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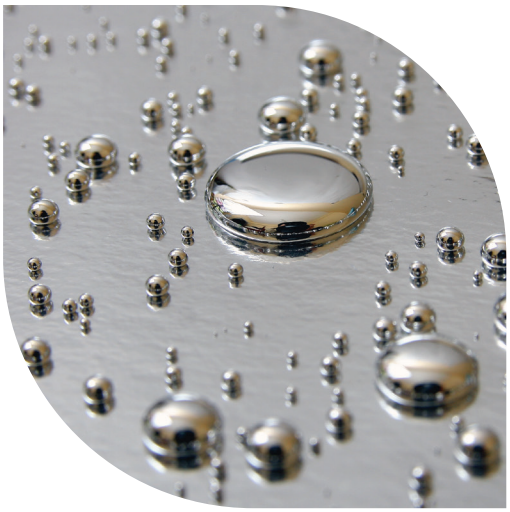

EVALUATION OF THE EFFECTIVENESS OF RISK MANAGEMENT MEASURES FOR MERCURY

Canada

Cat. No.: En14-411/2020E-PDF
ISBN: 978-0-660-34949-7

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Executive Summary

Mercury is a toxic substance under the *Canadian Environmental Protection Act*. Mercury takes many forms and moves from one place to another, through air, water and soil. As a gas, mercury can stay in the air for months and can travel far from where it was first emitted before being deposited to land and water. Mercury is released to the environment from natural sources such as volcanic activity, forest fires and erosion as well as from human activities. Natural sources account for roughly 60% of the mercury deposited in Canada each year. Industrial and other human activities account for the remaining 40% of annual deposits. The most dangerous form of mercury is called methylmercury, which can cause serious problems for animals and humans. Methylmercury is highly toxic and accumulates in the tissues of living organisms. As a result, animals that eat other animals have more mercury in their bodies. Mercury in humans comes mostly from eating food, especially fish and sea mammals.

Over many years, the Government of Canada has worked to protect Canadians and their environment from the risks of mercury by minimizing, and where feasible, eliminating mercury emissions and releases. This report shows the progress made since 2007 in achieving this objective. It provides the status of emissions and releases of mercury from human activities, outlines trends in environmental monitoring data and human biomonitoring data, and discusses the different actions taken by the Government of Canada to manage the risks of mercury and how well they have performed overall. The report offers the following conclusions:

1. **Progress has been made to reduce mercury levels in the environment.** From 2007-2017, mercury emissions to air from human activities in Canada were reduced by 61% and mercury releases to water declined by 66%. Mercury levels in air and animals have mostly declined or are stable in most areas in Canada. Notable exceptions are the Arctic and areas of western Canada where mercury levels were found to be increasing in the air at some sites and in some animals.

2. **Canadians' exposure to mercury has been reduced.** Levels of mercury in the general Canadian population are low and stable, although there is some variance within First Nations populations. Northern Inuit populations have higher levels of mercury but their levels have been decreasing over time possibly due to a decrease in consumption of certain country foods that contain mercury. Regarding other potential exposure sources, previous management actions have been taken for paints, toys, cosmetics, natural health products, drinking water and pesticides.

3. **Risk management measures have contributed to the overall objectives of protecting Canadians and their environment from mercury.** An analysis of the performance of the *Canada-wide Standards for Mercury Emissions from Coal-fired Electric Power Generation Plants* and for the Pollution Prevention Notices for mercury switches and dental amalgam waste showed that the risk management

objectives were met. New risk management measures put in place include: the *Products Containing Mercury Regulations*; the *Reduction of Carbon Dioxide from Coal-Fired Generation of Electricity Regulations; Export of Substances on the Export Control List Regulations; National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act;* and the *Code of Practice for the Environmentally Sound Management of End-of-life Lamps Containing Mercury*.

4. **As a Party to the Minamata Convention on Mercury, Canada has also worked actively to lower the amount of mercury that enters the Canadian environment from human activities in other countries.** The majority of mercury from human activities that is deposited in Canada comes from emissions in other countries. Because of this, the Government of Canada has been actively working with its international partners to develop and implement the Minamata Convention on Mercury, which requires countries that are Parties to the Convention to reduce and control mercury throughout its lifecycle.

5. **Additional risk management actions and ongoing performance measurement and monitoring activities are essential to further protect Canadians and their environment from the harmful effects of mercury.** As the risks of mercury shift away from industrial emissions and releases, new risk management actions will be needed. Performance measurement is a useful tool for evaluating the success of risk management actions and identifying areas where additional actions may be needed. Ongoing monitoring is particularly important since changes in emissions and releases and ecosystems shifts are altering trends of mercury levels in the environment.

Based on the results in this report, the Government of Canada will focus its efforts in four main areas: monitoring mercury levels in humans and the environment, managing risks associated with mercury, in particular related to the responsible management of waste associated with the disposal of products containing mercury, communicating with the public, and engaging internationally.

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1 Introduction

1.1 Sources and effects of mercury

Mercury[1] is a toxic substance under the *Canadian Environmental Protection Act*. Mercury occurs naturally in the Earth's crust and can enter the environment as a result of natural processes such as volcanic activity, erosion and forest fires. It can also be released into the environment through human (anthropogenic) activities such as the burning of coal, the extraction of metals from ore and the use and disposal of products containing mercury. Natural sources account for roughly 60% of the mercury deposited in Canada each year (Environment and Climate Change Canada, 2016). Industrial and other human activities account for the remaining 40% of annual deposits.

Mercury moves through the environment in complex ways over decades. Once in the environment, mercury cycles between air, water, soil, plants, and animals. Because elemental mercury (that is, mercury in its pure form) evaporates, it can move easily through the air, ending up thousands of kilometers away from where it was first released; this makes it a global concern. For example, the vast majority of mercury from human activities deposited in Canada originates from other countries. In addition, mercury deposited from both natural and anthropogenic sources can be re-emitted by natural processes and then end up in the atmosphere again. Scientists are still working to determine how much the movement of mercury is affected by climate change. All of these factors affect the levels of mercury in Canada's environment.

Once in the environment, mercury can be converted into various forms, including methylmercury. Methylmercury is a highly toxic compound that accumulates in living organisms, especially animals at higher levels of the food chain. Levels of methylmercury in the environment vary due to human activities and natural factors in the environment such as temperature, acidity, presence of bacteria, and organic matter. Most mercury released to the environment directly from human activities is in its inorganic form, and naturally turns into methylmercury under certain environmental conditions.

Human activities can change environmental conditions, making it more likely that methylmercury will form. Climate change and the acidification of waterbodies are thought to be two of the biggest influences increasing the rates of methylmercury formation. It is the amount of methylmercury available for uptake that drives mercury levels in animal species and not emissions alone. Mercury levels in the environment may still be changing in certain areas because of the complex way that mercury cycles in the environment. For this reason, a direct link between the deposition of anthropogenic emissions and mercury levels in the environment and in animals is not always clear.

[1] In this document, the term "mercury" refers to mercury and its compounds.

Mercury poses significant risks to Canada's environment and the health of Canadians. High levels of mercury in the environment can harm wildlife and ecosystems. Humans are most often exposed to methylmercury by eating fish and sea mammals. Methylmercury affects the central nervous system and is particularly damaging to fetuses, infants, and young children, who are vulnerable due to their developing nervous systems.

1.2 Government approach to mercury risk management

Over the last 50 years, the Government of Canada has used different risk management approaches to tackle the risks created by releases of mercury including regulations, pollution prevention plans, codes of practice and national guidelines.

In 2009, the Commissioner of the Environment and Sustainable Development (the Commissioner) published a review of federal action on toxic substances. The review noted that there was no consolidated risk management strategy for mercury and that "departments lack a systematic process for periodically assessing progress made in managing the risks [of toxic substances such as mercury]".

In response to this review, Environment and Climate Change Canada and Health Canada committed to conducting "substance-based performance measurement" for toxic substances. This kind of measurement looks at the outcomes of the actions taken to deal with the risks of a substance, including looking at levels of the substance found in people or the environment. Through this assessment, the government can determine if it has made progress to reach its risk-reduction objectives.

In 2010, the Government of Canada published the *Risk Management Strategy for Mercury* (the Strategy) (Government of Canada, 2010a). The Strategy reviewed federal and international actions up to 2007, which were focused on managing the risks posed by mercury, and outlined planned actions to address ongoing risks. The Strategy noted that, between the 1970s and 2007, the amount of mercury entering the Canadian environment from industrial releases was reduced by approximately 72 tonnes (91%). Additionally, it found that more science was needed to help manage risks from mercury. This included monitoring to improve our understanding of the movements and changes in mercury levels and the chemical forms of mercury in the environment. The Strategy also showed that more needed to be done to reduce the human health and environmental risks of mercury.

Accordingly, the Strategy proposed new risk management actions the Government of Canada could take to deal with non-industrial sources such as products and waste containing mercury. It highlighted that Canadians would benefit from actions taken to reduce mercury at the North American and global levels since most of the mercury deposited in Canada (97%) comes from other countries.

Following publication of the Strategy, the Government has continued to move forward with both domestic and international actions to further reduce mercury. The current report assesses whether progress has been made in achieving the Strategy's main objective of

protecting the health of Canadians and their environment from the harmful effects of mercury by minimizing and, where feasible, eliminating anthropogenic[2] mercury releases. The following sections provide the status of emissions and releases of mercury from human activities, outline trends in environmental monitoring data and human biomonitoring data, and discuss how well the different actions taken by the Government of Canada to manage the risks of mercury have performed overall.

2 Status of Emissions and Releases of Mercury from Human Activities in Canada

Mercury from human activities such as industrial processes, use of products containing mercury, and waste management can affect mercury levels in the environment over time.

To evaluate the effectiveness of the risk management measures that Canada has implemented to control mercury releases and achieve the Strategy objective, data on anthropogenic emissions and releases were gathered from the Air Pollutant Emissions Inventory and the National Pollutant Release Inventory for the period of 2007-2017.

2.1 Air emissions

The Air Pollutant Emissions Inventory includes mercury air emissions data (Table 1). Between 2007 and 2017, national mercury air emissions decreased by 61%. Major industrial sectors decreased by over 50%, with the most notable decreases being coal-fired electric power generation (72%), incineration (92%), and non-ferrous smelting and refining (90%).

[2] Mercury from human activities

Table 1. National mercury air emissions, in tonnes

CATEGORY/SECTOR	2007	2017	% change
Coal-fired electric power generation	**2.07**	**0.58**	**-72%**
Commercial/residential/institutional[1]	**0.57**	**0.30**	**-48%**
Incineration and waste	**1.49**	**0.44**	**-70%**
Incineration	0.78	0.06	-92%
Crematoria	0.20	0.28	+42%
Waste treatment and disposal	0.51	0.10	-80%
Ore and mineral industries	**2.63**	**1.21**	**-54%**
Iron and steel	0.89	0.73	-18%
Non-ferrous smelting and refining	1.41	0.15	-90%
Cement and concrete	0.32	0.33	+4%
Other industrial sources[2]	**0.68**	**0.25**	**-64%**
Other electric power generation and fuel combustion sources[3]	**0.40**	**0.25**	**-37%**
TOTAL[4]	**7.84**	**3.03**	**-61%**

Source: Air Pollutant Emissions Inventory (2019)

[1] Includes emissions from cigarette smoking, combustion of fossil fuels and biogenic fuels for heating in buildings, heating of construction materials, and mercury in products and facility reported data from sectors that are not included elsewhere.

[2] Other industrial sources include emissions from the aluminum, asphalt paving, iron ore, mining and quarrying, manufacturing, and upstream and downstream oil and gas industries.

[3] These sources include emissions from natural gas, waste materials, other electric power generation, and combustion of fuel used for transportation and mobile equipment, agriculture, home firewood burning, construction and residential purposes.

[4] Totals and percent change may not calculate correctly due to rounding.

Over the period 2007-2017, the picture of major mercury emitters has changed dramatically. Figure 1 presents the breakdown of atmospheric mercury emissions in 2007 and 2017. While emissions from the iron and steel industry make up the largest part of the total mercury emissions in Canada in 2017, emissions from this source have decreased from 2007 by 18%. In addition, as Figure 2 shows, during this period mercury emissions to air decreased in every province.

