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Data Sources and Methods for the Perfluorooctane Sulfonate (PFOS) in Fish and Water Indicators

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1 Introduction

The perfluorooctane sulfonate (PFOS) in fish and water indicators (<http://www.ec.gc.ca/toxiques-toxics/Default.asp?lang=En&n=ECD5A576-1>) are part of the Canadian Environmental Sustainability Indicators (CESI) program (<http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=47F48106-1>), which provides data and information to track Canada's performance on key environmental sustainability issues.

The CESI program tracks environmental levels of certain toxic substances released by human activity. These indicators help to inform Canadians about key water pollutants that have been listed as toxic to the environment. The indicators also help the government identify priorities, and develop and track progress on strategies and policies put in place to reduce or control pollution.

2 Description and rationale of the Perfluorooctane Sulfonate (PFOS) in Fish and Water indicators

2.1 Description

The perfluorooctane sulfonate (PFOS) in fish and water indicators are established by determining whether the concentrations of PFOS in fish and water in each of Canada's drainage regions exceed the draft Federal Environmental Quality Guidelines (FEQGs). The draft FEQGs, which have not yet been finalized, were developed under the Chemicals Management Plan (CMP) and are used in various ways (<http://www.chemicalsubstanceschimiques.gc.ca/plan/index-eng.php>). In this report they are used to evaluate the significance of PFOS concentrations measured in the environment.

2.2 Rationale

PFOS is a synthetic substance belonging to a larger class of organic fluorochemicals that are partially or completely saturated with fluorine. PFOS and its precursors were used primarily as water, oil, soil and grease repellents for paper and packaging, and carpets and fabrics, as well as in aqueous film-forming foam for fighting fuel fires.

Because of its chemical properties and use patterns, PFOS is typically found at higher concentrations in water than in air and it can travel to locations far from its point of release through oceanic currents. In addition, PFOS precursor compounds can travel through air and often end up in the Arctic, where they degrade to PFOS. PFOS is a highly persistent substance. It bioaccumulates, potentially harming many species, including top predatory fish, birds and mammals, depending on their actual exposure.

The Government of Canada declared PFOS to be "toxic" as defined under the *Canadian Environmental Protection Act, 1999* (CEPA 1999). As a result, the government published regulations in 2008 that prohibit the manufacture, use, sale, offer for sale and import of PFOS (with a limited number of exemptions).

Because PFOS and its precursors can be transported over long distances through water and air, the PFOS found in the Canadian environment may originate from both domestic and foreign sources. Consequently, Canada is engaged in two international agreements that restrict and ultimately target the elimination of PFOS production, use, trade, release, and storage. These agreements are the Stockholm Convention on Persistent Organic Pollutants

(<http://chm.pops.int/default.aspx>) and the Protocol on Persistent Organic Pollutants (POPs) of the United Nations Convention on Long-range Transboundary Air Pollution (LRTAP) (http://www.unece.org/env/lrtap/pops_h1.html). The objective of these international agreements is to protect human health and the environment from persistent organic pollutants (POPs).

Several chemicals have properties and use patterns similar to those of PFOS. PFOS was selected as the subject of indicators because of the existence of both a representative monitoring data set in fish and water, and draft FEQGs that help characterize the risk associated with its occurrence in the aquatic environment.

3 Data

3.1 Data source

The perfluorooctane sulfonate (PFOS) environmental concentration data were obtained from Environment Canada's CMP Monitoring and Surveillance program (<http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=F48952A0-3F54-4D76-BAA6-EA6CF5529590>).

The draft Federal Environmental Quality Guidelines (FEQGs) were developed under the Chemicals Management Plan (CMP) and are used to evaluate the significance of monitoring data. Where measured concentrations of PFOS do not exceed the guidelines, there is little risk of detrimental effects on aquatic organisms or their wildlife predators. Exceedance of guidelines may signal the need for additional evaluation. Four different FEQGs were used in the development of the indicators: two guidelines for PFOS in fish tissue and PFOS in water are protective of aquatic life, and two additional FEQGs for PFOS are used to compare measured concentrations in fish tissue and are designed for the protection of wildlife (e.g. mammals and birds) that prey on aquatic life.

Table 1. Draft Federal Environmental Quality Guidelines (FEQGs) for perfluorooctane sulfonate (PFOS)

Guideline	Draft FEQGs for PFOS
Fish tissue	8300 ng/g wet weight
Water	6000 ng/L
Wildlife diet for mammals*	4.6 ng/g wet weight
Wildlife diet for birds*	8.2 ng/g wet weight

* For the purpose of this indicator, these guidelines are compared with the measured fish tissue concentrations.

Note: Only the draft FEQGs for PFOS that were used in the indicators are shown in the table.

