in food. In support of risk assessment activities, scientists monitor the concentrations of various environmental contaminants in foods through the ongoing Total Diet Study. Health Canada scientists also research and evaluate the toxicity of environmental contaminants to humans, participate in international evaluations of the toxicity of contaminants, and monitor the results of new studies as they become available.

In human health risk assessments, maximum levels (MLs) like No-Observed-Adverse-Effect Levels (NOAEL) are used to determine the highest exposure level at which there are no significant adverse effects, helping to establish safe exposure limits and guide risk management strategies. When necessary, Health Canada sets/develops MLs for contaminants in foods.

One such risk-management measure is the development of MLs for chemical contaminants in retail foods. The List of Contaminants and Other Adulterating Substances in Foods establishes the ML in fish for 2,3,7,8- tetrachlorodibenzo-p-dioxin (TCDD; Health Canada 2025). The List of Maximum Levels for Various Chemical Contaminants in Foods establishes the ML for PCBs (Health Canada 2020). These limits are enforceable by the Canadian Food Inspection Agency (CFIA) and replace the Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products. The ML for TCDD is based on the TEQ and is 20 pg TEQ/g, whereas the ML for PCBs was previously 2000 ng/g but is currently under review. Tissue concentrations in brook trout from Chrystina Lake and Edith Lake are well below the ML for TCDD and the previous ML for PCBs. Tissue concentrations in 2024 are therefore not compared with the Health Canada MLs.

4.1 Contaminant Mixture Toxicity Quantification

Dioxins, furans, and dioxin-like (also referred to as coplanar) PCBs produce toxic effects through similar physiological pathways that are mediated by the aryl hydrocarbon receptor. Consequently, toxicity of these compounds can be quantified by combining their respective toxic effects into a TEQ. The TEQ approach uses the toxic equivalency factor (TEF), which is based on the concept of dose addition, where the toxicity of individual dioxin and dioxin-like compounds in a mixture is combined into the single TEQ metric that can be used to facilitate risk assessment. The summed concentration of these “dioxin-like” PCBs multiplied by their respective TEF is commonly referred to as the “PCB-TEQ” concentration (i.e. the dioxin equivalent concentration that comes from PCBs). “Total TEQ” refers to the sum of 2,3,7,8-TCDD equivalency from PCBs, dioxins, and furans combined.

The TEQs calculated during the FTMP are based on the 2005 World Health Organization (WHO) TEFs, which express the toxicity of each dioxin, furan, and dioxin-like PCB relative to the most toxic form of dioxin (Van den Berg et al. 2006; Table 4-1).

Results below detection were replaced with half the detection limit (ND = 0.5 DL), and reported estimated maximum values are used to calculate TEQ. Substituting non-detections with half the detection limit is widely accepted in Canada for risk assessment programs (Health Canada 2010a), and using estimated maximum values provides a more conservative risk estimate.

Table 4-1: Toxic Equivalence Factor for Dioxin-Like PCBs, Dioxins, and Furans

Dioxin-Like PCBs Congener	TEF	Dioxins Congener	TEF	Furans Congener	TEF
77	0.0001	2,3,7,8-TCDD	1	2,3,7,8-TCDF	0.1
81	0.0003	1,2,3,7,8-PeCDD	1	1,2,3,7,8-PeCDF	0.03
126	0.1	1,2,3,4,7,8-HxCDD	0.1	2,3,4,7,8-PeCDF	0.3
169	0.03	1,2,3,6,7,8-HxCDD	0.1	1,2,3,4,7,8-HxCDF	0.1
105	0.00003	1,2,3,7,8,9-HxCDD	0.1	1,2,3,6,7,8-HxCDF	0.1
114	0.00003	1,2,3,4,6,7,8-HpCDD	0.01	1,2,3,7,8,9-HxCDF	0.1
118	0.00003	OCDD	0.0003	2,3,4,6,7,8-HxCDF	0.1
123	0.00003			1,2,3,4,6,7,8-HpCDF	0.01
156	0.00003			1,2,3,4,7,8,9-HpCDF	0.01
157	0.00003			OCDF	0.0003
167	0.00003				
189	0.00003				

Notes: The TEF used for the HHRA is based on the 2006 WHO mammalian TEFs listed in the Re-evaluation of Human and Mammalian TEFs for Dioxins and Dioxin-like Compounds (Van den Berg et al. 2006).

4.2 Acute Exposure Limits

Acute exposure limits, also known as health criteria values or benchmarks, are parameters used to quantitatively assess potential human health risks associated with short term exposure to environmental contaminants. These limits are used to determine the maximum acceptable levels of exposure to a substance to prevent adverse health effects and are expressed separately for carcinogens versus non-carcinogens and route of exposure. For oral exposures, the maximum acceptable limit for COC takes the form of a TDI. The TDI is a crucial concept in human health risk assessments, specifically related to the potential harm from exposure to chemicals in food or water. It represents the amount of a chemical that can be safely consumed daily over a person's lifetime.

The TDIs for PCBs and dioxins/furans are established by Health Canada and were recently updated in Version 3 of the Toxicological Reference Values (TRV) that was released in 2021 (Health Canada 2021). The TDI for total TEQ (dioxin-like PCB, dioxin, and furan toxicity) did not change from the 2009 TRVs (Health Canada 2010b), however the TDI for total PCBs was reduced from 0.13 µg/kg/day.

The updated TDIs for organic COCs, including total PCBs and dioxins/dioxin-like compounds, near the SHTC are:

- Total (non-dioxin-like) PCBs = 0.01 µg/kg/day; and
- Total TEQ (dioxin-like PCBs, dioxins and furans) = 2.3 pg TEQ/kg/day.

It is important to note that the TDI for dioxin-like PCBs, dioxins, and furans is based on the combined TEQ of these COCs and that the TDIs for total PCBs and total TEQ are provisional in the 2021 TRV list (Health Canada 2021). The FTMP compares total PCB concentrations with advisory levels established for the Great Lakes area, which establishes advisories for high to low consumers based on a TDI of 0.05 µg/kg/day (GLSFATF 1993). The advisory limits used for the Great Lakes assume a body weight of 70 kg to calculate criteria based on this TDI and assume that removing skin/fat and cooking reduces residues by 50%. The Great Lakes limits were incorporated into the 2024 FTMP for reference but have not been used for the HHRA given that Alberta Health gives preference to TDIs supported by Health Canada (Puhallo, Jennifer 2025. pers. comm.).

The previous TDI published by Health Canada in 2009 was based on the NOAEL found in rhesus monkeys following long-term exposure to an aroclor mixture of PCBs (Health Canada 2010b). The current TDI is derived from oral exposure of rhesus monkey to an aroclor mixture as well. However, the TDI is corrected for the sum of seven specific congeners used for environmental monitoring of PCBs (primarily used in Europe; Baars et al. 2001). The seven PCB congeners used to correct the Health Canada TDI represent those used by the International Council for the Exploration of the Sea (ICES) and include PCB congeners 28, 52, 101, 118, 138, 153, and 180 (ICES-7). These PCB congeners typically make up 40% to 50% of the total PCB content of environmental samples and are collectively referred to as ICES-7 marker PCBs throughout this report for conciseness. Although total PCB concentrations are based on the sum of all 209 PCB congeners currently used for the SHTC EMP, it is appropriate to compare tissue concentrations based on the sum of ICES-7 marker PCBs to avoid overestimating risk from non-dioxin-like PCBs (see Section 5.1).

For the 2024 HHRA, no changes were made with regards to the exposure limit for the risk characterization of dioxins, furans, and dioxin-like PCBs and the current Health Canada TDI for total TEQ is used. For the assessment of non-dioxin-like PCBs, the sum of all 209 PCB congeners and the sum of ICES-7 marker PCBs was calculated separately based on tissue residue data collected since 2019 (See Section 5.1). These concentrations were then used for comparison with the 2021 Health Canada TDI to provide consistency with historical reports and to avoid overestimating risk.

4.3 Chronic Exposure Limits

Unlike acute exposure limits, chronic exposure limits use TRVs to assess the potential for adverse health effects resulting from long-term exposure to a substance.

There are currently no long-term exposure limits from Health Canada for potential carcinogenic effects of PCBs, dioxins, or furans, and the SHTC HHRA has not historically assessed chronic effects from PCB exposure. Consequently, the HHRA continues to focus on the acute effects of PCB exposure through ingestion based on the currently published Canadian TDIs (Health Canada 2021).

5. Exposure Assessment

In the context of HHRA, the exposure assessment involves estimating the following:

1. Magnitude, frequency and duration aim to quantify how much, how often and how long humans (e.g. daily intake or dose) are exposed to a substance (chemical).
2. Population characteristics - Adults, adolescents, children, and toddlers were identified as receptors exposed to PCBs through ingestion of fish tissue collected near the SHTC.
3. Routes and pathways – This HHRA is aimed only at the fish consumption pathway in this instance (see Section 3).

5.1 Contaminant Concentration in Edible Fish Tissue

For this HHRA, direct measurements were used as it provides the most accurate estimate of current chemical concentrations in fish tissue from the lakes. Exposure through ingestion of fish (tissue residue concentration) was the only pathway analyzed. Although this approach is not holistic and does not account for other exposure pathways, this meets the objective of this study as defined in Section 1.3. Brook trout caught in Chrystina Lake and Edith Lake are divided by age group (as determined using implanted coded wire tags), and up to 10 fish are composited into a single sample for analysis. Tissue samples submitted for analysis are identified by the lake they are captured in (CH=Chrystina and ED=Edith), fish species (BKTR=brook trout), and age group (1⁺= one-year-old, 2⁺=two-year-old, etc.). Brook trout that are analyzed but do not have a known age (coded wire tag could not be recovered) are identified by lake and fish species followed by UNK to denote that the age is not known for the corresponding sample.

5.1.1 Analytical Methods

The HHRA is based on analysis of fish tissue samples collected from both lakes using congener-specific PCB analysis (based on EPA method 1668C) for all 209 PCB congeners, reported as 162 individual/coeluting congeners. Brook trout tissue concentrations for each dioxin, furan, and dioxin-like PCBs, including PCB 77, 81, 126, and 169, were measured using EPA method 1613B, also. Tissue homogenization, sample compositing, and both analyses were completed at the ALS laboratory in Burlington, Ontario.

5.1.1.1 PCB Tracking Congeners

Laboratory results for PCBs were presented as the sum of all 209 individual PCB congeners. Additionally, this year, we also analyzed the sum of ICES-7 marker PCBs. Congener-specific PCB analysis is an analytical method used widely to determine concentrations of all 209 congeners. This method is costly, labour-intensive, and time-consuming, which often are major considerations for determining sample size/distribution during large-scale or long-term environmental monitoring programs. Many studies have recognized the constraints of congener-specific PCB analysis and that routine analysis of all 209 congeners may not be necessary, possible, or practical (Batang et al. 2016; WHO 2001; Henry and DeVito 2003).

Various subsets of indicator PCB congeners have been used to address the limitations of congener-specific analysis of all 209 congeners. In Europe, OSPAR's Coordinated Environmental Monitoring Program established a monitoring protocol using seven indicator PCB congeners listed in Table 5-1 (OSPAR 2016). This subset of indicator PCB congeners is referred to as the ICES-7.

Table 5-1: PCB Congeners in the ICES-7 Marker PCB Subset

Subset of Indicator Congeners	PCBs in Congener Subset
ICES-7	28, 52, 101, 118, 138, 153, 180

Analysis of an indicator subset is useful if the PCB concentration for the subset is closely correlated with that for all 209 congeners. Marker PCB congener subsets and their associated accuracy, including the ICES-7 marker PCBs, were discussed in relation to data collected from Swan Hills during the 2018 and 2019 FTMP (Advisian 2019; Advisian 2020). Using data collected from 2013 to 2019, Worley determined that total PCB concentrations estimated from the concentration of the ICES-7 marker PCB subset had similar precision to that of the analytical method. This suggested that the concentration of ICES-7 marker PCBs could be reliably used to determine total PCB concentrations based on all 209 congeners for comparison with historical data.

The current Health Canada TDI is adjusted to account for only the ICES-7 marker PCBs and there are no existing guidelines for specific non-dioxin-like PCBs in Canada. In addition, congener profiles have been well-documented in both Chrystina Lake and Edith Lake brook trout since 2006. Consequently, much of the congener-specific data for non-dioxin-like PCBs is not utilized during the HHRA.

The ALS Laboratories Ltd. (ALS) in Burlington, Ontario, is currently the analytical laboratory used for the SHTC FTMP and HHRA. This laboratory has developed a method for the quantification of dioxins, furans, all dioxin-like PCBs, and the ICES-7 marker PCBs. This analysis is being used by CFIA for its Food Safety Action Plan and provides sufficient resolution to maintain the quality of total TEQ estimates, while focusing on key marker PCBs to provide efficient PCB tracking. Incorporation of this analysis into the SHTC FTMP and HHRA could reduce per sample analytical costs, while maintaining the reliability of tissue concentration measurements used for determining risk potential.

5.1.2 Tissue Residue Concentrations used for Risk Assessment

A weighted average of fish samples submitted each year is calculated for Chrystina Lake and Edith Lake brook trout, and total PCB and total TEQ are used to determine potential risks. Notably, the total TEQ accounts for toxicity of dioxin-like PCBs, dioxins, and furans, whereas assessment of total PCBs accounts for the potential non-dioxin-like effects of PCBs. The maximum total PCB and TEQ provides an overly conservative estimate of risk but is included to provide a worst-case scenario for comparison with exposure limits. Since 2019, the weighted average of brook trout 2+ years old and up has been included in the HHRA given that these fish are generally targeted by recreational fishing people based on size.

These brook trout are generally referred to as 'keeper' fish throughout the remainder of this report for conciseness. In addition, larger, untagged fish captured since 2022 have been analyzed and are included in the 'keeper' category, given the large size of these individuals.

5.2 Acute Exposure Estimation

Total PCB and TEQ exposure estimates for dioxins, furans, and dioxin-like PCBs were calculated for each life-stage using the exposure assessment parameters previously described in Section 3. Exposure factors currently used for the SHTC HHRA are provided in Table 3-1. Key changes proposed for the HHRA are also presented in this report and include:

1. increasing the assumed body weight of adult consumers from 73 kg to 80 kg;
2. determining exposure based on concentrations of ICES-7 marker PCBs rather than all 209 PCB congeners; and
3. basing risk potential estimates on the medium consumer group rather than the high consumer group.