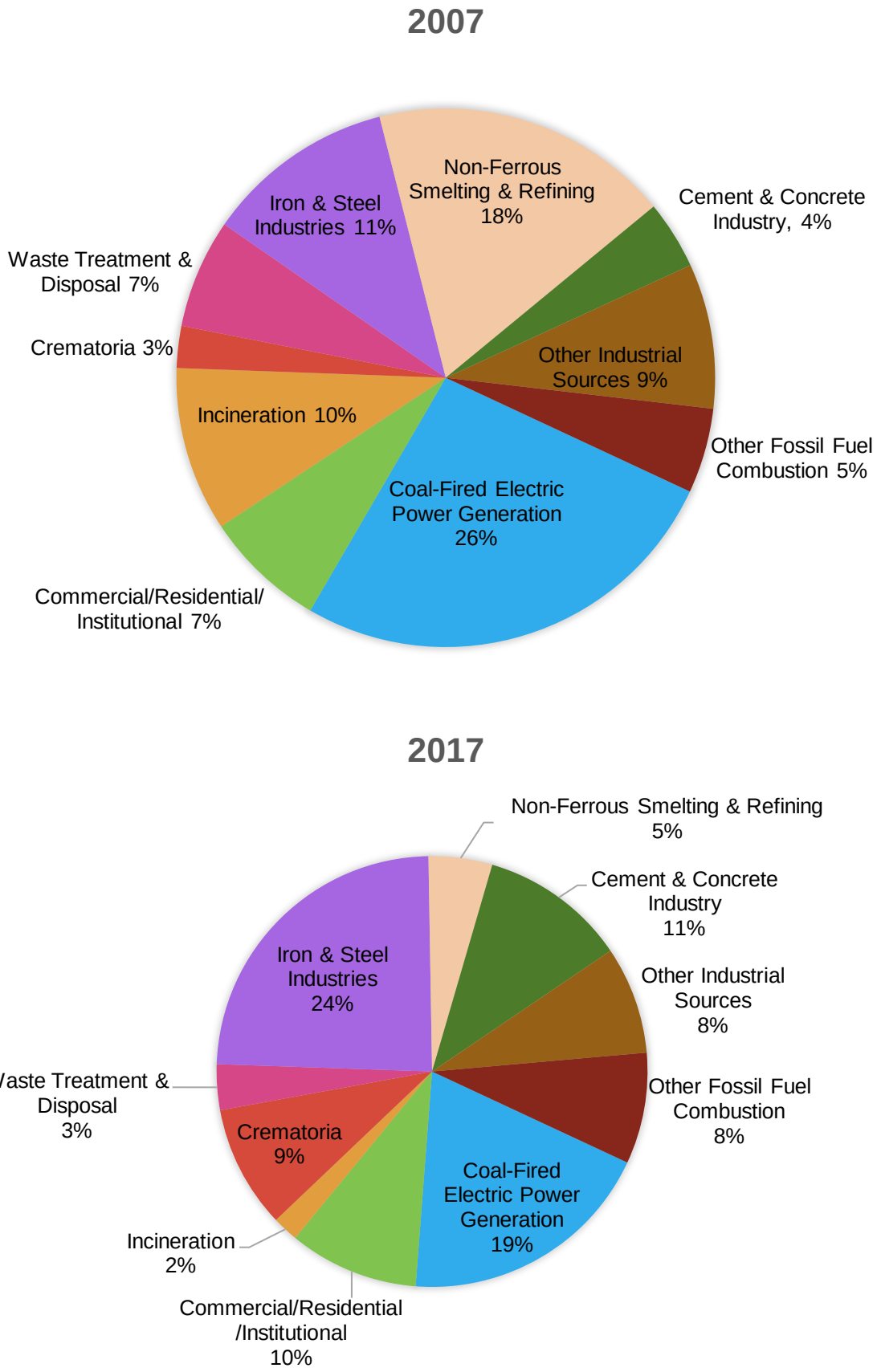

Figure 1. Canadian atmospheric mercury emissions in 2007 (approx. 7.8 tonnes) and 2017 (approx. 3.0 tonnes) * Totals may not add up due to rounding

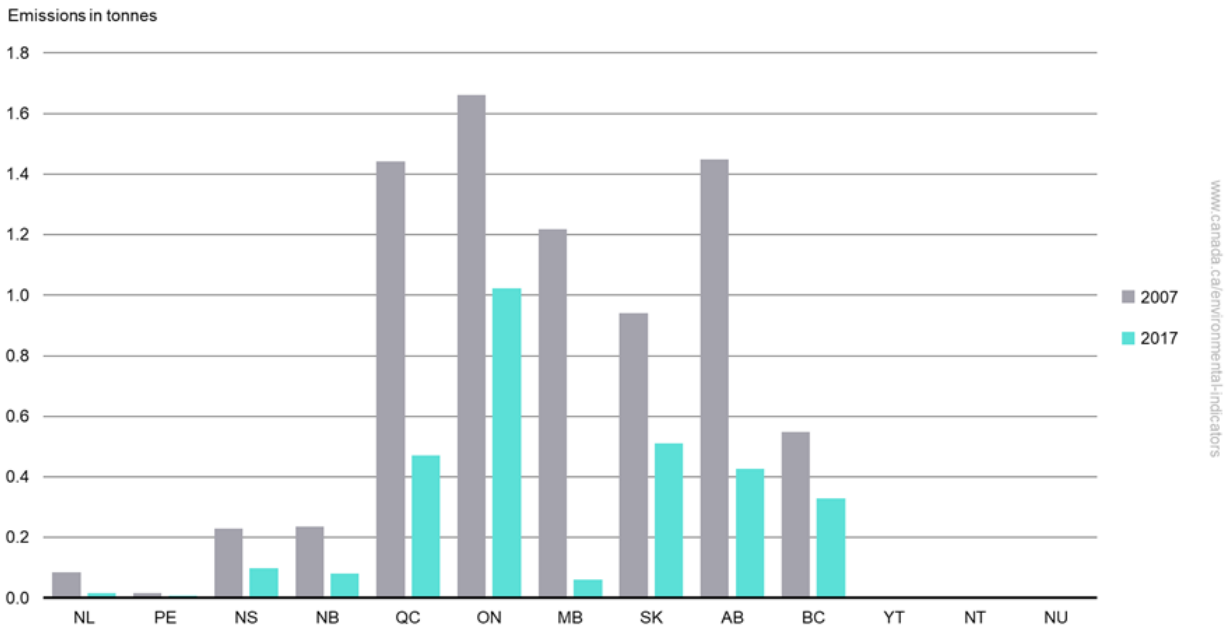

Figure 2. Mercury emissions to air by province and territory, Canada, 2007 and 2017
(Source: Environment and Climate Change Canada (2019), Air Pollutant Emissions Inventory)

Over the past ten years, mercury emissions decreased because of the closure of industrial operations (including a smelter in Manitoba in 2010 and coal-fired electricity generation facilities in Ontario), the use of new emission control technologies, and increased use of best management practices.

Mercury emissions to air were the highest in Ontario in 2017, accounting for 34% (1.0 tonne) of the national total. These emissions came mostly from the iron and steel industry and cement and concrete industry, which together accounted for 60% of Ontario's total.

2.2 Water releases

The National Pollutant Release Inventory requires facilities to report annually on mercury releases to water if they release 5 kg or more of mercury during their operations. As shown in Figure 3, total reported releases of mercury to water have been relatively low.

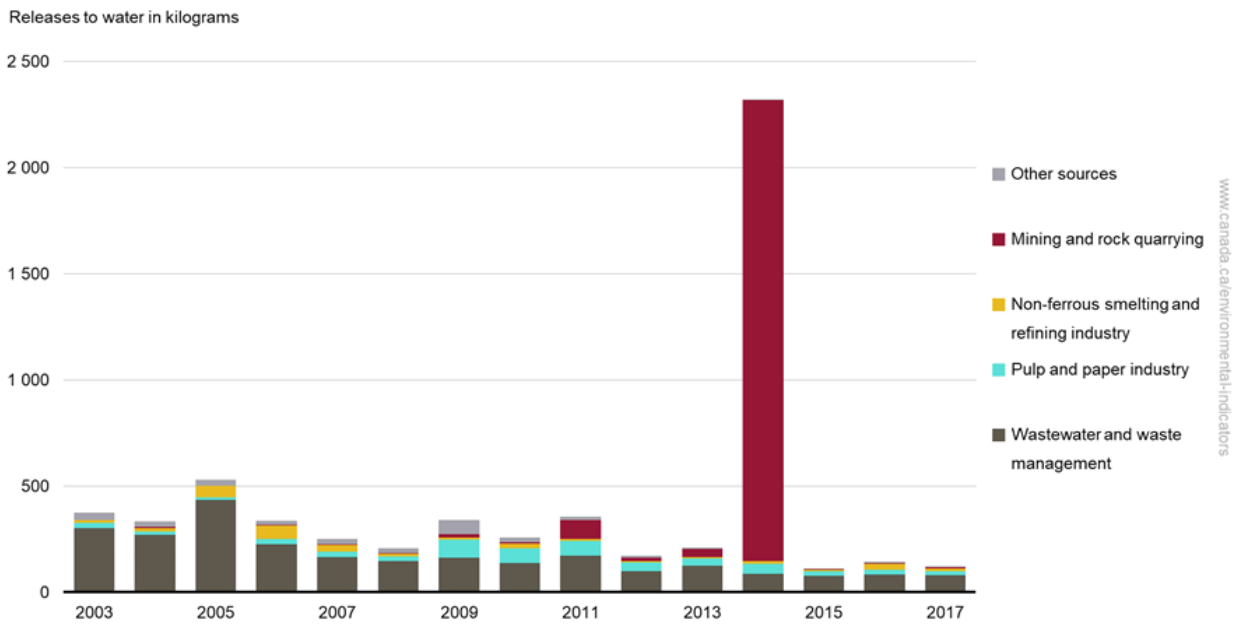

Figure 3. Kilograms[1] of mercury releases[2] to water by source in Canada, 2003 to 2017

Notes: [1] 1000 kilograms = 1 tonne.
[2] Releases from human activities only. Amounts indicated include elemental mercury and mercury in any compound, alloy, or mixture reported in the National Pollutant Release Inventory based on the inventory reporting criteria. "Other sources" include electric utilities, manufacturing (except pulp and paper), the oil and gas industry, and ore and mineral industries (except non-ferrous smelting and refining), among others (For more details on sources, see data sources and methods used for the inventory).

Excluding 2014, the total annual average release of mercury to water between 2007 and 2017 was 217 kg. Mercury releases declined by 66% from 2007 to 2017. In 2014, total releases were significantly higher, at 2,321 kg, due to the breach of a dam that was securing mine waste in a tailings pond from the Mount Polley mine in central British Columbia (accounting for 92% of mercury released that year).

Between 2007 and 2017, mercury released via wastewater treatment facilities accounted for the majority of total mercury released to water. In 2017, four sectors contributed 119 kg to the 120 kg of total national releases of mercury to water: sewage treatment and waste management, pulp and paper, non-ferrous smelting and refining, and mining and rock quarrying. The largest source was the sewage treatment and waste management sector, representing 81 kg (68%) of the total. This sector does not generate mercury; rather, it releases mercury generated upstream from the use or disposal of products containing mercury.

2.3 Deposits from foreign sources

Despite reductions from sources across the country, air emissions continue to be a major source of mercury deposits in Canada. Mercury, unlike other metals, easily evaporates. Once mercury is released into the air, it can remain there for six months to a year, where it is carried long distances and is deposited across Canada, including in the Arctic. The Arctic is

especially vulnerable to mercury deposition because of its unique chemistry, which results in precipitation of mercury from the air to the snow and ice during the spring.