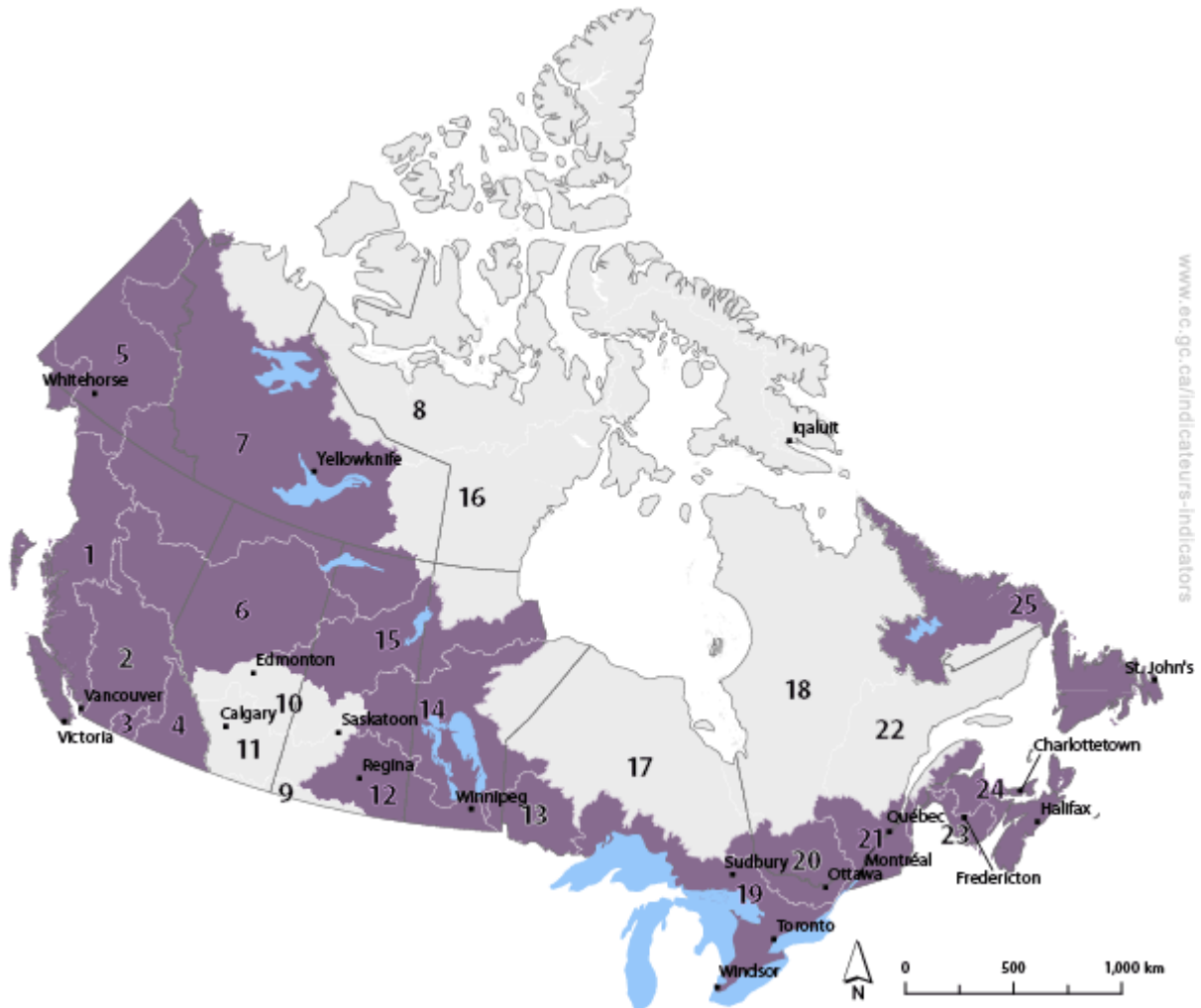
Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

3.2 Spatial coverage

The PFOS in fish and water indicators use water drainage regions as a geographical unit for the calculation of the national indicators. These drainage regions correspond to those defined in Statistics Canada's Standard Drainage Area Classification (<http://www.statcan.gc.ca/subjects->

sujets/standard-norme/sdac-ctad/sdacinfo2-ctadinfo2-eng.htm). The drainage regions in Figure 1, Table 2, and Table 3 outline the regions where sampling for PFOS was conducted.

Figure 1. Geographic extent of the drainage regions used for the PFOS in fish and water indicators



Source: Statistics Canada (2009) Standard Drainage Area Classification (SDAC) 2003 (<http://www.statcan.gc.ca/subjects-sujets/standard-norme/sdac-ctad/sdacinfo2-ctadinfo2-eng.htm>).

