CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

ANNUAL REPORT TO PARLIAMENT FOR APRIL 2018 TO MARCH 2019

Environment and Climate Change Canada
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1. INTRODUCTION

This annual report provides an overview of the activities conducted and results achieved under the *Canadian Environmental Protection Act, 1999* (CEPA) from April 1, 2018, to March 31, 2019. It responds to the statutory requirement in Section 342 of the Act to provide annual reports to Parliament on the administration and enforcement of the Act.

CEPA provides authority for the Government of Canada to take action on a wide range of environmental and human health risks – from chemicals to pollution to wastes. For the most part, it functions as an enabling statute, providing a suite of instruments and measures for identifying, assessing and addressing risks.

The general steps followed to address each risk can be organized into a management cycle (see Figure 1): information is collected to understand risks and inform decisions; risks are assessed to determine if action is required; risk management instruments are ut in place to reduce or eliminate risks to the environment and human health; these instruments may require compliance promotion and enforcement; and information is once again collected to monitor progress and determine if additional action is required. At each stage in the cycle, stakeholders are engaged, the public has the opportunity to be involved, the government works closely with provincial, territorial and Indigenous counterparts, and information is reported to the public.

Figure 1. The CEPA management cycle

This report provides information on all stages of the management cycle. Section 2 – "Addressing key risks of toxic substances" covers information gathering, monitoring, risk assessment, and risk management for toxics, air pollution and greenhouse gases, water quality, and waste. Section 3 – "Reporting programs and emission inventories" covers information on releases of pollutants and greenhouse gases. Section 4 – "Administration and public participation" covers stakeholder engagement and inter-jurisdictional relationships. The report also includes Section 5 – "Compliance promotion and enforcement" and Section 6 – "Report of research".

This report includes the following mandatory information:

- Section 6 (all subsections) provides examples of the types of research initiatives and their key contributions in the reporting period.
- Section 4.1 describes the activities of the National Advisory Committee. There were no other committees established under paragraph 7(1) (a) of CEPA during the reporting period.
- Section 4.1 also describes the activities under federal-provincial agreements.
- There were no activities under the international air pollution provisions (Division 6 of Part 7) of CEPA during the reporting period.
- There were no activities under the international water pollution provisions (Division 7 of Part 7) of CEPA during the reporting period.

The online CEPA Registry is a comprehensive source of information about activities taking place under the Act, including proposed and existing policies, guidelines, codes of practice, government notices and orders, agreements, permits, and regulations.

1.1 REVIEW OF THE ACT

In 2017, the House of Commons Standing Committee on Environment and Sustainable Development completed its parliamentary review of CEPA and tabled a report, entitled "*Healthy Environment*, *Healthy Canadians, Healthy Economy: Strengthening the Canadian Environmental Protection Act, 1999*" to the House of Commons. In its October 2017 response to the Committee, the government committed to return with a follow-up report by June 2018 on actions taken and to be taken in response to the Committee's recommendations.

On June 29, 2018, the government submitted a follow-up report to the Committee, outlining the government's commitments to continue to strengthen protection of the environment and health of Canadians through policy and program improvements, future law reform, and continued engagement on key issues. This included a commitment to continue working with stakeholders through the Chemicals Management Plan (CMP) Post-2020 process to seek further input on the important chemicals management issues highlighted by the Committee.

2. ADDRESSING KEY RISKS

2.1 CHEMICALS

Parts 4, 5 and 6 of CEPA include specific provisions for data collection, assessment and management of toxic substances. Substances include both chemicals and living organisms (specific information on living organisms begins in section 2.2). For chemicals, the Minister of the Environment and the Minister of Health were required by 2006 to sort through, or "categorize", the substances on the original Domestic Substances List (DSL), an inventory of approximately 23,000 existing substances manufactured in, imported into or used in Canada in the mid 80s. The categorization process identified the need for a more detailed assessment of approximately 4,300 substances that were suspected to be inherently toxic to humans or to the environment, and are persistent (take a very long time to break down) or bioaccumulative (collect in living organisms and end up in the food chain), or present the greatest potential for exposure to Canadians.

THE CHEMICALS MANAGEMENT PLAN UPDATE

The Chemicals Management Plan (CMP) is a program developed to protect Canadians and their environment from exposure to toxic substances. At its core is a commitment to assess by 2020 the approximately 4,300 substances of potential concern that were already in commerce in Canada. Under the CMP, the government also conducts pre-market assessments of health and environmental effects of approximately 500 substances that are new to Canada each year.

Since the launch of the CMP in 2002, the Government of Canada has:

- **assessed 3,639 of the 4,363 existing substances identified as priorities for attention by 2020-2021**
- **found 459 existing chemicals to be harmful to the environment and human health**
- **implemented over 90 risk management actions for existing chemicals**
- **received approximately 5,909 notifications for new substances prior to their introduction into the Canadian market, which were assessed and over 291 risk management actions were taken to manage potential risks to Canadians and their environment**

2.1.1 Monitoring

Monitoring and surveillance activities are essential to identify and track levels and trends of chemicals in the environment and human exposure to those chemicals. Monitoring activities also support Canada's contribution to international efforts, such as the multilateral cooperation under the Arctic Council's Arctic Monitoring and Assessment Programme and the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution, and helps Canada fulfill its obligations under the United Nations Environment Programme's Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury.

A broad range of monitoring activities for chemicals was conducted to support a number of domestic programs including:

- the Chemicals Management Plan
- the Northern Contaminants Program
- the Freshwater Quality Monitoring Program
- the Great Lakes Water Quality Agreement
- the Great Lakes Herring Gull Contaminants Monitoring Program
- the St. Lawrence Action Plan

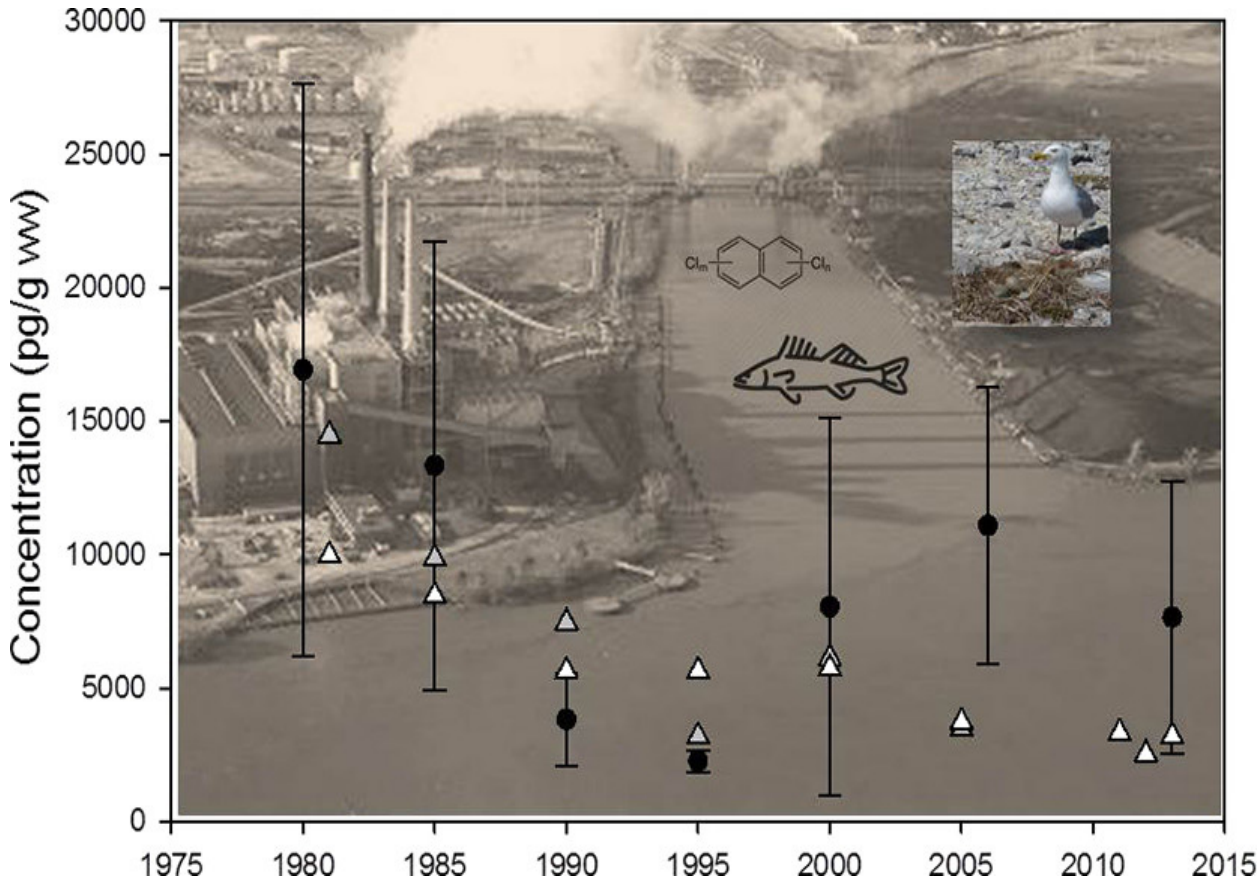
The CMP Environmental Monitoring and Surveillance Program involves the collection of data on the concentration of chemical substances in various environmental compartments at locations across Canada. Environmental compartments include surface water, sediment, air, aquatic biota and wildlife. Wastewater system influent, effluent and biosolids are also monitored at select locations representing a range of input and treatment system types. These monitoring and surveillance activities provide data to inform the assessment and management of chemical substances in the environment.

Priority substances monitored in 2018-2019 as part of the CMP Environmental Monitoring and Surveillance Program

For example, a retrospective analysis of the concentration of polychlorinated naphthalenes in gulls, fish and sediment of the lower Great Lakes revealed a consistent decrease in biota from 1980 (when its use was banned) until 1995. There was an unexpected spike in concentrations in biota in Detroit River and western Lake Erie in 1995 that persisted until 2005, after which it resumed a declining trend. This spike in biota was associated with sediment remediation activities involving dredging in the Detroit River at that time[1] (see Figure 2).

[1] McGoldrick DJ, Pelletier M, de Solla SR, Marvin CH, Martin PA, 2018. Legacy of legacies: Chlorinated naphthalenes in Lake Trout, Walleye, Herring Gull eggs and sediments from the Laurentian Great Lakes indicate possible resuspension during contaminated sediment remediation. Science of the Total Environment, 634(2018), pp 1424-1434. DOI: 10.1016/j.scitotenv.2018.04.077

Figure 2. Concentrations of polychlorinated naphthalene's in walleye (Western Basin, ●), and herring gull eggs (Fighting Island, ▲); Middle Island, ▲) in Lake Erie/Detroit River from 1979 to 2013



ECCC also monitors similar suites of bioaccumulative chemicals in the eggs of a wildlife sentinel species as part of the Great Lakes Herring Gull Contaminants Monitoring Program, where eggs have been collected annually for 45 years.

ECCC monitors hazardous airborne chemicals through the Great Lakes Monitoring Program, the Global Atmospheric Passive Sampling network (GAPS), and the atmospheric component of the Northern Contaminants Program (NCP). Air and precipitation monitoring in the Great Lakes Basin measures persistent organic pollutants (POPs), other priority chemicals and trace metals to determine the atmospheric loadings of these substances to the Great Lakes. GAPS uses cost-effective and simple passive air samplers designed by ECCC scientists to collect data. The atmospheric component of NCP conducts long-term monitoring of POPs and other priority chemicals in the Canadian Arctic to evaluate trends and to assess the influence of long-range atmospheric transport.

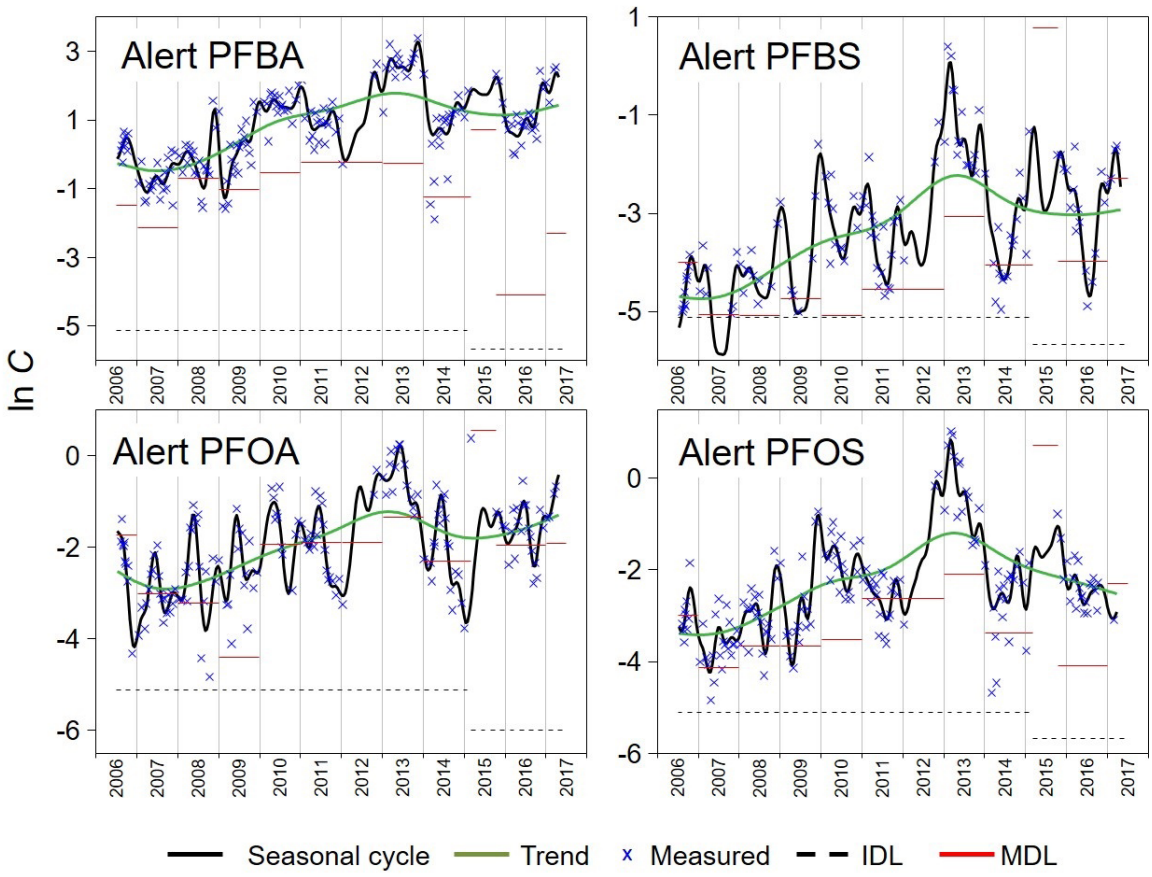
PERFLUOROOCTANE SULFONATE (PFOS) STARTED TO DECLINE IN THE ARCTIC AIR

ECCC has been monitoring organic pollutants in the arctic atmosphere since the 1990s in support of the Northern Contaminants Program (NCP) to determine the effectiveness of source reduction measures and factors influencing air concentrations due to long-range transport of pollutants. Per- and polyfluoroalkyl substances (PFASs) are water and oil-repellents that have been applied in a wide variety of consumer and industrial products. They are commonly found in the environment, including in remote regions, such as the Arctic.

Perfluorobutanoic acid (PFBA), a short-chain PFAS that contains 4 carbon atoms, was found in 100% of the samples. Its concentrations were relatively higher than other PFASs. Furthermore, it exhibited an increasing trend over the studied period, suggesting a shift from long to short chain fluorochemical production. Continual measurement of these substances is necessary to ensure regulatory efforts are working. There may be a lag time between regulation control and observed air concentration decline in arctic air.

PFASs that contain eight carbon atoms, namely perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) are of concern due to their hazardous health effects, and their usages are regulated by domestic and international chemical management strategies. Research by ECCC scientists shows that PFOS in air at Alert, Nunavut has started to decline and PFOA concentration has stopped increasing in arctic air in 2013 (Figure 3).

Figure 3. Time trends of PFBA, PFBS, PFOA and PFOS in air in Alert from 2006 to 2017. IDL - indicated instrumental detection limit; MDL - indicated method detection limit.



Health Canada (HC) continued analysis and publication of biomonitoring and research results from the Maternal-Infant Research on Environmental Chemicals (MIREC) Research Platform. In 2018-2019, 19 MIREC papers were published. This included studies of environmental exposures and outcomes in infants (birth weight, obesity, behavioral and cognitive outcomes, hearing function) and pregnant women (gestational diabetes). Other research included the importance of maternal diet on child outcomes and the utility of using specific measurements as indicators of health outcomes. Notably, it was found that non-smoking women living in an apartment had 1.7 times higher odds of detectable plasma cotinine, a marker of exposure to smoking, than those living in a single family home after adjusting for other variables.

In 2018-2019, participant recruitment began for the latest MIREC Research Platform study, MIREC-ENDO (Pubertal Timing, Endocrine and Metabolic Function). MIREC-ENDO studies the effects of prenatal exposure to environmental chemicals on puberty and metabolic function in the child, as well as maternal health. As a result, the number of biological samples in the MIREC Biobank continues to grow. Researchers from outside the MIREC Platform continue to access the data and biospecimens in the biobank, and 6 of the 19 papers published this year were the result of Biobank research projects.

HC's human biomonitoring efforts continued in 2018-2019 with the Canadian Health Measures Survey (CHMS), measuring environmental chemical exposures in blood and urine of a nationally representative sample of Canadians aged 3 to 79. During this period, laboratory analyses of 99 environmental chemicals in blood and/or urine samples collected as part of CHMS cycle 5 (2016-2017) were carried out and the *Fifth Report on Human Biomonitoring of Environmental Chemicals in Canada* was drafted for publication in November 2019. In addition, sample collection for cycle 6 is ongoing and is scheduled for completion in December 2019. The selection and prioritization of chemicals to be included in cycles 7 and 8 (2020-2023) was finalized, and the development of new laboratory analytical methods was undertaken.

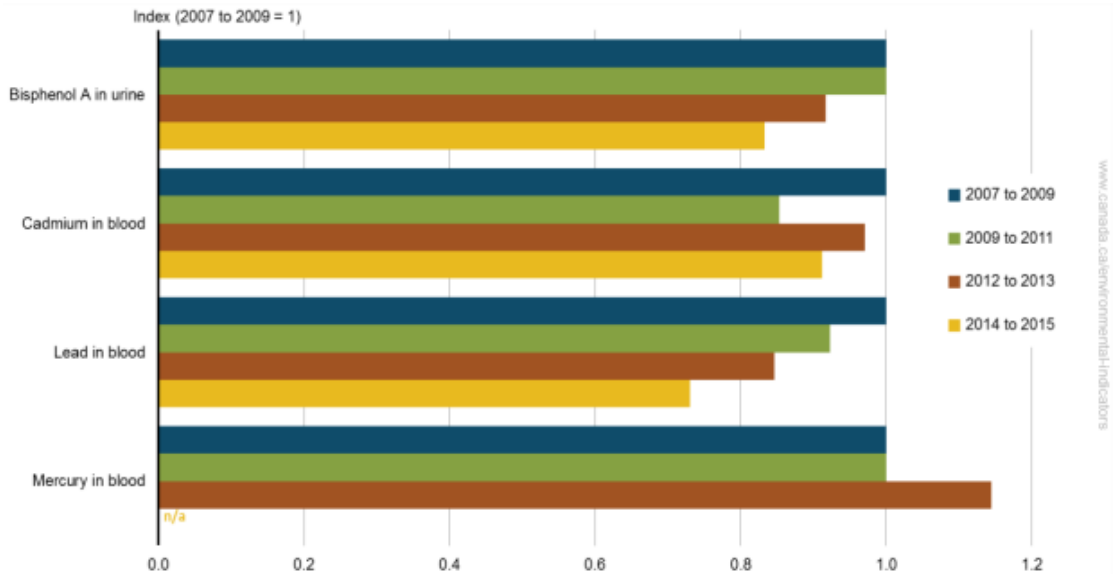
During this reporting period, two HC authored peer-reviewed journal articles were published including a review of biomonitoring and other environmental health-related CHMS data use over the past decade, and an analysis of factors associated with plasma concentrations of polychlorinated biphenyls and dichlorodiphenyldichloroethylene (p,p'-DDE).