It can be difficult to distinguish between mercury from foreign and domestic sources because mercury can be transported long distances on wind currents. Environment and Climate Change Canada estimates that in 2015, Canada contributed 0.2% (4.3 tonnes out of 2223 tonnes) of global mercury emissions to the atmosphere from human activities. However, approximately 40 tonnes of mercury from human activities were deposited in Canada in 2015. (Dastoor and Ryjkov, internal communication 2018, Environment Climate Change Canada, 2019). Through modeling and analysis, over 97% of these deposits are estimated to have come from other countries, with approximately 37% from East Asia, 9% from Southeast Asia, 8% from both South Asia and Sub-Saharan Africa, 7% from Europe and 4% from the United States. For this reason, Canada is taking an active role in regional and international efforts to reduce global flows of mercury (particularly through the Minamata Convention; see section 7).

2.4 Conclusion

It is evident that industrial sectors in Canada have reduced the amount of mercury they release into the environment. Despite domestic reductions, anthropogenic air emissions from foreign sources continue to be a major source of mercury in Canada.

3 Mercury in the Environment

The *Canadian Mercury Science Assessment* (the Assessment) published in 2016 is the first comprehensive scientific evaluation and synthesis of information on mercury in the Canadian environment (Environment and Climate Change Canada, 2016). In Canada, environmental monitoring programs measure levels of mercury in air, water, plants, and animals. This monitoring is undertaken by Environment and Climate Change Canada primarily through the Addressing Air Pollution Horizontal Initiative and Chemicals Management Plan monitoring programs as well as by Crown-Indigenous Relations and Northern Affairs Canada, including through the Northern Contaminants Program. The monitoring data summarized below are (unless otherwise noted) drawn from the assessment.

3.1 Air

Mercury levels in the air decreased by 18% on average between 1995 and 2011. Total concentrations of mercury in gaseous form were (with some exceptions) generally 1.2 – 1.9 nanogram[3] per cubic metre (ng/m^3) throughout Canada. Mercury deposited as a result of precipitation averaged 100 – 800 ng/m^2 per month (Cole et al., 2013). In addition, many areas have experienced greater than average reductions in atmospheric mercury concentrations during the same period.

There are a lot of factors that affect the amount of mercury in the air. For example, it will take much longer for mercury levels in air to decline in and around areas where mercury has

[3] One nanogram is equal to one billionth of a gram

accumulated over many years, such as areas around base metal smelting facilities or other industrial sites. Another factor includes the movement of mercury from sources outside Canada. This is reflected, for example, in recent findings of increasing mercury levels in the air in two places in Canada: Little Fox Lake in the Yukon Territory and Whistler Mountain, British Columbia. Additionally, localized areas of high mercury deposition have been noted along the west coast and in coastal areas in the western Arctic and sub-Arctic. Trends in mercury deposition are changing over time and are now different than reported in the Canadian Mercury Science Assessment. These observations have been attributed to mercury emissions from sources in Asia and variations in weather conditions as a result of climate change.

3.2 Water

Monitoring of surface water levels of mercury, and in some cases levels of methylmercury, is done for major fresh water bodies across Canada, including in the Pacific region, tributaries in the Athabasca River oil sands region, the Great Lakes and connecting channels, the Saint-Lawrence Seaway, and Hudson's Bay, as well as Atlantic Canada. Air pollutants such as nitrogen oxides and sulphur oxides from industrial sources are known to acidify lakes and streams. Nutrient-deficient bodies of waters that are either naturally acidic or acid-impacted tend to have higher methylmercury concentrations than nutrient-rich, less acidic bodies of water. Acidic lakes typically contain fish and fish-eating wildlife with relatively higher mercury levels compared to non-acidic lakes. In studies reviewed for the Canadian Mercury Science Assessment, no water samples exceeded the *Canadian Water Quality Guidelines for the Protection of Aquatic Life for Inorganic and Methylmercury* values of 26 ng/L for mercury and 4 ng/L for methylmercury.

3.3 Animals

The amount of methylmercury in the environment determines the mercury levels in animals. Methylmercury (the most toxic form of mercury) accumulates in animals' bodies. Animals and humans tend to absorb and retain over time most of the methylmercury in the food they consume (bioaccumulation). At each step in the food chain, predators accumulate mercury from their prey. As a result, over their lifetime, they have much higher mercury levels in their bodies than their prey (biomagnification). Consequently, large predatory fish, fish-eating mammals, and fish-eating birds are at greatest risk of impaired health and reproduction from exposure to methylmercury.

Monitoring of methylmercury levels in animals has revealed a wide variation between species and regions. Overall, methylmercury levels have remained stable in nearly half (48%), decreased in 21%, and increased in 31% of the populations monitored. Most of the fish or wildlife species reviewed in the Assessment had methylmercury levels below the level thought to cause death or physical harm. However, despite this, the Assessment also highlighted that the levels of methylmercury in some populations of fish-eating fish and wildlife species in Canada may be high enough to cause behavioural changes and affect reproductive success.

Of the populations showing an increase in methylmercury levels, the large majority (83%)[4] are in the Arctic. The environmental conditions in the Arctic are rapidly changing due to climate change and large amounts of foreign mercury emissions are deposited there. These two factors are thought to have played a role in the increases in methylmercury levels observed in many Arctic populations. The greatest increases in methylmercury levels have been seen in seabirds. According to data from short-term monitoring, the only animal population in the Arctic showing a decreasing trend in methylmercury levels is fish. Despite this decrease, levels in some types of fish may still be a concern because the traditional diets of Indigenous communities in this region rely heavily on fish and sea mammals.

The Great Lakes region has shown the largest and most frequent declines in methylmercury levels in individual populations (40% of fish and seabird populations reported). However, recent data illustrate that some populations that have previously shown declines or stable trends in methylmercury concentrations are now showing increasing trends (Environment and Climate Change Canada and the United States Environmental Protection Agency, 2017). Climate change, changes in food web structure due to invasive species, and fluctuating water levels are thought to be contributing factors to the observed increasing trends (Blukaz-Richards et al., 2017). Additional data is being collected through Canadian and American monitoring programs to better understand why these increases are occurring.

Figure 4. Overall trends in methylmercury concentrations in Canadian land-based mammals, fish, polar bears, beluga whales, seals, seabirds, and mussels, 1967 to 2012

[4] The Arctic region represents over half of the populations reported on, as shown in Figure 4

3.4 Conclusion

Overall, environmental monitoring data outlined above show decreases in levels of mercury in air, water and biota across Canada. However, increasing trends in mercury levels have been noted in the air and some animals in some locations, particularly in the Arctic and some areas of western Canada. The Arctic's unique chemistry, weather conditions, climate change and being downwind of foreign sources of mercury emissions may be contributing factors to the observed increases. The increases in methylmercury levels in some animal populations in the Arctic are concerning because of the importance of fish and sea mammals in the diets of northern and Indigenous communities. Environmental monitoring should continue to better understand spatial and temporal trends of mercury in the environment. This ongoing monitoring is particularly important since changes in emissions and releases and ecosystem shifts are altering the trends of mercury levels in the environment.

4 Mercury and Human Health

4.1 Human biomonitoring results

The most direct way to measure human exposure is through human biomonitoring. Measurements of mercury levels or concentrations are usually taken in blood or urine but can also be taken in other tissues and fluids such as hair, nails and breast milk. The measurement indicates how much of a chemical is present in a person.

Canada has biomonitoring programs for mercury in the general population, First Nations populations and Inuit populations. These measurements can be compared to the Health Canada blood guidelines.

Health Canada set guidelines for acceptable levels of methylmercury in blood at 20 micrograms[5] per litre (µg/L) or lower for men over 18 and for women 50 and older (Health Canada, 1999). In 2010, an acceptable level of 8 µg/L or lower was developed for children 18 years of age and under, women of childbearing age (19 to 49 years), and pregnant women, recognizing that the developing nervous systems of the fetus and of young children place them at greater risk of health effects from methylmercury (Legrand et al., 2010).

Trends in blood levels may be seen when measurements are taken at more than one point in time. The data below was taken from the Canadian Health Measures Survey (Statistics Canada 2013 & 2017) and a number of recent comprehensive reviews including the Canadian Mercury Science Assessment (2016) and the Arctic Monitoring and Assessment Programme's Human Health Assessment (2015).

4.1.1 Canadian general population

[5] One microgram is equal to one millionth of a gram

Total mercury in the general Canadian population is measured on an ongoing basis as part of the nationwide Canadian Health Measures Survey[6]. This survey began in 2007 and is led by Statistics Canada in partnership with Health Canada and the Public Health Agency of Canada. The survey includes assessment of blood, urine, and hair collected from survey participants for a wide variety of environmental chemicals (Health Canada, 2017; Statistics Canada, 2017).

As shown in Figure 5, for 2007 to 2009 the mean level of mercury in blood was 0.88 µg/L, for 2009 to 2011, 0.92 µg/L; for 2012 to 2013, 0.92 µg/L; for 2014 to 2015, 0.77 µg/L. Therefore the majority of Canadians have mercury levels well below the Canadian blood guidelines and their levels are not changing over time (Statistics Canada, 2017). As shown in Figure 6, younger Canadians have lower levels of mercury compared to older Canadians.

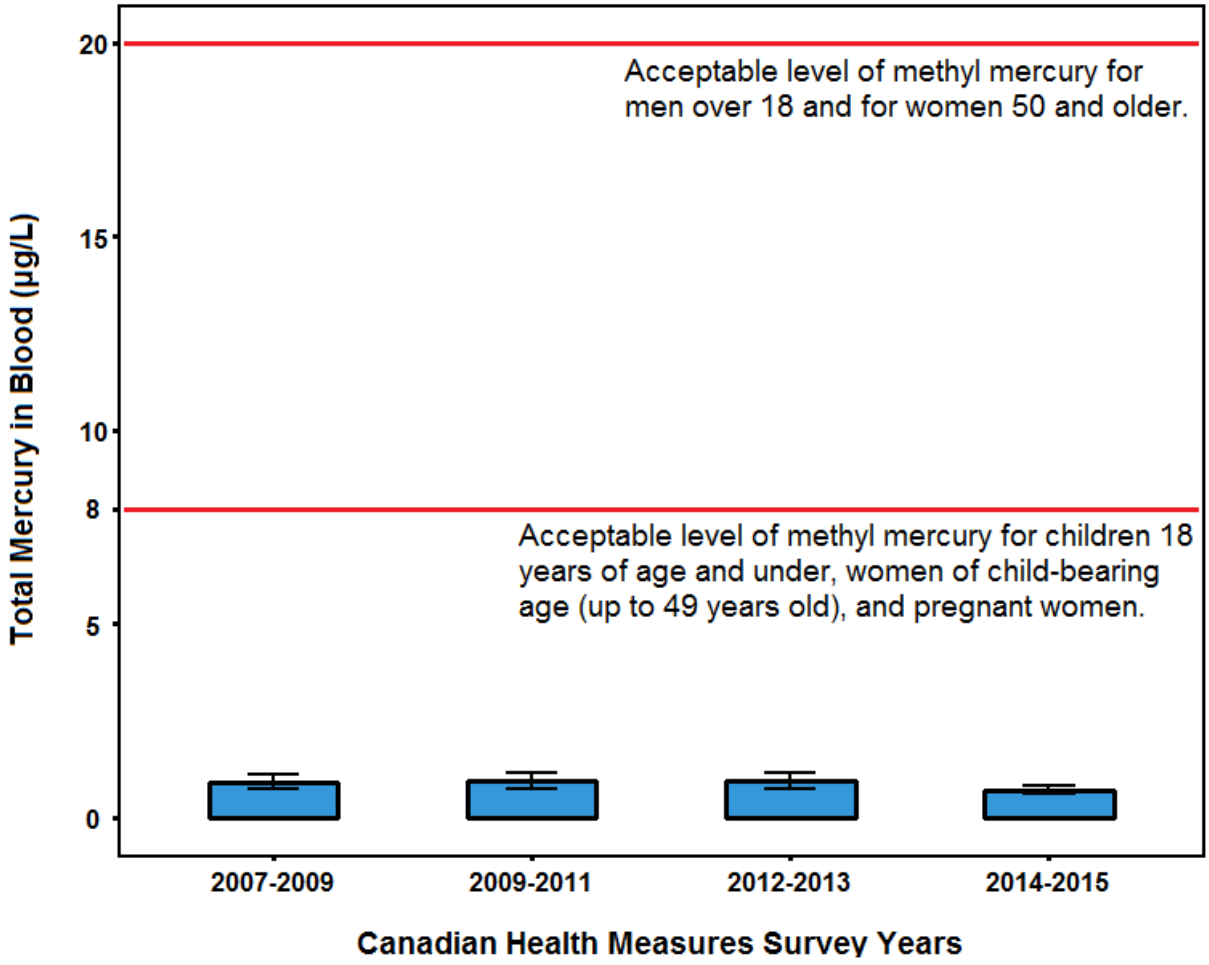

Figure 5. Mean (geometric) levels of mercury in blood in Canadians aged 20 to 79 years compared to mercury blood guidelines

[6] In population biomonitoring, total mercury is generally used as a proxy for methylmercury, due to costs associated with speciation of mercury compounds. Note that methylmercury would comprise a fraction of total mercury measured.