Exposure estimates based on the currently used exposure factors (current HHRA case) and with proposed exposure factors (proposed HHRA case) are provided to show the influence of using the new exposure factors for risk characterization.

The estimated exposure calculations are based on Equation 1 to be consistent with exposure estimates previously calculated for the HHRA (G&P Resource Services Inc. 2021). Where C is the tissue residue concentration (based on the sum of all 209 PCB congeners or ICES-7 marker PCBs) for each respective test group (e.g., weighted average of high consumer adults). The units provided in Equation 1 are based on total and subset PCB concentrations, exposure estimates for total TEQ are based on pg TEQ/kg/day.

Equation 1

$$\text{Exposure } (\mu\text{g/kg/day}) = \frac{C (\mu\text{g/g}) * \text{Consumption Rate (g/day)}}{\text{body weight (kg)}} + \text{Background } (\mu\text{g/kg/day})$$

Exposure estimates based on the current HHRA case and proposed HHRA case are calculated for the 2024 HHRA based on contaminant concentrations, including:

- the annual weighted average of all brook trout sampled from each lake since 2002;
- the weighted average of 'keeper' brook trout from each lake since 2019;
- the maximum concentration measured in brook trout from each lake in 2024; and
- the maximum concentration measured in brook trout from each lake since 2006.

6. Risk Characterization

In the context of HHRA, Risk characterization is the final step of the risk assessment process, which combines the information from the Exposure Assessment and Toxicity Assessment steps to yield estimated risks from exposure to COCs. In addition, risk characterization involves an evaluation of the uncertainties underlying the risk assessment process. The risk characterization was prepared in accordance with Health Canada guidance on risk characterization (Health Canada 2021).

6.1 Exposure Ratio Calculation

The results are presented in Section 7, and a discussion of uncertainties inherent to the exposure and toxicity assessments is presented, along with an evaluation of the uncertainty in risk characterization for the fish ingestion pathway in Section 8. Exposure estimates are divided by exposure limits described in Section 4.2 to determine the Exposure Ratio (ER) for the respective consumer groups.

Equation 2

$$\text{Exposure Ratio (ER)} = \frac{\text{Estimated exposure } (\mu\text{g/kg/day})}{\text{Exposure Limit (TDI)}}$$

Health Canada refers to ERs as a hazard quotient, but the terminology in this report continues to use ER to describe risk for consistency between monitoring years. Risks associated with ERs below 1 are considered negligible to be acceptable by Health Canada, where background exposure is considered (Health Canada 2021). In this Project, the ER's relevance to levels of risk used during the HHRA include:

- **ER ≤ 1.0** – estimated exposure from fish consumption are below the respective exposure limit and **no risk** of adverse health effects are expected.
- **1 < ER ≤ 10** – estimated exposure from fish consumption presents a **low risk** of potential adverse human health effects given the conservatism built into the HHRA.
- **10 < ER** – **medium risk** of potential adverse health effects, indicating that risk management and/or adaptive monitoring measures should be considered.

The conservatism adopted in HHRA plays a major role in characterizing risks. The toxicity and exposure assessments maintain a conservative approach to ensure that potential risks to human consumers are not underestimated. The SHTC HHRA maintains this conservatism by incorporating the following:

1. Dioxin, furan, and PCB concentrations below the detection limit are replaced with half the detection limit value to account for potential exposure to these COCs.
2. Risk estimates are based on the highest consumption rate from the 1997 Swan Hills survey to ensure ERs are protective of people consuming the highest tissue quantities.
3. Risks are characterized based on maximum concentrations reported in fish tissue to account for a worst-case scenario for human consumers of wild-caught fish.

4. The lowest regional background exposure rates available have not been incorporated into the HHRA, given that some other available diet surveys report higher background exposure rates.
5. Risks are characterized based on tissue concentrations of edible tissue with the skin on to account for higher COC concentrations of lipophilic COCs such as PCBs, dioxins, and furans.
6. Risks reported do not account for cooking prior to eating, which can remove up to 50% of the tissue residues present in edible tissue.

7. Health Risks Associated with Consuming Wild-Caught Brook Trout from Swan Hills Area

Tissue concentrations of PCBs, dioxins, and furans measured in brook trout from Chrystina and Edith lakes in 2024 are presented and compared with concentrations found in market foods and other lakes in Section 7.1. Adult health risk results for high consumers are presented as the current HHRA case that employs the same methods and exposure factors previously used for the SHTC HHRA to provide consistency with previous reports (Section 7.2). In addition, adult health risks were calculated using proposed exposure factors (e.g. medium consumer consumption rate used) and the ICES-7 marker PCBs to determine non-dioxin-like PCB concentrations (Section 7.3). Notably, exposure factors for adolescent, child, and toddler age groups did not change following the 2024 literature review, however, risk was characterized based on the concentrations of all 209 PCB congeners as well as the sum of the ICES-7 marker PCBs (Section 7.4). As part of the expanded program in 2024, the maximum risk for adult high consumers was determined based on maximum PCB concentrations in Chrystina and Edith Lake brook trout (Section 7.5). This assessment is intended to show how the maximum worst-case scenario has changed in the two lakes since 2006.

7.1 Tissue Concentrations

Weighted averages of total PCB concentrations measured since 2002 are summarized in Table 1. Tissue residue concentrations of PCBs, dioxins, and furans measured in brook trout sampled in 2024 are summarized in Table 7-1 (calculated TEQ for dioxin-like PCBs, dioxins, and furans). Notably, the sum of ICES-7 marker PCB congeners is also presented, given that the proposed HHRA case uses these concentrations to estimate exposure.

Table 7-1: Total PCB concentrations and TEQs measured in brook trout sampled for the 2024 HHRA

Station	Sample ID	Fish Number	Total PCB (ng/g)	ΣICES-7 PCBs (ng/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
Chrystina Lake	CHBKTR 1+	5	7.65	3.19	0.3339	0.1727	0.5066
	CHBKTR 2+	5	13.9	5.73	0.5850	0.1475	0.7325
	CHBKTR 3+	3	18.45	7.88	1.1347	0.1630	1.2977
	CHBKTR UNK A	1	15.6	6.8	0.7221	0.2032	0.9253
	CHBKTR UNK B	1	36.6	13.6	1.5555	0.2200	1.7755
	CHBKTR UNK C	1	14.0	5.95	0.5424	0.1568	0.6992
Edith Lake	EDBKTR 1+	5	3.03	1.22	0.0869	0.2114	0.2983
	EDBKTR 2+	6	5.1	2.38	0.6113	0.1434	0.7546
	EDBKTR 3+	2	3.29	1.53	0.2542	0.1430	0.3973
	EDBKTR 4+	1	2.56	1.18	0.2187	0.1424	0.3611
	EDBKTR 5+	1	8.63	3.94	0.6384	0.2105	0.8489

The 2024 weighted averages for total PCBs and TEQs for dioxin-like PCBs, dioxins, and furans are summarized for Chrystina Lake and Edith Lake brook trout in Table 7-2. Weighted averages for 'keeper' brook trout are also provided in Table 7-2. Dioxins and furans are primarily below detection in brook trout from both lakes, leading to similar TEQs for dioxins and furans; however, total PCB and TEQ from dioxin-like PCBs is higher in Chrystina Lake compared to Edith Lake (Table 7-2).

Table 7-2: Weighted averages for total PCB concentrations and TEQs measured in brook trout sampled for the 2024 HHRA

Age Group	Station	Total PCB (µg/g)	ΣICES-7 PCB (µg/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
All ages (weighted average)	Chrystina Lake	0.01433	0.00591	0.68	0.17	0.84
	Edith Lake	0.00423	0.00190	0.36	0.17	0.53
≥2+ years old ("Keeper")	Chrystina Lake	0.01737	0.00715	0.83	0.16	1.00
	Edith Lake	0.00484	0.00225	0.50	0.15	0.65

Weighted average total PCBs and the sum of the ICES-7 marker PCBs measured in brook trout from the FTMP are compared with historical concentrations in Figure 7-1 and Figure 7-2, respectively. The average total PCB concentration in Chrystina Lake brook trout decreased from the previous years and is similar to the weighted average observed in 2020. The total PCB weighted average in Edith Lake is slightly lower than that of Chrystina Lake and has been similar to that of hatchery fish since 2017. These results suggest that PCB accumulation in Chrystina Lake has been decreasing since 2011 and has been minimal in Edith Lake since 2017. Patterns observed based on the sum of ICES-7 marker PCBs since 2019 have been similar to those observed for total PCBs (based on all 209 congeners). Review of the ICES-7 marker PCBs suggests that PCB concentrations are higher in Chrystina Lake, but PCB levels in Edith Lake brook trout are similar to those observed in fish taken directly from the hatchery.

Total TEQs based on weighted average concentrations of dioxins, furans, and dioxin-like PCBs in brook trout from Chrystina Lake and Edith Lake are provided in Figure 7-3. The temporal patterns in total TEQ are similar to PCB concentrations in both lakes as well as hatchery brook trout. It is well-established that total TEQ in Chrystina Lake and Edith Lake is primarily driven by PCB concentrations, given that dioxin and furans are consistently below detection limits. Overall, TEQ increased in 2024 compared with 2023 in both lakes.

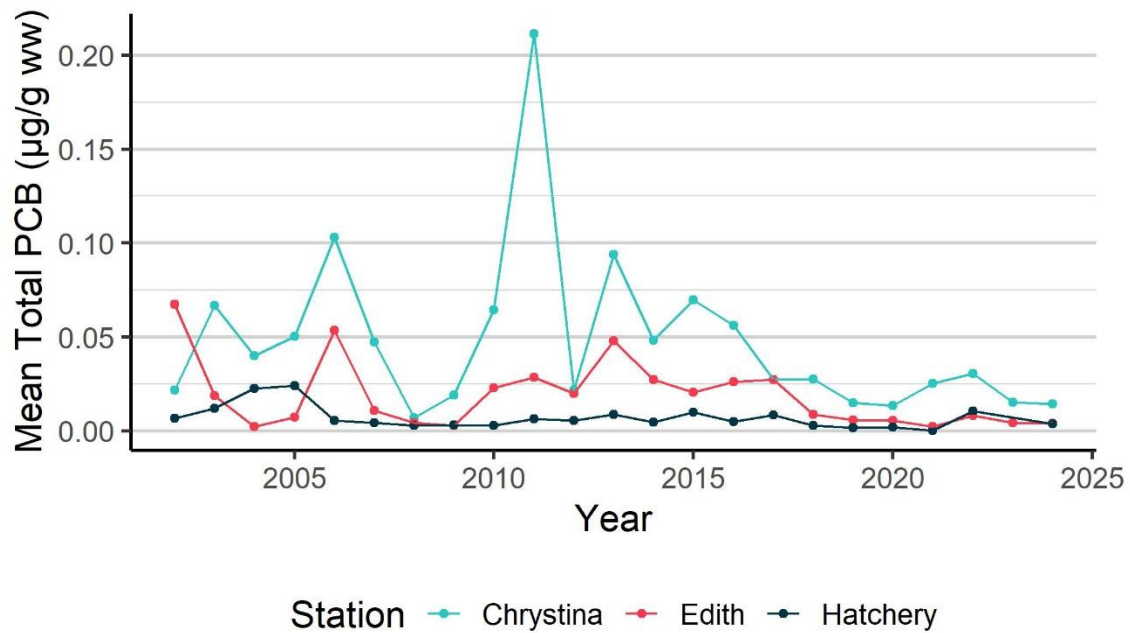


Figure 7-1: Weighted Average of Total PCBs in Brook Trout Sampled from Chrystina Lake, Edith Lake and the Hatchery (2002 to 2024)

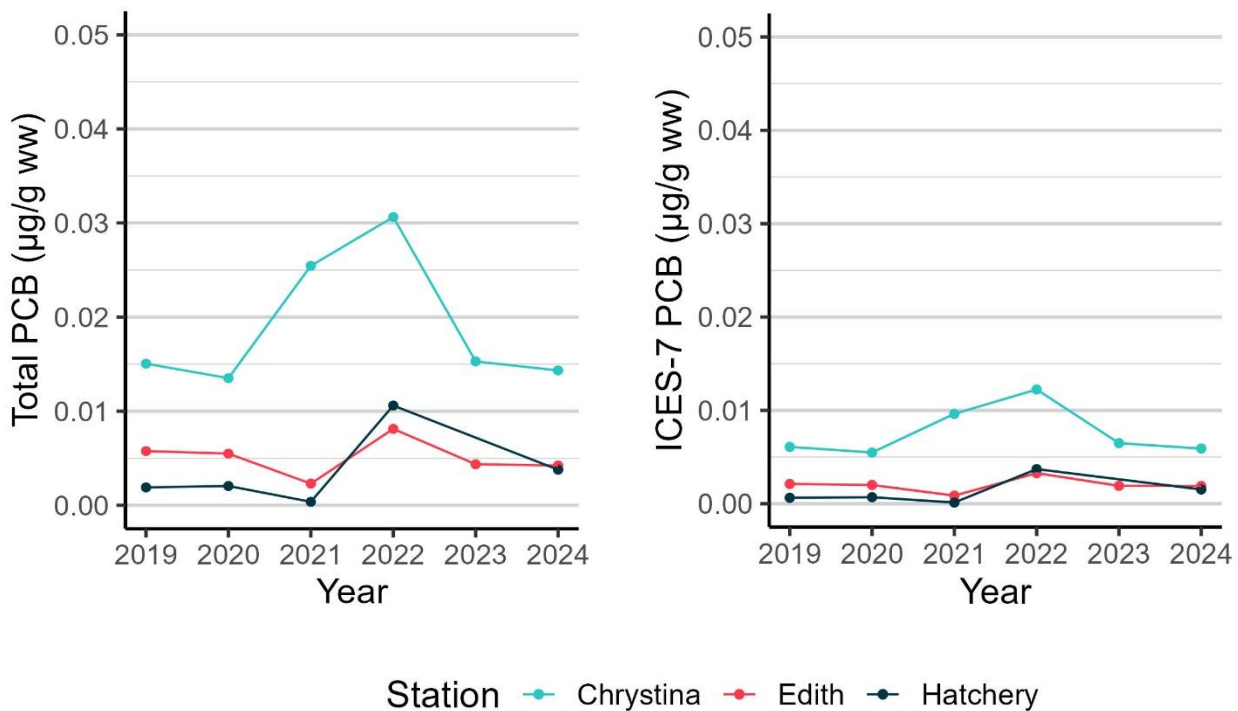


Figure 7-2: Weighted Average of the sum of 209 PCB congeners (Left) and the sum of ICES-7 marker PCBs (Right) in brook trout sampled from Chrystina Lake, Edith Lake and the Hatchery (2019 to 2024)