During the same period, CHMS data contributed to the re-evaluation of decisions for the pesticides deltamethrin, cypermethrin, cyfluthrin and their associated end-use products; the draft screening assessment report for antimony-containing substances; the health risk assessment of dietary exposure to cadmium; the public consultation document on copper and cadmium in drinking water; and the drinking water quality guideline technical document for perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and lead. The data also formed the basis for the Canadian Environmental Sustainability Indicators (CESI), Human exposure to harmful substances.

TRENDS IN ENVIRONMENTAL CHEMICAL LEVELS FROM THE CANADIAN HEALTH MEASURES SURVEY

Nationally representative biomonitoring data collected as part of the Canadian Health Measures Survey (CHMS) are an important tool in tracking trends over time and determining the efficacy of regulatory interventions. Data from four cycles of CHMS collected between the periods of 2007 to 2009 and 2014 to 2015 have been used to assess trends in the average concentrations of cadmium, mercury and lead in blood, and bisphenol A (BPA) in urine of Canadians (see Figure 4, adapted from the Canadian Environmental Sustainability Indicators: Human exposure to harmful substances). During this period, there was no significant trend for cadmium or mercury and a marginal decreasing trend for BPA. There was a significant decreasing trend in the average concentration of lead with a 26% decrease between the periods 2007 to 2009 and 2014 to 2015, and an 80% decrease since 1978 to 1979. This is mainly attributed to the successful phase-out of lead in gasoline, lead-based paints and lead-solder in food cans.

Figure 4. Changes in the average concentrations of selected substances in Canadians, between the periods 2007 to 2009 and 2014 to 2015



Both ECCC and HC contribute to the Northern Contaminants Program (NCP) led by Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). HC partners with CIRNAC on the human health component of the NCP, which addresses concerns about human exposure to elevated levels of contaminants in wildlife species important to the traditional diets of northern Indigenous peoples. In 2018-2019, HC supported four human biomonitoring and health projects under the NCP. These projects addressed exposure to contaminants and links to country foods and nutritional status in multiple northern regions (Yukon, Northwest Territories, Nunavik) and the development and evaluation of health communication tools.

ECCC has been a major contributor in monitoring abiotic media, aquatic biota and wildlife, as well as Arctic ecosystem health. ECCC monitors wildlife at numerous sites across the Canadian Arctic on a biennial or annual basis under the NCP, for a large suite of legacy and new Chemicals of Emerging Arctic Concern (CEACs), as well as metals including mercury.

2.1.2 Information gathering

Mandatory surveys (or information gathering notices) issued under sections 46 and 71 of CEPA request commercial use information needed to support priority setting, risk assessment, or risk management activities. During 2018-2019, the Government of Canada published three mandatory survey Notices. Two Notices were issued under section 71 of CEPA to inform risk management decision-making for 1,4-benzenediamine, N,N′-mixed phenyl and tolyl derivatives (BENPAT) (published in August, 2018) and coal tars and their distillates (published in December, 2018). A third notice was issued in November, 2018, under section 46 of CEPA, to collect basic information on the commercial status of approximately 800 quaternary ammonium compounds (QACs) for the purposes of creating an inventory of QACs in Canada.

Targeted voluntary data gathering activities also contribute to risk assessments and risk management activities. This year, the Government conducted voluntary data requests for 23 substances or substance groupings to support risk assessments.

2.1.3 Risk assessment activities

There are two streams of risk assessment for substances in Canada based on when they enter into commerce. Substances on the Domestic Substances List (DSL) are referred to as existing substances and many have been in use in Canada for over three decades. Substances that are not on the DSL are considered "new" substances.

New substances risk assessment

Substances that are new to Canada require notification to the government prior to beginning commercial activity in Canada. In 2018-2019, 398 new substance notifications were received pursuant to section 81 of CEPA and the *New Substances Notification Regulations* (Chemicals and Polymers).

A new initiative to promote transparency was launched in 2018 to expand the practice of publishing summaries of new substance risk assessments. A total of 144 new substance risk assessment summaries were published online in 2018-2019.

During 2018-2019, a total of 60 waivers of information requirements were granted and published in the *Canada Gazette*, for new chemical and polymer substances.

Substances in products regulated under the *Food & Drug Act* are subject to the new substances provisions in CEPA for examination of potential risks to the environment and indirect exposure to humans. For new substances in products regulated under the FDA, 89 notifications for chemical/polymer substances and living organisms were received in 2018-2019.

Existing substances assessment

ECCC and HC conduct risk assessments or screening assessments to determine whether existing substances meet or are capable of meeting any of the criteria for toxicity as set out in section 64 of the Act. Draft screening assessments are published on the Chemical Substances website, along with a notice in the *Canada Gazette*, Part I which includes a summary of the report. Following publication, interested parties can submit written comments during a 60-day public comment period. These comments are taken into consideration during the completion of the final screening assessment, a summary of which is then published in the *Canada Gazette*, Part I. The Chemical Substances website is also updated.

During 2018-2019 (see Table 1), the Minister of Health and the Minister of the Environment:

- published 18 draft screening assessment reports covering 128 substances
- published 21 final screening assessment reports covering 599 substances
- concluded that, of the 727 substances assessed, 32 meet or are proposed to meet one or more of the toxicity criteria set out in section 64 of CEPA
- published one Science Approach Document covering 80 substances with low ecological concern

Table 1. Summary of existing substance assessment decisions published from April 2018 to March 2019
(NFA – no further action)

Substances (and number of substances)	Meet s. 64 criteria	Proposed measure	Publication date of draft notice	Publication date of final notice
Second Phase of Polymer Rapid Screening (285)	No	NFA	March 18, 2017	April 7, 2018
Approach for a subset of inorganic and organometallic substances (59)		NFA	April 20, 2018	
Organic Peroxides Group (2)	No	NFA	April 28, 2018	
EDTA and its Salts Group (4)	No	NFA	April 29, 2017	May 5, 2018
Macrocyclic Lactones and Ketones, Iones and Cyclohexanone Group (11)	No	NFA	May 19, 2018	
Dinoseb (1)	Yes	add to Schedule 1	June 2, 2018	
Phenacetin (1)	No	NFA	April 15, 2017	July 28, 2018
Benzophenone (1)	Yes	add to Schedule 1	August 4, 2018	
Fatty Acids and Derivatives Group (10)	No	NFA	August 18, 2018	
Commercial Napthenic Acids Group (2)	No	NFA	August 18, 2018	
Sector-specific Inorganic UVCBs Group (57)	No	NFA	July 22, 2017	August 25, 2018
Furan Compounds Group (4)	Yes	add to Schedule 1	September 1, 2018	
Ethylene Glycol Ethers group (7)	No	NFA	March 4, 2017	September 1, 2018
Nitro Musks Group (2)	No	NFA	September 15, 2018	
Antimony Containing Substance Group (11)	No	NFA	September 15, 2018	
Acrylates and Methacrylates Group (6)	No	NFA	September 23, 2017	September 29, 2018
Base oils (39)	No	NFA	October 6, 2018	
Thiols Group (4)	No	NFA	July 22, 2017	October 20, 2018
72 Substances identified as being of low concern (72)	No	NFA	June 17, 2017	November 3, 2018
Anthraquinones Group (7)	Yes	add to Schedule 1	November 3, 2018	
Poly (amines) Group (9)	No	NFA	November 10, 2018	
Epoxides and Glycidyl Ethers Group (5)	No	NFA	November 24, 2018	
Poly(bios) Group (5)	No	NFA	November 18, 2017	November 24, 2018
Talc (1)	Yes	add to Schedule 1	December 8, 2018	

Substances (and number of substances)	Meet s. 64 criteria	Proposed measure	Publication date of draft notice	Publication date of final notice
Triarylmethanes (6)	Yes	add to Schedule 1	December 8, 2018	
Calcium 2-ethylhexanoate and 2 ethylhexyl-2 ethylhexanoate (2)	Yes	add to Schedule 1	March 25, 2017	December 15, 2018
Rapid screening of substances with limited general population exposure (88)	No	NFA	June 10, 2017	December 15, 2018
Eugenol and Isoeugenol Derivatives Group (2)	No	NFA	September 30, 2017	December 22, 2018
Pigments and Dyes Group (6)	No	NFA	January 5, 2019	
Ketones Group (10)	Yes	add to Schedule 1	January 19, 2019	
Stilbenes Group (2)	No	NFA	September 30, 2017	February 2, 2019
Alkyl Aryl Phosphites Group (2)	No	NFA	October 28, 2017	February 2, 2019
Benzoates Group (9)	No	NFA	December 30, 2017	February 9, 2019
Aliphatic Diesters Group (1)	No	NFA	December 2, 2017	February 9, 2019
Trimellitates Group (3)	No	NFA	December 2, 2017	February 16, 2019
Arenes Group (2)	No	NFA	July 22, 2017	March 9, 2019
Carboxylic Acid Anhydrides Group (3)	No	NFA	December 9, 2017	March 9, 2019
Carboxylic Acids Group (4)	No	NFA	December 30, 2017	March 9, 2019
DTPMP (1)	No	NFA	March 16, 2019	

Along with the results of the screening assessment, the Ministers must publish in the *Canada Gazette* their final decision with respect to the assessment by choosing one of the following three "measures":

1. recommending to the Governor in Council the addition of the substance to Schedule 1 of CEPA (the List of Toxic Substances)

2. adding it to the Priority Substances List for further assessment

3. proposing no further action in respect of the substance

Ministers may recommend the addition of a substance to Schedule 1 of CEPA if a screening assessment shows that a substance meets one or more of the toxicity criteria set out in section 64 of CEPA. The Governor in Council may then approve an Order specifying its addition to Schedule 1. The decision to recommend adding a substance to Schedule 1 obliges the Ministers to develop a "regulation or instrument respecting preventive or control actions" within specific time periods.

In 2018-2019, the Ministers proposed that one substance be added to Schedule 1 of CEPA as listed in Table 2.

Table 2. Orders proposing adding substances to Schedule 1 of CEPA 1999 from April 2018 to March 2019

Substance	Proposed Order
2-Ethylhexyl 2-ethylhexanoate	March 2, 2019

In 2018-2019, four substances or groups of substances were added to Schedule 1 as listed in Table 3.

Table 3. Orders adding substances to Schedule 1 of CEPA 1999 from April 2018 to March 2019

Substance	Proposed Order
2-Ethylhexyl 2-ethylhexanoate	July 11, 2018
Phenol, 5-chloro-2-(2,4-dichlorophenoxy)-, which has the molecular formula $C_{12}H_7Cl_3O_2$	July 11, 2018
Petroleum gases, liquefied (a complex combination of hydrocarbons — obtained from the distillation of crude oil — consisting of hydrocarbons having carbon numbers predominantly in the range of C_3 through C_7 and boiling in the range of approximately -40°C to 80°C) Petroleum gases, liquefied, sweetened (a complex combination of hydrocarbons — obtained by subjecting liquefied petroleum gases to a sweetening process to convert mercaptans or to remove acidic impurities — consisting of hydrocarbons having carbon numbers predominantly in the range of C_3 through C_7 and boiling in the range of approximately -40°C to 80°C)	April 18, 2018

In 2014, ECCC and HC formalized their ongoing approach for the identification of risk assessment priorities (IRAP) for chemicals and polymers under CEPA. As a result of the IRAP process, substances may be considered for future risk assessment. Results of the 2017-2018 IRAP review were published in early 2019 and identified one new candidate for risk assessment, 1-H-benzotriazole (CAS RN 95-14-7). This substance fits within a group of substances already under assessment in the CMP work plan and therefore was added to that group. Another 1,094 substances (or 13 groups of substances) were recommended for further scoping/problem formulation post 2020. Another 60 substances were identified for further data collection.

Substances in products regulated under the *Food and Drugs Act* (FDA) between 1987 and 2001 that are on the administrative *Revised in Commerce List* (~2600) were prioritized in 2016, and substances found to be listed on the DSL were removed from the *Revised in Commerce List*. A subset of higher priority substances (~675) were the subject of a section 71 inventory update in 2017 in order to gather information on their commercial status and quantities in use. Substances that were identified for further consideration are being assessed to determine whether they meet or are capable of meeting any of the toxicity criteria set out in section 64 of CEPA.

2.1.4 Risk management activities

In general, when a draft risk assessment proposes a conclusion that the substance is "toxic" under CEPA, a risk management scope document is developed and published at the same time as the draft assessment report. Risk management scopes are used as discussion documents to engage stakeholders on potential risk management actions. A scope briefly describes the health or environmental concern, the activities potentially impacted and the type of risk management actions being considered. In 2018-2019, risk management scope documents were published for the following seven substances, or groups of substances:

- dinoseb
- benzophenone
- furan compounds group (furfuryl alcohol and tetrahydrofuran)
- solvent violet 13 (anthraquinones group)
- talc
- triarylmethanes group (basic violet 3, malachite green, basic violet 4, basic blue 7)
- ketones group (MEK, MIBK, 2,4-PD)

Similar to the risk management scopes, when the final screening assessment report concludes that a substance is "toxic" under CEPA and proposed for addition to Schedule 1 of the Act, a risk management approach document is developed and published at the same time as the final risk assessment report. The risk management approach document provides a more detailed description of the risk management being considered, such as regulations, pollution prevention planning notices, environmental performance agreements, guidelines, codes of practice or significant new activity notification provisions. These instruments can address any aspect of the substance's life cycle, from the research and development stage through manufacture, use, storage, transport and ultimate disposal or recycling. In 2018-2019, a risk management approach document was published for 2-ethylhexyl-2-ethylhexanoate.

Regulations

Final Regulations

The *Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations* were amended by an Interim Order in October 2018, which revised the Canadian HFC baseline value to reflect information received following its entry into force on April 16, 2018. These regulations control hydrofluorocarbons (HFCs) through the phase-down of consumption of bulk HFCs and controls on specific products containing or designed to contain HFCs, including refrigeration and air-conditioning equipment, foams and aerosols.

In October 2018, the final *Prohibition of Asbestos and Products Containing Asbestos Regulations* were published in the *Canada Gazette*, Part II. These regulations prohibit the import, sale and use of asbestos, as well as the manufacture, import, sale and use of products containing asbestos, with some exceptions.

Proposed Regulations

On April 28, 2018, the proposed *Regulations Repealing the Chlor-Alkali Mercury Release Regulations* were published in the *Canada Gazette*, Part I. The *Chlor-Alkali Mercury Release Regulations* were established to limit the release of mercury into air from chlor-alkali facilities using the mercury cell process, but are no longer needed because the last chlor-alkali facility employing the mercury cell process closed in 2008.

On December 15, 2018, the proposed *Regulations Amending the Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations* were published in the *Canada Gazette*, Part I. These proposed Regulations address a number of concerns with these regulations that have been raised by the Standing Joint Committee on the Scrutiny of Regulations[2].

Consultations

On October 13, 2018, ECCC and HC published a Notice of intent to amend the *Prohibition of Certain Toxic Substances Regulations, 2012* to further restrict the following substances: (perfluorooctane sulfonate, its salts and its precursors (PFOS); perflurooctanoic acid, its salts and its precursors (PFOA); long-chain perfluorocarboxylic acids, their salts and their precursors (LC-PFCA)); and two flame retardants (hexabromocyclododecane (HBCD) and polybrominated diphenyl ethers (PBDEs)). The amendments would also prohibit two additional flame retardants (Dechlorane Plus (DP) and decabromodiphenyl ethane (DBDPE)), should their final screening assessment reports confirm that they are toxic under section 64 of CEPA. In December 2018, a consultation document was published to inform and solicit comments from stakeholders on this proposed regulatory approach.

In February 2019, ECCC published a consultation document outlining proposed amendments to the *Ozone Depleting Substances and Halocarbon Alternatives Regulations*. The proposed amendments would revise the Canadian hydrofluorocarbon (HFC) baseline value in accordance with the October 2018 Interim Order, before it expires in October 2020. In addition, the proposed amendments would allow the consumption of HCFC-123 (hydrochlorofluorocarbon) for the servicing of existing fire protection equipment until 2029, in accordance with recent adjustments to the Montreal Protocol on Substances that Deplete the Ozone Layer.

Regulatory administration

The *Ozone-depleting Substances and Halocarbon Alternatives Regulations* are the main instrument that implements Canada's obligations under the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol), including the Kigali Amendment to phase down HFCs. These regulations control the export, import, manufacture, sale and certain uses of ozone-depleting substances and hydrofluorocarbons as well as certain products containing or designed to contain them. In 2018-2019, approximately 195 permits were issued under these Regulations.

The *Federal Halocarbon Regulations, 2003* reduce and prevent emissions of halocarbons to the environment from refrigeration, air conditioning, fire extinguishing and solvent systems that are located on aboriginal or federal lands or are owned by federal departments, boards and agencies, Crown corporations, or federal works and undertakings. In 2018-2019, 12 permits to charge a fire-extinguishing system with a halocarbon were issued under these Regulations.

[2] With members from both the Senate and the House of Commons, the Joint Committee is responsible for ensuring that, whenever Parliament delegates regulation-making authority to another body, that authority is exercised appropriately.

Other risk management tools

Cosmetic hot list

The Cosmetic Ingredient Hotlist is an administrative tool that HC uses to communicate to manufacturers and others that certain substances may be prohibited or restricted for use in cosmetics. In June 2018, pigment red 4 was added to the Cosmetic Ingredients Hotlist. Due to potential health concerns, this ingredient was added to the list of restricted substances with a maximum concentration of 3% permitted.

Pollution Prevention Planning Notices

On July 14, 2018, the *Proposed Notice requiring the preparation and implementation of pollution prevention plans in respect of reaction products of 2-propanone with diphenylamine (PREPOD), CAS RN 68412-48-6, in industrial effluents*, was published in *Canada Gazette*, Part I, for a 60-day comment period. The Notice applies to persons who own or operate a facility within the chemical manufacturing and rubber sectors that has industrial effluent and that manufacturers or uses PREPOD in quantities greater than 100 kg.

On November 10, 2018, ECCC published, in the *Canada Gazette*, Part I, the final Notice *Requiring the Preparation and Implementation of Pollution Prevention Plans for Hydrazine in the electricity sector*. Hydrazine was classified as a toxic substance under CEPA and added to the List of Toxic Substances on September 20, 2012.