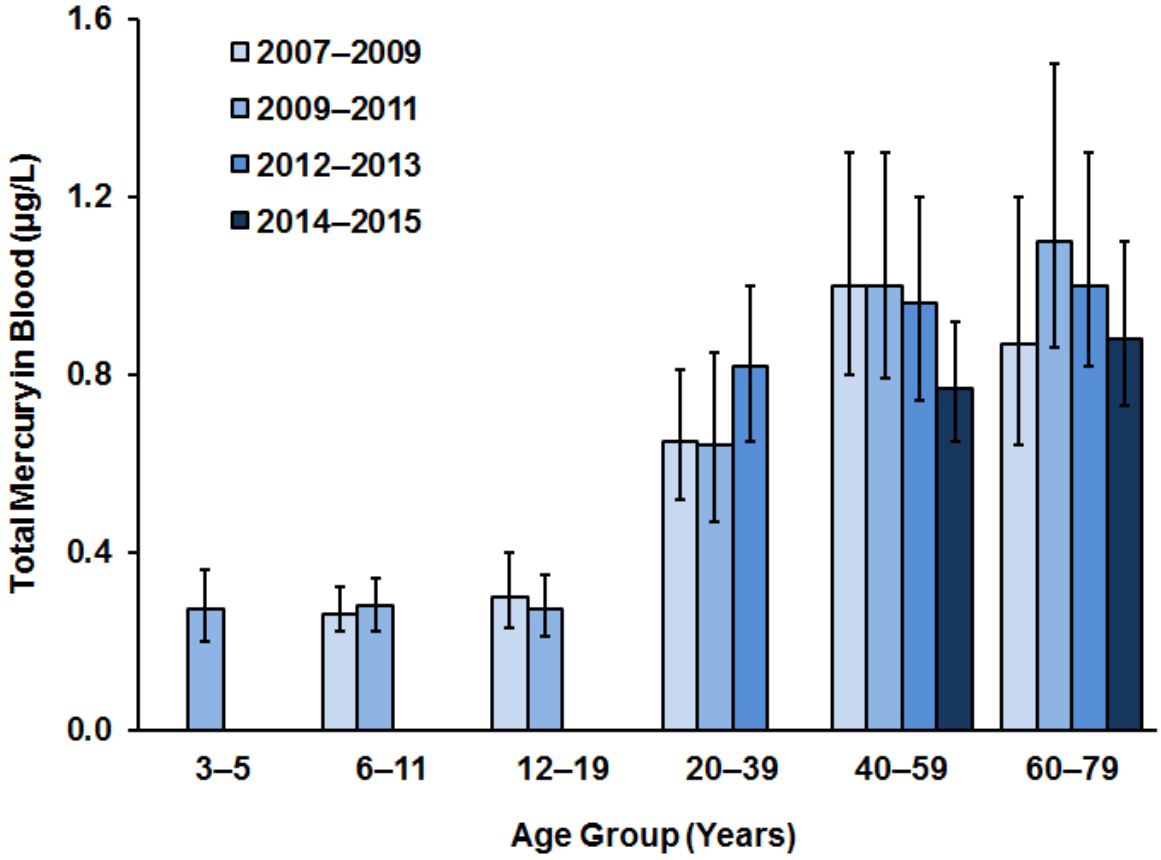

Figure 6. Mean (geometric) levels of mercury in blood in Canada by age group over time
Note: Means could not be calculated in some cases because mercury levels of people sampled in that age group were too often below the detection limit.

In the 2007 to 2009 Canadian Health Measures Survey, less than 1% of the general population (6–79 years old) had mercury concentrations above the 20 µg/L guideline (Health Canada, 2010). In the same survey, 1.61% of Canadian pregnant women, women of childbearing age, and children were above the 8 µg/L guideline (Lye et al., 2013). As mercury levels in the general Canadian adult population have not changed significantly between 2007 and 2015 (Statistics Canada, 2017), the percentage of Canadians with mercury blood concentrations above acceptable levels has also remained constant. Almost all Canadians are expected to have blood mercury concentrations below the 8 µg/L and 20 µg/L guidelines. Public health risk to the general population continues to be low. Health advisories and interventions may have contributed to this outcome.

4.1.2 Indigenous communities

Mercury exposures are generally higher among those whose diet is high in fish or sea mammals, such as members of many Indigenous communities, especially Inuit communities. Although traditional diets consisting of harvested country foods have significant nutritional

benefits, they may also increase exposures to mercury (Arctic Monitoring and Assessment Programme, 2011).

As part of the First Nations Biomonitoring Initiative (the Initiative) average total blood mercury levels of First Nations adults (20 years old or above) living on reserve in southern Canada were studied. Mean levels of total mercury in blood in this subpopulation were not significantly different than those of the general Canadian population measured in the Canadian Health Measures Survey, although there was much more individual variability within the subpopulation. As well, six of the thirteen First Nations communities who participated in this initiative showed statistically higher mercury levels than the general Canadian population. The Initiative demonstrated that the mean level of mercury in blood for 95% of the population was less than 9.28 µg/L, well below the 20 µg/L blood guideline. The mean level for 90% of all females was less than 6.42 µg/L. However, by broadening the range to 95% of females, the mean level increased up to 9.85 µg/L, which is above the 8 µg/L blood guideline for women of childbearing age (Assembly of First Nations, 2013).

For Inuit, blood mercury levels are higher than populations in southern Canada, with mean levels ranging from 2.8 µg/L to 12 µg/L across the Inuvialuit Settlement Region, Nunavut, Nunavik, and Nunatsiavut communities. For women of childbearing age in these areas, mean levels range from 1.7 µg/L to 8.4 µg/L (Arctic Monitoring and Assessment Programme, 2015). For Nunavut, the relative frequency of mercury levels above Health Canada's guidance value of 20 µg/L in whole blood was higher for men, all women, and women of childbearing age, than in other regions of northern Canada. Specifically, for women of childbearing age in all regions surveyed, exceedances of the 8 µg/L blood guideline for this age group ranged from 9.3 to 36% (Figure 7) (Arctic Monitoring and Assessment Programme, 2015).

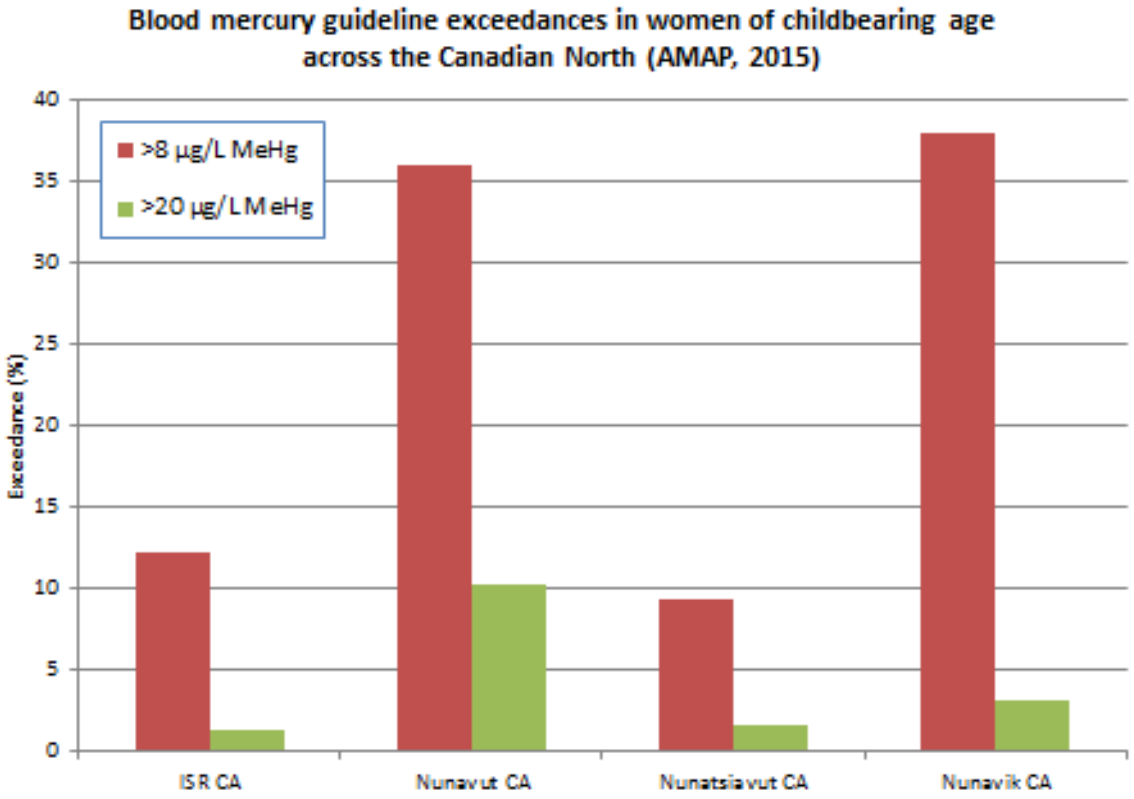

Figure 7. Blood mercury guideline exceedances in women of childbearing age across the Canadian North (Arctic Monitoring and Assessment Programme, 2015)
Note: "ISR" - Inuvialuit Settlement Region

Nonetheless, mercury blood levels have decreased over time in certain Inuit populations, including those most susceptible to effects. For example, there has been:

- a 47% decrease in mercury blood levels in Inuit mothers from the Inuvik region of the Northwest Territories between 1998/99 and 2005/06 (Arctic Monitoring and Assessment Programme, 2009)
- a 40% decrease in mercury blood levels in Inuit mothers from the Qikiqtaaluk (Baffin) region of Nunavut between 1997 and 2005/07 (Arctic Monitoring and Assessment Programme, 2009)
- a 57% decrease in mercury blood levels in pregnant Inuit women from the Nunavik region of Quebec between 1992 and 2013 (Figure 8) (Arctic Monitoring and Assessment Programme, 2015)