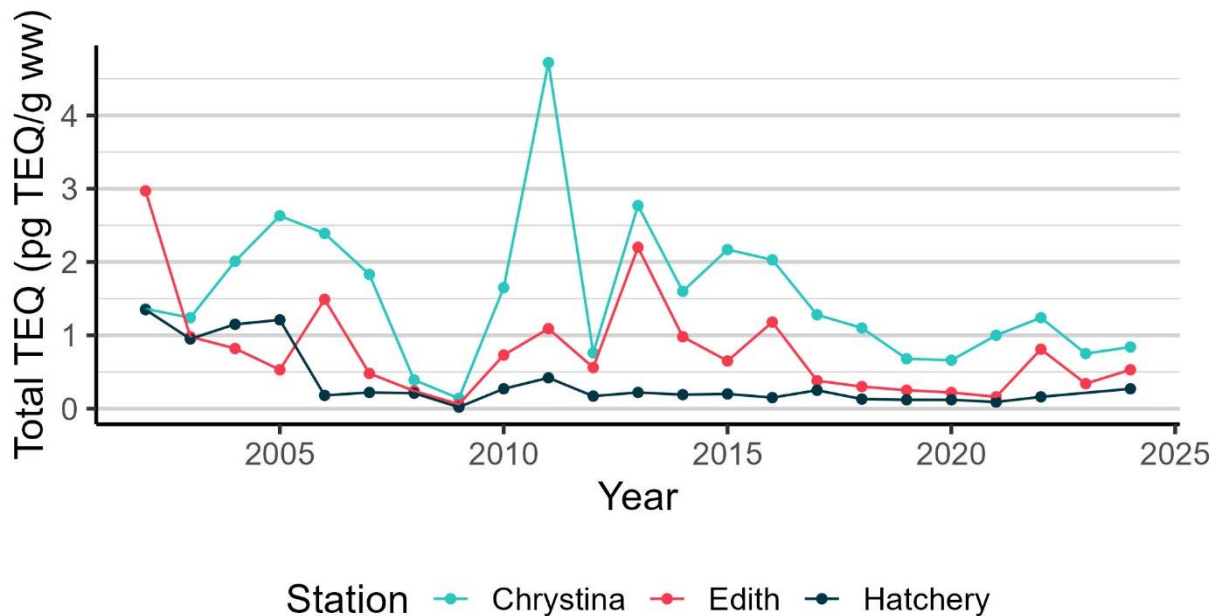


Figure 7-3: Weighted Average Total TEQ for Brook Trout Sampled from Chrystina Lake, Edith Lake and the Hatchery (2002 to 2024)

Maximum total PCB and ICES-7 marker PCB concentrations measured in Chrystina Lake and Edith Lake brook trout in 2024 are provided alongside TEQs based on dioxin-like PCBs, dioxins, and furans in Table 7-3.

Table 7-3: Maximum total PCBs and TEQ for Chrystina Lake and Edith Lake brook trout in 2024

Station	Total PCB (µg/g)	ΣICES-7 PCB (µg/g)	PCB TEQ (pg/g)	Dioxin/Furan TEQ (pg/g)	Total TEQ (pg/g)
Chrystina Lake	0.0366	0.0136	1.5555	0.2200	1.7755
Edith Lake	0.00863	0.00394	0.6384	0.2114	0.8489

7.1.1 Total PCB and TEQ Concentration Comparison with Other North American Lakes and Supermarkets

Total PCB concentrations in Chrystina Lake and Edith Lake were last compared with other North American lakes and market foods in 2021. These comparisons were updated during the 2024 HHRA following the literature review. The range of PCB concentrations found in Chrystina Lake and Edith Lake brook trout in 2024 are presented with concentrations found in other North American lakes in Table 7-4.

Tissue concentrations in Chrystina Lake were similar to the mean total PCB concentration found in trout used as traditional foods in the Yukon between 2008 and 2018, while tissue concentrations in Edith Lake were below the average in all age classes (Chan et al. 2021).

The mean and maximum PCB concentrations reported in the boreal plains region of Alberta were comparable with concentrations found in Edith Lake brook trout and below PCB concentrations found in Chrystina Lake brook trout (Table 7-4).

Table 7-4: Total PCB concentrations in other lakes compared with concentrations in Chrystina and Edith Lake brook trout (adapted and updated from G&P Resource Services Inc. 2021)

Location	Species	Concentration (ng/g)	Time-Period
Chrystina Lake	Brook Trout	7.65 to 36.6	2024
Edith Lake	Brook Trout	2.56 to 8.63	2024
Canada – Boreal Plains	Trout	18.06 (ND to 298.51) ¹⁷	2008 to 2018
Alberta – Boreal Plains	Trout	Mean = 2.71; max = 4.29 ¹⁸	2013
Lake Huron	Lake Trout Lake Trout (skinless filet) Whitefish (skinless filet)	81-650 ^{1,2,3} 150 ⁴ 37 ⁴	2006 to 2017
Lake Superior	Lake Trout Lake Trout (skinless filet) White Fish (skinless filet)	169-215 ^{1,2} 76 ⁴ 48 ⁴	
Lake Michigan	Lake Trout Lake Trout, Walleye Lake Trout White suckers	920 ² 935 ³ 1000 ⁵ 203 ⁷	
Lake Ontario	Lake Trout Lake Trout (skin on filets) Brown Trout (skin on filets) Sports fish (skin removed filets)	445-550 ^{1,2} 422 ⁷ 196 ⁸ 241 (20-6,000) ⁹	
Lake Erie	Walleye, Lake Trout Rainbow Trout (skin on filets) Lake Trout (skin on filets) White Fish (skinless filets)	575-850 ^{1,2} 223 ⁶ 346 ⁶ 110 ⁴	
Great Lakes Coastal Waters	Predatory fish species (filets)	179 (6-2379) ¹⁰	
Lake Champlain	Lake Trout (whole fish) Lake Trout (skin on filets)	395.7 (217-836) ¹¹ 217.6 (137-313)	
St. Lawrence River	White suckers Walleye, pike, perch (fillets)	169-326 ¹² 5-130	2002 to 2007 2010 to 2013
Ontario and Manitoba Lakes	Walleye, whitefish, trout, perch, pike	9-77 ¹³	2011 to 2015
Washington State Lakes	Variety of species (mean for each area)	33.6- 200 ¹⁴	2013

Location	Species	Concentration (ng/g)	Time-Period
U.S. National Lake study (500 lakes)	Bottom dwelling fish (e.g. carp, white suckers, catfish)	Median = 13.9 (0.6-1266) ¹⁵	2000 to 2003
U.S. National River study	15 species of fish (skin on fillets)	47.1 ¹⁶	2008 to 2009

*whole fish samples were analysed unless otherwise noted

Bold text indicates concentrations in Chrystina and Edith Lake brook trout measured as the total sum of all PCB congeners.

Italic text indicates concentrations obtained after 2020 during literature review.

Superscript 1 - Whole body total PCB concentrations measured by Environment Canada via Aroclor method 20 10-2017 (SOLEC, 2017; McGoldrick, D.J 2019 and 2020. pers. comm.)

Superscript 2 - Whole body total PCB concentrations measured by the U.S. EPA via sum of congener method 20 10-2014 (SOLEC, 2017; Zhou et al., 2018))

Superscript 3 - Average whole-body PCB concentration (sum of congeners) measured in lake trout from main basin of Lake Huron (2010 -2012) (Paterson et al. 2016)

Superscript 4 - Total PCBs in skinless fillets measured by Health Canada via sum of congener method in 2006 -2007 (Rawn et al. 2017)

Superscript 5 - Steady state total PCB concentrations measured in Lake Trout in Lake Michigan by 2014 (Hites and Holsen, 2019)

Superscript 6 - Average total PCB concentration measured in white suckers from Lake Michigan in 2016 (Stapanian et al., 2018)

Superscript 7 - Total PCB concentrations in skin on lake trout fillets collected in 2010-2012 by New York State Dept of Environmental Conservation via the Aroclor method (Li et al. 2014) (measured as Aroclor 1254/1260)

Superscript 8 - Total PCB concentrations in skinless fillets of Brown Trout collected from the Toronto harbour in 2010 (Aroclor method) (Bhavsar, 2017).

Superscript 9 - Median and range of total PCB concentrations in skinless sports fish filets caught between 2010 and 2012 in Lake Ontario (Government of Ontario, 2016)

Superscript 10 - Median and range of total PCB concentrations (sum of congener) in 157 Great Lakes predatory fish fillet samples in 2010 as part of the National Coastal Condition Assessment (USEPA, 2016).

Superscript 11 - Average total PCB concentrations in whole fish lake trout and skin on lake trout fillets collected from Lake Champlain in 2012 -2018 (Lake Champlain is a large, deep lake in northeastern United States that that reaches into Quebec; the sixth biggest lake in the United States) (Pagano and Garner, 2020)

Superscript 12 - Average PCB concentrations measured in various monitoring station areas along the St. Lawrence River; whole white suckers were analysed in 2002-2007, while fillets only were measured in walleye, Northern pike and yellow perch in 2010-2014) (Government of Quebec 2010, 2016).

Superscript 13 - Range of average total PCB concentrations reported in fish from lakes near First Nations communities across Ontario and Manitoba (Marushka et al. 2017, 2018).

Superscript 14 - Total PCB concentrations in skin on filets collected in 2013 from 3 areas in Washington State as part of the Freshwater Fish Contaminant Monitoring Program (FFCMP) (mid-Columbia River area McNary National Wildlife Refuge and Liberty Lake) (FFCMP, 2017). NB: both Aroclor and congener methods used but results were found to be comparable) (species included: (catfish, carp, sucker, whitefish, rainbow trout, bass and walleye).

Superscript 15 - Whole body total PCB concentrations (sum of 209 congeners) in bottom dwelling fish species sampled in 2000-2003 in 500 lakes randomly selected across 48 States (excluding Great Lakes) as part of effort to define a national baseline of fish contamination in United States (Stahl et al. 2009)

Superscript 16 - Mean concentration of PCBs (measured as sum of 21 congeners) in composite samples of 15 species of fish (skin-on fillets) in 2008-2009 (Batt et al., 2017).

Superscript 17 - Mean concentration and range of total PCBs (measured as sum of 36 congeners) in food samples submitted from Canadian reserves (Chan et al. 2021).

Location	Species	Concentration (ng/g)	Time-Period
Superscript 18 – Mean and maximum total PCB concentrations (measured as sum of 36 congeners) in food samples submitted from reserves in the Boreal Plains region of Alberta (Chan et al. 2016).			

The comparison of PCB concentrations and total TEQ of market foods completed in 2021 indicated that concentrations in Chrystina Lake and Edith Lake brook trout were similar to farmed trout and at the low end of concentrations found in canned fish (G&P Resource Services Inc. 2021). The average concentration of PCBs found in foods analyzed for the 2015 total diet study is similar to the maximum concentration measured in Edith Lake, while the maximum concentration measured in the total diet study was similar to the maximum concentration measured in Chrystina Lake brook trout in 2024 (Table 3-2).

7.2 Adult Health Risks (Current HHRA Case)

The current HHRA case presents risk characterized using the exposure factors and assumptions previously used for the SHTC HHRA to provide consistency with previous reports. Adult consumer risk in the following section is characterized using exposure factors summarized for high consumers in Table 3-1, total PCB concentrations based on all 209 PCB congeners to estimate exposure, and compares exposure estimates to the 2021 Health Canada TDI.

7.2.1 Total PCBs (using all 209 PCBs)

The 2024 ERs for total PCBs for each adult consumer group are summarized for Chrystina Lake and Edith Lake in Table 7-5. There are no ERs that exceed 10 in Chrystina Lake or Edith Lake in 2024 based on currently used risk characterization methods. The ER is between 1 and 10 for high fish consumers from both lakes, as well as for medium consumers eating brook trout from Chrystina Lake. These results are consistent with those documented from 2021 to 2023 for high and medium consumers (Worley 2024). The ERs based on the consumption rate advised by Alberta Health (22 g/day) for lakes within 20 km of Swan Hills were below 1 for Chrystina Lake and Edith Lake brook trout in 2024. These results were consistent for the weighted average, 'keeper', and maximum contaminant concentrations documented in brook trout analyzed in 2024. Notably, the ERs based on the PCB concentration in hatchery fish were similar to those observed for Edith Lake brook trout in 2024 (Table 7-5).

Table 7-5: Exposure Ratios based on total PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	8.57	3.48	4.17
	Medium (47 g/day)	2.56	1.12	1.32
	Low (13 g/day)	0.85	0.46	0.51
	Very Low (2 g/day)	0.30	0.24	0.25
	Advisory (22 g/day)	1.30	0.63	0.72
Edith Lake	High (167 g/day)	2.17	1.17	1.31

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
	Medium (47 g/day)	0.76	0.47	0.51
	Low (13 g/day)	0.35	0.28	0.29
	Very Low (2 g/day)	0.22	0.21	0.21
	Advisory (22 g/day)	0.46	0.33	0.35
Hatchery	High (167 g/day)	1.06		
	Medium (47 g/day)	0.44		
	Low (13 g/day)	0.27		
	Very Low (2 g/day)	0.21		
	Advisory (22 g/day)	0.31		
Notes:				
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.				

The ERs for total PCBs from the consumption of brook trout from Chrystina Lake suggest that there is a potential for a low risk of adverse effects for both high and medium consumers. There is no risk of adverse effects for people within the low or very low consumer groups, or those following the current consumption advisory. There is a potential for a low risk of adverse effects for high consumers of brook trout from Edith Lake, but no risk to the other adult consumer groups. In addition, risk potential from the consumption of brook trout in Edith Lake is similar to those posed by brook trout taken directly from the rearing hatchery.