On November 24, 2018, ECCC published a *Proposed Notice Requiring the Preparation and Implementation of Pollution Prevention (P2) Plans with Respect to Triclosan in Certain Products* in the *Canada Gazette*, Part I for a 60-day comment period. The intent of the Notice is to reduce the amount of triclosan that is washed down drains into waterways by 30% from triclosan-containing cosmetics, natural health products and drugs.

On February 16, 2019, ECCC published, in the *Canada Gazette*, Part I, the *Final Notice requiring the preparation and implementation of pollution prevention plans in respect to toluene diisocyanates* (TDIs). This Notice replaces the *P2 Planning Notice for the Polyurethane and other foam sector (except polystyrene) in respect of toluene diisocyanates (TDIs)* published on November 26, 2011. The new Notice streamlines testing and administrative requirements while broadening the coverage to any facility that releases more than 100 kg of TDIs annually.

In progress

A P2 Planning Notice in respect of specified toxic substances released from the iron, steel and ilmenite sector was published in 2017 and is in effect. Of the 14 facilities subject to the notice, 13 submitted a declaration that a pollution prevention plan has been prepared and is being implemented. The remaining facility closed. All 13 facilities have also submitted their first interim progress reports. Facilities are required to submit annual interim reports until 2028 at which time they will submit a final report.

A P2 Planning Notice in respect of specified toxic substances released from base metals smelters and refineries and zinc plants was published in 2006. Three facilities were granted a three-year extension to December 31, 2018 to implement their plans. The declarations of implementation for the three facilities were received by the deadline of January 2019. The Notice is no longer in effect.

The *Notice requiring the preparation and implementation of pollution prevention plans in respect of halocarbons used as a refrigerant* published in 2016 is still in effect. This Notice is in place to manage halocarbon refrigerants in an environmentally sound manner in order to minimize releases of halocarbons into the environment. The

declarations of implementation were due on December 20, 2018, for the nine companies that were subject to the Notice at the time of publication. All nine companies have met the objective. One more company became subject to the Notice in 2018 and has submitted its declaration of preparation.

A P2 Planning Notice for Isoprene was published in 2012 and is in effect. One facility was subject to the Notice at the time of publication. A time extension was granted to the facility. The deadline to implement the plan was extended to December 31, 2018. A declaration of implementation was received in January 2019.

Final reports

In April 2018, ECCC published a final performance report on the implementation of the *Notice Requiring the Preparation and Implementation of Pollution Prevention Plans with Respect to Siloxane D4*. With a 56% reduction of D4 releases, the Notice achieved two thirds of its risk management objective (80% reduction in total D4 releases). However, five facilities out of six subject to the Notice have reduced the D4 concentration in their effluents to a level that is less than or equal to 17.3 µg/L or have reduced the release of D4 in their effluents to less than 3 kg per year. ECCC and the facility that did not meet the risk management objective of the Notice continue to work together to examine measures that can be undertaken to further reduce the D4 releases of the facility.

Environmental Performance Agreements

An Environmental Performance Agreement (EPA) is negotiated around the key principles and design criteria outlined in ECCC's Policy Framework for EPAs. Results from EPAs are posted online. No EPAs were finalized in 2018-2019.

Export Control List

The Export Control List, Schedule 3 of CEPA includes substances whose export from Canada is controlled because their use in Canada is prohibited or restricted, or because they are subject to an international agreement that requires notification or consent of the country of destination before the substance is exported from Canada, such as under the *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade*. CEPA requires exporters to submit prior notice of export for substances on the Export Control List.

The *Export of Substances on the Export Control List Regulations* set out the content of Notices of proposed export and export permits, and the period and manner in which they must be provided. The regulations ensure that Canada complies with its export obligations under the *Rotterdam Convention*, *Stockholm Convention on Persistent Organic Pollutants*, and *Minamata Convention on Mercury*.

The *Export of Substances on the Export Control List Regulations* were amended to list all forms of asbestos on the Export Control List. An Order amending Schedule 3 to CEPA 1999 was published in October 2018. These amendments support the Regulations Prohibiting Asbestos and Asbestos Products by adding new provisions to prohibit (with some exceptions) the export of asbestos and products containing asbestos. They also ensure that Canada is compliant with its export obligations under international conventions, including the *Rotterdam Convention*.

In 2018-2019, 51 Notices of proposed export were submitted to the Minister of the Environment. No export permits were requested or issued by the Minister.

Release guidelines

Release guidelines recommend limits, including limits expressed as concentrations or quantities, for the release of substances into the environment from works, undertakings or activities. They may be issued by the Minister of the Environment under section 54, or by the Minister of Health under section 55 of CEPA.

On February 23, 2019, the Government of Canada published in the *Canada Gazette*, Part I *Proposed Release Guidelines for Disperse Yellow 3 (DY3) and 25 other azo disperse dyes in the textile sector* under paragraph 54 of the Act. The proposed Guidelines were open for a 60-day public comment period which ended on April 24, 2019. The objective of the Guidelines is to limit releases of DY3 and 25 other azo disperse dyes with molar weights below 360 g/mol to levels below the Predicted No Effect Concentration (PNEC) of 2.3 µg/L at the final discharge point of textile facilities.

Environmental quality guidelines

Environmental quality guidelines provide benchmarks for the quality of the ambient environment. They may be developed nationally through the Canadian Council of Ministers of the Environment (CCME) as Canadian Environmental Quality Guidelines (CEQGs) or federally under section 54 of CEPA as Federal Environmental Quality Guidelines (FEQGs).

Table 4 lists the CEQGs that were published or being developed nationally through CCME in 2018-2019. Table 5 lists the seven FEQGs for various CMP substances that ECCC finalize in 2018-2019 and the substances for which FEQGs are under development.

Table 4. Canadian Environmental Quality Guidelines under development or finalized published in 2018-2019

Environmental compartment	Finalized	Under development
Water		Manganese (awaiting publication) Nickel Neonicotinoid Pesticides (4)
Soil	Zinc*	Perfluorooctane sulfonate (PFOS)
Groundwater		Guidelines for n = 100 substances
Soil vapour		Guidelines for n = 100 substances

* Published on CCME website June 12, 2018

Table 5. Federal Environmental Quality Guidelines in 2018-2019

Environmental compartment	Finalized	Under development
Water	Bisphenol A (BPA)* Hexavalent Chromium* Perfluorooctane Sulfonate (PFOS)*	Copper Iron Lead Quinoline Strontium Aluminum D4 Siloxane
Sediment	Bisphenol A (BPA)*	D4 Siloxane
Fish tissue	Perfluorooctane Sulfonate (PFOS)*	D4 Siloxane
Wildlife diet	Bisphenol A (BPA)* Perfluorooctane Sulfonate (PFOS)*	Selenium D4 Siloxane
Bird egg	Perfluorooctane Sulfonate (PFOS)*	Selenium
Soil		Quinoline
Groundwater		Quinoline

* Published in the *Canada Gazette* June 2018

Significant New Activity requirements

A Significant New Activity (SNAc) requirement is applied when a substance has been assessed and no current risk-based activities were identified; however, there is a suspicion that new activities may pose a risk to human health and/or the environment. When it is applied, new uses or activities must be reported to the government. This ensures that departmental experts can evaluate whether the new use of a substance poses a risk to human health or the environment, and determine if risk management should be considered as a result of the new use.

In 2018-2019:

- 7 SNAc Notices were issued for new substances (Table 6)
- 5 SNAc Notices of intent were issued for 20 existing substances (Table 7)

Table 6. Significant New Activity Notices for new substances from April 2018 to March 2019

Substance	Publication date*
Nickel, [1,3-dihydro-5,6-bis[[(2-hydroxy-1-naphthalenyl)methylene]amino]-2H-benzimidazol-2-onato(2-)-N5,N6,O5,O6]-, (SP-4-2)- (CAS RN 42844-93-9)	June 23, 2018
Siloxanes and silicones, di-Me, mono[3-[(2-methyl-1-oxo-2-propenyl)oxy]propyl] group-terminated, polymers with Bu methacrylate, 2-ethylhexyl acrylate and Me methacrylate (CAS RN 756819-45-1)	September 22, 2018
1-tetradecene homopolymer, hydrogenated (CAS RN 1857296-89-9)	November 24, 2018
Benzaldehyde, reaction products with polyalkylenepolyamines, hydrogenated (CAN 18498-3)	November 24, 2018
2-propenenitrile, reaction products with alkylenediamine, hydrogenated, N-benzyl derivs. (CAN 19155-3)	November 24, 2018
2-Propenoic acid, 2-methyl-, 3-[1,1-bis[[dimethyl[2-[3,3,3-trimethyl-1,1-bis[(trimethylsilyl)oxy] disiloxanyl]ethyl]silyl]oxy]-3,3-dimethyl-3-[2-[3,3,3-trimethyl-1,1-bis[(trimethylsilyl)oxy]-1-disiloxanyl] ethyl]-1-disiloxanyl]propyl ester, polymer with butyl 2-propenoate and methyl 2-methyl-2-propenoate (CAS RN 262299-63-8)	March 16, 2019
2-Propenoic acid, 2-methyl-, methyl ester, polymer with isooctyl 2-propenoate and 3-[3,3,3-trimethyl-1,1-bis[(trimethylsilyl)oxy]-1-disiloxanyl]propyl 2-methyl-2-propenoate (CAS RN 175283-06-4)	March 30, 2019

* The dates are those on which the Final Notices or Orders were published in the *Canada Gazette*, Part I.

Table 7. Significant New Activity Notices of intent for existing substances from April 2018 to March 2019

Substance	Publication date
Acetamide, *N*-(4-ethoxyphenyl)- (CAS RN 62-44-2)	July 28, 2018
Ethane, 1-2-dimethoxy- (CAS RN 110-71-4)	September 01, 2018
Ethane, 1,1'-oxybis[2-methoxy- (CAS RN 111-96-6)	November 03, 2018
2,5,8,11-Tetraoxadodecane (CAS RN 112-49-2)	November 03, 2018
Methane, iodo- (CAS RN 74-88-4)	December 15, 2018
1,2-Benzenediamine (CAS RN 95-54-5)	December 15, 2018
Benzoyl chloride (CAS RN 98-88-4)	December 15, 2018
Benzene, 1-chloro-4-nitro- (CAS RN 100-00-5)	December 15, 2018
Oxirane, 2,2'-[1,3-phenylenebis(oxymethylene)]bis- (CAS RN 101-90-6)	December 15, 2018
Benzene, 2-methyl-1,3,5-trinitro- (CAS RN 118-96-7)	December 15, 2018
Benzene, 1-methyl-2,4-dinitro- (CAS RN 121-14-2)	December 15, 2018
1,3-Butadiene, 2-chloro- (CAS RN 126-99-8)	December 15, 2018
Benzofuran (CAS RN 271-89-6)	December 15, 2018
Oxiranemethanol (CAS RN 556-52-5)	December 15, 2018

Substance	Publication date
Ethane, 1,1,1,2-tetrachloro- (CAS RN 630-20-6)	December 15, 2018
Benzenamine, 4-[(4-aminophenyl)(4-imino-2,5-cyclohexadien-1-ylidene)methyl]-2-methyl-, monohydrochloride (CAS RN 632-99-5)	December 15, 2018
9,10-Anthracenedione, 1,4,5,8-tetraamino- (CAS RN 2475-45-8)	December 15, 2018
Benzene, mixed with toluene, dealkylation product (CAS RN 68953-80-0)	December 15, 2018
Hexanoic acid, 2-ethyl-, calcium salt (CAS RN 136-51-6)	December 15, 2018
Hexanedioic acid, diisodecyl ester (CAS RN 27178-16-1)	February 9, 2019

Conditions and prohibitions on new substances

When the assessment of a new substance identifies a risk to human health or the environment, CEPA allows the Minister of the Environment to intervene prior to or during the earliest stages of its introduction into Canada. In this case, there are three actions that may be taken.

The Minister may:

a) permit the manufacture or import of the substance subject to specified conditions

b) prohibit the manufacture or import of the substance

c) request additional information considered necessary for the purpose of assessment

In 2018-2019, the Minister of the Environment issued 11 Notices of Ministerial Conditions for new substances (Table 8).

Table 8. Notices of Ministerial Conditions for new substances from April 2018 to March 2019

Substance	Publication date*
Benzene, 1,1′-(1,2-ethanediyl)bis(2,3,4,5,6- pentabromo- (CAS RN 84852-53-9)	April 28, 2018
Saccharomyces (ALX104-17-148.38)	August 25, 2018
Amides, tall-oil fatty, N-[3-(dimethylamino)propyl] (CAS RN 68650-79-3)	October 13, 2018
1,2-ethanediol, 1,2-dibenzoate (CAS RN 94-49-5)	October 27, 2018
1,2-ethanediamine, N-(2-aminoethyl)- (CAS RN 68411-70-1)	November 24, 2018
Hexanoic acid, 3,5,5-trimethyl-,2-ethylhexyl ester (CAS RN 70969-70-9)	December 1, 2018
Sulfonic acids, C20-24-alkane hydroxy and C20-24-alkene, sodium salts (CAS RN 97766-43-3)	February 23, 2019
Phenol, methylstyrenated (CAS RN 68512-30-1)	February 2, 2019
Phenol, methylstyrenated (CAS RN 68512-30-1)	February 2, 2019
Iron(1+), chloro[dimethyl 9,9-dihydroxy-3-methyl-2,4-di(2-pyridinyl-kN)-7-[(2-pyridinyl-kN)methyl]-3,7-diazabicyclo[3.3.1]nonane-1,5-dicarboxylate-kN3,kN7]-, chloride (1:1) (CAS RN 478945-46-9)	March 30, 2019
2-Pyrrolidinone, 1-butyl- (CAS RN 3470-98-2)	March 2, 2019

* The dates are those on which the Notices were published in the *Canada Gazette*.

2.2 LIVING ORGANISMS

Products of biotechnology that are living organisms are regulated for health and safety purposes by a variety of federal departments and agencies across the government. CEPA sets the federal standard for assessment and risk management of new and existing living organisms that are new animate products of biotechnology. Other Canadian legislation meeting the CEPA standard is listed in Schedule 4 of the Act. Living organisms manufactured or imported for a use not covered by an Act listed on Schedule 4 are regulated under CEPA. These include naturally occurring and genetically modified organisms (such as bacteria, fungi, viruses, and higher organisms such as fish or pigs) used for various environmental, industrial and commercial purposes.

The Act requires that all living organisms on the DSL (about 68 existing micro-organisms) undergo a screening assessment to determine whether the living organism is toxic or capable of becoming toxic.

2.2.1 Risk assessment activities

Risk assessment of new animate products of biotechnology

During 2018-2019, 30 notifications of new animate products of biotechnology were received and assessed as new animate products under the *New Substances Notification Regulations (Organisms)*. All notifications that were accepted as new animate products were assessed within the statutory assessment period.

For new substances in products regulated under the *Food and Drugs Act*, 10 notifications for new animate products of biotechnology were received in 2018-2019.

Also during 2018-2019:

- 25 pre-notification consultations were held to help companies better understand the notification requirements for their specific organism before submitting a Notification
- 25 waivers of information requirements for new living organisms were granted and published in the *Canada Gazette*

Risk assessment of existing animate products of biotechnology

ECCC and HC jointly perform the screening assessment of micro-organisms listed on the DSL. In 2018-2019, final screening assessments for two micro-organisms were published in the *Canada Gazette*, Part I (see Table 9). Neither of these organisms met the toxicity criteria in section 64 of the Act.

Table 9. Summary of existing living organisms assessment decisions published from April 2018 to March 2019

Assessment	Publication date final
Bacillus cereus (strain ATCC 14579 and *Bacillus subtilis* strain 11685-3)	August 4, 2018

Note: The date is that on which the notice was published in the *Canada Gazette*.

Risk assessment of higher organisms

The *Voluntary Public Engagement Initiative* on the risk assessment of higher organisms (e.g. genetically modified plants and animals) was launched in 2018. This initiative promotes greater public engagement in the risk assessment of higher organisms. Two public comment periods were completed in July and September 2018 on a total of six new genetically modified fishes to inform risk assessments.

2.2.2 Risk management activities

The significant new activity (SNAc) provisions trigger an obligation for a person to provide the Government of Canada with information about a substance when proposing to use, import or manufacture the substance for a significant new activity. The government then assesses the substance for potential risks to human health and/or the environment. If risks are identified, the government may impose management measures.

Significant New Activity requirements

On May 30, 2018, the Minister of the Environment applied the SNAc provisions of CEPA to the DSL strains of *A. oryzae* and *P. putida* (see Table 10).

Table 10. Significant New Activity Notices of intent and Orders for existing living organisms from April 2018 to March 2019

Assessment	Number of strains	Notice of intent*	Final Order*
Aspergillus oryzae (ATCC No. 11866)	1	January 21, 2017	May 30, 2018
Pseudomonas putida (ATCC No. 12633) *Pseudomonas putida (ATCC No. 31483)* *Pseudomonas putida (ATCC No. 31800)* *Pseudomonas putida (ATCC No. 700369)*	4	January 21, 2017	May 30, 2018

* The dates are those on which the Notices of intent and final Orders were published in the *Canada Gazette*, Part I or Part II, respectively.

2.3 AIR POLLUTANTS AND GREENHOUSE GASES

Air pollutants and greenhouse gases (GHGs) originate from numerous domestic and international sources, such as industry and transportation.

2.3.1 Monitoring

Monitoring and reporting activities are important for identifying and tracking levels and trends of air pollutants that impact both the environment and human health, as well as greenhouse gases that impact climate change.

Air pollution

Ambient (outdoor) air quality monitoring informs air quality management in Canada, including tracking progress relative to the Canadian Ambient Air Quality Standards. The data is used for validation of numerical air quality prediction models, for evaluating the benefits and effectiveness of control measures, as well as for assessments of the impact of air pollution on Canadians and the environment.