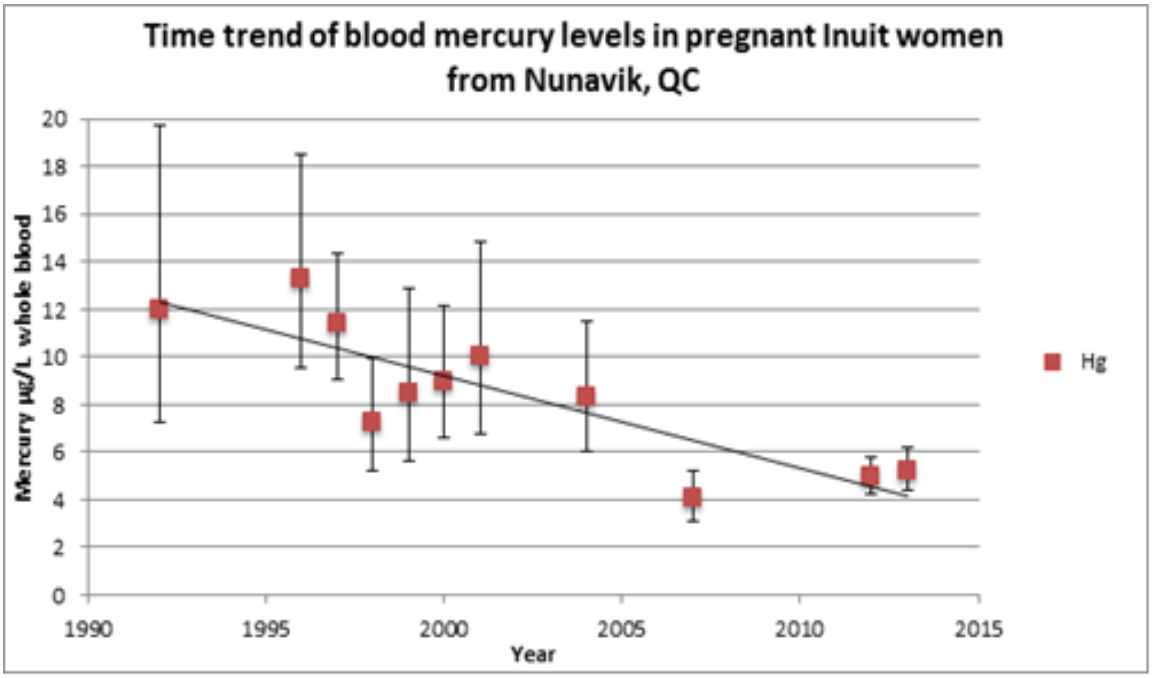

Figure 8. Time trend of blood mercury values in pregnant Inuit women from Nunavik, QC (Arctic Monitoring and Assessment Programme, 2015)

An examination of the various human biomonitoring studies previously discussed was undertaken to determine the presence of trends in mercury levels in Canadians. This is summarized in Table 2. Also included in this table are proportions of populations that were found to exceed Canadian blood guideline levels for mercury. While levels of mercury appear to be decreasing over time in Inuit populations, populations in Canada's North continue to exceed mercury guideline levels at much higher percentages than the general population. The general decrease seen in the Inuit population's exposure to mercury may be because of changes in their diets, in particular, a move away from their traditional diets, rather than a change in the levels of mercury in fish and sea mammals that make up this diet. No trend can be determined for First Nations populations, and levels in the general Canadian population are basically unchanged from 2007 to 2015.

Table 2. Summary of blood guideline exceedances and trends in Canada for various populations

Population	Above the Blood Guideline of 20 µg/L for men (over 18 years old) and women (over 49 years old)	Study Name (sample years)	Trend for this population
General, women and men (6 to 79 years old)	<1%	Canadian Health Measures Survey[1] (2014-2015)	Stable
First Nations men and women (over 20 years old) (on reserve, south of 60th parallel)	< 5%	First Nations Biomonitoring Initiative[2] (2011)	No trend can be determined
Inuit women (18 to 90 years old) (in the Arctic)	16.2%	Inuit Health Survey[3] (2007 to 2008)	Decreasing
Inuit men (18 to 89 years old) (in the Arctic)	23.2%	Inuit Health Survey[3] (2007 to 2008)	Decreasing
Population	**Above the Blood Guideline of 8 µg/L for children (18 years old or younger) and women of childbearing age (18 to 49 years old)**	**Study Name (sample years)**	**Trend for this population**
General, pregnant women, women of childbearing age and children	1.61%	Canadian Health Measures Survey[4] (2007 to 2009)	Stable
First Nations women (over 20 years old) (on reserve, south of 60th parallel)	5 to 10%	First Nations Biomonitoring Initiative[2] (2011)	No trend can be determined
Inuit – women of childbearing age (18-39 years old) (in the Arctic)	30.6%	Inuit Health Survey[3] (2007 to 2008)	Decreasing

[1] Statistics Canada, 2017
[2] Assembly of First Nations, 2013
[3] Arctic Monitoring and Assessment Programme, 2015
[4] Lye et al., 2013

Sea mammals in the Arctic have significantly elevated levels of mercury making these country foods an important contributor to mercury levels in the Inuit. Among Nunavut children, dietary intake of these mammals has been shown to be the biggest contributor to methylmercury in their bodies. Furthermore, biomonitoring results showed that 25% of these children exceeded the World Health Organization reference value for mercury in hair (Arctic Monitoring and Assessment Programme, 2011). Accordingly, the Nunavut government issued dietary advice for women of childbearing age to lower their intake of ringed seal liver in June 2012 (Government of Nunavut, 2012). Laird et al. (2013) further documented the ringed seal liver as the major source of mercury among Inuit in Nunavut. Additionally, the Nunavik

government issued dietary advice for beluga meat, which is the major source of mercury for Inuit (Lemire et al. 2015).

4.1.3 Conclusion

The biomonitoring results show that progress is being made towards minimizing human exposure to mercury. Levels of mercury in the general Canadian population are low and relatively stable. Regarding southern First Nations, mercury levels observed were similar to levels observed in the general Canadian population. However, there are limitations in the comparison of southern First Nations data with that of the general Canadian population. This is because there is a wide range of mercury blood concentrations from individual to individual in southern First Nations communities, a range not seen within the general Canadian population. A statistical comparison performed on a community basis was possible in six of the thirteen First Nation communities. In this case, the six First Nation communities had statistically higher levels than the Canadian population. Northern Inuit populations have higher levels of mercury than the general Canadian population, but their levels have been decreasing over time. These decreases may be due to a decrease in consumption of certain country foods. Given the nutritional, cultural, and spiritual benefits of traditional diets, efforts need to continue to decrease mercury levels in these food webs, as much as possible, to protect human health.

5 Domestic Approach: Progress on Actions in Canada

The following section provides an update on domestic initiatives and discusses the implementation of risk management measures proposed in the *Risk Management Strategy for Mercury*. Actions prior to the strategy have also been taken by the Government of Canada to manage potential exposure sources of mercury, including paints, toys, cosmetics, natural health products, drinking water and pesticides. A list of these additional actions can be found in Annex I of this document.

5.1 Industrial sectors: coal-fired electricity power generation

5.1.1 Canada–wide Standard for Mercury Emissions from Coal-fired Electric Power Generation Plants

The *Canada-wide Standard for Mercury Emissions from Coal-fired Electric Power Generation Plants* (the Standard) was developed in 2006 by the Canadian Council of Ministers of the Environment as a transitional risk management measure to address the largest mercury emitting sector in Canada. The Standard was the leading mercury control instrument in Canada until the publication of the *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations* in 2012 (see section 5.1.2).

The Standard has two risk management objectives:

1. to reduce mercury emissions from the largest remaining human generated source of mercury emissions in Canada

2. to set provincial caps on mercury emissions and performance standards or emission limits based on best available control technology for new units

The Standard also has two targets that set specific:

1. caps on mercury emissions for each signatory jurisdiction, representing a 60% national capture rate[7] of mercury from coal burned from these facilities by 2010 (total cap of 1,130 kg)
2. capture rates or emission limits for new facilities, based on best available control technology, effective in 2006

With the exception of Ontario, all provinces endorsed the Canada–wide Standard. Ontario phased-out mercury emissions from coal-fired electric power generation in 2014 with the *Ending Coal for Cleaner Air Act* (Government of Ontario, 2015).

Emissions of mercury from the plants covered by the Canada-wide Standard represented 96% of Canada's total mercury emissions from electric power generation in 2010 (National Pollutant Release Inventory, 2018). The remaining 4% was emitted from electric power generation facilities using biomass and natural gas as fuel sources.

Results: Despite a 30% reduction in emissions between 2007 and 2010, emissions of mercury from the coal-fired electricity sector were 1,452 kg, 28% higher than the targeted emissions cap of 1,130 kg in 2010. The total emissions cap target was met in 2011 when mercury emissions from plants in all provinces totalled 913 kg. Since then, annual mercury emissions have been well below the cap. Overall mercury emissions from coal-fired electricity generation decreased by approximately 72% between 2007 and 2017 (Table 3).

Although the total emission cap was first met in 2011, the capture rate of mercury emissions was only 56%, 4% below the targeted capture rate of 60%. In 2014, approximately 662 kg of mercury were emitted and there was a total of 1947 kg of mercury in the coal burned, meaning that the capture rate of mercury was 67% and the 60% capture rate target was surpassed.

[7] The capture rate is the ratio of mercury that is prevented from entering the environment relative to what enters the environment. Higher capture = less mercury entering the environment

Table 3. Mercury emissions from coal-fired electric power generation plants by province

Province (with coal-fired power plants)	2007 Mercury Emissions (kg)	2010 Mercury Emissions Caps (kg)	2010 Mercury Emissions (kg)	2011 Mercury Emissions (kg)	2014 Mercury Emissions (kg)	2017 Mercury Emissions (kg)
AB	829	590	643	216	236	143
MB	0	20	1	1	0	0
NB	95	25	31	18	15	12
NS	156	65[1] (110)	81	95	54	66
ON	304	Not set	95	32	0	0
SK[2]	688	430	600	551	357	363
TOTAL[3]	**2,072**	**1,130**	**1,452**	**913**	**662**	**584**

[1] The cap for 2010 was changed in Nova Scotia regulations from 65 kg to 110 kg, with the cap gradually declining to 35 kg/year in 2020.

[2] Although these are the actual emissions for these years, this cap was achieved with accumulated credits for early action.

[3] Totals may not add up due to rounding

Source: Air Pollutant Emissions Inventory (2019), reported under Source: Electric Power Generation (Utilities) Sector: Coal.

In a review of the Standard, the Air Management Committee of the Canadian Council of Ministers of the Environment indicated that provincial caps for the Standard should be maintained, and monitoring and biennial reporting of mercury emissions from coal-fired electric power generation plants should continue until 2020.

Conclusion: The risk management objectives of the Standard were surpassed, but the transition to cleaner electric power generation in Canada progressed more slowly than anticipated between 2007 and 2010. The Canada-wide Standard itself was only one of the drivers for reducing mercury emissions from coal-fired plants. In some cases, the closing of coal-fired electric power generation facilities, introduction of non-coal facilities, and/or increased emissions abatement for existing facilities occurred after 2010 and also contributed to the decreased emissions.

5.1.2 The Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations

The Regulations set a stringent performance standard for new coal-fired electricity generation units and those that have reached the end of their useful life. These regulations came into force on July 1, 2015 and are specific to greenhouse gases. However, because mercury is released during the combustion of coal, mercury will also be reduced when facilities close by the end of their economic lives, which is generally 50 years after commissioning.

In November 2016, the Government of Canada published a Notice of Intent to amend the Regulations in order to accelerate the phase-out of traditional coal-fired electricity by 2030 and replace it with cleaner sources. The Amendments were published in the *Canada Gazette, Part II* in December 2018 (Government of Canada, 2018).

Conclusion: Mercury emissions from coal-fired electricity generation units are expected to be reduced as a co-benefit by an estimated 1.4 tonnes. It is too early to assess the performance of this risk management instrument as most reductions are expected between 2020 and 2030.

5.2 Mercury pollution from products

Mercury has many useful properties, which have led to its use in a variety of different products traded globally. For example, it forms alloys with other metals, conducts electricity, and expands in response to changes in pressure and temperature. In 2008, an estimated 8,100 kg of mercury entered the Canadian marketplace in products (through manufacturing or import), with more than half (4,700 kg) contained in dental amalgam (Government of Canada, 2014). Mercury was also used in lamps, thermostats, switches and relays, batteries, thermometers, other measuring devices, and tire-balancing products. Since 2007, the Government of Canada has implemented several risk management instruments to address the use of mercury in products, as well as to manage the disposal of these products.

5.2.1 The Products Containing Mercury Regulations

The risk management objective for the Regulations is to protect human health and the environment by reducing releases of mercury from products used in Canada to the lowest level that is technically and economically feasible. The Regulations came into force in 2015 and prohibit the manufacture and import of products containing mercury or any of its compounds, with some exemptions for essential products with no technically or economically viable alternatives. The Regulations also include labelling, record-keeping, and reporting provisions and identify the maximum total quantities of mercury allowed to be contained in some exempted products. They additionally set phase-out dates for some exempted products.