Table 2. Spatial coverage for PFOS in fish, 2006 to 2010

Sampled drainage regions	Location	Province or territory
Pacific Coastal (1)	Frederic Lake	British Columbia
Okanagan-Similkameen (3)	Osoyoos Lake	British Columbia
Columbia (4)	Columbia River	British Columbia
Yukon (5)	Lake Kusawa	Yukon
Peace-Athabasca (6)	Lake Athabasca	Alberta / Saskatchewan
Lower Mackenzie (7)	Great Slave Lake	Northwest Territories
Lower Mackenzie (7)	Great Bear Lake	Northwest Territories
Assiniboine-Red (12)	Lake Diefenbaker	Saskatchewan
Winnipeg (13)	Lake Winnange	Ontario
Lower Saskatchewan-Nelson (14)	Codette Reservoir	Saskatchewan
Lower Saskatchewan-Nelson (14)	Lake Winnipeg	Manitoba
Churchill (15)	Cold Lake	Alberta
Churchill (15)	Reindeer Lake	Saskatchewan
Great Lakes (19)	Peninsula Lake	Ontario
Great Lakes (19)	Lake Superior	Ontario
Great Lakes (19)	Lake Huron	Ontario
Great Lakes (19)	Lake Erie	Ontario
Great Lakes (19)	Lake Ontario	Ontario
St. Lawrence (21)	Lake Champlain	Quebec
St. Lawrence (21)	St. Lawrence River Corridor	Quebec
Maritime Coastal (24)	Lake Kejimikujik	Nova Scotia

Note: The numbers in parentheses refer to the number identifier of the drainage region in Figure 1.

Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

Table 3. Spatial coverage for PFOS in water, 2007 to 2010

Sampled drainage regions	Location	Province or territory
Pacific Coastal (1)	Still Creek	British Columbia
Pacific Coastal (1)	Serpentine River	British Columbia
Fraser-Lower Mainland (2)	Fishtrap Creek	British Columbia
Fraser-Lower Mainland (2)	Fraser River, North Arm	British Columbia
Fraser-Lower Mainland (2)	Fraser River, Main Arm	British Columbia
Fraser-Lower Mainland (2)	Fraser River, at Agassiz	British Columbia
Okanagan-Similkameen (3)	Okanagan River, downstream from Kelowna	British Columbia
Okanagan-Similkameen (3)	Okanagan River, south of Oliver	British Columbia
Okanagan-Similkameen (3)	Osoyoos Lake at the US/Can. border	British Columbia
Okanagan-Similkameen (3)	Mill Creek, in downtown Kelowna	British Columbia
Okanagan-Similkameen (3)	Mill Creek, upstream from Kelowna, reference site	British Columbia
Yukon (5)	Lake Kusawa	Yukon
Assiniboine-Red (12)	Lake Diefenbaker	Saskatchewan
Assiniboine-Red (12)	Wascana Creek	Saskatchewan
Great Lakes (19)	Lake Superior	Ontario
Great Lakes (19)	Thames River, upstream from City of London	Ontario
Great Lakes (19)	Thames River, downstream from City of London	Ontario
Great Lakes (19)	Grand River, upstream from City of Waterloo	Ontario
Great Lakes (19)	Grand River, downstream from City of Waterloo	Ontario
Great Lakes (19)	Niagara River, Fort Erie	Ontario
Great Lakes (19)	Niagara River, Niagara-on-the-Lake	Ontario
Great Lakes (19)	Hamilton Harbour	Ontario
Great Lakes (19)	Lake Ontario	Ontario
Ottawa (20)	Ottawa River	Ontario
St. Lawrence (21)	St. Lawrence River at Wolfe Island	Ontario
St. Lawrence (21)	St. Lawrence River at Quebec City	Quebec
St. Lawrence (21)	St. Lawrence River at City of Lavaltrie	Quebec
St. Lawrence (21)	St. Lawrence Estuary	Quebec
St. John-St. Croix (23)	Napan River at City of Miramichi	New Brunswick
Maritime Coastal (24)	Little Sackville	Nova Scotia
Newfoundland-Labrador (25)	Waterford River	Newfoundland and

Sampled drainage regions	Location	Province or territory
		Labrador

Note: The numbers in parentheses refer to the number identifier of the drainage region in Figure 1.

Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

3.3 Temporal coverage

Data collected over the five years from 2006 to 2010 were used to calculate the PFOS in fish indicator. For the PFOS in water indicator, data collected over the four years from 2007 to 2010 were used. For the PFOS trend in fish in Lake Ontario indicator, data collected between 1979 and 2010 were used.

3.4 Data completeness

The sampling locations for fish and water varied throughout the reporting years. Data for fish and water were gathered in as many drainage regions as permitted by program capacity in any year. To provide a better representation of each drainage region, all the samples for all the available years (2006 to 2010 for fish and 2007 to 2010 for water) were used to calculate the indicators.