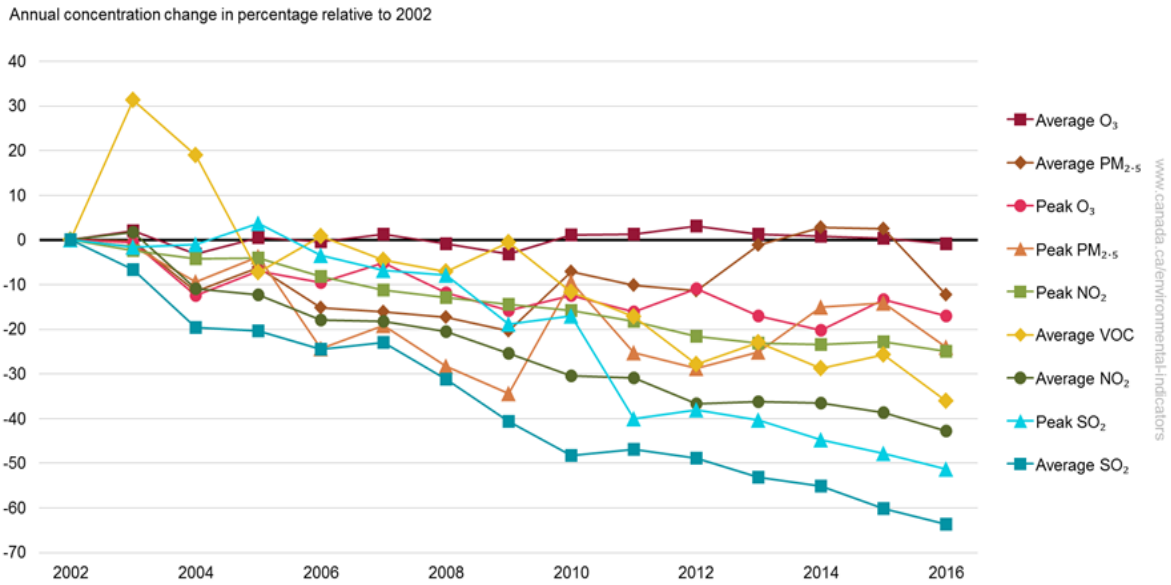
ECCC monitors ambient air quality across the country through two complementary networks known as the National Air Pollution Surveillance (NAPS) program and the Canadian Air and Precipitation Monitoring Network (CAPMoN). NAPS is managed by ECCC via a cooperative agreement with the provinces, territories and two municipalities in order to provide long-term air quality data from populated regions of Canada. CAPMoN provides information on regional patterns and trends of atmospheric pollutants in both air and precipitation at rural and remote sites.

Data collected through NAPS, CAPMoN and other provincial, territorial and municipal monitoring stations are used to calculate air quality indicators. In October 2018, the indicators were updated. The air quality indicators track ambient concentrations of fine particulate matter ($PM_{2.5}$), ground-level ozone (O_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs) at the national, regional and urban levels and at local monitoring stations.

Between 2002 and 2016:

- nitrogen dioxide (NO_2), sulphur dioxide (SO_2), volatile organic compound (VOC) and peak ozone (O_3) concentrations decreased
- average ozone (O_3) concentrations showed almost no change
- fine particulate matter concentrations exhibit variable results

Figure 5. Air pollutant concentrations, Canada, 2002 to 2016



Note: For more information on the air quality indicators, consult the air quality indicators definitions in the Methods section.

Source: Environment and Climate Change Canada (2018) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.+

Additional air pollutant monitoring carried out by ECCC includes:

- AEROCAN, the Canadian sub-network of NASA's global AERONET satellite network, takes optical readings of solar radiation in order to measure atmospheric aerosols.
- The Canadian Brewer Spectrophotometer Network measures the total thickness of the ozone layer (known as total column ozone) and ultraviolet radiation (UV) at selected locations across Canada.
- The Canadian Ozonesonde Network measures vertical column ozone from ground level up to 36 km altitude by launching weekly ozonesondes affixed to balloons, providing long-term ozone data.

Greenhouse gases

The Canadian Greenhouse Gas Monitoring Program includes observations of carbon dioxide and other GHGs from 16 long-term measurement sites across Canada (Figure 6). Among the sites is the Alert Global Atmosphere Watch Observatory. Alert serves as one of three global GHG inter-comparison sites to ensure consistent measurement of carbon dioxide (CO_2) and other greenhouse gas concentrations across the world.

Figure 6. Canadian Greenhouse Gas Measurement Program monitoring sites

ECCC makes its atmospheric monitoring data available to the public through national and international databases, including the Government of Canada Open Data Portal; World Meteorological Organization (WMO); World Data Centres for GHGs; WMO World Data Centre for Precipitation Chemistry; and the WMO World Ozone and Ultraviolet Data Centre, which is operated by the Meteorological Service of Canada.

TRENDS IN ENVIRONMENTAL CHEMICAL LEVELS FROM THE CANADIAN HEALTH MEASURES SURVEY

Measurements of atmospheric CO_2 began in March 1975 at Alert, Nunavut (Figure 7). The seasonal decline in late May to early June is due to the transport of air from southern latitudes that is depleted in CO_2 from photosynthetic uptake. The annual average CO_2 value at Alert in 2018 was 409.5 parts per million (ppm). The annual average CO_2 value at Alert in 2017 and 2016 were 407.7 ppm and 404.3 ppm, respectively.

In addition to CO_2, ECCC also conducts measurements of atmospheric methane (CH_4), which began in August 1985 at Alert, Nunavut (Figure 8). The annual average CH4 value at Alert in 2018 was 1940.2 parts per billion (ppb). The rate of annual increase in CH_4 concentrations steadily declined since the late 1980s and hovered around zero from 1999 to 2006, reflecting a near global balance between emissions and removal by atmospheric chemical processes. However, since 2007, CH4 has increased every year on average by 6 ppb per year.

Figure 7. Atmospheric carbon dioxide measured at Alert, Nunavut

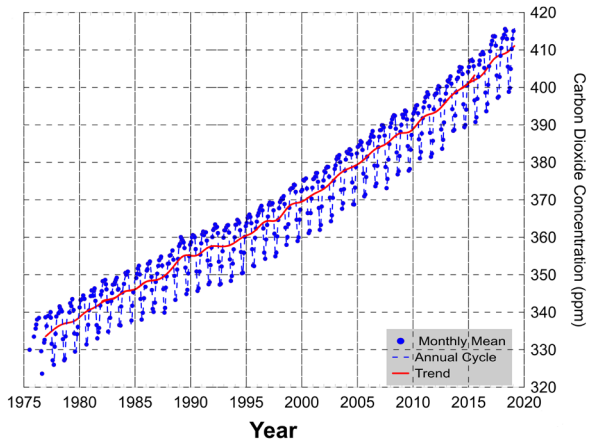
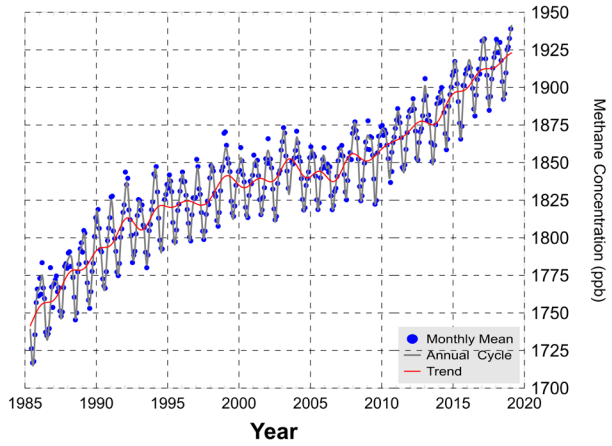


Figure 8. Atmospheric methane measured at Alert, Nunavut



2.3.2 Risk management activities

Different instruments are available under the authorities provided by CEPA to limit and reduce emissions of air pollutants and greenhouse gases from vehicles, engines and fuels, consumer and commercial products, and industrial sectors, as well as for establishing national ambient air quality objectives to drive air quality improvements.

Cooperation among governments is key in managing air pollution. The Air Quality Management System (AQMS), agreed by federal, provincial and territorial environment ministers in 2012, provides a collaborative approach to reducing air pollution and improving the health of Canadians and the environment. The AQMS includes:

- Canadian Ambient Air Quality Standards (CAAQS)
- local air zones and regional airsheds
- industrial emission requirements for major industries
- intergovernmental working group for enhanced collaboration and the reduction of emissions from mobile sources
- reporting to Canadians on the state of the air

CAAQS are environment- and health-based-standards that apply to the concentration of specific air pollutants in the outdoor air. They provide the drivers for air quality management actions across the country. ECCC and HC lead the process under the Canadian Council of Ministers of the Environment (CCME) to develop, review and amend CAAQS. Once agreed under the CCME, CAAQS are published as environmental quality objectives under CEPA.

CEPA provides authorities to establish CAAQS as environmental quality objectives to be met across the country and to develop and administer regulatory and non-regulatory instruments to reduce the releases of air pollutants and GHGs.

Industrial sector emissions requirements

Multi-Sector Air Pollutants Regulations

In 2016, the *Multi-Sector Air Pollutants Regulations* (MSAPR) came into force. The MSAPR establish nationally consistent industrial emissions performance standards and limits nitrogen oxide (NO_x) emissions from large industrial boilers and heaters, as well as from stationary sparkignition engines, used in several industrial sectors, that burn gaseous fuels (such as natural gas). The MSAPR also limit NO_x and SO_2 emissions from kilns at cement manufacturing facilities. The MSAPR will contribute significantly to reducing emissions that contribute to smog and acid rain, including 2,000 kilotonnes of NO_x emission reductions in the first 19 years.

For stationary spark-ignition engines, the on-line reporting system for engine registrations was tested and launched, with over 250 enquiries handled, 10 information sessions and 9 webinars held as part of compliance promotions activities. Registrations for 53 modern and 4,657 preexisting engines were received from over 100 regulated parties. Emissions requirements for the modern engines are in force with reports due in 20192020. Emission requirements for preexisting engines apply in 2021.

Methane is a potent GHG, with a global warming potential 28 times greater than carbon dioxide. The federal government has committed to reduce methane emissions to 40 45 percent below 2012 levels by 2025.

Oil and gas sector emission requirements

In April 2018, the final *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)* were published in the *Canada Gazette*, Part II and introduced control measures (facility and equipment level standards) to reduce fugitive and venting emissions of hydrocarbons, including methane, from the oil and gas sector.

Electricity sector emissions requirements

In December 2018, ECCC published in the *Canada Gazette*, Part II, final amendments to the *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*. The amendments require all coal-fired electricity generating units to comply with a carbon dioxide emissions performance standard at the end of their useful life as specified by the existing coal-fired electricity regulations, or by the end of 2029, whichever comes first. The purpose of the amendments is to accelerate the phase-out of traditional coal-fired electricity.

To support the transition away from coal towards cleaner sources of generation, the Government published the final *Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity* in the *Canada Gazette*, Part II in December 2018. The regulations for natural gas-fired electricity have been designed to ensure that new natural gas-fired electricity generation facilities use efficient technology, while providing flexibility for new units to meet electricity system demand and incorporate variable renewables, like wind and solar.

For coal units that convert to run on natural gas, the regulations encourage companies to convert their coal units to natural gas ahead of their end-of-life under the amended coal regulations, while also providing assurance that higher emitting coal-to-gas converted units will be phased out more rapidly than better performers.

Forest products sector emissions requirements

In July 2018, ECCC published the *Code of Practice for the Management of Air Emissions from Pulp and Paper Facilities*. The Code provides best practices to facilitate and encourage ongoing improvements in the environmental performance of pulp and paper facilities with respect to air emissions of SO_2 and total particulate matter from combustion sources.

Transportation sector emissions requirements

ECCC administered six vehicle and engine regulations and nine fuel regulations under CEPA.

ECCC and the U.S. Environmental Protection Agency continued to collaborate closely through the Canada U.S. Air Quality Committee towards the development of aligned vehicle and engine emission standards, related fuel quality regulations and their coordinated implementation.

Greenhouse gas emissions regulations

In May 2018, ECCC published final amendments to the *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations*. These amendments have introduced progressively more stringent GHG emission standards for on-road heavy-duty vehicles and their engines, as well as for trailers hauled by transport tractors.

In August 2018, ECCC published a discussion paper to begin consultations on the mid-term evaluation of Canada's light-duty vehicle greenhouse gas emission regulations for the 2022 to 2025 model years. The mid-term evaluation aims to determine whether the established GHG emission standards for the 2022 to 2025 model years remain appropriate for Canada. The discussion paper facilitated consultations by seeking early views on factors to be considered when assessing the appropriateness of Canadian requirements. A summary of the comments received in response to the discussion paper was published in March 2019.

Air pollutant emissions regulations

In December 2018, ECCC published final *Regulations Amending the Regulations Prescribing Circumstances for Granting Waivers Pursuant* to Section 147 of the Act. The Amendments are administrative in nature, and have no impact on stakeholders.

In March 2019, ECCC published proposed Off-Road Compression-Ignition (*Mobile and Stationary*) *and Large Spark-Ignition Engine Emission Regulations* in the *Canada Gazette*, Part I. The proposed Regulations would repeal and replace the current *Off-road Compression-Ignition Engine Emission Regulations* and introduce new emission standards and requirements in alignment with the U.S. Environmental Protection Agency's standards for large spark-ignition engines and stationary compression-ignition engines, in addition to improving the requirements for mobile compression-ignition engines. The proposed Regulations would reduce harmful emissions of smog-forming air pollutants from machines, such as forklifts, ice resurfacers and large stationary generators, as well as reduce emissions, such as black carbon, from combustion of diesel fuel in stationary compression-ignition engines, many of which are found in Canada's North.

Regulatory administration of the transportation regulations

ECCC administers a compliance program under the transportation and fuels regulations. This includes processing of regulatory reports, importation declarations, managing notice of defects and recalls and testing of selected vehicles and engines to verify compliance with the regulations.

Some of the transportation regulations require companies to submit annual compliance reports documenting fleet performance, the quantity of products or fuel quality parameters. During 2018-2019, the department received over 260 regulatory reports for vehicles and engines and over 720 reports for fuels.

In 2018-2019, ECCC processed about 270 Canada-unique[3] submissions and almost 1,760 importation declarations for vehicles and engines. Additionally, the department processed 78 Notices of defect and recall notifications covering over 599,000 vehicles and engines. Of those, ECCC influenced 5 Notices of defect covering over 44,000 vehicles and engines. ECCC also began posting basic information summarizing notices of defect and other company notifications submitted to the department on the Government of Canada's Open Data portal.

The regulatory administration of the transportation regulations is supported by ECCC laboratory emissions testing on vehicles and engines, and fuel quality testing in order to verify compliance with the regulations. Occasionally, private laboratories will be used by ECCC to conduct testing. In 2018-2019, the department conducted testing on 102 vehicles and engines.

During 2018-2019, ECCC responded to almost 1,500 inquiries regarding the vehicles and engines regulations and over 500 regarding the fuels regulations.

[3] A Canada-unique vehicle or engine is a vehicle or engine that is specifically listed on a United States Environment Protection Agency (EPA) certificate and sold in Canada, but not sold in the United States; or a vehicle or engine that is not specifically listed on an EPA certificate.

In 2018-2019, ECCC continued to expand its capacity to verify compliance with the transportation sector's emission regulations, including identifying devices to defeat the emission regulations, and carrying out five major inspections at fuels facilities. The expanded program increases opportunities to identify non-compliant regulatees and take enforcement action where required.

During 2018-2019, the department also made the required improvements to NO_x performance reports for the 2017 model year light-duty vehicle fleets to reflect the more stringent Tier 3 provisions and published the 2011 to 2016 model year light-duty vehicle GHG performance report. Those reports, compiled from the annual compliance reports submitted by automobile companies, document the overall fleet performance for each of the specified model years. Aggregated fuel quality data was shared for the first time in 2018-2019 using the Open Data Portal.

More information on ECCC's vehicle, engine and fuel regulations is available online.

Clean fuel standard

The government is developing a Clean Fuel Standard, a key part of the Pan-Canadian Framework on Clean Growth and Climate Change that will reduce the carbon intensity of the liquid, gaseous and solid fuels used in transportation, industry, and buildings. The Clean Fuel Standard aims to lower the carbon intensity of fossil fuels, resulting in significant GHG emissions reductions, while sending a market signal for investment and innovation in low carbon fuels and technologies and reducing compliance costs through a flexible regulatory design.

Since its announcement in 2016, extensive stakeholder engagement and consultations with industry, provinces and territories, Indigenous groups, and environmental non-governmental groups have helped inform the design of the Clean Fuel Standard, including the formation of a Multi-Stakeholder Consultative Committee and a Technical Working Group. Consultations are ongoing to continue informing the development of the gaseous and solid fuel class regulations.

Consumer and commercial products

ECCC has been targeting the reduction of emissions of Volatile Organic Compounds (VOCs) from consumer and commercial products. VOCs are a contributing factor in the creation of air pollution. Control measures have been developed that set VOC content limits in some products, which in turn reduce their emissions. The ECCC VOC in products laboratory conducts testing in order to verify compliance with the regulations. In 2018-2019, the Department completed testing on 120 products including architectural coatings and automotive refinishing products; 56 of these were tested for a special project looking at traffic marking coatings.

In 2018-2019, ECCC published the *2017 Progress report on the Code of Practice for the reduction of VOC emissions from cutback and emulsified asphalt* (the Code). The objective of the Code is to protect the environment by reducing VOC emissions from the asphalt sector by at least 40 percent over a six year period. The Code includes reporting provisions targeting asphalt manufacturers. The first reporting period covered activities from the 2017 calendar year.

In 2018-2019, ECCC worked on the preparation of proposed Volatile Organic Compound Concentration Limits for Certain Products Regulations. The proposed Regulations would establish VOC concentration limits for 130 product categories including personal care, automotive and household maintenance products; adhesives, adhesive removers, sealants and caulks; and other miscellaneous products.

Indoor air quality

In addition to the penetration indoors of outdoor pollutants, indoor air can be contaminated by emissions from building materials, products, and activities inside the home, and by the infiltration of naturally occurring radon from the soil under the building.

The Residential Indoor Air Quality Guidelines summarize the health risks posed by specific indoor pollutants, based on a review of the best scientific information available at the time of the assessment.

In 2018-2019, Health Canada continued risk assessments on indoor carbon dioxide and acrolein. Health Canada also began a new round of risk assessments based upon a recently completed prioritization process. Work has commenced on an assessment of xylenes and the reassessment of benzene.

Health Canada developed a public awareness campaign on carbon monoxide (CO) in indoor air carried out in 30 retail locations in Ontario and British Columbia. A study of air quality in ice arenas was begun with the objective of developing broadly applicable risk management practices. In collaboration with the National Research Council, emission testing of 100 composite wood products and laminate products was conducted in support of the development of regulations.

HC scientists contributed to many other publications, including a series of fact sheets on air quality.

IN 2018-2019 HC PUBLISHED A SERIES OF FACT SHEETS ON AIR QUALITY INCLUDING

Air pollution: what is sulphur dioxide?

Air pollution: what is nitrogen dioxide?

Air pollution: what is ozone?

Air pollution: what are diesel and gasoline exhaust?

Air pollution: what is particulate matter (PM)?

Cooking and Indoor Air Quality

2.4 WATER QUALITY

Water quality is affected in many ways, including by nature's own patterns. The water quality of rivers and lakes changes with the seasons and geographic areas, even when there is no pollution present. It is also affected by human development, particularly by the release of human wastes, animal wastes and chemical substances into the environment.

Water quality is a shared responsibility with provinces and territories. In addition to CEPA, the federal government addresses water quality under other statutes, such as the *Fisheries Act*. Work on water quality under CEPA includes monitoring, scientific research, and leadership on the development of guidelines for water quality.

2.4.1 Monitoring

ECCC's Fresh Water Quality Monitoring program continues to implement a risk-based adaptive management framework in conjunction with statistical analyses to better target monitoring activities to the risks of contaminants and human activities in Canadian watersheds. The approach has been used to optimize monitoring locations and adjust monitoring frequencies relative to the environmental risks and to report on changes in environmental condition.