The Regulatory Impact Analysis Statement indicated that the Regulations are expected to reduce the use of mercury in products by about 41,000 kg between 2015 and 2032. Releases of mercury from products to the environment during that period are estimated to decrease by 21,000 kg.

Results: In March 2017, industries submitted their first report for the year 2016. Fewer than 10 of the 123 reporting organizations manufactured products containing mercury in Canada. A preliminary analysis of the data collected indicates that in 2016, over 40 million units of permitted and exempted products were imported into Canada and over 25 million units were manufactured. These products together contain a total of approximately 1000 kg of mercury. Out of all exempted or permitted imported and manufactured products 54% were dental amalgams and 41% were lamps.

Conclusion: Additional data are needed to assess this instrument's performance and will be collected through reports from industry that are required every three years. Data from the first report will be used as a baseline against which to measure progress in meeting the risk management objective. Amendments to the *Products Containing Mercury Regulations* are underway to achieve further mercury reductions in some product categories and to align with international agreements.

5.2.2 Controlling the export of mercury

Canada's ratification of the Minamata Convention required comprehensive controls to be placed on the export of elemental mercury. As a result, in February 2017, the *Regulations Amending the Export of Substances on the Export Control List Regulations* were published in the *Canada Gazette, Part II* (Government of Canada, 2017c) and amendments were made to the *Export Control List (Schedule 3 of CEPA*). These amendments restrict the export of mixtures containing elemental mercury at a concentration of 95% or more (by weight), with certain exemptions in Canada[8]. These new controls help to reduce the global supply of elemental mercury, which can be used for artisanal small-scale gold mining in developing countries. This activity is the largest source of global anthropogenic mercury emissions.

Conclusion: As these regulatory requirements were recently introduced, there is not enough data at this time to report on their progress. Future evaluations will assess the effectiveness of these regulations by examining relevant import and export data.

5.3 Waste management

Products containing mercury enter the waste stream each year. Releases of mercury to the environment can also occur at any stage of a product's life cycle, including manufacturing, use, recycling, and disposal. Mercury can also enter surface water from wastewater treatment facilities or landfills that contain mercury-containing consumer products, including batteries, compact fluorescent light bulbs, and electrical switches.

Risk management action on products containing mercury is expected to reduce the accumulation of mercury in the waste stream and associated mercury emissions and releases. Providing consumers with more information on how to dispose of their mercury-containing products will also change consumer behaviour and in turn help further protect Canadians and their environment from mercury emissions.

[8] In Canada, hazardous waste or hazardous recyclable material containing mercury is regulated under the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*. These Regulations do not, however, control trade in elemental mercury, unless it is (or is contained in) hazardous waste or hazardous recyclable material.

5.3.1 Notice Requiring the Preparation and Implementation of Pollution Prevention Plans in Respect of Mercury Releases from Mercury Switches in End-Of-Life Vehicles Processed by Steel Mills

Before January 1, 2003, mercury switches (small devices for activating the lights in automobile hoods and trunks and some anti-lock braking systems) were used in some vehicles. Each switch contained less than one gram of mercury. The pollution prevention planning notice on mercury switches in end-of-life vehicles processed by steel mills was published in 2007 and targeted all 13 manufacturers of vehicles and 10 steel mills processing vehicles being scrapped or the steel scrap derived from these vehicles.

The vehicle manufacturers and steel mills subject to the notice were required to prepare pollution prevention plans for managing mercury switches from vehicles by July 2008 and to submit interim progress reports in 2009 and 2010 (Government of Canada, 2007). The risk management objective was to reduce releases of mercury to the environment through participation of vehicle manufacturers and steel mills in a mercury switch management program. The target of this program was to collect 90% of mercury switches in vehicles within the first four years of the program (2008-2011) based on forecasts made using a model in 2004.

Results: A total of 413,328 mercury switches[9] were collected and reported under the pollution prevention notice within the first four years (2008 to 2011) (Table 4). This notice on mercury switches led to a vehicle mercury switch recovery program in all Canadian provinces and territories. With a vehicle life of 10 to 15 years, new vehicles manufactured in 2002 would likely be on the road until 2013 to 2018, with most mercury switches expected to be collected by 2018. For this reason, the national program has now been completed. During the course of the 10 year program, nearly 650 kg of mercury was recovered. All of this mercury was recycled or disposed of in an environmentally sound manner.

However, 90% of switches were not collected within the first four years of the pollution prevention notice. This was because the 2004 forecasts for number of switches available for annual collection were too high and reflected inaccurate assumptions about vehicle scrappage and decay rates. In addition, data gaps existed for the number of switches per vehicle, vehicle mortality rates, process rates of recyclers, and the scrapping of vehicles (dismantling, shredding, flattening, etc.) (Environment and Climate Change Canada 2013).

[9] This total reflects the number of switches collected and reported under the National Vehicle Mercury Switch-Out Recovery Program (320,586 switches) as well as the Evraz Mercury Recovery Program (92,724 switches).

Table 4. Cumulative results of Mercury Switch-out Program

	2008	2009	2010	2011	2018
Number of switches	64,011	112,167	76,866	67,542	448,203
Cumulative total		176,178	253,044	320,586	768,789
Average g of mercury/switch	0.859	0.856	0.824	0.829	0.843
Approximate mercury recovered (kg)	55	96	63	56	378
Cumulative total (kg)		151	214	270	648

Conclusion: The risk management objective of reducing releases of mercury to the environment through participation of vehicle manufacturers and steel mills in a mercury switch management program in Canada was achieved. While all vehicle manufacturers and steel mills subject to the notice on mercury switches participated in the mercury switch management program, 90% of mercury switches were collected after the target date.

5.3.2 Notice Requiring the Preparation and Implementation of Pollution Prevention Plans in Respect of Mercury Releases from Dental Amalgam Waste

The pollution prevention planning notice on dental amalgam waste was published on May 8, 2010 in the *Canada Gazette, Part I* (Government of Canada, 2010b). It targeted dental facilities that had not implemented the best management practices set out in a memorandum of understanding between the Canadian Dental Association and Environment and Climate Change Canada (2002) that required these dental facilities to prepare and implement pollution prevention plans for mercury releases from dental amalgam waste. In 2009, it was estimated that between 6,300 to 8,100 of the existing 9,000 dental facilities were already using dental amalgam separators and implementing best management practices. The risk management objective of the notice was to implement plans to divert mercury waste and limit environmental releases from dental amalgam.

The notice on dental amalgam waste was intended to encourage a 95% national reduction of mercury releases to the environment from dental amalgam waste from a base year of 2000 (1,879 kg), a target that was originally established under the *Canada-wide Standard on*

Mercury for Dental Amalgam Waste. The 900 to 2,700 dental facilities that were subject to the pollution prevention notice were expected to prepare and implement a pollution prevention plan by August 2010.

Results: As of December 31, 2010, Environment and Climate Change Canada had received a total of 204 declarations that a pollution prevention plan was prepared under the notice and had been implemented. In response to the low participation rate, a survey of dental facilities across Canada was commissioned in 2012 with the goal to assess the awareness of the pollution prevention plan notice, the overall implementation of best management practices for dental amalgam waste and the effectiveness of the notice. The survey complemented data collected from two earlier national surveys conducted in 2003 and 2007. The data from all the surveys are summarized below (Table 5).

Table 5. National survey of dental facilities in 2003, 2007, and 2012

	Base year 2000	2003	2007	2012
Percentage[1] of dental facilities using ISO-certified dental amalgam separators[2] (%)	negligible	27	70	97[4]
Quantity of mercury being released to the environment from dental amalgam waste(kg)	1,879[3]	1,046	452	75

[1] Over 3,000 dentists were surveyed in each of 2003, 2007 and 2012. There were 984, 1,185, and 1,250 respondents, respectively.

[2] A high-efficiency amalgam separator that meets ISO 11143:1999 standards.

[3] These numbers were estimated with best available data at the time.

[4] Three percent of respondents were unsure if their separator was ISO-certified. As the ISO 11134 standard was developed at the same time as the best management practices (2002), it was important at the time to specify if the separator was ISO certified or not. Some years after, the major retailers of amalgam separators were only selling ISO-certified equipment.

By 2007, 70% of dentists across Canada were using International Organization for Standardization (ISO)-certified amalgam traps (corresponding to a 57% reduction in mercury reaching dental wastewaters compared to the year 2000). The 2012 survey revealed that the national reduction target of 95% was surpassed, with an estimated 75 kg being released to wastewater. The survey also indicated that 97% of the 1,250 facilities that responded had put in place best management practices and installed an amalgam separator to collect mercury from waste.

The 2012 survey also revealed that the use of dental amalgam in Canada had decreased by 43% since 2003; this trend was also observed elsewhere, including the European Union. In addition, removal of dental amalgam has increased by approximately 70% since 2000. This

reduction in the use of dental amalgam is likely due to preferences for other dental materials as well as increased awareness of dental amalgam's environmental effects.

Conclusion: The risk management objective for this instrument was achieved, meaning that there was a 95% national reduction in mercury releases to the environment from dental amalgam from a base year of 2000. While the notice on dental amalgam waste itself may have played a role in the implementation of best management practices for managing mercury from dental amalgam waste, increased environmental awareness of mercury waste management among dental facilities, efforts made by dental amalgam separator suppliers, and provincial and municipal initiatives also played a role.

5.3.3 Code of Practice for the Environmentally Sound Management of End-of-Life Lamps Containing Mercury

In February 2017, Environment and Climate Change Canada published *A Code of Practice for the Environmentally Sound Management of End-of-Life Lamps Containing Mercury* (the Code) (Government of Canada, 2017b). This voluntary Code provides best practices for the collection, storage, transport, processing, and disposal of lamps containing mercury, as well as guidance for northern and remote areas where access to proper disposal is limited. The Code is designed to encourage collectors, transporters, and recyclers to incorporate best practices into their end-of-life management of mercury-containing lamps to prevent releases of mercury to the environment.

In the future, the Code will be updated to take into account advances in technologies and practices and new developments under international agreements. While the Code itself does not contain a specific target, it will be promoted and its implementation will be measured as part of the *National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act*.

5.3.4 National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act

On 22 June 2017, the *National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act* received Royal Assent (Government of Canada, 2017a). The Act required the Minister of Environment and Climate Change Canada to develop a national strategy by June 2019 and to report to Parliament on its implementation every five years. The Minister tabled the final strategy in Parliament on July 17, 2019.

The vision of the strategy is to eliminate lamps as a source of mercury pollution in Canada. In order to do so, it identifies six priorities:

1) prohibit the manufacture and import of the most common types of lamps containing mercury
2) increase public awareness of mercury lamps, their diversion programs, and energy efficient mercury-free alternatives

3) increase participation in diversion programs by strengthening requirements and reducing barriers
4) improve government operations
5) increase accessibility and implementation of guidelines and best practices
6) improve performance measurement and reporting

A national strategy web page is available featuring a baseline report, information on lamps, and a map of lamp collection sites in Canada. The web page will be updated as new information, data, and communications products become available.

In collaboration with key stakeholders, including provinces and territories, the Government of Canada will study the potential for and effectiveness of regulatory measures, such as extended producer responsibility programs and landfill disposal bans, and release an interim report in 2022.

Conclusion: it is too early to measure the performance of this risk management instrument. The strategy's performance measurement framework describes the information the Government of Canada will collect and report on to assess the effectiveness of the strategy. In 2024, the Minister will present to Parliament the first report on the effectiveness of the strategy and their recommendations regarding the strategy.

5.4 Reducing exposure to mercury

The main source of exposure to mercury for most Canadians is eating fish and other seafood (Government of Canada, 2010a). However, the Government of Canada recognizes that both retail fish and country foods (foods caught for personal consumption through hunting or fishing) have significant nutritional benefits. Health Canada has set maximum levels for mercury in all retail fish. These levels are enforced by the Canadian Food Inspection Agency. The Canadian Food Inspection Agency regularly tests domestic and imported commercial fish and shellfish, both freshwater and marine, to enforce the mercury guidelines.