7.2.2 Total TEQ

Total TEQ ERs determined for consumers of Chrystina Lake and Edith Lake brook trout in 2024 are summarized in Table 7-6. The ERs for total TEQ in Chrystina Lake brook trout were below 1 for all consumer groups, apart from high consumers. The ERs for the high consumer group exceeded 1 for the maximum, 'keeper', and weighted average TEQs measured in Chrystina Lake brook trout, whereas only the maximum TEQ measured in Edith Lake brook trout had an ER above 1 in 2024 (Table 7-6). The ERs calculated based on the TEQ measured in hatchery brook trout were slightly lower than those for consuming brook trout from Chrystina Lake and Edith Lake in 2024.

The ERs for total TEQ in 2024 indicate that exposure to dioxin-like PCBs, dioxins, and furans is below the exposure limit for most consumers of Chrystina Lake and Edith Lake brook trout. Consequently, no adverse effects are expected for consumer groups apart from high consumers. There is a low potential risk to high consumers of Chrystina Lake brook trout; however, this risk is low given the conservatism incorporated into the HHRA.

Table 7-6: Exposure Ratios based on total TEQ for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	1.98	1.05	1.21
	Medium (47 g/day)	0.71	0.45	0.50
	Low (13 g/day)	0.35	0.28	0.29
	Very Low (2 g/day)	0.24	0.23	0.23
	Advisory (22 g/day)	0.45	0.33	0.35
Edith Lake	High (167 g/day)	1.06	0.74	0.86
	Medium (47 g/day)	0.46	0.37	0.40
	Low (13 g/day)	0.28	0.26	0.27
	Very Low (2 g/day)	0.23	0.22	0.23
	Advisory (22 g/day)	0.33	0.29	0.30
Hatchery	High (167 g/day)	0.49		
	Medium (47 g/day)	0.29		
	Low (13 g/day)	0.24		
	Very Low (2 g/day)	0.22		
	Advisory (22 g/day)	0.25		
Notes:				
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.				

7.2.3 Temporal Risk Comparison for High Consumers from 2002 to 2024 (Current HHRA Case)

The SHTC HHRA has included a historical comparison of ERs for high consumers based on weighted averages since 2002 to identify temporal risk trends in Chrystina Lake and Edith Lake. The 2021 Health Canada provisional TDI for non-dioxin-like PCBs is more conservative, partially because the TDI is corrected to account for the concentration of only the ICES-7 marker PCBs. Since 2021, the SHTC HHRA has continued to compare this TDI with total PCB concentrations based on the sum of all 209 congeners. This risk case is presented in 2024 to provide consistency with previous reports; however, it is understood that this method will overestimate risk given that the TDI only accounts for the sum of ICES-7 marker PCBs. In 2024, estimated risks based on the ICES-7 marker PCBs have also been calculated, and these risks are presented in Sections 7.3, 7.4, and 7.5.

Total PCB and TEQ ERs for high consumers of Chrystina Lake, Edith Lake, and hatchery brook trout since 2002 are summarized in Table 1.

7.2.3.1 Total PCBs (using all 209 PCBs)

The ERs for high consumers of Chrystina Lake, Edith Lake, and hatchery brook trout since 2002 based on weighted average and 'keeper' PCB concentrations following the current HHRA case are provided in Figure 7-4. The ERs for high consumers of Chrystina Lake brook trout have been between 1 and 10 since 2017, and the ER in 2024 was slightly lower than that observed in 2023. Alternatively, the ERs for high consumers of Edith Lake brook trout have exceeded 1 but have typically been near 1, and similar to hatchery fish since 2018 (Figure 7-4). It is important to consider that these ERs are based on the high consumer group that represents only 2% of the respondents to the diet and activity survey used to estimate ingestion rates (GOA 2013). Therefore, the high consumption rate used and the inclusion of all PCB congeners into total PCB concentrations make these risk estimates overly conservative.

7.2.3.2 Total TEQ

The ERs based on a weighted average and 'keeper' TEQ measurements and the high consumption rate of Chrystina Lake, Edith Lake, and hatchery brook trout since 2002 are provided in Figure 7-5. The ERs for consumption of Chrystina Lake brook trout decreased from 2015 to 2020 before increasing slightly in 2021 and 2022. Despite this increase, the TEQ-based ER in Chrystina Lake for high consumers has remained near 1 since 2018. The more conservative ERs based on TEQs measured in 'keeper' brook have remained at or slightly above 1 since 2019. The total TEQ ER for consumption of brook trout from Edith Lake has been consistently lower than Chrystina Lake, and this trend continued in 2024. Apart from a slight increase in 2022, the ER for Edith Lake brook trout has been below 1, and similar to hatchery brook trout for high consumers.

The review of exposure factors used currently in the SHTC HHRA indicated that the high consumption rate obtained during the 1997 diet and activity study in and around Swan Hills overestimates the current consumption of fish from the Swan Hills area (see Section 3.4.1). Based on this review, as well as discussions with Alberta Health (Puhallo, Jennifer 2025. pers. comm.), the medium consumption rate from the 1997 Swan Hills survey provides a more realistic estimate of current consumption rates by recreational and subsistence fishers in the Swan Hills area. Notably, potential risk based on this highly conservative consumption rate has been low for Chrystina Lake since 2019, and ERs since 2017 primarily suggest there is no risk to consumers of Edith Lake brook trout.

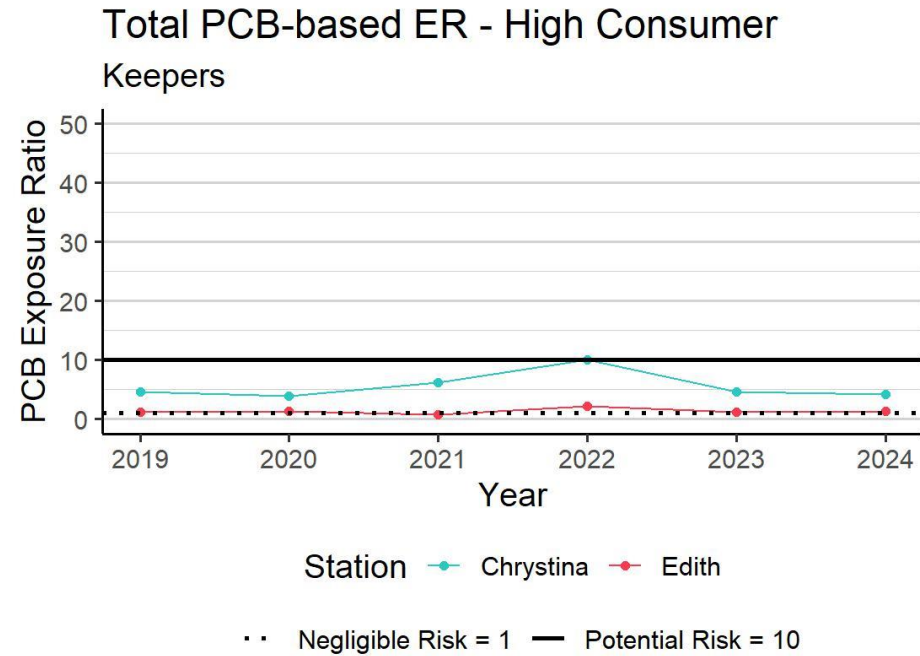
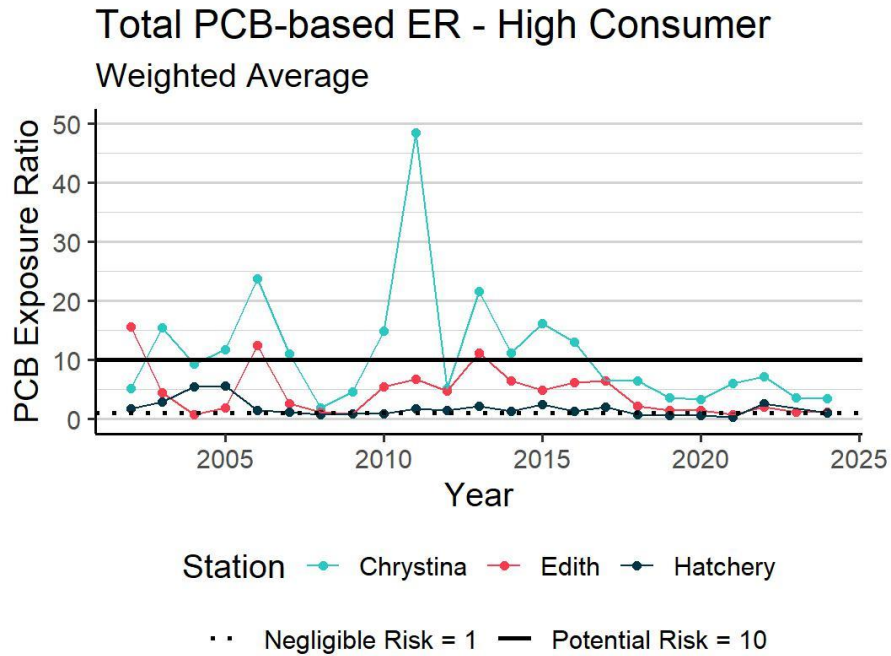


Figure 7-4: Exposure ratios based on methods used in the SHTC HHRA for high consumers, using the concentration of all PCB congeners, and comparing exposure estimates to the 2021 Health Canada TDI

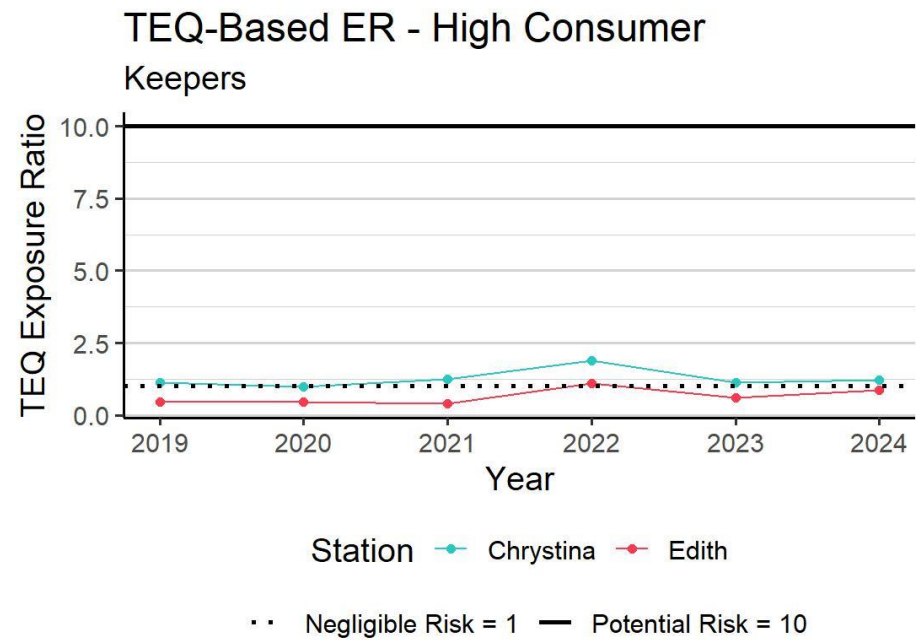
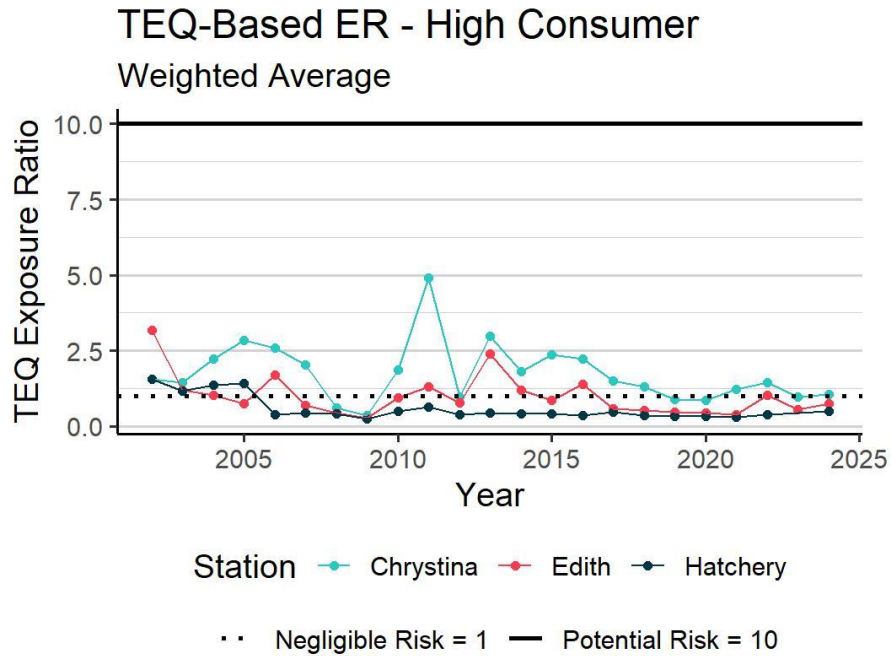


Figure 7-5: Exposure ratios for dioxin-like PCBs, dioxins, and furans measured as TEQ based on methods currently used in the SHTC HHRA for high consumers

7.3 Adult Health Risks (Proposed HHRA Case)

The review of exposure factors and limits applied in the SHTC HHRA identified that body weight estimates previously used were low and should be increased to 80 kg and that health risks would be more accurately characterized using the medium consumption rate from the 1997 Swan Hills diet and activity study (see Section 3.4.1.). In addition, both historical and current analytical methods, including the sum of all 209 congeners, did not provide an appropriate comparison to the 2021 Health Canada TDI for non-dioxin-like PCBs, which is based on the sum of only the ICES-7 marker PCBs. This year, we also characterized risks and ERs based on the concentration of ICES-7 marker PCBs, which are presented in Figure 7-6. This can be compared with those presented in Figure 7-4 to show how this change affects the ERs calculated for the SHTC HHRA. It is important to note that ERs based on the ICES-7 marker PCBs (proposed HHRA case) have remained near 1 for Chrystina Lake and at or below 1 for Edith Lake for high consumers of brook trout since 2019 (Figure 7-6).