2.4.2 Risk management activities

HC works in collaboration with the provinces and territories to establish a list of priority contaminants for developing or updating Guidelines for Canadian Drinking Water Quality (GCDWQ) and their technical documents. Priorities for guideline development are established approximately every four or five years, using exposure information from federal, provincial and territorial sources and up-to-date science, international actions, as well as taking into consideration jurisdictional needs. Health-based guidelines are developed for drinking water contaminants that are found or expected to be found in drinking water supplies across Canada and at levels that could lead to adverse health effects. The GCDWQ are used by all provinces and territories as a basis to establish their own regulatory requirements regarding the quality of drinking water in their jurisdictions to manage the risk from drinking water.

HC has also been modernizing its drinking water program to increase openness and transparency and further engage the Canadian public. New or updated GCDWQ are published in the *Canada Gazette*, Part I, while the technical document continues to be published on Health Canada's website. The final GCDWQ are also accompanied by a plain language summary to increase public's access.

As part of the drinking water program's modernization efforts, the process for prioritizing the development and update of GCDWQ was published in 2019. The list of priority contaminants will be finalized and form the basis for the future workplan for the Federal-Provincial-Territorial Committee on Drinking Water (CDW).

For increased transparency, each guideline contains a section dedicated to a comparison with standards of international agencies and other jurisdictions, including new or updated standards. In some instances, drinking water values for specific pollutants vary internationally due to a number of considerations. All leading international agencies and jurisdictions consider the science that has been used by other agencies on contaminants of joint concern. However, each jurisdiction maintains its own considerations that are specific to climate, geology, industrial uses and other factors which are characteristic of the country, thus accounting for the potential for different values in different jurisdictions (whether higher or lower). An international comparison is more than choosing the most stringent value or lowest number for drinking water standards around the world.

To help inform the development of the guidelines, HC keeps abreast of new scientific studies and reviews and continually assesses standards and guidelines respecting the quality of drinking water from leading international agencies, including:

- United States Environmental Protection Agency (U.S. EPA)
- World Health Organization (WHO)
- Australia National Health and Medical Research Council (ANHMRC)
- European Union (EU)

Internationally, Canada is considered a leader in the development of drinking water quality guidelines. Health Canada is recognized as a Collaborating Centre for Water Quality by the World Health Organization, highlighting Canada's international prominence and expertise.

It was determined that for 2018-2019, there were no updates from other jurisdictions that should be considered for the development of a new guideline or an update to an existing one. However, priorities are continuously informed by new data, science and international actions.

Table 11 lists the guidelines that were published in 2018-2019.

Table 11. Guideline documents for Canadian drinking water quality from April 2018 to March 2019

Published final guidelines	In progress
Chromium	Quantitative microbial risk assessment (QMRA)
Bromate	Copper
Cyanobacterial Toxins	Strontium
Perfluorooctanoic Acid (PFOA)	1,4-dioxane
Perfluorooctane Sulfonate (PFOS)	Barium
Lead	Enterococci
	Chloramines
	Cadmium
	Natural organic matter
	Total coliforms

2.5 WASTE

Waste generally refers to any material, non-hazardous or hazardous, that has no further use, and which is managed at recycling, processing or disposal sites or facilities.

In Canada, the responsibility for managing and reducing waste is shared between the federal, provincial, territorial and municipal governments. Municipal governments are responsible for collecting and managing waste from homes for recycling, composting and disposal, while provincial and territorial authorities are responsible for the approval, licensing and monitoring of waste management operations.

For its part, ECCC exercises responsibilities with respect to disposal at sea of specified materials, as well as the international and interprovincial movements of hazardous waste and hazardous recyclable material.

2.5.1 Monitoring

Disposal at sea site monitoring program

By monitoring disposal sites, ECCC is able to verify that the permitting of disposals is sustainable and that permit holders can have continued access to suitable sites. Where monitoring indicates a problem or where the site has reached its capacity over time, management action in the form of closing, moving or altering the site use can occur.

Due to the timing of field work and the length of time required for data analysis, the results of disposal at site monitoring projects are typically not available until at least a year after they are completed. Therefore the 2017-2018 results are presented in this CEPA report for all regions, as well as the 2018-2019 results where available. Any pending 2018-2019 results will be presented in the 2019-2020 CEPA report. In 2017-2018, monitoring projects were completed at 13 ocean disposal sites nationally (or 13% of the 104 actively used sites that fiscal year).

In April 2017, in the Pacific and Yukon region, monitoring was conducted at four disposal at sea (DAS) sites.

- At the Cape Mudge, Comox (Cape Lazo), Malaspina and Point Grey DAS sites, monitoring consisted of sediment sampling and analysis for physicochemical parameters toxicity testing, and sediment profile imaging (SPI) surveys to better understand the potential effects related to disposal activities. The results were as follows:
    - For all sites, the mean of concentrations of contaminants (cadmium, mercury, total PAHs and total PCBs) were found to be below national screening levels.
    - With the exception of the field duplicate sample from the ambient area at Point Grey, all samples from all sites passed the acute and sub-lethal toxicity tests and showed no evidence of toxicity to amphipods, echinoids and bacteria. The field duplicate composite failed the amphipod test and passed both of the sub-lethal toxicity tests. Proximity to anthropogenic sources could attribute to the failure. Toxicity tests will be performed as part of subsequent monitoring programs to verify there is no issue at the site.
    - All sites where Sediment Profile Imaging (SPI) was conducted (Cape Mudge, Comox (Cape Lazo), and Point Grey), the surveys revealed that disposal activity did not appear to affect the benthic habitat quality outside of disposal site, and physicochemical sediment sampling and SPI surveys confirmed that all disposal material remains within the footprints of the disposal sites. Some wood waste was observed outside the disposal site at Cape Mudge, which could be attributed to current and historical forestry activities in the area.

In 2018-2019, disposal site monitoring surveys were conducted at Cape Mudge, Sand Heads and Newcombe Channel. These included physicochemical sediment sampling, toxicity testing and Sediment Profile Imaging benthic studies. Preliminary SPI results at all sites indicate that no concerns exist with regard to impacts to benthic habitat outside of the disposal site. All other results for the 2018-2019 surveys are pending.

In the Quebec region, in 2017-2018, the efforts of the ECCC's environmental monitoring programs were focused on six disposal sites under two separate projects to monitor the presence or absence of the deposited material. Hydro acoustic surveys were conducted at the following disposal sites M-5(Millerand), PBCM-1 (Pointe-Basse), IE-6 (Ile-d'Entree), in the Magdalen Islands, as well as three sites in Gaspésie, ST-4 (Sainte-Thérèse), SG-2 (Saint-Godefroi), and G-5 (Gascons).

- At site M-5, measurements did not detect deposited volumes in place, which suggests material was moved by currents. They also show that there is still sufficient draft for safe navigation, however this site will be monitored more closely to study the sediment dynamics at this location.

- At sites PBCM-1 and IE-6, it was found that all dredged material was deposited at the coordinates set out in the permit and that approximately 80% to 90% of material is still in place. No management actions are required at these sites.
- At site ST-4, where no permitted deposit occurred, results confirmed that there were no unreported deposits and no management actions are required.
- The hydrographic surveys conducted at disposal sites SG-2 and G-5 suggest that no material was deposited in the authorized area. However, permit records show that 8,896 m^3 and 2,575 m^3 of dredged material, respectively, was placed at the sites between 2013 and 2017. Further work will be done to ensure that when these disposal sites are next used, the material is placed only at the authorized disposal site.

In 2018-2019, hydroacoustic surveys were conducted at five sites in Gaspésie: Sainte-Thérèse-de-Gaspé (ST-4), L'Anse-à-Beaufils (AB-5), L'Anse-à-Brillant (ABR-1), Saint-Godefroi (SG-2) and Port-Daniel-Est (PD-6) to determine if disposal activities had been carried out in accordance with the conditions of the DAS permits. The results from 2018-2019 are still pending.

A preliminary study on the presence of micro-plastics in sediments in the Quebec region was initated. In 2017-2018, 22 sediment samples were collected from commercial harbours of Magdalen Islands that are currently in use and that are regularly dredged. In 2018-2019, additional samples were collected in harbours of Gaspésie in order to expand the geographic coverage of this project to all harbours currently in use in the Quebec region. The study also aimed at evaluating a new method to measure the concentration of plastics in sediments. This project is ongoing.

In the Atlantic region, in 2017-2018, monitoring studies were conducted at three DAS sites; the Outer False Harbour DAS site in Nova Scotia, the Woods Island DAS site in Prince Edward Island and the Pigeon Hill Bar DAS site in New Brunswick.

- At the Outer False Harbour site in Nova Scotia, a post-disposal combined bathymetric and backscatter survey was conducted to assess the dredged material remaining at the site following the winter storm period and to classify the seafloor bottom. A high resolution optical imaging study was also conducted in order to characterize the benthic substrate and identify macroflora and fauna. Macroflora appeared consistent in composition except for the area closest to the open ocean. Macrofauna was generally evenly observed throughout all sampled areas. Benthic substrate composition and habitat types varied throughout the project area. The results of both these studies will be used to refine future monitoring at this site.
- At the Woods Island site in Prince Edward Island, a post-disposal survey was conducted on December 5, 2017 to determine the location and surface area of the sediments disposed at sea. The survey, conducted the day after disposal operations had concluded, determined that within the entire site, approximately 16% of material was remaining and covered an area of 11,640 m^2.
- At Pigeon Hill Bar site in New Brunswick, a post-disposal hydrographic survey was conducted to assess the compliance with the permit conditions, and to define the immediate post-disposal footprint. Disposal activities were conducted in compliance with the disposal permit. It was determined that the footprint of the disposed material was still largely contained within the disposal site, fifteen days after disposal operations had ceased.

In 2018-2019, monitoring studies were conducted at four disposal sites: Woods Island, Black Point, Chance Harbour, and Pigeon Hill Bar.

- For the Woods Island DAS site, a survey was conducted to test the prediction that the disposal site would return to pre-disposal conditions in less than one year following the completion of disposal activities. Fifty weeks after disposal operations had concluded, less than 3% of the total volume of disposed material remained within the disposal site and covered about 9% of the disposal site. These results showed that disposed material had mostly moved offsite within one year.
- For the Black Point DAS site, a survey was carried out as part of the monitoring in support of the ten-year Management Plan for the Black Point Dredged Material Disposal Site, Saint John Harbour, New Brunswick. Supplementary analyses of the results of the 2018 and 2016 hydrographic surveys were also conducted. The supplemental analyses determined that disposals had occurred beyond the western boundary of the site, possibly occurring as early as the year 2000. It appears that the disposal outside the boundary resulted from an incorrect defining of the boundary rather than non-compliant disposal activities or slumping of the disposed material. As a result, the western boundary of the Active Area was extended. It was also recommended that the surveyed area be extended along the western, northern and eastern sides of the disposal site in future surveys. Lastly, it was determined that in order to better manage the disposal site, the hydrographic surveys should be conducted annually rather than biennially.
- For the Chance Harbour DAS site, a post-disposal hydrographic survey was required to confirm the location and surface area of the sediments disposed at sea and was conducted approximately four months after the completion of disposal activities. After four months, it was not possible to define a footprint arising from the disposal activities. However, there were features on the seabed that were suggestive of the disposed material.
- A hydrographic survey was conducted at the Pigeon Hill Bar DAS site immediately following the completion of the 2018 disposal activities. The results of the August 2018 hydrographic survey were compared to the November 2017 survey. Changes in the footprint and depth differences between the two surveys were noted. From the comparison, there appeared to be some erosion of the material disposed in 2017. It was recommended that another post-disposal survey be conducted to verify the accuracy of the dispersion predictions following the expiration of the current dredging permit in 2019.

2.5.2 Risk management activities

In addition to the activities listed below, risk management actions described in section 2.1.4 on toxic substances also contribute to the overall improvement of waste management.

Disposal at sea

Part 7, Division 3 of CEPA imposes a general prohibition on the disposal at sea of substances or onto sea ice. Disposal at sea activities conducted under a permit from ECCC are exempt from this prohibition and permits are only available for a short list of low risk wastes. A permit is only granted after an assessment, and only if disposal at sea is the environmentally preferable and practical option.

On October 12, 2018, ECCC and the Tsleil-Waututh Nation approved an agreement for collaborative decision making on disposal at sea permitting, monitoring and related science in Tsleil-Waututh Nation core territory in the Burrard Inlet near Vancouver, BC. This agreement will help the department meet its duty to consult with Tsleil-Waututh Nation on disposal at sea matters, including at the Point Grey disposal site, which is one of the most actively used disposal sites in Canada.

The negotiation of this agreement confirmed that the Crown and Tsleil-Waututh Nation share many important interests, including protecting the marine environment and promoting sustainable development.

International activities

Implementing the DAS requirements helps Canada meet its obligations as a party to the 1972 London Convention and the more modern London Protocol (1996). Canada reports the number of permits, quantities and types of wastes, and results of disposal site monitoring to the London Protocol Secretariat each year.

In 2018-2019, ECCC successfully hosted more than 20 countries in Vancouver for the Scientific Group Meetings of the London Protocol and Convention. In advance of the main meetings, ECCC developed and delivered a new workshop to train participants on how to assess and issue permits to prevent marine pollution from disposal of waste or other matter at sea.

During the meetings, progress was made by the delegates on issues including marine plastics, better disposal assessment guidance for platforms and fiberglass vessels, and other science issues to support decision making. The hands-on workshop was acknowledged by participants to have increased their ability to implement the London Protocol, with the International Maritime Organization suggesting that the new format be repeated in the future as a means of increasing ratification of the London Protocol Treaty, and assisting new parties to implement the treaty.

In 2018, Canada continued to Chair the London Protocol Compliance Group, which encourages and supports compliance and ratification of the treaty. Canada also completed a four year term as Chair of the Scientific Groups of the Protocol and Convention.

Disposal at sea permits

In 2018-2019, 93 permits were issued in Canada for the disposal of 9.4 million tonnes of waste and other matter at sea (Tables 12 and 13), compared to 70 permits for the disposal of 6.2 million tonnes in 2017-2018. The significant increase from the previous year was largely due to the permitting of a few major projects for port development and the continued need to remove dredged material from harbours and waterways to keep them safe for navigation. Also permitted was excavated native till (geological matter) that is disposed of at sea in the lower mainland of British Columbia, where on-land disposal options for clean fill are extremely limited. Fishprocessing waste was also permitted in remote communities where there is no access to reuseandrecycling opportunities.

Table 12. Disposal at sea quantities permitted (in tonnes) and permits issued in Canada from April 2018 to March 2019

Material	Quantity permitted	Permits issued
Dredge material	7,395,050	53
Fisheries waste	38,420	28
Geological matter	1,959,100	10
Vessels	6,755	2
Organic matter	0	0
Total	9,399,325	93

Note: Dredged material and geological matter were converted to tonnes using an assumed density of 1.3 tonnes per cubic metre.

Table 13. Disposal at sea quantities permitted (in tonnes) and permits issued by region from April 2018 to March 2019

Material	Atlantic		Quebec		Pacific and Yukon		Prairie and Northern	
	Quantity permitted	Permits issued	Quantity permitted	Permits issued	Quantity permitted	Permits issued	Quantity permitted	Permits issued
Dredge material	1,805,70	16	46,950	11	5,036,200	25	83,200	1
Fisheries waste	37,270	25	1,150	3	--	--	--	--
Geological matter	--	--	--	--	1,959,100	10	--	--
Vessels	2,417	1	--	--	4,338	1	--	--
Organic matter	--	--	--	--	--	--	--	--
Total	1,845,387	42	48,100	14	6,999,638	36	83,200	1

Note: Dredged material and geological matter were converted to tonnes using an assumed density of 1.3 tonnes per cubic metre.

The number of permits issued increased in 2018-2019 (Figure 9). The quantities permitted continue to fluctuate from year to year. Building of infrastructure led to an increase in both dredged material and inert, inorganic geological matter (excavated material) this past fiscal year (Figure 10).

Figure 9. Number of disposal at sea permits issued in each fiscal year by type of material

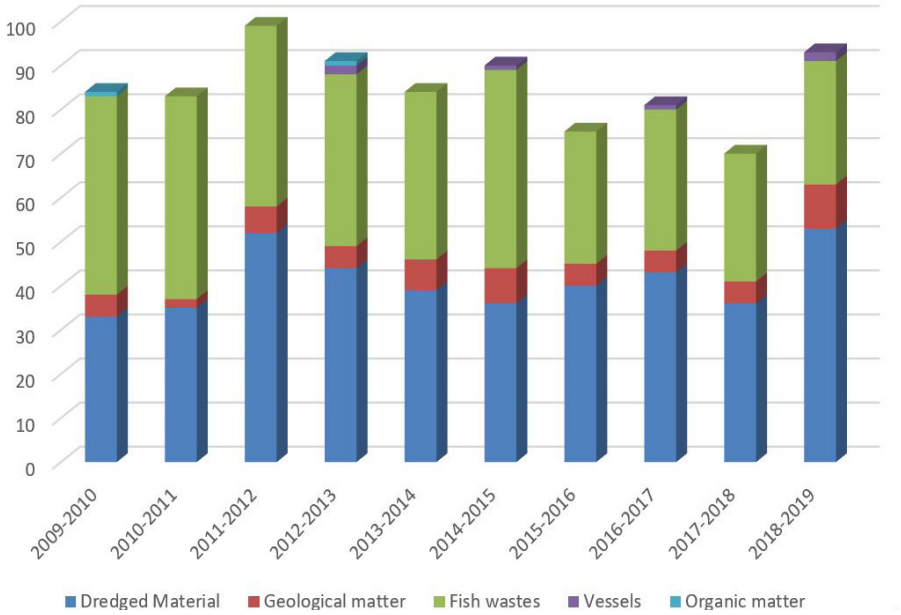
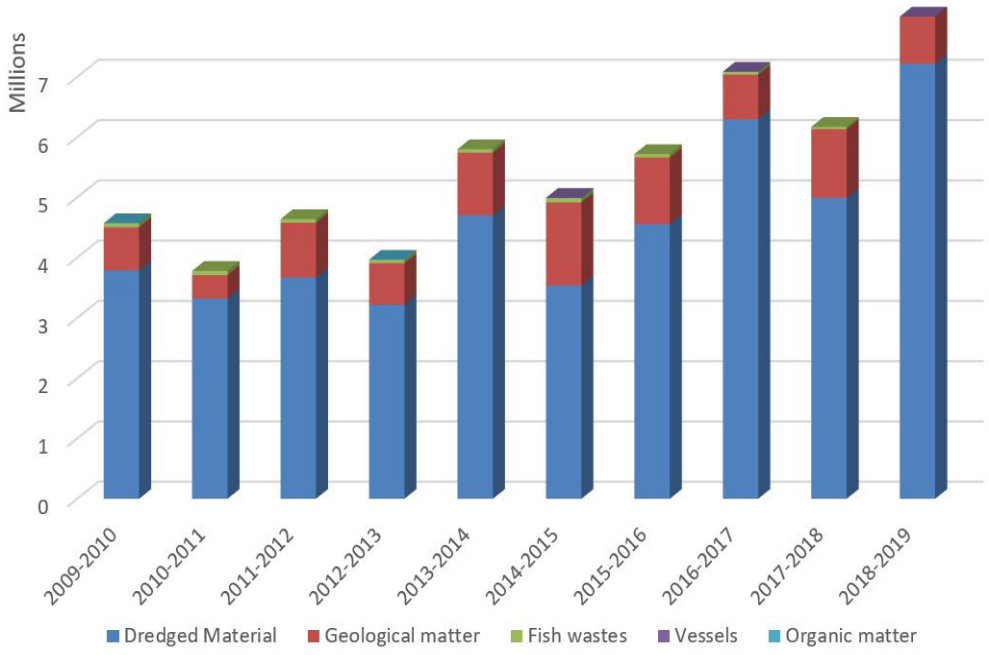


Figure 10. Annual disposal at sea quantities permitted (in millions of tonnes)



Further information on disposal at sea is available online.