Health Canada also provides consumption advice for certain types of fish that contain elevated mercury levels, such as tuna, shark, swordfish, marlin, orange roughy and escolar. For example, it is recommended that Canadians limit consumption of large, predatory species of fish such as shark, swordfish, fresh or frozen tuna and marlin to no more than one meal (150 grams) per week. Children, pregnant women and women of childbearing age are advised to eat no more than one meal per month of these kinds of fish. Most types of canned tuna are exempted from this advice, because they are regularly tested and found to be below the Health Canada guideline of 0.5 parts per million of mercury. Canned albacore or canned white tuna can have higher mercury levels compared to other canned tuna so consumption advice is also provided for this fish. Advisories on the consumption of country foods due to concerns about mercury are made by the appropriate authorities (e.g. local public health authorities in the North, or provinces).

6 Communicating with Canadians

The Government of Canada communicates with Canadians on mercury in the Canadian environment, through its website (https://www.canada.ca/en/environment-climate-change/services/pollutants/mercury-environment.html). This site provides information on environmental and health concerns related to mercury, products containing mercury, regulatory measures that the government has taken, and steps which can be taken to reduce mercury exposure.

As well, Health Canada maintains a website (https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/environmental-contaminants/mercury/mercury-fish.html) that provides fish consumption advice. Health Canada also advises Canadians to be aware of provincial and territorial advisories related to fish caught in local waters.

Additional information on mercury in Canada is available from the Canadian Council of Ministers of the Environment (https://www.ccme.ca/en/resources/air/mercury.html).

7 Strengthening International Agreements

Given that the majority of anthropogenic mercury deposited in Canada comes from foreign sources, the Government must work collaboratively with other countries to reduce global mercury emissions and to minimize the cross-border movement of mercury into Canada. The following section describes two international agreements that address mercury releases, to which Canada is a Party. Information on additional international agreements can be found in Annex I.

7.1 Great Lakes Water Quality Agreement

Canada and the United States first signed the Great Lakes Water Quality Agreement in 1972. It was amended in 1983, 1987, and most recently 2012 to enhance water quality programs that ensure the Great Lakes' "chemical, physical, and biological integrity". Annex 3 of the 2012 Agreement seeks to reduce anthropogenic releases into the air, water, land, sediment, and biota of the Great Lakes basin ecosystem of chemicals, including mercury, that are of concern to both Canada and the United States. A commitment under Annex 3 was made by the two Parties to designate Chemicals of Mutual Concern in consultation with stakeholders and the public, and prepare binational strategies to tackle risk management concerns in the Great Lakes by each Party. Mercury was designated as a Chemical of Mutual Concern in 2016.

Emissions and deposition of mercury into the atmosphere were identified in a 2010 report as the Great Lakes region's largest source of mercury, with the greatest proportion of this coming from coal-fired electric power generation facilities (Great Lakes Regional Collaboration, 2010).

The Governments of Canada and the United States have prepared a draft Binational Strategy for mercury to focus their efforts, including by cooperating and consulting with many partners

and the public, to reduce mercury in the Great Lakes region (Environment and Climate Change Canada and the US Environmental Protection Agency, 2017). This strategy identifies many issues that must be addressed, including the impact of climate change on the mercury cycle, the need to enhance emissions data, and the need for comprehensive evaluation of existing regulatory programs to reduce mercury impacts on the Great Lakes.

7.2 Minamata Convention on Mercury

The Minamata Convention on Mercury is an international treaty to protect human health and the environment from anthropogenic emissions and releases of mercury by taking a life-cycle approach to mercury management. The treaty entered into force on August 16, 2017. Parties to the Convention commit to:

- control, and where feasible, reduce mercury air emissions from: coal-fired power plants, coal-fired industrial boilers, certain non-ferrous metals smelting and roasting operations (lead, zinc, copper and industrial gold), waste incineration, and cement clinker production, including use of best available techniques and best environmental practices for new and substantially modified sources
- phase out mercury in certain products (e.g. batteries, switches, lights, cosmetics, pesticides, and measuring devices) and phase down the use of mercury in dental amalgam
- phase out or reduce the use of mercury in manufacturing processes such as chlor-alkali production, vinyl chloride monomer production, and acetaldehyde production
- address the supply and trade of mercury, its interim storage, and its final disposal, and develop strategies for contaminated sites
- report on measures taken to implement certain provisions

Additionally, Parties will evaluate the effectiveness of the Minamata Convention. This evaluation will measure how well the treaty is working to meet its objective to protect human health and the environment from anthropogenic mercury emissions and releases. Canadian environmental monitoring and biomonitoring data will play a key role in evaluating the effectiveness of the treaty. The first evaluation of the effectiveness of the Minamata Convention is expected to begin no later than 2023. As such, the Government of Canada will continue to provide data via the Northern Contaminants Program, the Canadian Health Measures Survey, the work under the Arctic Monitoring and Assessment Programme, and other environmental monitoring programs.

The impacts of the Minamata Convention may take decades to be observed in the Canadian environment despite the wide and growing adherence to the treaty. This is mostly due to the amount of time and complexity of the mercury cycling that is necessary for the reductions of global emissions to result in less mercury being deposited in Canadian ecosystems. Furthermore, some treaty obligations only become mandatory many years after the Convention enters into force, which could further delay global emission reductions. While the treaty requires stringent controls on mercury emissions from specific industrial sectors, it is expected that the growth of coal-fired power plants in developing countries may cause global mercury emissions to increase in the near term.

Results: The Minamata Convention has 128 signatory countries and has now been ratified by over 115 parties, including Canada. Canada participated in the first three Conferences of the Parties, was a member on expert groups to develop guidance on atmospheric emission reductions and to work on effectiveness evaluation; and has helped other governments to implement treaty requirements by providing technical assistance.

Canada will continue to take a leadership role under the Minamata Convention, in particular, as it relates to atmospheric emission reductions and assessing the effectiveness of the treaty.

8 Conclusions

This evaluation of the Government of Canada's risk management of mercury has allowed the consolidation of the results of various actions. In addition, a process has been established to track the progress made in achieving the Risk Management Strategy objective. Key conclusions of this evaluation are as follows:

1. Progress is being made in minimizing, and where feasible, eliminating anthropogenic emissions and releases of mercury to the environment. Given continuing adverse environmental effects, efforts should continue to be made to lower mercury levels in the environment

- domestic mercury emissions to air and releases to water continued to decrease since 2007 as Canadian industries and businesses implemented legal requirements and voluntary best practices
- environmental monitoring data have shown some decreases in levels of mercury in air and some animal populations. However, increasing trends in mercury levels have been noted in air at some locations in the Arctic and western Canada and in some Arctic and Great Lakes animal populations. Mercury emissions from sources in Asia, changing food webs, and changes in weather conditions due to climate change may play a role in these increasing trends
- the levels of mercury found in the environment are the result of both natural and human factors. Climate change, changes in land use, interactions with other chemical substances, the complex behaviour of mercury in the environment, and other factors, often make it difficult to see a direct connection between the actions taken to manage the risks posed by mercury and the actual levels of mercury in the environment

2. There has been progress in minimizing human exposure to mercury. Efforts should continue to decrease mercury exposure as much as possible in order to protect human health

- levels of mercury in the general population are low and stable
- levels in southern First Nations populations sampled under the First Nations Biomonitoring Initiative were not significantly different than those of the general Canadian population, although there was much more individual variability within these populations. As well, six of the thirteen First Nations communities in this study showed statistically higher mercury levels than the general Canadian population

- Northern Inuit populations have higher levels of mercury in their blood but their levels have been decreasing over time. These decreases may be due to a reduction in consumption of certain country foods. Given the nutritional, cultural, and spiritual benefits of traditional diets, efforts need to continue to decrease mercury levels in these food webs, as much as possible, to protect human health
- additional actions have been taken by the Government of Canada to manage other potential exposure sources of mercury, including paints, toys, cosmetics, natural health products, drinking water and pesticides

3. Domestic controls put in place have contributed to the Risk Management Strategy's environmental objective. Newer controls may not yet have had their full effect given the short timeframe examined

- objectives were achieved for the Canada-wide Standard for coal-fired electric power generation plants and for the Pollution Prevention Notices for mercury switches and dental amalgam waste
- the *Products Containing Mercury Regulations,* the *Reduction of Carbon Dioxide from Coal-Fired Generation of Electricity Regulations,* and other controls proposed in the Risk Management Strategy are now in force and their performance will be evaluated in the future
- risk management efforts in mercury waste management (e.g. the *Code of Practice for the Environmentally Sound Management of End-of-life Lamps Containing Mercury*) are ongoing
- new controls for mercury have been introduced, including the *Export of Substances on the Export Control List Regulations* and the *National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury Act*

4. Canada has supported the international community in creating and implementing a legally binding mercury agreement, the Minamata Convention on Mercury. Continued engagement and leadership internationally are essential to support this agreement's ratification, implementation, and objectives

- mercury is a global pollutant, its cycling is complex, and its entry into the ecosystem is partly influenced by foreign-sourced mercury air emissions
- Canadian models have estimated that 97% of mercury deposited in Canada as a result of human activities originates outside the country
- significant global emission reductions are needed under the Minamata Convention to reduce the risks from mercury to Canadians

5. In light of the results of this performance evaluation, current and planned mercury risk management efforts should continue in order to manage risks from mercury. Performance measurement and monitoring activities play an important role in Canada's risk management efforts and should also continue

- while the Risk Management Strategy has proven useful in managing mercury from industrial emissions and releases, the risk is shifting to other sources, such as the

disposal of products containing mercury. Additional efforts are being made to responsibly manage waste from these products

- performance measurement is a useful tool for compiling and analyzing information on the collective efforts to manage the risks of mercury and communicating this information to the public
- data obtained through Canada's various human biomonitoring programs are essential to determine trends in Canadians' exposure to mercury
- data obtained through Canada's monitoring and surveillance activities are necessary to determine spatial and temporal trends of mercury in key environmental media
- environmental monitoring should continue as it provides information that is critical to performance measurement. Ongoing monitoring is important since changes in emissions and ecosystem shifts are causing changes in the trends of mercury levels in the environment as well. In particular, Environment and Climate Change Canada will continue hosting an informal data repository for long-term mercury air measurements called the Atmospheric Mercury Monitoring Network

9 Moving Forward

Continued sustained action on mercury is needed to protect the health of Canadians and their environment from the risks of mercury by minimizing, and where feasible, eliminating mercury emissions and releases from human activities. Based on the results in this report, the Government of Canada will continue its efforts in four main areas: monitoring, managing risks associated with mercury, communicating with the public and engaging internationally.

Data from biomonitoring and environmental monitoring initiatives provide important information for evaluating risk management performance for mercury. Therefore, the Government of Canada will continue human biomonitoring, both nationally and for vulnerable populations, and should seek complimentary dietary surveys. In particular, mercury will be monitored in the general population through the Canadian Health Measures Survey and, in the North, through the Northern Contaminants Program. The Government of Canada will also continue to participate in relevant international fora such as the Arctic Monitoring and Assessment Programme.

The Government of Canada will also continue monitoring mercury levels in the environment. This will allow for an assessment of the risk to animals and humans from mercury, will help to determine where mercury is a problem in Canada and whether levels are decreasing or increasing over time, and help to evaluate the contribution of emissions of mercury from other countries to total mercury emissions in Canada. Additionally, environmental monitoring will help improve mapping and modelling of how mercury moves through the environment in Canada.

Domestic efforts to manage the risks associated with mercury waste are ongoing. These include making amendments to the *Products Containing Mercury Regulations*, and putting in place a *National Strategy for the Safe and Environmentally Sound Disposal of Lamps Containing Mercury*. The Government of Canada will also continue to measure the

performance of these and other key risk management actions in protecting Canadians and their environment.

The Government of Canada plays a role in informing Canadians about health and environmental risks from mercury. This allows Canadians to make educated choices related to mercury. Health Canada will continue to gather data on Canadians' exposure to mercury, including through gathering information on levels in fish and will periodically re-evaluate the potential risk for the health of Canadians and subsequently adjust its risk management approach if required. The risks of mercury from fish will be communicated by providing consumption advice for retail fish and through ongoing work under the Northern Contaminants Program. This includes communicating the risks of mercury to pregnant women in the North and evaluating the effectiveness of this messaging.