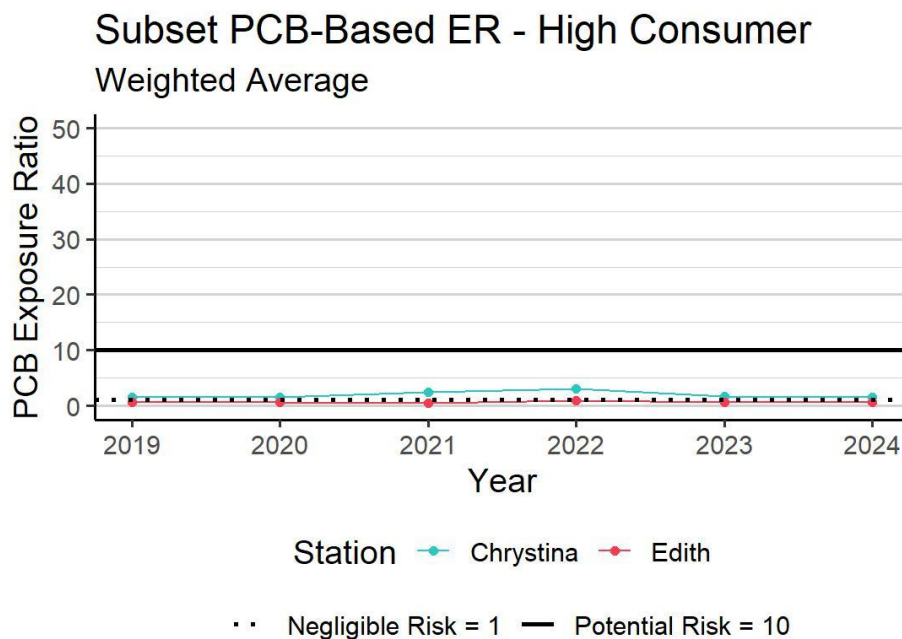


Figure 7-6: Exposure ratios for high consumers based on risk estimates using current exposure factors, weighted average concentrations of the sum of ICES-7 marker PCBs, and comparing with the 2021 Health Canada TDI

The following sections outline risk potential characterized using proposed methods outlined for the SHTC HHRA based on the 2024 review of exposure factors and limits.

7.3.1 Total PCBs (using ICES-7 Marker PCBs)

The ERs for non-dioxin-like PCBs for consuming brook trout from Chrystina Lake and Edith Lake based on the proposed SHTC HHRA risk characterization assumptions are presented in Table 7-7.

The ER for high consumers in Chrystina Lake was above 1 based on the weighted average, 'keeper' concentration, and maximum concentration for ICES-7 marker PCBs, as well as for the medium consumer based on the maximum ICES-7 marker PCB concentration in Chrystina Lake brook trout in 2024. Nearly all ERs for consumption of Edith Lake brook trout were below 1, and ERs based on the weighted average of ICES-7 marker PCBs were similar to those calculated for brook trout taken directly from the hatchery in 2024 (Table 7-7).

Table 7-7: Exposure Ratios based on the updated adult body weight estimate, and the sum of ICES-7 marker PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Exposure Ratio for Sum of ICES7 PCB (Maximum)	Exposure Ratio for Sum of ICES7 PCB (Weighted Average)	Exposure Ratio for Sum of ICES7 PCB ('keeper')
Chrystina Lake	High (167 g/day)	3.04	1.43	1.69
	Medium (47 g/day)	1.00	0.55	0.62
	Low (13 g/day)	0.42	0.30	0.32
	Very Low (2 g/day)	0.23	0.21	0.22
	Advisory (22 g/day)	0.57	0.36	0.40
Edith Lake	High (167 g/day)	1.02	0.60	0.67
	Medium (47 g/day)	0.43	0.31	0.33
	Low (13 g/day)	0.26	0.23	0.24
	Very Low (2 g/day)	0.21	0.20	0.21
	Advisory (22 g/day)	0.31	0.25	0.26
Hatchery	High (167 g/day)	0.52		
	Medium (47 g/day)	0.29		
	Low (13 g/day)	0.22		
	Very Low (2 g/day)	0.20		
	Advisory (22 g/day)	0.24		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

The ERs indicate that there is no risk to medium consumers of Chrystina Lake brook trout, however, larger fish (>300 mm long) that are typically older may contain PCB concentrations that present a low potential risk. There is no risk to medium consumers of brook trout from Edith Lake even based on the maximum concentration of PCBs measured in 2024. Three of the five tissue samples from Edith Lake reported ICES-7 marker PCB concentrations equal to or below concentrations in trout taken directly from the hatchery, leading to similar ERs between Edith Lake and hatchery brook trout in 2024 (Table 7-7).

7.3.2 Total TEQ

The ERs for potential risks from dioxin-like PCBs, dioxins, and furans based on the proposed SHTC HHRA case are summarized in Table 7-8. Only the assumed body weight of adults was updated following review of risk classification methods currently used for determining risk from dioxin-like PCBs, dioxins, and furans. This increased assumed body weight led to a slight reduction in the ERs of each consumer group compared with current methods. Currently, the potential risks assessment has been based on risks posed to high consumers; however, recent consumption rate estimates align more with the medium consumer group. The total TEQ-based ERs for the medium consumer group are below 1 for brook trout from Chrystina Lake and Edith Lake in 2024 (Table 7-8). This suggests that there are no potential risks to consumers of brook trout from these lakes. It is notable that the more conservative ERs for the high consumer group are near 1 for consumers of Chrystina Lake brook trout in 2024, indicating a low potential risk for adults consuming high quantities of brook trout from Chrystina Lake.

Table 7-8: Exposure Ratios for consumption of brook trout near Swan Hills in 2024, based on the updated adult body weight estimate

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	High (167 g/day)	1.83	0.98	1.13
	Medium (47 g/day)	0.67	0.43	0.47
	Low (13 g/day)	0.34	0.27	0.29
	Very Low (2 g/day)	0.24	0.23	0.23
	Advisory (22 g/day)	0.43	0.32	0.34
Edith Lake	High (167 g/day)	0.99	0.70	0.81
	Medium (47 g/day)	0.43	0.35	0.38
	Low (13 g/day)	0.28	0.25	0.26
	Very Low (2 g/day)	0.23	0.22	0.22
	Advisory (22 g/day)	0.32	0.28	0.30
Hatchery	High (167 g/day)	0.46		
	Medium (47 g/day)	0.29		
	Low (13 g/day)	0.24		
	Very Low (2 g/day)	0.22		
	Advisory (22 g/day)	0.25		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

7.3.3 Temporal Risk Comparison for Medium Consumers from 2019 to 2024 (Proposed HHRA Case)

The risk characterization methods currently used for the SHTC HHRA potentially overestimate risks given the findings of the exposure factors and limits review in 2024 (see Section 3).

Revisions to these methods were therefore proposed for the 2024 HHRA and ERs were calculated based on more reliable and robust assumptions. Replacing total PCB concentrations based on the sum of all 209 PCB congeners with the sum of ICES-7 marker PCBs provides a more accurate comparison with the Health Canada TDI. The weighted average PCB concentration based on the ICES-7 marker PCBs was calculated as far back as 2019 given that conditions prior to this are unlikely to represent current conditions in Chrystina Lake or Edith Lake. The ERs for medium consumers are presented in Table 2 and discussed in the following sections given that this consumption rate is more reflective of more recent consumption rate estimates within the province of Alberta.

7.3.3.1 Total PCBs (using ICES-7 Marker PCBs)

Based on the proposed risk characterization methods, the ERs for non-dioxin-like PCBs for consumers of Chrystina Lake brook trout have been below 1 since 2019 (Figure 7-7). The ER for consumption of Chrystina Lake brook trout in 2022 was nearly 1 and has decreased both in 2023 and 2024. Meanwhile, the ER for consumption of Edith Lake brook trout is consistently below 1 and similar to the ERs calculated for brook trout taken directly from the hatchery (Figure 7-7).

The lower ERs for non-dioxin-like PCBs based on the proposed HHRA case indicate that there is no risk to consumers of brook trout from Chrystina Lake or Edith Lake. Although the risk to consumers of brook trout from Chrystina Lake is slightly elevated compared with Edith Lake, there was no risk to consumers of Chrystina Lake brook trout. In addition, the risk posed to consumers has remained relatively consistent since 2019, particularly for consumers of brook trout taken from Edith Lake.

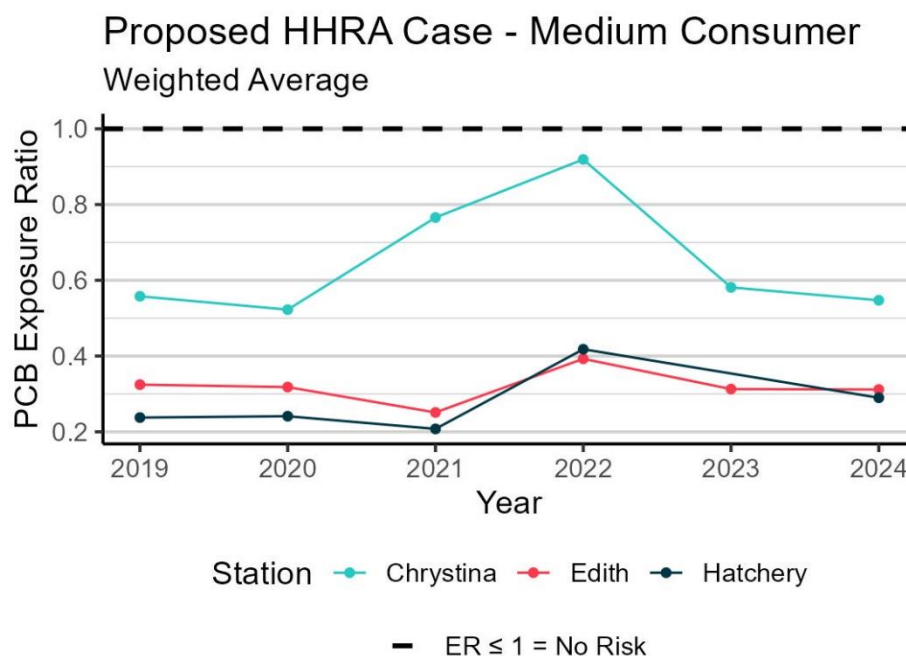


Figure 7-7: Exposure ratios for medium consumers using revised exposure factors and weighted average concentrations of the sum of ICES-7 marker PCBs

7.3.3.2 Total TEQ

Apart from a change to assumed body weight, the TEQs calculated for the SHTC HHRA remained consistent with current methods, therefore historical trends for medium consumers are presented from 2002 to 2024 (Figure 7-8). The ERs based on the annual weighted average provide historical context for the risk to medium consumers, whereas the ERs based on TEQs of 'keeper' brook trout provide a more conservative risk assessment for Chrystina Lake and Edith Lake since 2019. The ERs calculated for dioxin-like PCBs, dioxins, and furans (combined as TEQ) have been below 1 for consumers of Chrystina Lake and Edith Lake brook trout since 2013 based on weighted average concentrations. In addition, the ERs based on TEQ measured in 'keeper' brook trout from both lakes has been below 1 for medium consumers since at least 2019. There is no risk associated with dioxin-like PCBs, dioxins, and furans for consumers of brook trout from Chrystina Lake and Edith Lake based on the HHRA results since 2019 and literature review in 2024.

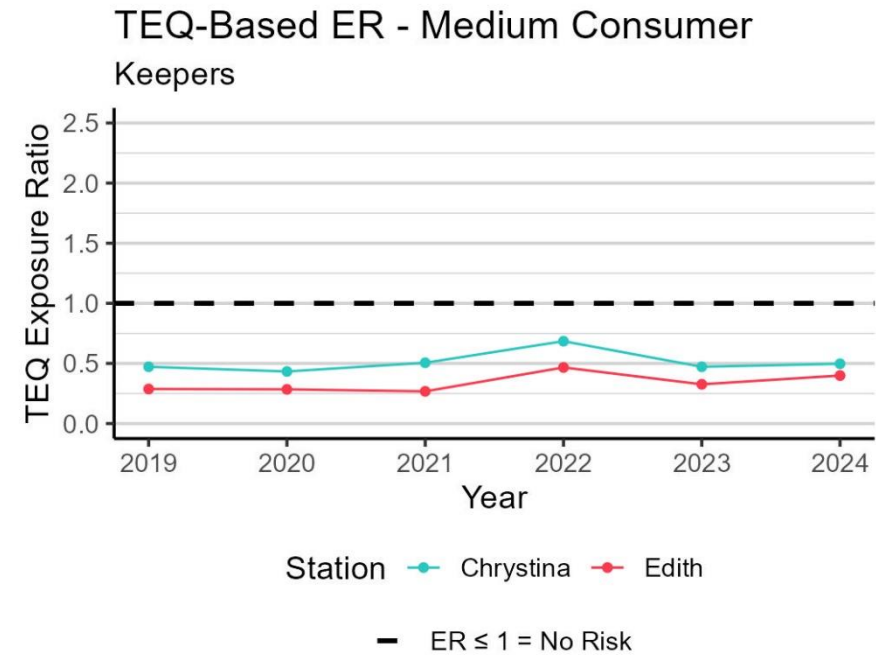
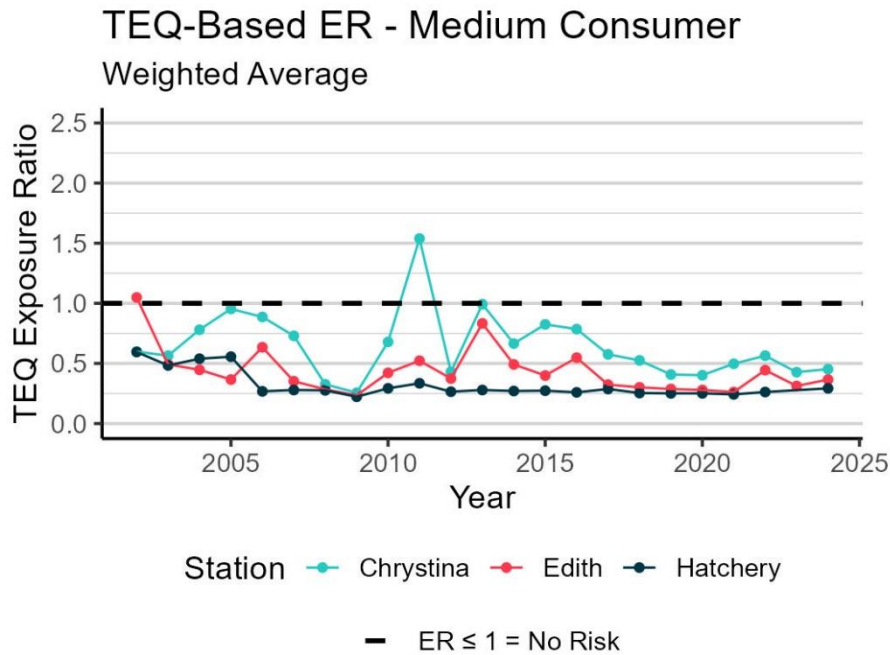


Figure 7-8: Exposure ratios for dioxin-like PCBs, dioxins, and furans measured as TEQ based on proposed HHRA revisions for medium consumers

7.4 Adolescent, Child, and Toddler Health Risks

The only change to the risk characterization methods for adolescents, children, and toddlers during the 2024 SHTC HHRA is the inclusion of the ICES-7 marker PCBs for determining total PCB concentrations for the assessment of risks from non-dioxin-like PCBs. The following sections present the potential risks to adolescent, child, and toddler consumers using the sum of all 209 PCB congeners and the sum of ICES-7 marker PCBs to characterize risks from non-dioxin-like PCBs. In addition, the risks posed by dioxin-like PCBs, dioxins, and furans are assessed using methods consistent with those currently used for the SHTC HHRA.