Controlling the movement of hazardous waste and hazardous recyclable material

With respect to managing the movement of hazardous waste and hazardous recyclable material, CEPA provides authority to:

- make regulations governing the export, import and transit of waste (including both hazardous and prescribed non-hazardous waste) and hazardous recyclable materials
- establish criteria for refusing an export, import or transit permit, should the hazardous waste or hazardous recyclable material not be managed in a manner that will protect the environment and human health
- make regulations governing movements of hazardous waste and hazardous recyclable materials between provinces and territories

Through the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations, the Interprovincial Movement of Hazardous Waste Regulations* and the *PCB Waste Export Regulations*, 1996, Canada implements its international obligations as a party to the:

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)
- Organization for Economic Co-operation and Development Decision on the Control of Transboundary Movement of Wastes Destined for Recovery Operations (OECD Decision)
- Canada-United States Agreement on the Transboundary Movement of Hazardous Waste

In 2018, ECCC processed 2,062 notices for proposed imports, exports and transits of hazardous wastes and hazardous recyclable materials under the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*. The notices received covered 29,369 waste streams, which exhibited a range of hazardous properties such as being flammable, acutely toxic, oxidizing, corrosive, dangerously reactive and environmentally hazardous. Of the notices received, 1,771 permits were issued. From these permits, 32,765 individual transboundary shipments of hazardous waste and hazardous recyclable material were reported in movement documents received by ECCC. By comparison, in 2017, 31,759 individual transboundary shipments were done; an increase of about 3%, in 2018.

In 2018, almost all imports (99.6%) and exports (96.5%) of hazardous wastes and hazardous recyclable materials occurred between Canada and the United States. The remaining import exchanges occurred with Germany, the United Kingdom, Australia and Vietnam while the remaining exports occurred with Mexico, the Republic of Korea, Belgium, Germany and Austria.

The quantity of hazardous wastes and hazardous recyclable materials imported into Canada was 388,289 metric tonnes (t) in 2018. This represents an increase of 18,317 t or 4.7% compared to 2017.

Shipments imported destined for recycling totaled 241,457 t and represented about 62% of all imports in 2018. Imports of all hazardous wastes and hazardous recyclable materials in 2018 were shipped to authorized facilities in five provinces: Quebec, Ontario, British Columbia, New Brunswick and Alberta. Hazardous recyclable material imported into Canada in the greatest quantities were:

- hydraulic fluids (used oil)
- spent lead-acid batteries
- spent sulfuric acid, corrosive liquids, waste liquors from pickling of metals
- flammable liquids, organic solvents
- metal-bearing waste

The remaining 146,832 t imported were hazardous wastes (about 38%) and were mostly composed of:

- soil, sand, or clay, including dredging spoils
- waste oil/water, hydrocarbon/water mixtures, and emulsions
- organic solvents/flammable liquids
- waste tarry residues arising from refining, distillation, and any pyrolytic treatment
- sludges from water-purification plants and wastewater treatment plants
- wastes from the production, formulation and use of biocides and phytopharmaceuticals, pesticides, and herbicides

The quantity of hazardous waste and hazardous recyclable materials exported was 378,315 t in 2018. This represents a decrease of 8,998 t or 2.3% from 2017.

Shipments exported for recycling totaled 315,221 t and represented about 83% of all exports in 2018. Exports of hazardous recyclable materials in 2018 originated from seven provinces and one territory: Ontario, Quebec, New Brunswick, British Columbia, Alberta, Saskatchewan, Manitoba and Northwest Territories. The majority of hazardous recyclable material exported abroad for recycling included:

- spent catalyst materials
- waste acidic or basic solutions

- residue from pollution control operations
- waste oil/water, hydrocarbon/water mixtures, and emulsions, hydraulic fluids (used oil)
- batteries and other electrical cells
- ashes or cinders, metal-bearing waste

The remaining 63,094 t exported were hazardous wastes (16.7%) and were mostly composed of:

- waste oil/water, hydrocarbon/water mixtures, and emulsions (used oils)
- liquids or sludges containing metal
- contaminated equipment
- clinical and related wastes
- wastes resulting from surface treatment of metals and plastic
- spent sulfuric acid, corrosive liquids, and waste liquors from pickling of metals

Tables 14 and 15 list the quantities of hazardous wastes and hazardous recyclable materials exported and imported from 2009 to 2018.

Table 14. Hazardous waste and hazardous recyclable material, imports, 2009-2018 (Metric tonne)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Waste	268,391	146,499	151,295	101,796	190,841	159,008	118,403	118,130	129,311	146,832
Recyclables	221,778	217,663	243,491	243,434	245,110	221,354	249,323	258,984	240,661	241,457
Total imports	490,169	364,162	394,786	345,230	435,951	380,362	367,726	377,114	369,972	388,289

Table 15. Hazardous waste and hazardous recyclable material, exports, 2009-2018 (Metric tonne)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Waste	105,234	70,740	86,500	91,847	93,786	94,601	86,623	63,513	70,929	63,094
Recyclables	315,631	357,627	374,207	413,614	422,388	436,608	429,391	349,412	316,384	315,221
Total imports	420,865	428,367	460,707	505,461	516,174	531,209	516,014	412,925	387,313	378,315

Note: Data are revised periodically as new information becomes available. Therefore, information presented here may differ from information published in other reports.

The proposed *Cross-Border Movement of Hazardous Waste and Hazardous Recyclable Materials Regulations* were published in the *Canada Gazette*, Part I on Saturday, December 15, 2018. The proposed regulations would consolidate and streamline the requirements set out *under the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations, the Interprovincial Movement Regulations of Hazardous Waste Regulations* and the *PCB Waste Export Regulations, 1996.*

2.6 ENVIRONMENTAL EMERGENCIES

Part 8 of CEPA (Environmental Matters Related to Emergencies) addresses the prevention of, preparedness for, response to and recovery from uncontrolled, unplanned or accidental releases into the environment of substances that pose potential or immediate harm to the environment or danger to human life or health.

Part 8 of CEPA provides the authority, among other things, for making related regulations, guidelines and codes of practice. It also establishes a regime that makes the person who owns or has the charge, management or control of such a substance liable for restoring the damaged environment and for the costs and expenses incurred in responding to an environmental emergency.

The *Environmental Emergency Regulations* (referred to as the E2 Regulations) require any person who owns, manages, or has the control of a regulated substance at a place in Canada, at or above the established threshold, to notify ECCC when this quantity threshold is met or when the maximum container capacity meets or exceeds this threshold. If the total quantity and container capacity thresholds are both met, there is an additional requirement to prepare and exercise an environmental emergency (E2) plan for prevention, preparedness, response and recovery in the event of an environmental emergency.

When the new regulations come into force, there were approximately 4,895 regulatees from various sectors under the E2 Regulations. Of these regulatees, approximately 3,000 were required to prepare E2 plans. The seven most commonly identified substances requiring E2 plans are propane, anhydrous ammonia, butane, pentane, gasoline, hydrochloric acid, and chlorine.

In 2018-2019, ECCC's regional activities associated with the implementation of the E2 Regulations included conducting site visits, delivering presentations to the regulated community, and promoting and enforcing compliance with regulated persons. As a result of targeted efforts to increase the implementation of E2 plans by regulated parties, approximately 95% of those regulated parties which require E2 plans reported to the department that they have fully implemented and tested their plans.

On August 21, 2019, the *Environmental Emergency Regulations* were repealed and replaced by the *Environmental Emergency Regulations, 2019*. The new regulations clarified the requirements of the legislation and reinforce sound environmental emergency management and timely public notifications before, during and after an environmental emergency. They also better protect Canadians and the environment by adding 33 new substances to the list of regulated substances in Schedule 1. The responsible person subject to the Environmental Emergency Regulations, 2019 is able to submit required information through the new reporting platform which is accessible through ECCC's Single Window Information Management (SWIM) system.

3. REPORTING PROGRAMS AND EMISSION INVENTORIES

3.1 REPORTING PROGRAMS

There are two mandatory reporting programs under CEPA, which require facilities to report on their releases or emissions of specified substances into the environment. They are the:

- National Pollutant Release Inventory reporting
- Greenhouse Gas Reporting Program

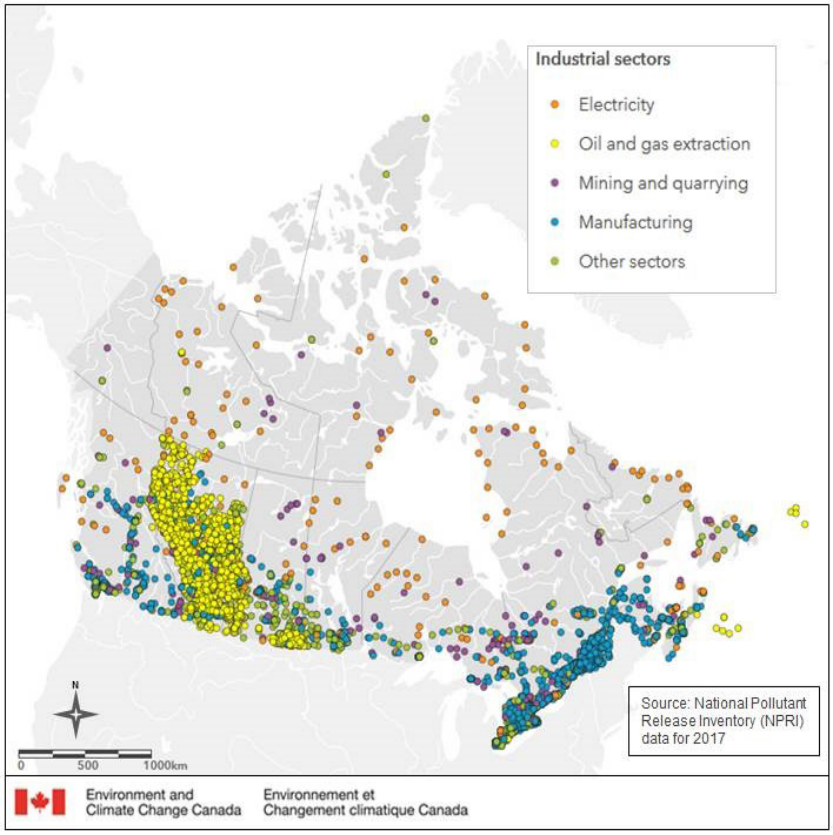
Data for both programs is submitted through ECCC's Single Window Information Management (SWIM) system. Further information on the SWIM system is available online.

National Pollutant Release Inventory Reporting

The National Pollutant Release Inventory (NPRI), Canada's legislated, publicly accessible national inventory, collects information from Canadian industrial, commercial and institutional facilities on their releases (to air, water and land), disposals, and transfers of pollutants and other substances of concern. Since 1993, owners or operators of facilities that have met the NPRI reporting requirements have reported on an annual basis. Data collected under the NPRI is a key input to Canada's comprehensive Air Pollutant Emissions Inventory (APEI) and the Black Carbon Inventory, described below.

NPRI data for the 2017 reporting year was published in preliminary form in July 2018 and in reviewed form in December 2018. Over 7,000 facilities, located in every province and territory, reported to the NPRI for the 2017 reporting year (Figure 11).

Figure 11. Location of facilities that reported to the NPRI for the 2017 reporting year



The NPRI Multi-Stakeholder Work Group is the primary consultation mechanism for the NPRI program, with representatives from industry associations, environmental groups and Indigenous organizations providing input on changes to the requirements and other aspects of the program, such as tools to access the data. Consultations during 2018-2019 included a number of teleconferences and paper-based consultations. Consultations focused on proposed changes to the requirements for 2020 reporting, including changes to reporting of air pollutants to provide more information for air quality modelling and for certain substances such as naphthenic acids, dioxins, furans, and hexachlorobenzene.

In addition to the above-mentioned consultations, the NPRI program shares information and gathers ideas from stakeholders and the public. Activities include engaging users of NPRI data to get input on how to meet their needs; working collaboratively with other government programs and international organizations; and updating stakeholders regularly on the NPRI.

During 2018-2019, ECCC undertook a number of initiatives to respond to the needs of various users of NPRI data. For example, the Department held consultations on proposed changes to NPRI reporting requirements that are proposed to take effect for the 2020 reporting year (see section 3.1). ECCC also continued to improve the accessibility of datasets to facilitate analysis by data users with the publication of 2017 data.

Greenhouse Gas Reporting Program

ECCC requires annual reporting of GHG emissions from facilities (mostly large industrial operations) through its Greenhouse Gas Reporting Program (GHGRP). The GHGRP is part of ECCC's ongoing effort to develop, in collaboration with the provinces and territories, a nationally consistent, mandatory GHG reporting system, in order to meet the GHG reporting needs of all jurisdictions and to minimize the reporting burden for industry and government.

Key objectives of the GHGRP are to provide Canadians with consistent information on facility-level GHG emissions, to support regulatory initiatives, and to support the National GHG Inventory. The data collected are also shared with provinces and territories.

In January 2019, a Notice was published in the *Canada Gazette*, Part I requiring the reporting of GHG emissions for the 2019 calendar year. As part of phase 2 of the program expansion, the Notice included the following changes from previous years: enhanced reporting and methodological requirements for facilities in nine additional industry sectors, including facilities engaged in electricity and heat generation, petroleum refining, pulp and paper manufacturing, mining, base metal smelting/refining, and the production of ethanol, ammonia, nitric acid and hydrogen. These changes build from similar expanded reporting requirements that were issued in 2017 (phase 1).

The 2017 reporting cycle marks the first year of the expansion to the program where one key change was the lowering of the reporting threshold from 50,000 to 10,000 tonnes CO_2 equivalent. This resulted in an additional 953 facilities reporting for the first time to the GHGRP in June 2018. The 2017 facility-reported data was made publicly available in April 2019. Information about the GHGRP, as well as the phase 2 consultations and the outcomes, which were posted in December 2018 are available online.

3.2 EMISSION AND RELEASE INVENTORIES

ECCC compiles and maintains five inventories of substances released into the environment. These are the:

- National Pollutant Release Inventory
- Air Pollutant Emissions Inventory
- Black Carbon Emissions Inventory
- Facility Greenhouse Gas Emissions Overview
- National Greenhouse Gas Inventory

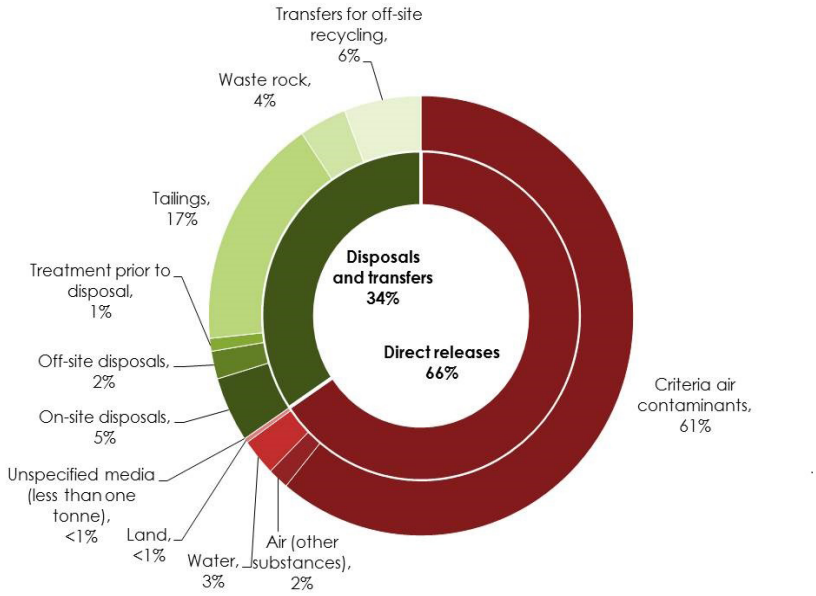
National Pollutant Release Inventory

NPRI information is a major starting point for identifying and monitoring sources of pollution in Canada, and in developing indicators for the quality of our air, land and water. The NPRI helps determine if regulatory or other action is necessary to ensure reductions, and if so, the form that action should take. Public access to the NPRI data through an annual data highlights, an online data search tool, location-based data for use in mapping and downloadable datasets encourages industry to prevent and reduce pollutant releases, and improves public understanding about pollution and environmental performance in Canada.