Finally, the Government of Canada will continue to support international action on mercury, through continued engagement and leadership on the Minamata Convention. This includes actively participating in negotiations and contributing to the work of the Convention during the period between meetings. It also includes providing the international community with relevant Canadian environmental monitoring data and human biomonitoring results that will assist in the evaluation of the effectiveness of the Minamata Convention.

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Annex I – Additional Risk Management Actions Implemented by the Government of Canada

Risk management actions taken by Environment and Climate Change Canada

- **Chlor-Alkali Mercury Liquid Effluent Regulations (1972; repealed 2018)** under the *Fisheries Act* and the ***Chlor-Alkali Mercury Release Regulations*** **(1978; repealed 2019)** under the *Canadian Environmental Protection Act*: Limited the amount of mercury to be deposited into water and controlled mercury emissions to ambient air from chlor-alkali facilities using the mercury cell process. The last mercury cell plant in Canada closed in July 2008. To prevent any future operation of chlor-alkali mercury cell facilities in Canada and to help support the federal Government in complying with its international obligations under the Minamata Convention, both of these regulations were recently repealed.
- **National Guidelines for the Use of Hazardous and Non-hazardous Wastes as Supplementary Fuels in Cement Kilns (1996)**: These guidelines provided operating and performance standards for cement kilns using wastes as supplementary fuels. They provided guidance on the criteria for the selection of wastes; handling and storage of wastes; emission limits; testing, monitoring, and reporting requirements; and solid residue management. The guidelines set a limit on mercury emissions in terms of a limit of 0.15mg/Rm^3 for the sum of mercury, cadmium, and thallium. These guidelines have been withdrawn from active circulation but remain available for reference and historical purposes.
- **National Emission Guideline for Cement Kilns (1998)**: This guideline provides a consistent national basis for restricting emissions of nitrogen oxides and other pollutants, while encouraging greater energy efficiency in the industry. The Guideline indirectly targets mercury by addressing fine particulate dust (to which mercury can be bound).
- **Canadian Environmental Quality Guidelines (1999 to 2003)**: These are national recommended goals for the quality of surface water for the protection of aquatic life (2003), sediment aquatic life (1997), and terrestrial (soil, 1999) ecosystems. These levels should result in negligible risk to biota, their functions, or any interactions that are integral to sustaining the health of ecosystems and the designated resource uses they support.
- **Canada-wide Standards for Mercury Emissions (Base Metal Smelters and Refiners) (2000)**: These standards address both existing and new facilities in the waste incineration and base metals smelting sectors. The waste incineration sector includes hazardous waste, sewage sludge, municipal waste, and medical waste incinerators. For base metals smelters, the Standards set a limit of mercury released to air per tonne of metal produced.
- **Canada-wide Standards for Mercury-containing Lamps (2001)**: The intent of this standard was to reduce releases of mercury to the environment from mercury-containing lamps. The target was a 70% reduction by 2005 and an 80% reduction by 2010 in the average content of mercury in all mercury-containing lamps sold in Canada, from a 1990 baseline.

- **Canada-wide Standards on Mercury for Dental Amalgam Waste (2001)**: This standard led to the signing of a *Memorandum of Understanding by Environment and Climate Change Canada and the Canadian Dental Association*, committing each to actions towards the voluntary implementation of this standard. The objective was to apply "best management practices" to achieve a 95% national reduction in mercury releases from dental amalgam waste discharges to the environment by 2005, from a base year of 2000.
- **Disposal at Sea Regulations (2001; last amended 2014)**: Under the *Canadian Environmental Protection Act* all disposal at sea is prohibited without a permit. Permits can only be considered for a small list of low risk wastes or other matter and then only after the material intended for disposal has been assessed. The small list includes dredged material from clearing navigation channels. Since this may contain mercury and other contaminants, the permit application for this material must provide information about contaminants. The *Disposal at Sea Regulations* specify that mercury levels higher than the "Lower action level" of 0.75 milligrams per kilogram dry weight are subject to biological toxicity testing before their suitability for disposal at sea can be determined. Toxicity test failure would generally result in a permit being denied.
- **Environmental Codes of Practice for Integrated Steel Mills and for Non-integrated Steel Mills (2001)**: These recommend good environmental protection practices for preventing and controlling atmospheric emissions and wastewater effluents and wastes from iron and steelmaking operations.
- **Metal and Diamond Mining Effluent Regulations (2018; previously Metal and Diamond Mining Effluent Regulations (2002)**: These regulations under the *Fisheries Act* set effluent quality standards for arsenic, copper, lead, nickel, zinc, suspended solids, radium-226, un-ionized ammonia, non-acute toxicity, and hydrogen potential (pH) for discharges from mines extracting precious metals, base metals, uranium, iron ore, and diamonds. While these regulations do not include effluent quality standards for mercury, they do require mines to monitor and report mercury concentrations in effluent and in water bodies into which effluent is discharged.
- **Environmental Emergency Regulations (2003; last amended 2019)**: These regulations require any person who owns or has the charge, management, or control of specified toxic or hazardous substances located at a facility at or above the specified quantity or concentration thresholds to provide certain information about the substances and facility to Environment and Climate Change Canada. The facility is also required to have environmental emergency plans in place when certain conditions are met.
- **Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (2005; last amended 2016)**: These regulations limit the cross-border movement of liquid elemental mercury to 50 millilitres per shipment. Mercury and mercury compounds are also covered under requirements for substances with specific physical characteristics, such as corrosiveness or leachate toxicity; and several mercury compounds are explicitly covered in schedules when those substances are being disposed of or recycled.

- **Notice requiring the preparation and implementation of pollution prevention plans in respect of specified toxic substances released from base metals smelters and refineries and zinc plants (2006)**: This notice required base metals smelters and refineries and zinc plants to prepare and implement pollution prevention plans for specified toxic substances that they release. The notice specified a reduction target of 373 kg by 2008 in annual releases of mercury for the largest emitter of mercury in Canada, the Hudson Bay Mining & Smelting Co. in Flin Flon, Manitoba. The 2008 target was met when the facility closed its copper smelter in 2010.
- **Environmental Code of Practice for Base Metals Smelters and Refineries (2006)**: This code recommends environmental protection practices to prevent and control emissions into the air and wastewater effluents and wastes from base metals smelting and refining operations. It includes mercury emission guidelines for existing and new facilities.
- **Environmental Code of Practice for Metal Mines (2009**): This code describes the operations of this industry and the environmental concerns it raises. The Code applies to the complete life cycle of mining, from exploration to mine closure, and recommends environmental management practices to reduce environmental concerns. The practices that this Code recommends include the development and implementation of environmental management tools, the management of wastewater and mining wastes, and the prevention and control of environmental releases to air, water, and land.
- **Environmental Code of Practice for the Environmentally Sound Management of End-of-Life Lamps Containing Mercury (2017)**: The Code of Practice is a voluntary tool that provides best practices for the environmentally sound management of mercury-containing lamps at end-of-life. The Code encourages collectors, transporters, and recyclers to incorporate best practices into their end-of-life management of mercury-containing lamps to prevent releases of mercury to the environment. The document includes options for managing lamps in remote and northern areas.

Risk management actions taken by Health Canada

- **Surface Coating Materials Regulations (2016)**: These regulations introduced a limit of 10 mg/kg total mercury in all consumer paints and similar surface coating materials manufactured, imported, advertised, or sold in Canada.
- **Toys Regulations (2011; amended 2016)**: These regulations prohibit the manufacture, import, advertising, or sale in Canada of toys intended for children under 14 that have a surface coating material containing any mercury compound.

  The same prohibition of mercury compounds in coatings applied to products appears in:

  - ***Carriages and Strollers Regulations* (2016),** s. 2(1);
  - ***Cribs, Cradles and Bassinets Regulations* (2016),** s. 3;
  - ***Expansion Gates and Expandable Enclosures Regulations* (2016),** s. 2;
  - ***Playpens Regulations* (2019),** s. 3.

- **Cosmetic Ingredient Hotlist (2018)**: This list of substances restricted or prohibited for use in cosmetics includes mercury and its compounds as prohibited substances.
- **Food and Drug Regulations (last amended 2019)**: These regulations include a prohibition on the use of mercury or any of its salts or derivatives except for drugs used in the eyes or the area of the eye, in the nose or in the ears and other drugs for injection that are packaged in multi-dose containers in which the mercury or the salt or the derivative of it is the only preservative that can satisfactorily maintain the drug's sterility or stability.
- **Pest Control Products Act (2002; last amended 2019)**: Mercury-based pesticides are no longer registered in Canada as of 1998.
- **Quality of Natural Health Products Guide**: This guide sets a tolerance limit for total mercury in finished natural health products to comply with the established tolerance limit for mercury.
- **Updating the Existing Risk Management Strategy for Mercury in Retail Fish (2007)**: This document sets the maximum level of mercury in retail fish and provides consumer consumption advice.
- **Blood and Hair Guidance Values (1970s; revised 1998):** The first blood and hair guidance for the general adult population in Canada deemed blood levels below 20 µg/L (or 6 mg/kg in hair) to be "acceptable", levels above 20 but below 100 to be "at increasing risk", and levels greater than 100 µg/L in blood (or 30 mg/kg in hair) to be "at risk". No specific threshold values were proposed for the developing foetus (though considered a sensitive subgroup). Later, the heightened risk to the developing foetus of methylmercury toxicity led to the development of a provisional Tolerable Daily Intake of 0.2 µg/kg bw/day for pregnant women, women of reproductive age, and infants. This corresponded to a blood guidance value of 8 µg/L for women of childbearing age, pregnant women, and children 18 years and under.
- **Drinking Water Guidelines:** The Federal-Provincial-Territorial Committee on Drinking Water sets the maximum acceptable concentrations of substances in drinking water to protect the health of all Canadians, including vulnerable subgroups such as children and the elderly. In 1986, the drinking water guideline for mercury was set at 0.001 milligrams per litre (mg/L) (0.001 ppm). Levels of mercury found in drinking water are generally well below the guideline level. All provinces and territories use the Guidelines for Canadian Drinking Water Quality as the basis for establishing their own requirements for drinking water quality.

International risk management actions

Other international initiatives, identified in the Risk Management Strategy, and listed below are expected to have no or minimal contribution to mercury levels during the current performance assessment period (e.g., they are completed) and are therefore not included in this performance measurement for mercury.

- **Basel Convention on the Control of Transboundary movements of Hazardous Wastes and their Disposal (1992):** Canada is a Party to this Convention which has the overall goal to protect human health and the environment against adverse effects from the generation, transboundary movements and management of hazardous wastes and other wastes. Work under the Basel Convention includes the development of *Technical Guidelines for the Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Mercury*.

- **Commission for Environmental Cooperation's North American Regional Action Plan on Mercury (Phase I 1998, Phase II 2000)** The purpose is to provide the governments of Canada, Mexico and the United States with a path forward in their joint and differentiated efforts to reduce the exposure of North American ecosystems, fish and wildlife, and especially humans, to mercury through the prevention and reduction of anthropogenic releases of mercury to the North American environment.

- **Protocol on Heavy Metals (1998)**: As part of the United Nations Economic Commission for Europe's *Convention on Long-range Transboundary Air Pollution* this Protocol requires Parties to reduce their emissions of lead, cadmium and mercury below 1990 levels[10].

- **Global Mercury Partnership (2005):** under the United Nations Environment Programme, the overall goal is to protect human health and the global environment from the release of mercury and its compounds by minimizing and, where feasible, ultimately eliminating global, anthropogenic mercury releases to air, water and land. The Partnership works closely with stakeholders to assist in the timely ratification and effective implementation of the Minamata Convention on Mercury.

[10] Note that by 2008, Canada had reduced its emissions of lead, cadmium and mercury by more than 50% from its reference year (1990). For this reason, Canada is exempted from having to apply the emission limit values for new and existing stationary sources and best available techniques for existing stationary sources.