7.4.1 Total PCBs (Current HHRA Case using all 209 PCBs)

The 2024 total PCB ERs for adolescent, child, and toddler (adolescent/juvenile) consumers of Chrystina Lake and Edith Lake brook trout are summarized in Table 7-9. The ERs calculated for total PCBs for adolescent, child, and toddler consumers from 2002 to 2024 are presented in Figure 7-9. ERs are between 1 and 10 for adolescent/juvenile consumers of Chrystina Lake brook trout in 2024 using risk classification methods previously used for the SHTC HHRA. In addition, the toddler consumer group had ERs between 1 and 10 for consumers of Edith Lake brook trout and for brook trout taken directly from the hatchery. Given that the Health Canada TDI considers only the concentration of the ICES-7 marker PCBs, the ERs based on currently used methods overestimate risk. Consequently, the ERs provided in Table 7-9 can be used for comparison with historical reports and ERs calculated using the proposed HHRA case.

Table 7-9: Adolescent/Juvenile Exposure Ratios based on total PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	Adolescent	2.45	1.08	1.27
	Child	3.78	1.69	1.98
	Toddler	5.46	2.55	2.95
Edith Lake	Adolescent	0.73	0.46	0.50
	Child	1.16	0.75	0.80
	Toddler	1.81	1.23	1.31
Hatchery	Adolescent	0.43		
	Child	0.70		
	Toddler	1.17		

Notes:

Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.

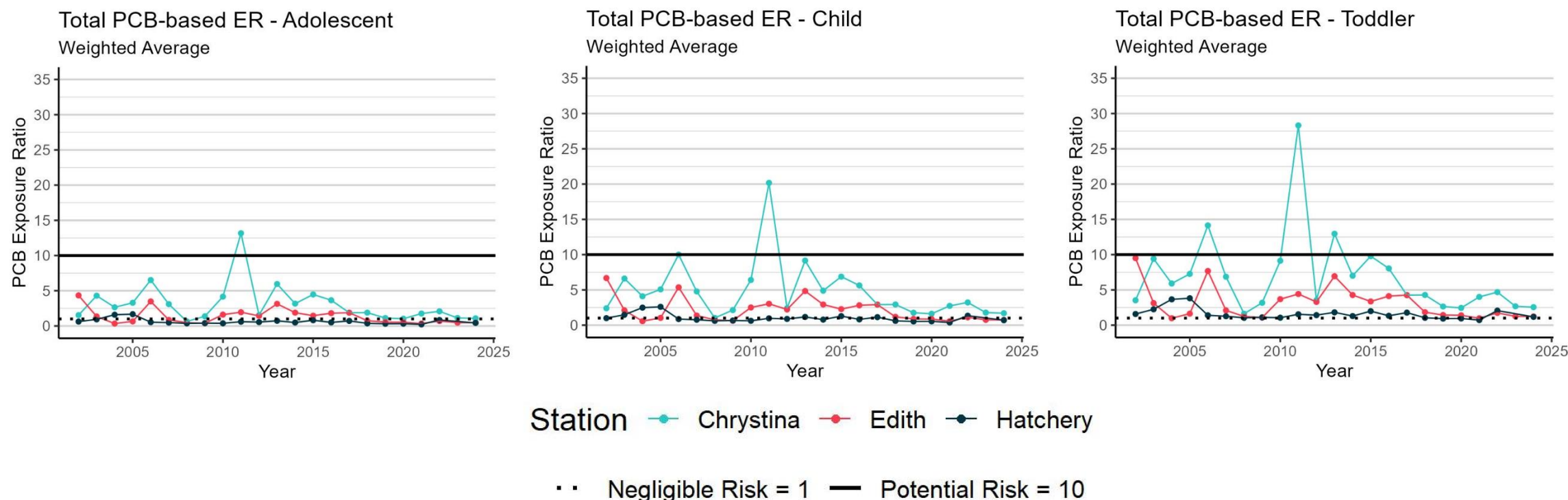


Figure 7-9: Exposure ratios based on methods currently used during the SHTC HHRA for adolescent, child, and toddler consumers of brook trout from Chrystina Lake, Edith Lake, and the hatchery. Total PCB concentrations used are based on the sum of all PCB congeners and exposure estimates are compared to the 2021 Health Canada TDI

7.4.2 Total PCBs (Proposed HHRA Case using ICES-7 Marker PCBs)

The 2024 total PCB ERs for adolescent/juvenile consumers of Chrystina Lake and Edith Lake brook trout using the subset of ICES-7 PCBs are summarized in Table 7-10. In 2024, the ERs for toddler consumers of Chrystina Lake brook trout are between 1 and 10 based on all PCB concentrations considered. In addition, the ER for child consumers of Chrystina Lake brook trout was above 1 based on the PCB concentrations measured in 'keeper' brook trout. Alternatively, the ERs for adolescent/juvenile consumers of Edith Lake brook trout were primarily below 1. Notably, the 2024 ERs based on weighted average concentrations in Edith Lake brook trout were similar to those observed in hatchery brook trout. These results are consistent with results observed during the SHTC HHRA since 2019 (Figure 7-10). The adolescent and child age groups consuming Edith Lake brook trout in 2024 were the only risk categories with ERs below 1 for all PCB concentration levels.

Table 7-10: Adolescent/Juvenile Exposure Ratios based on the subset of ICES7 PCBs for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	Adolescent	1.03	0.56	0.64
	Child	1.63	0.90	1.02
	Toddler	2.46	1.45	1.61
Edith Lake	Adolescent	0.44	0.32	0.34
	Child	0.72	0.53	0.56
	Toddler	1.20	0.93	0.97
Hatchery	Adolescent	0.29		
	Child	0.49		
	Toddler	0.88		
Notes:				
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.				

As expected, the use of total PCB concentrations based on the ICES-7 marker PCBs reduced exposure risk estimates for both lakes. Based on the maximum concentrations measured in 2024, there is low potential risk to consumers of brook trout from Chrystina Lake for all age groups considered. If the PCB concentrations measured in 'keeper' brook trout from Chrystina Lake are considered, there is low potential risk to child and toddler consumers, only. Alternatively, the risk to adolescent, child, and toddler consumers of brook trout from Edith Lake is minimal and similar to those posed by brook trout taken directly from the hatchery. Overall, consumption of Chrystina Lake brook trout by adolescents/juveniles poses a low potential risk of adverse effects from exposure to PCBs given the conservatism of the HHRA.

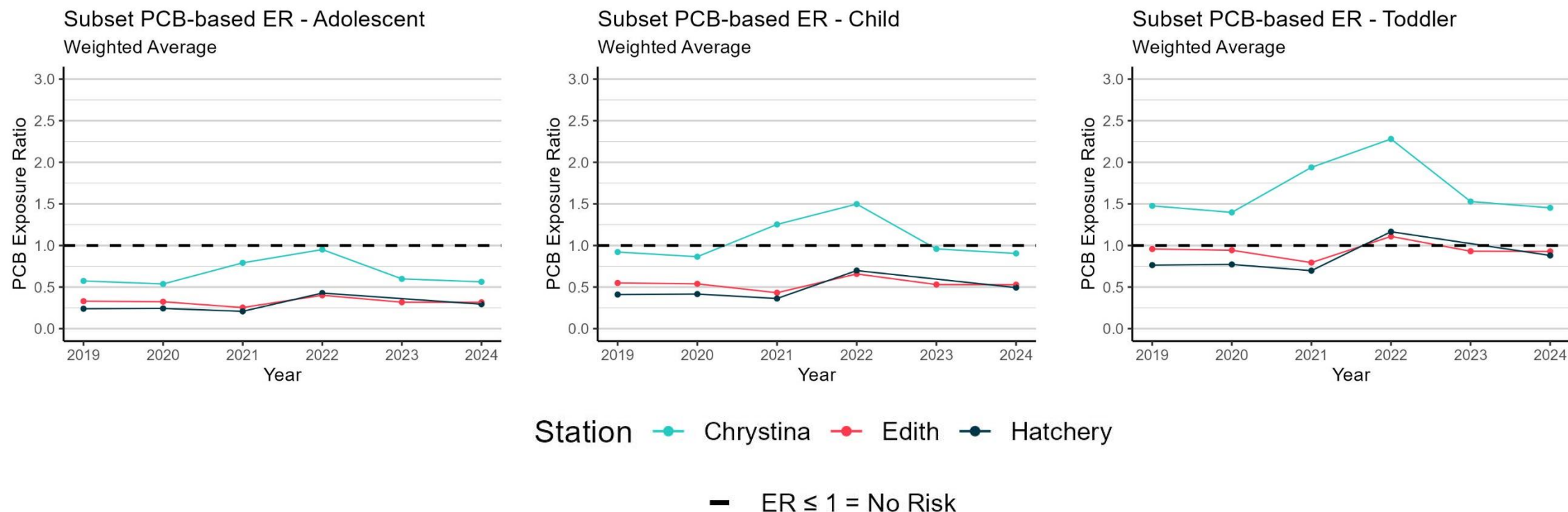


Figure 7-10: Exposure ratios based on the proposed SHTC HHRA methods proposed in 2024 for adolescent, child, and toddler consumers of brook trout from Chrystina Lake, Edith Lake, and the hatchery. Total PCB concentrations used are based on the sum of ICES-7 marker PCB congeners and exposure estimates are compared to the 2021 Health Canada TDI

7.4.3 Total TEQ

Exposure risk to dioxin-like PCBs, dioxins, and furans from consumption of Chrystina Lake and Edith Lake brook trout by adolescents/juveniles in 2024 is summarized in Table 7-11. No changes to risk classification methods were adopted for determining exposure risk based on total TEQ for adolescent/juvenile consumers in 2024. The ERs for total TEQ are primarily below 1 for adolescent and child consumers of Chrystina Lake and Edith Lake brook trout in 2024. The total TEQ ER for each concentration level slightly exceeded 1 for toddlers consuming brook trout from both Chrystina Lake and Edith Lake. Notably, the ER determined for toddler consumers based on the TEQ measured in hatchery brook trout slightly exceeded 1 as well (Table 7-11).

Risk from dioxin-like PCBs, dioxins, and furans to adolescent and child consumers is acceptable in 2024 based on ER values, however, maximal TEQs may result in low potential risks to child consumers of Chrystina Lake brook trout. There is a low risk to toddler consumers of brook trout from both lakes, however given the conservatism of the HHRA the risks posed by dioxins and dioxin-like compounds is low.

Table 7-11: Adolescent/Juvenile Exposure Ratios based on total TEQ for consumption of brook trout near Swan Hills in 2024

Station	Consumer Class	Maximum	Weighted Average	>2+ years old ("Keeper")
Chrystina Lake	Adolescent	0.75	0.50	0.54
	Child	1.15	0.77	0.84
	Toddler	1.83	1.30	1.39
Edith Lake	Adolescent	0.50	0.42	0.45
	Child	0.78	0.65	0.70
	Toddler	1.30	1.12	1.19
Hatchery	Adolescent	0.35		
	Child	0.54		
	Toddler	0.98		
Notes:				
Yellow highlighting indicates ER is between 1 and 10 and has a low risk of potential adverse effects on human fish consumers.				