In 2017, 7,001 facilities reported to the NPRI a total of 4,920,807 tonnes covering over 320 substances (Figure 12):

- 3,226,906 tonnes of pollutants were released directly to the environment
- 1,403,573 tonnes were disposed to landfills, applied to land or injected underground, either on the facility site or off-site
- 288,328 tonnes were transferred off the facility site for treatment prior to final disposal or for recycling and energy recovery

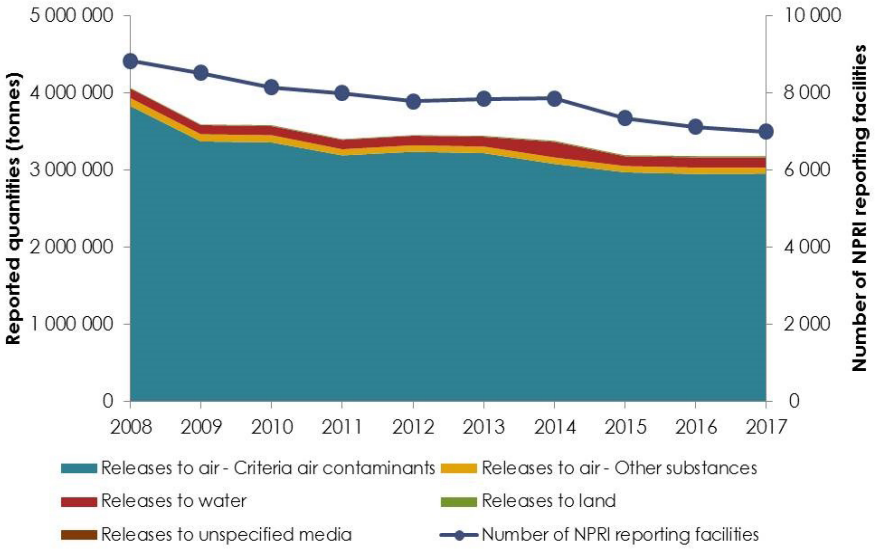
Figure 12. Breakdown of total quantities reported in 2017, by reporting category



Between 2008 and 2017, releases to the environment reported to the NPRI decreased by nearly 21% (845,277 tonnes) (Figure 13). In particular:

- oreleases to air decreased by 22% (838,026 tonnes)
- oreleases to water increased by 8% (9,749 tonnes)
- oreleases to land increased by 109% (8,168 tonnes)
- oreleases of substances (i.e., unspecified media) where the total release quantity was less than one tonne decreased by 49% (386 tonnes)

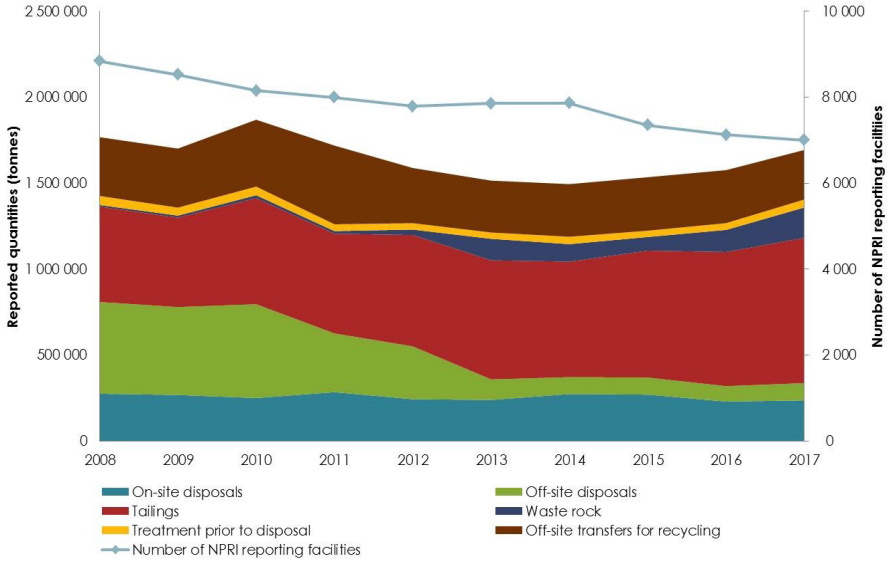
Figure 13. Total direct releases between 2008 and 2017



Between 2008 and 2017, releases to the environment reported to the NPRI decreased by nearly 21% (845,277 tonnes) (Figure 13). In particular:

- off-site disposals decreased by 81% (433,236 tonnes)
- on-site disposals decreased by 14% (38,724 tonnes)
- off-site transfers for recycling decreased by 16% (54,115 tonnes)
- disposals of waste rock (rock removed to reach ore) increased by 1,674% (167 095 tonnes)
- disposals of tailings (materials left when minerals are removed from ore) increased by 52% (290,609 tonnes)

Figure 14. Total disposals and transfers between 2008 and 2017



Pollution prevention data submitted to the NPRI is analyzed and outlined in the NPRI annual highlights. Pollution prevention activity data submitted by facilities is also summarized on the "How your business can prevent pollution" webpage, which provides an overview and examples of the implementation of the seven common pollution prevention techniques among Canadian facilities.

Air Pollutant Emission Inventory

Canada's Air Pollutant Emission Inventory (APEI) is a comprehensive inventory of air pollutant emissions at the national, provincial and territorial level primarily based on data in the NPRI. Since 1990, the APEI has compiled emissions of 17 air pollutants contributing to smog, acid rain and poor air quality.

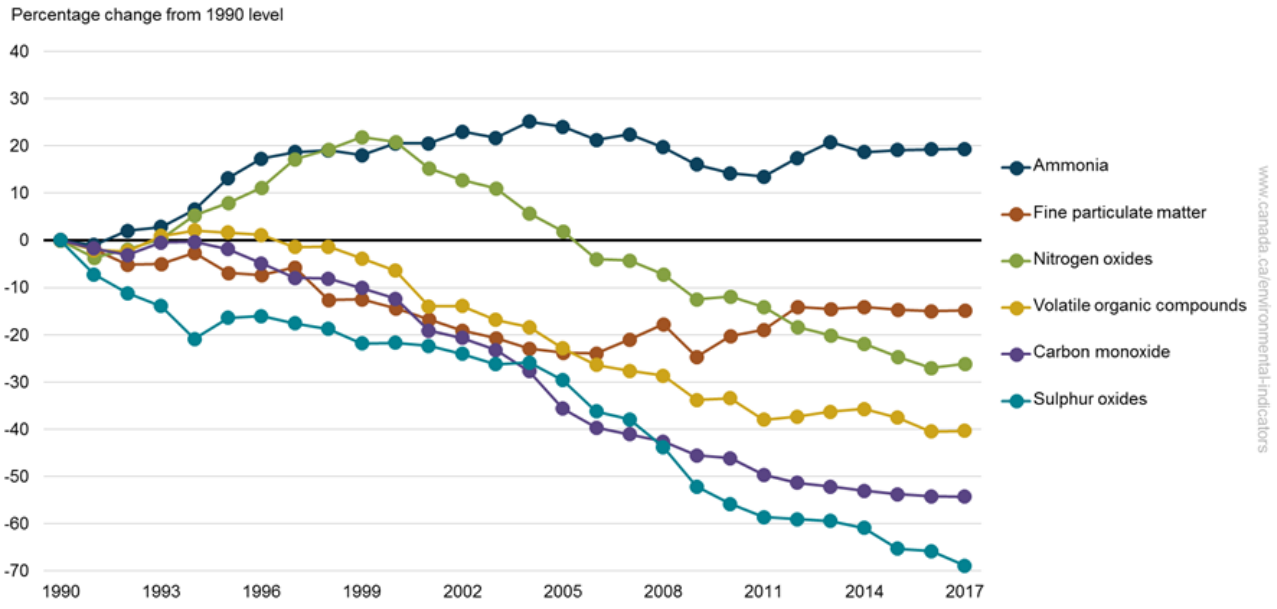
This inventory serves many purposes including fulfilling Canada's international reporting obligations under the 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the associated protocols ratified by Canada for the reduction of emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM), cadmium (Cd), lead (Pb), mercury (Hg), dioxins and furans, and other persistent organic pollutants (POPs). The APEI also supports monitoring and reporting obligations under the Canada-U.S. Air Quality Agreement, the development of air quality management strategies, policies and regulations, provides data for air quality forecasting models, and informs Canadians about pollutants that affect their health and the environment.

According to the APEI, 14 of the 17 reported air pollutants show decreases compared to historical levels.

- A few sources of pollutants exerted a dominant influence in the downward trends in emissions. In particular, decreases in emissions of sulphur oxides (SO_x), cadmium (Cd), lead (Pb), mercury (Hg) and polycyclic aromatic hydrocarbons (PAH) from non-ferrous refining and smelting, and from mining and rock quarrying strongly contributed to the overall downward trends in emissions of these pollutants.

- In addition, reductions in nitrogen oxide ($NO_{x)}$ emissions from light-duty gasoline trucks and vehicles, as well as in volatile organic compounds (VOC) and carbon monoxide (CO) emissions associated with the combustion of gasoline, liquid petroleum gas or natural gas by off-road equipment were instrumental in reducing national emissions of these pollutants.
- Improvements in incineration technologies contributed significantly to decreases in emissions of hexachlorobenzene (HCB) and dioxins and furans (D/F).
- Improved agricultural practices and the adoption of more modern wood combustion equipment also contributed to a 15% decrease in emissions of particulate matter with a diameter less than 2.5 micrometers ($PM_{2.5}$).
- An 11% increase in PM10 emissions since 1990 contrast with the general trends described above, which is largely due to increased transportation as well as construction operations.
- Another exception to the general downward trends is the observed increase in emissions of ammonia (NH_3), which were 19% above 1990 levels in 2017; the upward trend in ammonia emissions is driven by fertilizer application and animal production.

Figure 15. Emissions trends for selected air pollutants in Canada, 1990 to 2017



Black carbon (BC) is a short-lived, small aerosol (or airborne) particle linked to both climate warming and adverse health effects.

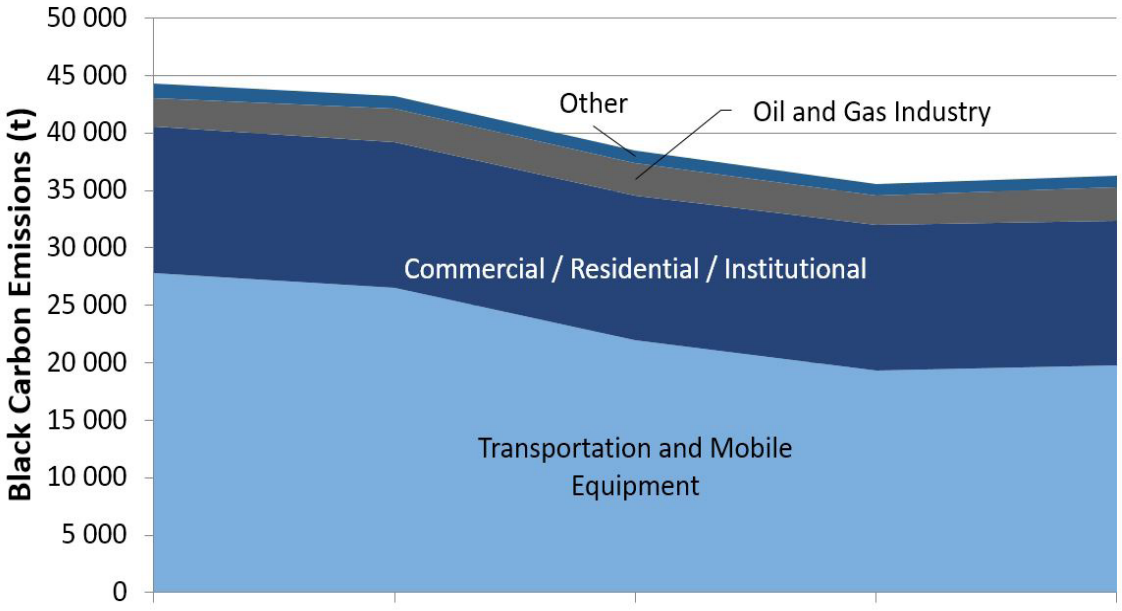
As a member of the Arctic Council, Canada has committed to producing an annual inventory of black carbon emissions. The associated report serves to inform Canadians about black carbon emissions and provide valuable information for the development of air quality management strategies.

The data used to quantify black carbon emissions are taken from the Air Pollutant Emission Inventory, specifically fine particulate matter ($PM_{2.5}$) emissions from combustion-related sources, such as transportation and mobile equipment and home firewood burning.

According to Canada's 2019 Black Carbon Emission Inventory the following trends were observed (see Figure 16).

- In 2017, approximately 36 kilotonnes (kt) of black carbon were emitted from human activities.
- Transportation and mobile equipment, and home firewood burning are the largest sources of black carbon, accounting for 20 kt (54%) and 12 kt (32%) respectively, of total emissions in 2017.
- Since 2013, black carbon emissions have decreased by 8.0 kt (18%). This overall decrease is attributed to declining emissions from transportation and mobile equipment, consistent with observed downward trends in emissions of fine particulate matter (upon which black carbon estimates are based).

Figure 16. Canada's black carbon emissions trends, 2013 to 2017

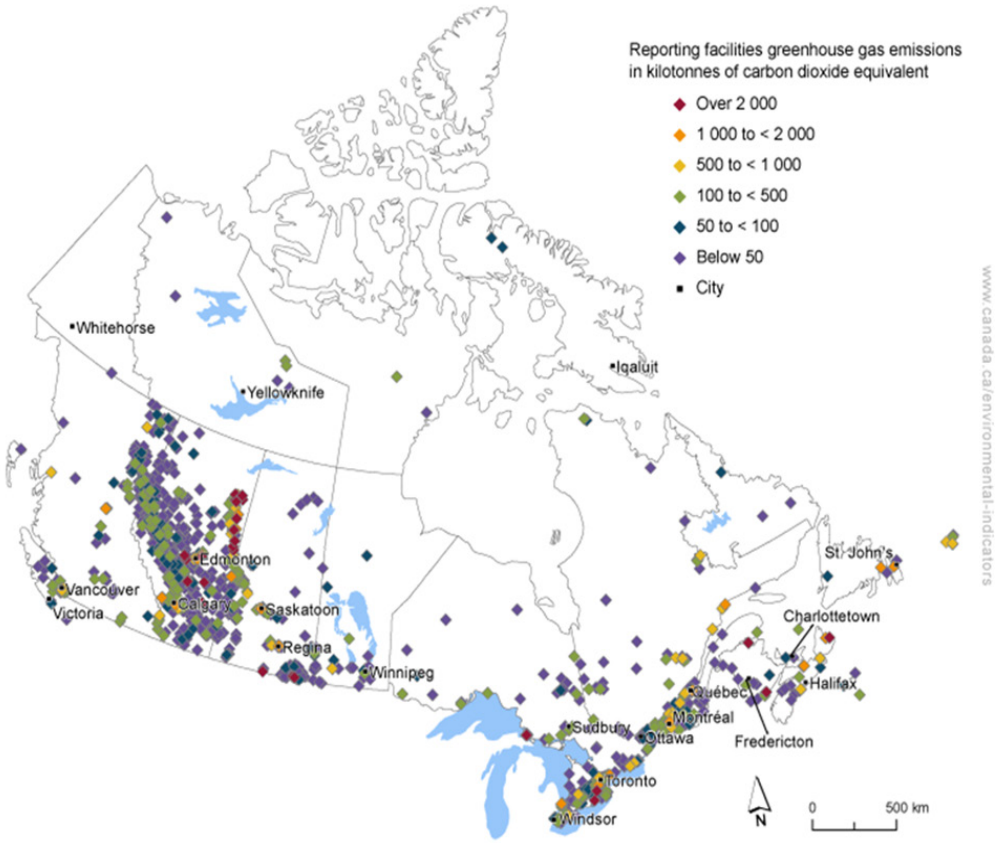


Facility Greenhouse Gas Emissions Overview

In 2017, 1,622 facilities reported their greenhouse gas (GHG) emissions, totalling 292 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq). The 2017 reporting cycle marks the first year of the expansion to the federal GHG reporting program (GHGRP) - the reporting threshold was lowered to 10 kilotonnes (kt) CO_2 eq and certain facilities in targeted sectors were also required to provide additional data. CO_2 represented the majority (93%) of the total reported emissions in 2017, while methane (CH_4) and nitrous oxide (N_2O) emissions contributed 6% and 1%, respectively.

The indicator for greenhouse gas emissions from large facilities provides consistent information on emissions from the largest emitting facilities in Canada and is published annually.

Figure 17. Greenhouse gas emissions in 2017 from large facilities



The latest indicator, based on data reported to the GHG Reporting Program, shows that:

- 292 megatonnes (Mt) of GHGs in carbon dioxide equivalent (CO_2 eq) were emitted in 2017 by 1,622 facilities reporting to the GHG Reporting Program
- emissions from the reporting facilities account for 41% of Canada's total GHG emissions in 2017

National Greenhouse Gas Inventory

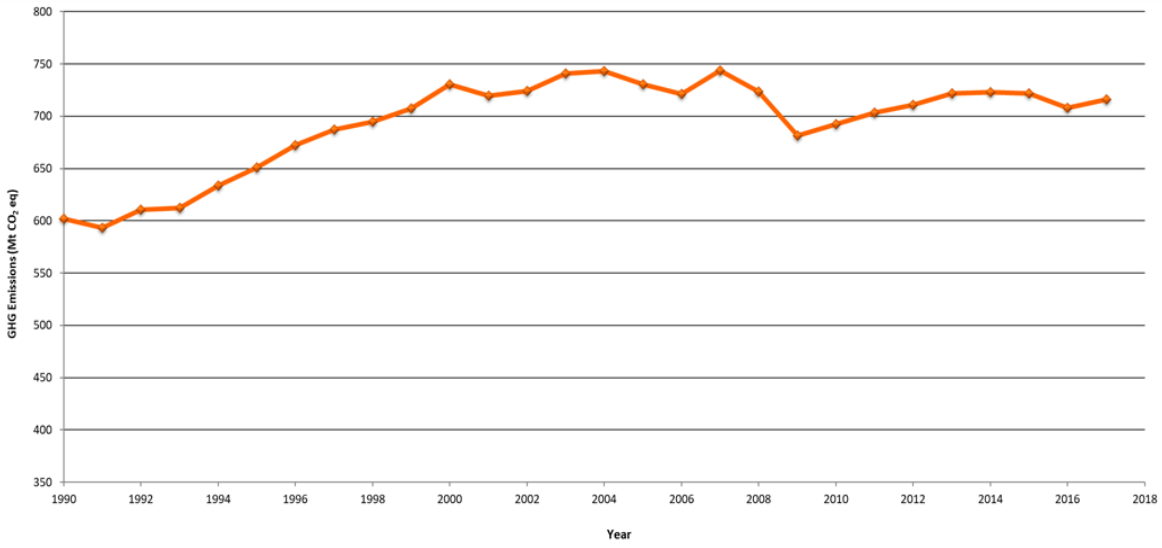
As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Canada is obligated to prepare and submit an annual national greenhouse gas (GHG) inventory covering anthropogenic emissions by sources and removals by sinks. ECCC is responsible for preparing Canada's official national inventory with input from numerous experts and scientists across Canada. The National Inventory Report (NIR) contains Canada's annual GHG emission estimates dating back to 1990. In addition to providing GHG emission data by mandatory reporting categories, the NIR also presents emission data by Canadian economic sectors, which better support policy analysis and development.

The NIR, along with the Common Reporting Format (CRF) tables, comprise Canada's inventory submission to the UNFCCC and are prepared in accordance with the UNFCCC Reporting Guidelines on annual inventories.

The National GHG Inventory shows that:

- Canada's total GHG emissions in 2017 were 716 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq), 18% (114 Mt CO_2 eq) above the 1990 emissions of 602 Mt CO_2 eq and a net decrease of 15 Mt CO_2 eq or 2.0% from 2005 emissions.
- Emission trends since 2005 continue to reflect emission increases in the oil and gas and transportation sectors, which are being more than offset by decreases in other sectors, notably electricity and heavy industry. The emission increases were driven by growth in oil and gas extraction as well as the number of light-duty gasoline trucks and heavy-duty diesel vehicles in operation. The emission decreases were largely driven by decreases in electricity generation using coal and oil.