3.5 Data timeliness

There is a time lag of two years between the last sampling dates and the publication of the indicators. This time is required to perform monitoring; compile, validate (perform quality assurance and control), analyze and review data; and report on the indicators.

4 Methods

4.1 PFOS in fish tissue and PFOS in water

The perfluorooctane sulfonate (PFOS) in fish and water indicators determine whether draft Federal Environmental Quality Guidelines (FEQGs) for PFOS in fish and water have been exceeded in each drainage region.

Monitoring for PFOS in fish was conducted in 13 drainage regions between 2006 and 2010, and in water in 11 drainage regions between 2007 and 2010. A sample with a PFOS concentration above the draft FEQGs was counted as one exceedance.

Table 4. Sample size per drainage region for PFOS in fish, 2006 to 2010

Sampled drainage regions	Sample size (number of fish)	Species of fish
Pacific Coastal (1)	16	Cutthroat Trout
Okanagan-Similkameen (3)	22	Yellow Perch, Smallmouth Bass, and Largemouth Bass
Columbia (4)	27	Walleye
Yukon (5)	39	Lake Trout
Peace-Athabasca (6)	29	Lake Trout
Lower Mackenzie (7)	27	Lake Trout
Assiniboine-Red (12)	23	Walleye
Winnipeg (13)	11	Lake Trout
Lower Saskatchewan-Nelson (14)	33	Walleye
Churchill (15)	59	Lake Trout
Great Lakes (19)	123	Lake Trout, Walleye
St. Lawrence (21)	29	Lake Trout, Walleye
Maritime Coastal (24)	33	Brook Trout

Note: The numbers in parentheses refer to the number identifier of the drainage region in Figure 1.

Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

Table 5. Sample size per drainage region for PFOS in water, 2007 to 2010

Sampled drainage regions	Sample size (number of water samples)
Pacific Coastal (1)	33
Fraser-Lower Mainland (2)	40
Okanagan-Similkameen (3)	105
Yukon (5)	3
Assiniboine-Red (12)	24
Great Lakes (19)	180
Ottawa (20)	22
St. Lawrence (21)	93
St. John-St. Croix (23)	27
Maritime Coastal (24)	24
Newfoundland-Labrador (25)	26

Note: Samples consist of surface water samples. The numbers in parentheses refer to the number identifier of the drainage region in Figure 1.

Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

4.2 PFOS trend in fish from Lake Ontario

A retrospective analysis of PFOS concentrations in Lake Trout from Lake Ontario was completed by Environment Canada using samples preserved in the National Aquatic Biological Specimen Bank in order to extend the monitoring timeline back to 1997 (<http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=D488F7DE-1>). These measurements were combined with PFOS concentrations determined in 2007 and 2008 by Furdui and co-workers covering 1979 to 2004.¹ Furdui and co-workers also obtained Lake Ontario Lake Trout from the National Aquatic Biological Specimen Bank and analyzed the samples at Ontario's Ministry of the Environment.

Table 6. PFOS sample size (Lake Trout) from Lake Ontario, 1979 to 2010

Year	Sample size (number of fish)
Samples analyzed by Furdui and co-workers	
1979	4
1983	5
1988	5
1993	5
1998	5
2001	10
2004	5
Samples analyzed by Environment Canada	
1997	7
1998	8
1999	6
2000	8
2001	3
2002	9
2003	7
2004	6
2005	6
2006	12
2007	5
2008	10
2009	10
2010	10

Source: Environment Canada Perfluorooctane Sulfonate in the Canadian Environment (<http://ec.gc.ca/toxiques-toxics/default.asp?lang=En&n=7331A46C-1>).

5 Caveats and limitations

Annual measurements of perfluorooctane sulfonate (PFOS) in lakes and rivers under the Chemicals Management Plan (CMP) began in 2006 (<http://www.chemicalsubstanceschimiques.gc.ca/plan/index-eng.php>). A retrospective study covering the years 1979 to 2008 was conducted on archived fish samples from Lake Ontario.

As sampling is not necessarily performed at the same location each year because of challenges in obtaining fish or water samples due to remoteness, shipping logistics and resource

¹ Furdui VI *et al.* (2008) Temporal trends of perfluoroalkyl compounds with isomer analysis in lake trout from Lake Ontario (1979-2004). *Environmental Science & Technology* 42: 4739-4744.

constraints, a comparison from one year to the next at the national scale is not yet possible. To address this limitation, the PFOS in fish and water indicators are estimated by pooling the samples for all available years at the drainage area scale (2006 to 2010 for fish and 2007 to 2010 for water).

6 References and further reading

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www.ec.gc.ca

Additional information can be obtained at:

Environment Canada

Inquiry Centre

10 Wellington Street, 23rd Floor

Gatineau, QC K1A 0H3

Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800

Fax: 819-994-1412

TTY: 819-994-0736

Email: Enviroinfo@ec.gc.ca