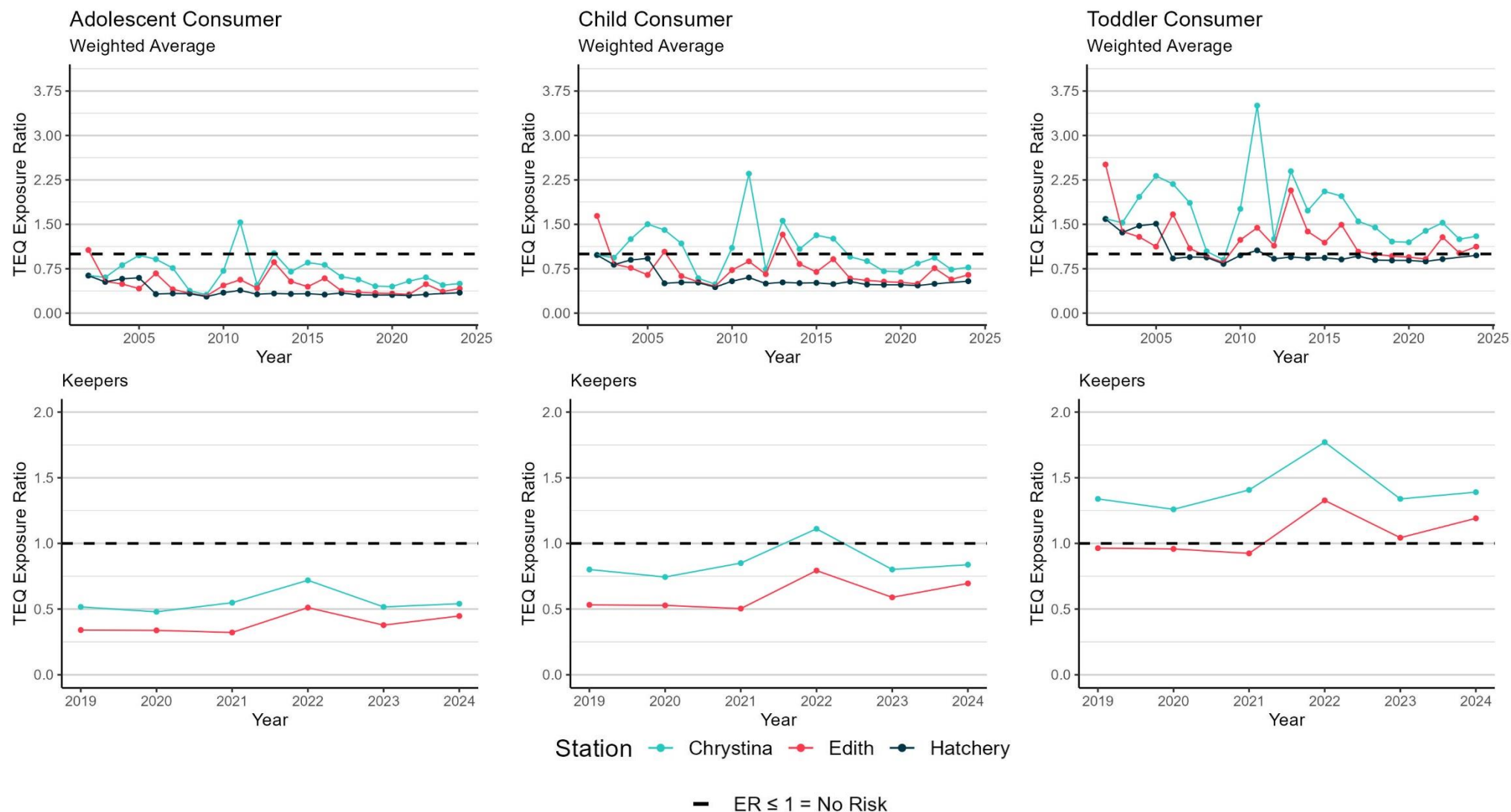


Figure 7-11: Exposure ratios for adolescent, child, and toddler consumers of brook trout from Chrystina Lake, Edith Lake, and the hatchery based on the proposed SHTC HHRA and total TEQs calculated from weighted average (Top row) and 'keeper' (Bottom row) concentrations of dioxin-like PCBs, dioxins, and furans. Exposure estimates are compared to the 2021 Health Canada TDI

7.5 Historical Maximum Worst-Case Scenario (2006 to 2024)

The maximal worst-case scenario is assessed for the SHTC HHRA, however, temporal trends associated with this scenario have not been investigated or presented. A review of the maximum worst-case scenario over-time was recommended for the expanded program in 2024 to provide an understanding of how the maximum risk has changed over time. It is understood that health decisions should be based on a 'reasonable' worst-case scenario (Health Canada 2023), however, overall trends in the maximum exposure potential may be useful for showing temporal risk trends. Risk estimates presented in the following sections are based on the body weight assumption adopted for adults in 2024 (80 kg) and total PCB concentrations based on the ICES-7 marker PCBs. The ERs are presented for high consumers to ensure the maximum worst-case scenario is provided. Notably, maximum concentrations of non-dioxin-like PCBs based on the ICES-7 marker PCBs were available from 2019 to 2024, only.

7.5.1 Total PCBs (using ICES-7 Marker PCBs)

The ERs for consumers of Chrystina Lake and Edith Lake brook trout based on maximum concentrations of ICES-7 marker PCBs reported from 2019 to 2024 are provided in Figure 7-12. Over this period, the ERs for consumers of Chrystina Lake brook trout ranged from 1.7 to 4.0, whereas ERs for consumers of Edith Lake brook trout are primarily below 1 and range from 0.6 to 1.4. Given these results for non-dioxin-like PCBs, the maximum potential risk to high consumers of Chrystina Lake brook trout since 2019 is low, whereas the maximum potential risk to consumers of Edith Lake brook trout is negligible to low.

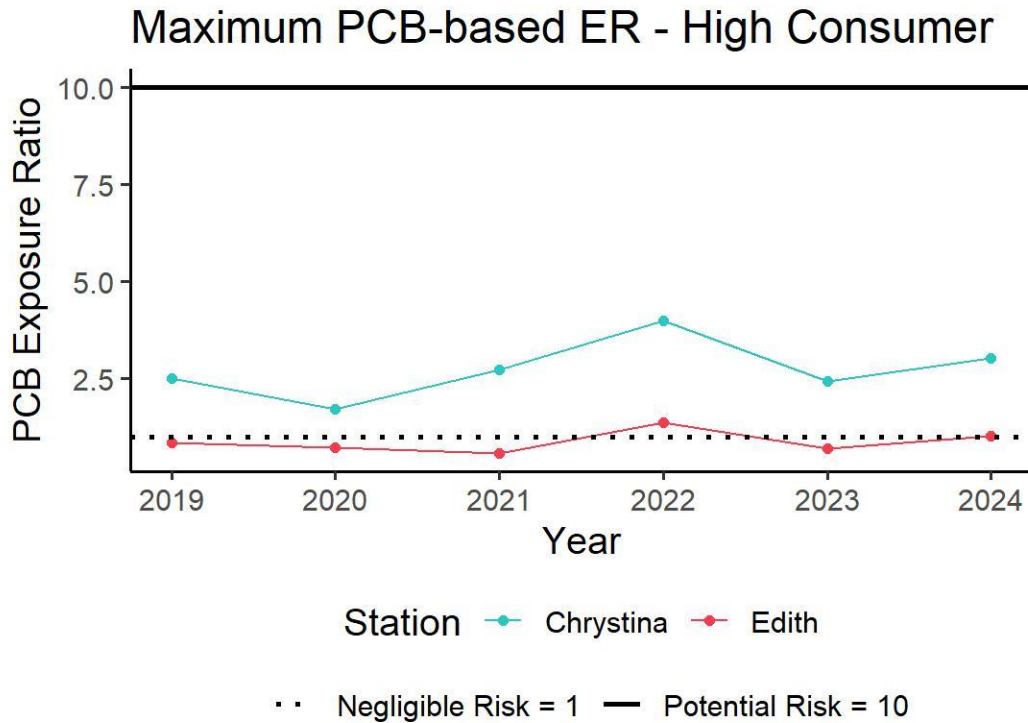


Figure 7-12: Exposure ratios for adult high consumers of Chrystina Lake and Edith Lake brook trout based on the annual maximum concentration of ICES-7 marker PCBs

7.5.2 Total TEQ

The ERs for adult high consumers of Chrystina Lake and Edith Lake brook trout based on the annual maximum concentrations of dioxin-like PCBs, dioxins, and furans (expressed as TEQ) from 2006 to 2024 are presented in Figure 7-13. Overall, the ERs for consumers of brook trout from both lakes appear to decrease over time with Chrystina Lake typically having higher ERs compared with Edith Lake. High consumers of Chrystina Lake brook trout have had an ER slightly above 1 since 2019, while historical ERs have primarily ranged between 1 and 10. Alternatively, the ERs for high consumers of Edith Lake brook trout have remained consistently low since 2017 with the only ERs greater than 1 occurring in 2022 and 2024. Apart from these two monitoring years, the ERs for Edith Lake brook trout are similar to those reported for brook trout taken directly from the hatchery. These results suggest that, although TEQs in both lakes have decreased recently, the maximum risk to high consumers of Chrystina Lake brook trout is low, while there is generally no risk based on the maximum risk to Edith Lake brook trout consumers.

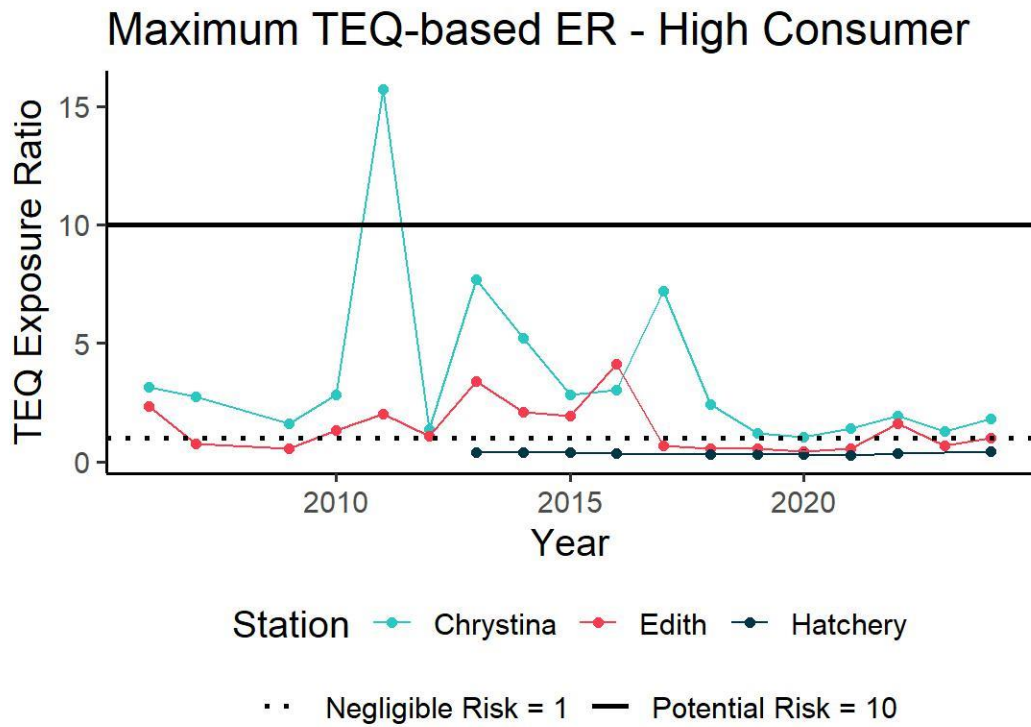


Figure 7-13: Exposure ratios for adult high consumers of Chrystina Lake, Edith Lake, and hatchery brook trout based on the annual maximum TEQ for dioxin-like PCBs, dioxins, and furans

8. Assessment Uncertainties

The assumptions for characterizing risk for the SHTC HHRA were reviewed in 2024 as part of the expanded program and further discussion of exposure factors and limits are provided in Section 3. The following discussion focuses on uncertainties associated with the assumptions used for the proposed HHRA risk characteristic methods.

8.1 Background Exposure Estimates

Background exposure for adults and adolescents/juveniles are based on the most recent published rates from Health Canada (Health Canada 2007). More recent estimates of background exposure to PCBs, as well as dioxins and dioxin-like compounds, suggest that background exposure is decreasing world-wide compared with those used currently for the HHRA (See section 3). A meta-analysis of PCB concentrations in retail foods concluded that background exposure from ingestion has been decreasing but background concentrations remain similar to those reported in the food survey done by the Bureau of Chemical Safety (BCS) between 2000 and 2002 (Saktrakulkla et al. 2020). As such, Health Canada has not established new background exposure levels for PCBs or dioxins and dioxin-like compounds.

8.2 Body Weight and Consumption Rate Assumptions

Assumed body weight and consumption rates currently used for the SHTC HHRA are from a market analysis in the Swan Hills area that was done in 1997 (Alberta Health 1997). There is, however, evidence that traditional food consumption has been decreasing (Chan et al. 2016). Average body weight estimates have also changed in the nearly 30 years since the Swan Hills study was completed. Consequently, the assumed body weight for the SHTC HHRA was increased to align with more recent health assessment guidance documents and average body weights reported for Central Alberta (GOA 2018).

Ingestion rate is highly correlated to body weight for adults. Using a single point estimate for these variables instead of a joint probability distribution ignores a variability that may influence the results by a factor of up to two or three. Consumption rates for adolescents/juveniles used by the HHRA are based on rates determined for subsistence populations with high consumption rates compared with other populations in Canada. A market facts survey in 1991 determined consumption rates of 10 g/day and 14 g/day of fish tissue is appropriate for children from 1 year to 4 years old and adolescents 5 to 11 years old, respectively (Health Canada 2007). The fish consumption rate for adults based on the same market facts survey was 40 g/day, which is approximately 25% of the high consumption rate from the 1997 Swan Hills consumption survey currently used for the HHRA. One limitation of the 1997 Swan Hills survey is that it depended on a 12-month recall, which can lead to higher reporting error (GOA 2018). The consumption rate reported by the FNFNES survey done in 2013 reported that fish consumption in the Boreal Plains region of Alberta was 39.7 g fish/day for heavy consumers regardless of sex and was 48.1 g fish/day for males (Chan et al. 2016).

Based on the review of more recent consumption estimates and recommended intake rates from Alberta Health (GOA 2018), the medium consumer group provides a more 'reasonable' worst-case scenario than the high consumer group previously used for the SHTC HHRA, which may overestimate risk. Alberta Health continues to review surveys to refine consumption estimates for wild-caught fish in the province and these will be reviewed in the context of the SHTC HHRA if/when these become publicly available (Puhallo, Jennifer 2025. pers. comm.).

8.3 Exposure Limits

The TDI values for total PCBs and total TEQ used in the 2024 HHRA are based on the provisional TRV values established by Health Canada in 2021 (Health Canada 2021). Notably, the TDI for total (non-dioxin-like) PCBs is corrected to the concentration of the ICES-7 marker PCBs and is based on oral exposure to PCB Aroclor mixture 1254. This commercially developed PCB mixture contains a specific distribution of PCB congeners that is altered over time by weathering (Baars et al. 2001). Consequently, the composition of PCB congeners that brook trout in Chrystina Lake and Edith Lake are exposed to is different than the PCBs used to develop the current TDI. A safety factor of 300 has also been incorporated into the current TDI to account for intraspecies variability, interspecies variability, and to extrapolate from a lowest observable adverse effect level (LOAEL) to a NOAEL (Health Canada 2021). The resulting TDI was then reduced by 50% to align the exposure limit with the analysis of the ICES-7 marker PCBs.

Humans may be exposed to Project-related COCs by several pathways, but not all of these pathways were quantitatively evaluated in this HHRA. This was because the contributions of the pathways other than ingestion were believed to be minor and not directly related to the objectives of this HHRA (Section 3.1). Pathways not included in this HHRA may result in a small underestimation of exposure and risk, but the magnitude of this underestimation is not expected to be significant.

9. Summary and Conclusions

The 2024 HHRA included risk characterization of brook trout samples collected from two lakes near Swan Hills (Chrystina Lake and Edith Lake). Total PCBs in edible brook trout tissue from both Chrystina Lake and Edith Lake in 2024 were similar to concentrations reported in 2023. The TEQ of dioxin-like PCBs, dioxins, and furans increased slightly in 2024 compared with 2023 but remains below tissue residue quality criteria in Edith Lake brook trout. A review of currently used exposure factors and limits in 2024 resulted in several proposed changes to improve reliability and incorporate more recent data into the HHRA, including:

- Assumed adult body weight was increased from 73 kg to 80 kg.
- High consumption rate from the 1997 Swan Hills diet and activity study was replaced with the medium consumption rate as the primary consumption rate for determining risk.
- Total PCB concentrations (for non-dioxin-like PCBs) based on the sum of all 209 PCB congeners was replaced with the ICES-7 marker PCB congeners to align with the current Health Canada TDI.

Risk outcomes of the proposed HHRA based on ERs for total PCBs and TEQ are briefly summarized in the following sections.

9.1 Total PCBs in Chrystina Lake

- Low potential risk of adverse effects for adults consuming brook trout at a high rate (ERs from 1.43 to 3.04).
- No risk ($ER \leq 1$) of adverse effects for adults consuming Chrystina Lake brook trout at medium consumption, low consumption, very low consumption, and Alberta Health recommended consumption rate.
- Low potential risk of adverse effects for child and toddler age categories consuming brook trout (ERs from 0.90 to 2.46).
- No risk ($ER \leq 1$) of adverse effects for adolescent consumers, however low risk may be present based on the maximum PCB concentration reported in 2024 ($ER = 1.03$).

9.2 Total PCBs in Edith Lake

- No risk ($ER \leq 1$) of adverse effects for adults other than those with a high consumption rate ingesting the maximum concentration reported in 2024 ($ER = 1.02$).
- No risk ($ER \leq 1$) of adverse effects for adolescent or child consumers, but low potential risk to toddler consumers (ERs from 1.23 to 1.81) and child consumers exposed to the maximum concentration reported in 2024 ($ER = 1.16$).

9.3 Total TEQ in Chrystina Lake

- Low potential risk of adverse effects for adults consuming brook trout at a high rate, based on risk estimates using maximum reported and 'keeper' tissue concentrations measured in 2024 (ERs from 1.13 to 1.83).

- No risk ($ER \leq 1$) of adverse effects for adults other than those with a high consumption rate.
- No risk ($ER \leq 1$) of adverse effects for adolescent and child consumers but low potential risk to toddlers (ERs from 1.30 to 1.83) and child consumers exposed to the maximum concentration reported in 2024 ($ER = 1.15$).

9.4 Total TEQ in Edith Lake

- No risk ($ER \leq 1$) of adverse effects for adults in any consumer group.
- No risk ($ER \leq 1$) of adverse effects for adolescent and child consumers but low potential risk to toddlers (ERs from 0.93 to 1.20).

Predicted total TEQ ERs are similar to those historically observed and remain near 1, suggesting that there is no risk from exposure to dioxin-like PCBs, dioxins, and furans to the different consumer groups of Chrystina Lake or Edith Lake brook trout. Risk estimates for non-dioxin-like PCBs suggest that there is a low potential risk to high consumers of Chrystina Lake and Edith Lake brook trout, however, this consumption rate may overestimate risk based on more recent fish consumption estimates for Alberta. It is notable that only the high and toddler consumer groups have a low potential risk based on tissue concentrations measured in 2024.

A common theme observed throughout the HHRA in 2024 is that risk estimates for consumers of Edith Lake brook trout based on weighted averages are similar to risk estimates for brook trout taken directly from the hatchery. This is a reflection of similar weighted average PCB concentrations in Edith Lake brook trout and control brook trout from the hatchery.

10. Recommendations

The risk assessment results suggest that there is little to no risk to consumers of Edith Lake brook trout, whereas non-dioxin-like PCBs pose a low potential risk to people consuming brook trout from Chrystina Lake at a high consumption rate. Risk potential and COC concentrations in Edith Lake brook trout have been consistently low, and most risk estimates based on weighted average concentrations since 2017 have been similar to brook trout directly from the hatchery. Therefore, it is recommended that:

- Sampling effort in Edith Lake be reduced to biannual sampling so that monitoring efforts can focus on better characterizing PCB variability in Chrystina Lake brook trout tissue.
- Sampling and the risk assessment to humans through the ingestion pathway via consumption of fish be continued for Chrystina Lake.
- A review of the fish consumption advisory by Alberta Health determines its applicability for Edith Lake and other lakes within 20 km of Swan Hills. Meanwhile, consumers should remain aware of the current Alberta fish consumption advisory of 150 g/week (22 g/day) of fish from lakes within 20 km of Swan Hills (including Chrystina Lake and Edith Lake).
- Consumers should remove fish skin from edible tissue and cook tissue before eating, as this will remove fatty tissue that contains higher proportions of COCs and will help in degradation of COCs before consumption.

The literature review of exposure factors and limits used for the HHRA identified that current assumed body weight for adult consumers may underestimate average body weight in Central Alberta. The high consumption rate from the 1997 Swan Hills diet and activity study is high compared to more recent consumption estimates for traditional foods, and PCB concentrations based on the ICES-7 marker PCBs provides a more accurate comparison with the 2021 Health Canada TDI. Therefore, it is recommended that:

- The proposed revisions to the risk classification methods implemented in 2024 should be used for future monitoring years and temporal risk trends should be based on the medium consumer group to prevent over-estimating risk.
- The ICES-7 subset is used as an indicator of overall PCB concentrations, while concentrations of the 12 coplanar PCBs is also measured to determine TEQ for assessing risk. Analytical methods providing these analytes is available from ALS in addition to the currently used congener-specific analysis, allowing for a defensible transition to subset analysis.

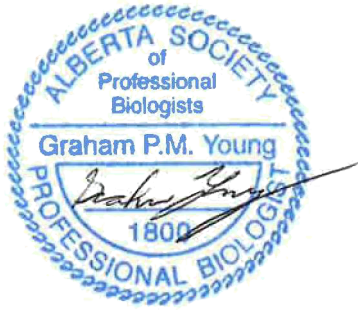
The ERs obtained from the proposed HHRA case using the ICES-7 marker PCB concentrations were more consistent with historical ERs based on the previous Health Canada TDI. Notably, the ERs calculated for non-dioxin-like PCBs based on these methods were also more closely aligned with ERs calculated for total TEQ. Therefore, it is recommended that:

- The trigger for analysis of PCB tissue concentrations in white sucker (*Catostomus commersonii*) from Chrystina Lake, which is an ER of 10 for brook trout tissue concentrations, remains suitable provided the methods of the proposed HHRA case are followed.

11. Closure

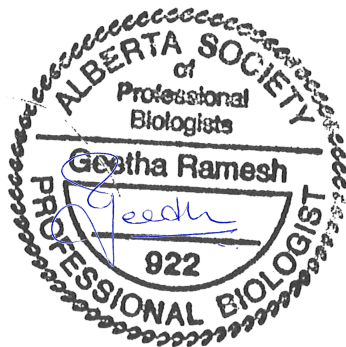
We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

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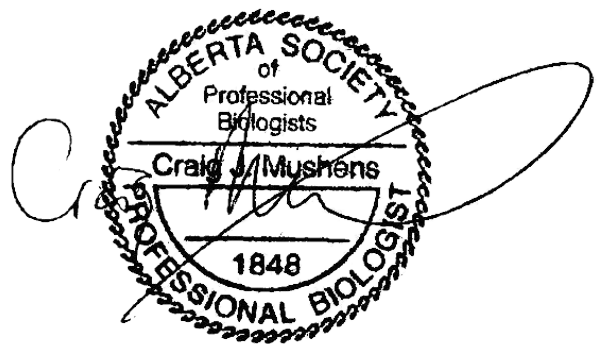


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Tables

Table 1
Total PCB and TEQ Concentrations and
Exposure Ratios for High Consumers of Brook Trout from Chrystina Lake,
Edith Lake, and the Hatchery (2002 -2024)

PROJECT No.: 217085-56230

Year	Total PCB (wt. avg. µg/g)	Total PCB Exposure Ratio	Total TEQ (wt. avg. pg/g)	Total TEQ Exposure Ratio
Hatchery				
2002	0.0069	1.8	1.3500	1.6
2003	0.0120	2.9	0.9500	1.2
2004	0.0228	5.4	1.1500	1.4
2005	0.0240	5.7	1.2100	1.4
2006	0.0055	1.5	0.1800	0.4
2007	0.0045	1.2	0.2200	0.4
2008	0.0028	0.8	0.2100	0.4
2009	0.0033	1.0	0.0200	0.2
2010	0.0029	0.9	0.2700	0.5
2011	0.0066	1.7	0.4200	0.6
2012	0.0057	1.5	0.1700	0.4
2013	0.0087	2.2	0.2200	0.4
2014	0.0047	1.3	0.1900	0.4
2015	0.0100	2.5	0.2000	0.4
2016	0.0050	1.3	0.1500	0.4
2017	0.0084	2.1	0.2500	0.5
2018	0.0028	0.8	0.1300	0.3
2019	0.0019	0.6	0.1210	0.3
2020	0.0021	0.7	0.1178	0.3
2021	0.0004	0.3	0.0888	0.3
2022	0.0106	2.6	0.1580	0.4
2024	0.0038	1.1	0.2659	0.5
Chrystina Lake				
2002	0.0218	5.2	1.3600	1.6
2003	0.0668	15.5	1.2400	1.5
2004	0.0400	9.4	2.0100	2.2
2005	0.0504	11.7	2.6300	2.8
2006	0.1030	23.8	2.3900	2.6
2007	0.0473	11.0	1.8300	2.0
2008	0.0072	1.8	0.3900	0.6
2009	0.0191	4.6	0.1400	0.4
2010	0.0646	15.0	1.6500	1.9
2011	0.2114	48.6	4.7200	4.9
2012	0.0219	5.2	0.7600	1.0
2013	0.0939	21.7	2.7700	3.0
2014	0.0484	11.3	1.6000	1.8
2015	0.0697	16.1	2.1700	2.4
2016	0.0563	13.1	2.0300	2.2
2017	0.0274	6.5	1.2800	1.5
2018	0.0276	6.5	1.1000	1.3
2019	0.0168	4.0	0.7490	1.0
2020	0.0135	3.3	0.6621	0.9
2021	0.0255	6.0	1.0033	1.2
2022	0.0306	7.2	1.2442	1.5
2023	0.0153	3.7	0.7508	1.0
2024	0.0143	3.5	0.8430	1.1

Table 1
Total PCB and TEQ Concentrations and
Exposure Ratios for High Consumers of Brook Trout from Chrystina Lake,
Edith Lake, and the Hatchery (2002 -2024)

PROJECT No.: 217085-56230

Year	Total PCB (wt. avg. µg/g)	Total PCB Exposure Ratio	Total TEQ (wt. avg. pg/g)	Total TEQ Exposure Ratio
Edith Lake				
2002	0.0675	15.6	2.9700	3.2
2003	0.0187	4.5	0.9800	1.2
2004	0.0023	0.7	0.8200	1.0
2005	0.0073	1.9	0.5300	0.7
2006	0.0535	12.4	1.4900	1.7
2007	0.0108	2.7	0.4800	0.7
2008	0.0043	1.2	0.2400	0.5
2009	0.0030	0.9	0.0600	0.3
2010	0.0230	5.5	0.7300	0.9
2011	0.0286	6.7	1.0900	1.3
2012	0.0200	4.8	0.5600	0.8
2013	0.0479	11.2	2.2000	2.4
2014	0.0275	6.5	0.9800	1.2
2015	0.0205	4.9	0.6500	0.9
2016	0.0263	6.2	1.1800	1.4
2017	0.0274	6.5	0.3800	0.6
2018	0.0089	2.2	0.3000	0.5
2019	0.0056	1.5	0.2720	0.5
2020	0.0055	1.5	0.2218	0.4
2021	0.0023	0.7	0.1599	0.4
2022	0.0081	2.1	0.8057	1.0
2023	0.0044	1.2	0.3400	0.6
2024	0.0042	1.2	0.5349	0.7

NOTES: 1. --- in detail data row(s) denotes parameter not analyzed.

X

2. Highlighting indicates exposure ratios between 1 and 10 which indicate potential adverse effects are possible but risk is low given conservatism of the risk assessment.

X

3. Highlighting indicates exposure ratio exceeds 10 which indicates a potential risk of adverse effects from human consumption and risk management strategies should be considered.

Table 2
Sum of ICES7 Marker PCBs, TEQ Concentrations and
Exposure Ratios for Medium Consumers of Brook Trout from Chrystina Lake,
Edith Lake, and the Hatchery (2019 -2024)

PROJECT No.: 217085-56230

Year	ICES7 PCB (wt. avg. µg/g)	Total PCB Exposure Ratio	Total TEQ (wt. avg. pg/g)	Total TEQ Exposure Ratio
Hatchery				
2019	0.0006	0.2	0.1210	0.57
2020	0.0007	0.2	0.1178	0.57
2021	0.0001	0.2	0.0888	0.55
2022	0.0037	0.4	0.1580	0.59
2024	0.0015	0.3	0.2659	0.66
Chrystina Lake				
2019	0.0061	0.6	0.7490	0.90
2020	0.0055	0.5	0.6621	0.89
2021	0.0096	0.8	1.0033	1.09
2022	0.0122	0.9	1.2442	1.23
2023	0.0065	0.6	0.7508	0.94
2024	0.0059	0.5	0.8430	0.99
Edith Lake				
2019	0.0021	0.3	0.2720	0.65
2020	0.0020	0.3	0.2218	0.63
2021	0.0009	0.3	0.1599	0.59
2022	0.0033	0.4	0.8057	0.98
2023	0.0019	0.3	0.3400	0.70
2024	0.0019	0.3	0.5349	0.81

NOTES: 1. --- in detail data row(s) denotes parameter not analyzed.

X

2. Highlighting indicates exposure ratios between 1 and 10 which indicate potential adverse effects are possible but risk is low given conservatism of the risk assessment.

X

3. Highlighting indicates exposure ratio exceeds 10 which indicates a potential risk of adverse effects from human consumption and risk management strategies should be considered.