Figure 18. Canada's greenhouse gas emissions trend, 1990 to 2017



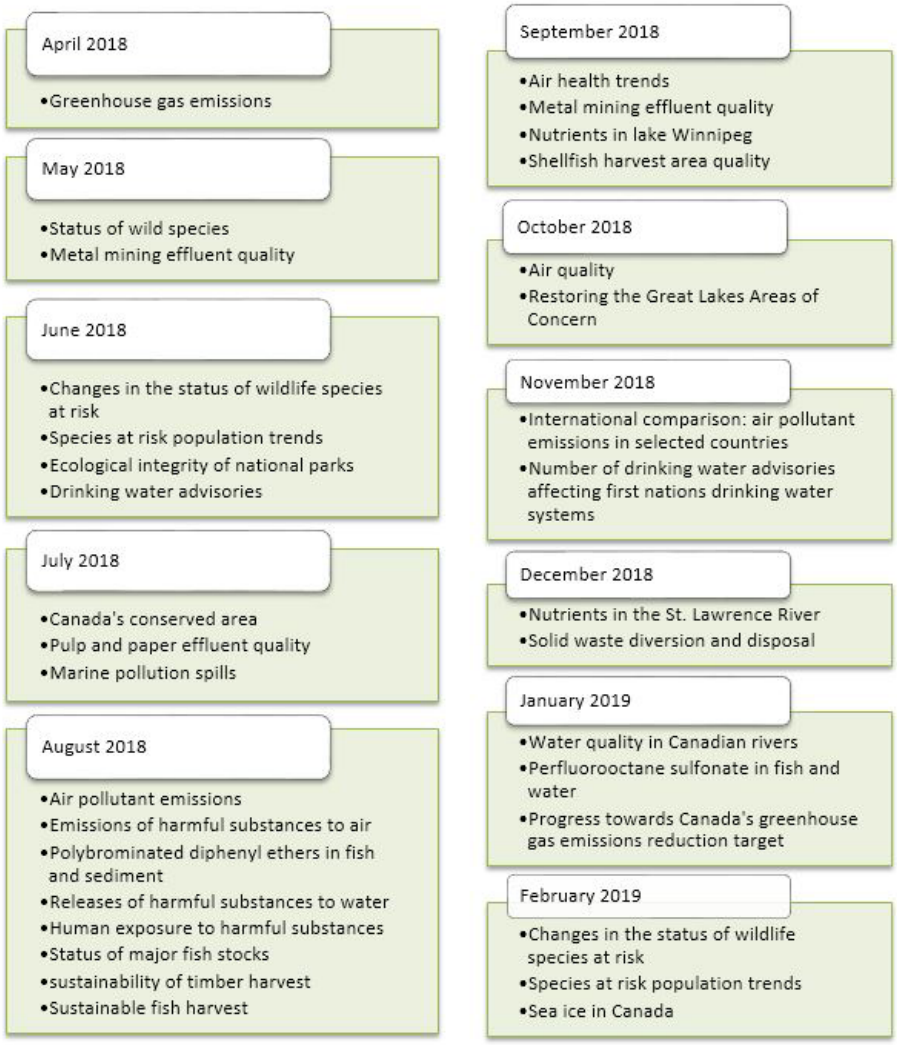
Further information on the National GHG Inventory is available online.

Please note that inventories mentioned above are available on the departmental data catalogue and the Open Data Portal.

3.3 CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

The Canadian Environmental Sustainability Indicators (CESI) program reports on key environmental sustainability issues including, climate change, air quality, water quality and availability, wildlife, biodiversity, habitat, pollution, waste and toxic substances. It is designed to convey the state of Canada's environment, including historical trends, in a straightforward and transparent manner. CESI is used to inform citizens, Parliamentarians, policy makers and researchers with comprehensive, unbiased and authoritative environmental information. The CESI program responds to ECCC's commitments under CEPA and the *Department of the Environment Act* to report to Canadians on the state of the environment and is the prime instrument to measure progress of the Federal Sustainable Development Strategy.

Table 16. Canadian Environmental Sustainability Indicators (CESI) updates and new releases in 2018-2019



ECCC prepares the indicators through close collaboration with science and data experts across the federal government, including Health Canada, Statistics Canada, Natural Resources Canada, Agriculture and Agri-Food Canada, and Fisheries and Oceans Canada, as well as relevant provincial and territorial counterparts. The data used to calculate indicators originate from a variety of sources, including surveys, measurement networks and other research initiatives that are expected to be maintained and updated for the foreseeable future.

The indicators are published on the CESI website showing national and regional results along with the methodology explaining each indicator and links to related socio-economic issues and information. CESI also has an interactive map that enables the user to quickly explore Canada's local and regional environmental indicators.

4. ADMINISTRATION AND PUBLIC PARTICIPATION

4.1 FEDERAL, PROVINCIAL, TERRITORIAL COOPERATION

National Advisory Committee

The National Advisory Committee (NAC) provides a forum for provincial, territorial and Aboriginal governments to advise the Ministers on certain actions being proposed under the Act, enables national cooperative action, and seeks to avoid duplication in regulatory activity among governments. The Committee was provided opportunities to advise and comment on initiatives under the Act.

To carry out its duties in 2018-2019, the CEPA NAC held a teleconference in October, and the NAC Secretariat corresponded regularly with committee members regarding various initiatives implemented under CEPA. These initiatives included opportunities to comment on and be informed of numerous actions taken under the Act.

This includes various risk assessment activities under the CMP, including:

- the publication of 16 draft screening assessments which included 103 substances and 3 groups of substances
- the publication of 21 final screening assessments which included 520 substances, 9 groups of substances, and 2 living organisms
- 3 final Orders which added the substances disperse yellow 3, triclosan, and liquefied petroleum gases (LPGs), to Schedule 1

Members were also informed of numerous risk management activities. This included:

- Final Regulations
    - *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*
    - *Regulations Amending the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations*
    - *Prohibition of Asbestos and Products Containing Asbestos Regulations and the Related Amendments to the Export of Substances on the Export Control List Regulations*
    - *Administrative Amendments to the Regulations Prescribing Circumstances for Granting Waivers Pursuant to Section 147 of the Act*

- *Administrative Amendments to the Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations*
- *Environmental Emergency Regulations, 2019*

- Pollution Prevention Plan Notices with respect to:
  - hydrazine related to the electricity sector
  - 2-propanone with diphenylamine in industrial effluents (PREPOD)
  - toluene diisocyanates
- Code of Practice
  - *a Code of Practice for the Management of Air Emissions From Pulp and Paper Facilities*

In addition, members were also provided with an opportunity to comment on:

- a study entitled "Moving Towards Lead-Free Products – Invitation to be Part of Our Conversation"
- proposed *Off-Road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations*
- Pollution Prevention Plans with respect to triclosan in certain products
- proposed Equivalency Agreement on the Equivalency of Federal and British Columbia Regulations Respecting the Release of Methane from the Oil and Gas Sector in British Columbia
- upcoming meetings of the Conferences of the Parties to the Basel, Rotterdam and Stockholm Conventions
- applying the Significant New Activity (SNAc) provisions to calcium 2-ethylhexanoate

Members were provided with an offer to consult on:

- on interim Order modifying the *Ozone-depleting Substances and Halocarbon Alternatives Regulations* to address a significant danger to the environment, by correcting the Canadian consumption baseline for hydrofluorocarbons (HFCs)
- a Notice of intent to amend the *Prohibition of Certain Toxic Substances Regulations, 2012*
- a proposed update to the Canadian Ambient Air Quality Standards (CAAQS) for Ozone
- the Proposed Release Guidelines for Disperse Yellow 3 and 25 Other Azo Disperse Dyes in the Textile Sector

Members were provided an opportunity to advise on proposed regulatory initiatives related to:

- proposed Amendments to the *Contaminated Fuels Regulations* pursuant to subsection 93(1) of the Act
- proposed *Regulations Repealing the Chlor-Alkali Mercury Release Regulations*
- proposed Regulations (*Cross-Border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations*)
- consultation document on proposed amendments to the *Prohibition of Certain Toxic Substances Regulations*, 2012 for PFOS, PFOA, LC-PFCAS, HBCD, PBDEs, DP and DBDPE

Members were also informed of:

- the Federal Environmental Quality Guideline (FEQG) for Bisphenol A, Hexavalent Chromium and Perfluorooctane Sulphonate
- information gathering under section 71 and section 46
- publication of reviewed 2017 National Pollutant Release Inventory data

Federal-provincial/territorial agreements

Part 1 of the Act also allows the Minister of the Environment to negotiate an agreement with a provincial or territorial government, or an Aboriginal people, with respect to the administration of the Act. It also allows for equivalency agreements, which allow the Governor in Council to suspend the application of federal regulations in a jurisdiction that has equivalent regulatory provisions. The intent of an equivalency agreement is to eliminate the duplication of environmental regulations.

Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health

Since 1971, Canada and Ontario have worked together through a series of Canada-Ontario agreements to protect Great Lakes water quality. The 2014 Canada-Ontario Agreement (COA) guides the efforts of Canada and Ontario to restore, protect and conserve Great Lakes water quality and ecosystem health to assist in achieving the vision of a healthy, prosperous and sustainable region for present and future generations. It is also an important mechanism for implementing Canada's obligations under the Canada-United States Great Lakes Water Quality Agreement.

In 2018-2019, progress to clean up Canadian Great Lakes Areas of Concern (AOC) continued. Through the Great Lakes Protection Initiative, Canada provided funding to support action at the local level for planning, developing and implementing remedial and monitoring actions to restore beneficial uses in several AOCs. In 2018-2019, ten beneficial uses were re-designated to "Not Impaired", bringing the total number of restored beneficial uses across all Canadian AOCs to 78. Efforts continue to address the remaining 79 of the 157 beneficial uses initially identified as impaired or requiring further assessment.

In 2018-2019, at Randle Reef in the Hamilton Harbour Area of Concern, Canada and partners completed construction of a six hectare, double-walled "box" (engineered containment facility) that will house severely contaminated sediments from the harbour floor. Containing approximately 695,000 cubic metres of sediment contaminated with polycyclic aromatic hydrocarbons (PAHs) and other toxic chemicals, Randle Reef is the largest and most severely contaminated sediment site on the Canadian side of the Great Lakes. ECCC is collaborating with Ontario Ministry of Environment, Conservation and Parks, Stelco Canada, Hamilton Oshawa Port Authority, City of Hamilton, City of Burlington, and Halton Region to restore this area.

Canada undertook numerous scientific activities in 2018-2019 in partnership with the Governments of Ontario and the United States in support of managing phosphorus concentrations and loadings to Lake Erie. Implementation of the Canada-Ontario Lake Erie Action Plan began with the goal of reducing annual phosphorus loading into Lake Erie by 40% from a 2008 baseline to achieve the binational (Canada-US) phosphorus targets. The first annual report on phosphorus loadings and algal conditions in Lake Erie was issued.

Canada also undertook numerous scientific activities in 2018-2019 in partnership with the Governments of Ontario and the United States in support of reducing toxic substances in the Great Lakes:

- Canada finalized binational Strategies for Hexabromocyclododecane and Polychlorinated Biphenyls, and initiated measures to reduce anthropogenic inputs of these Chemicals of Mutual Concern into the waters of the Great Lakes.

- Through the Great Lakes Protection Initiative, Canada supported activities that will increase participation in the application of "beyond compliance" measures to reduce releases of Chemicals of Mutual Concern to the Great Lakes from Canadian sources.
- A range of continuing chemical risk management initiatives were delivered under the Chemicals Management Plan, as described elsewhere in this report, which supported implementation of the Harmful Pollutants Goals under COA.

Memorandum of Understanding between Canada and Quebec

The Province of Quebec and the Government of Canada have been collaborating since 1994. The parties currently co-operate through a memorandum of understanding for data collection, whereby Quebec provides a single data-entry portal for regulatees for the following federal regulations:

- *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* made pursuant to CEPA
- *Pulp and Paper Mill Defoamer and Wood Chip Regulations* made pursuant to CEPA
- *Pulp and Paper Effluent Regulations* made pursuant to the *Fisheries Act*

Canada-Nova Scotia Equivalency Agreement

An equivalency agreement between the Government of Canada represented by the Minister of the Environment and the Government of Nova Scotia represented by their Minister of Environment regarding the federal *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations* took effect in July 2015. Further to this agreement, the Governor in Council adopted an Order suspending the application of the federal regulation in Nova Scotia. In accordance with the five-year term limit in CEPA, the agreement is set to terminate at the end of 2019.

On March 30, 2019, a draft renewed equivalency agreement with the province of Nova Scotia on the *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity* Regulations was published, with a *Notice of Availability* in the *Canada Gazette*, Part I. This agreement would cover the period of January 1, 2020 to December 31, 2024.

Canada-Saskatchewan Equivalency Agreement

On December 29, 2018, a draft equivalency agreement with the province of Saskatchewan on the *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations* was published, with a Notice of Availability in the *Canada Gazette*, Part I. This agreement would cover the period January 1, 2020 to December 31, 2024. Further to this draft agreement, a proposed Order suspending the application of the federal regulation in Saskatchewan was published on February 16, 2019.

Canada-Alberta Equivalency Agreement

As a result of the 1994 Agreement on the Equivalency of Federal and Alberta Regulations for the Control of Toxic Substances, the following CEPA regulations, or parts thereof, do not apply in Alberta:

- *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* (all sections)
- *Pulp and Paper Mill Defoamer and Wood Chip Regulations* [4(1), 6(2), 6(3)(b), 7 and 9]
- *Secondary Lead Smelter Release Regulations* (all sections)

Alberta Environment indicated that in 2018-2019, there were no reported violations by the four pulp and paper mills regulated under the provincial pulp and paper regulations.

Canada-British Columbia Equivalency Agreement

In March 2019, a draft equivalency agreement with the province of British Columbia on the release of methane from the oil and gas sector was published in the *Canada Gazette*, Part I, for public consultation.

Environmental Occurrences Notification Agreements

Federal, provincial and territorial laws require, in most cases, notification of the same environmental emergency or environmental occurrence, such as an oil or chemical spill. To reduce duplication of effort, ECCC and Fisheries and Oceans Canada entered into environmental occurrences notification agreements with the governments of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Northwest Territories and Yukon, which are in effect until March 2021.

4.2 PUBLIC PARTICIPATION

CEPA Registry

Part 2 of CEPA (Public Participation) provides for the establishment of an environmental registry, whistleblower protection, and the right of an individual to request an investigation and pursue court action.

The CEPA Registry was launched on ECCC's website when the Act came into force on March 31, 2000. Continuous efforts are made to increase the Registry's reliability and ease of use. The Registry encompasses thousands of CEPA-related documents and references. It has become a primary source of environmental information for the public and private sectors, both nationally and internationally, and has been used as a source of information in university and college curricula.

From April 2018 to March 2019, the CEPA Registry website had 289,701 visits, making it the third-largest area visited on the ECCC website, after Weather and Ice. There were approximately 1,000 public enquiries made concerning CEPA in the last fiscal year. Areas of enquiry included: substances, regulations (e.g. engine emissions, fuels, dry cleaning, import and export of hazardous waste, storage tank systems), permits and enforcement.

Public consultation

CEPA includes many requirements to provide the public with access to information, to provide comments on proposed initiatives and to provide access to justice. These provisions include a mandatory consultation and public comment periods for proposed Orders, Regulations and other statutory instruments; and requirements to publish information. Other provisions allow for a member of the public to bring civil actions against alleged offenders, to request reviews of existing laws and policies, as well as providing protection for whistle-blowers.

In addition, engaging stakeholders and the public is central to several programs under CEPA. For example, at each stage in the CMP management cycle stakeholders are engaged and the public has the opportunity to be involved and comment on proposed assessments of substances or groups of substances.

During 2018-2019, there were 57 opportunities posted on the Registry for stakeholders and the members of the public to provide comments on proposed initiatives to be taken under CEPA. These included:

- 21 draft screening assessment reports
- 3 investigations of substances
- 1 final assessment
- 1 substance proposed for addition to the List of Toxic Substances
- 5 drinking water guidelines
- 3 proposed pollution prevention plan Notices
- 1 Notice of intent to regulate
- 12 proposed Regulations
- 2 consultation documents on proposed risk management initiatives
- 6 Notices regarding amendments to the Domestic Substances List
- 1 proposed equivalency agreement
- 1 notice related to a substance on the NPRI

Please see the CEPA Registry public consultations, available online.

Pollution Prevention resource finder

Part 4 of CEPA provides the authority for the establishment of a national pollution prevention information clearinghouse to facilitate the collection, exchange and distribution of information regarding pollution prevention.

In fall 2017, the Canadian Pollution Prevention Information Clearinghouse (CPPIC) was redesigned and rebranded the Pollution Prevention resource finder (P2 finder). The P2 finder is Canada's largest publicly accessible database of links to practical resources that can help individuals and organizations be more environmentally friendly. It received more than 10,000 views in 2018-2019. It is searchable and filterable to allow users to easily search for specific types of resources. The P2 finder contains links to resources for:

- Employees or volunteers
- Homeowners or renters
- Travelers
- Youths or educators
- Businesses (including non-profit organizations)
- Community groups
- Governments
- Health care facilities

CMP-related committees and activities

The CMP Science Committee supports a strong science foundation to CMP by providing external national and international scientific expertise to Health Canada and ECCC on scientific issues. The second meeting of the CMP Science Committee took place in July 2018 on the topic of "Advancing Consideration of Endocrine Disrupting Chemicals under CEPA 1999". The third meeting was held in November 2018 on "Public Health Approach to Chemicals Management in Canada." Members engaged in constructive discussions as they continued developing the Committee's scientific input for the Government of Canada. Meeting records and reports are available online.

The CMP Stakeholder Advisory Council (CMP SAC) met twice in 2018-2019. The purpose of CMP SAC is to obtain advice from stakeholders for implementing the CMP and to foster dialogue between stakeholders and government, and among different stakeholder groups. In May and November 2018, the government hosted multi-stakeholder workshops to exchange information and gather input from stakeholders on managing chemicals in Canada. During the May 2018 SAC meeting, views were sought on improving and communicating a strategy for Endocrine Disrupting Chemicals (EDCs). Representatives of vulnerable groups also shared their perspectives to determine views on strengthening the approach for vulnerable populations under the CMP.

Health Canada and ECCC jointly prepare CMP Progress Reports to update stakeholders and other interested parties on CMP activities and programs. CMP Progress Reports were published in July 2018 and March 2019.

The public plays a major role in reducing health risks posed by chemicals. Launched in January 2019, the goal of the new Health Canada Healthy Home campaign is to raise Canadian's awareness about health risks from chemicals of concern and pollutants that may be found in and around the home and motivate them to take action to protect health. The new campaign delivers CMP findings and practical advice to Canadians regarding pollutants and chemicals, such as mould, carbon monoxide, radon, asbestos, and formaldehyde. It is promoted to Canadians through new web content, social media, search engine marketing and face to face engagement at events. The campaign links to plain language summaries for the public on specific CMP substances (such as, furans, solvent violet 13, and talc) that are promoted through social media (Facebook and Twitter). National-media outreach, including articles and radio clips on priority substances reached 40M impressions.

The Health Canada regional offices deliver CMP and environmental health outreach to Canadians by educating and enabling key influencers such as those who work with vulnerable populations (i.e., daycare workers, nurses, seniors, Indigenous groups, and health practitioners). This was accomplished through adaptation and delivery of the Chemicals Learning and Awareness modules at workshops, and presenting CMP and environmental health materials during trade shows and conferences. Public outreach materials and workshop products were also developed for immigrant communities including Chinese, South Asian, and Arabic Canadians.

5. COMPLIANCE PROMOTION AND ENFORCEMENT

To achieve greater compliance with the Act and its risk management tools, both compliance promotion activities and enforcement measures are used. The goal of compliance promotion is to increase awareness and contribute to the understanding of risk management instruments to help ensure these instruments are effective in achieving desired environmental results. Compliance promotion officers across Canada provide information to regulated communities on what is required to comply with CEPA, the benefits of compliance, and the consequences of non-compliance.

Compliance promotion activities focus on reducing pollution, including the release of toxic substances to air, water or land, and the import and export of hazardous waste that present a risk to the environment and/or human health. These activities aim to increase voluntary compliance with regulatory and non-regulatory instruments, thereby mitigating consequential enforcement actions.

Enforcement of the Act is done in a fair, predictable and consistent manner. CEPA provides enforcement officers with a wide range of powers to enforce the Act, including the powers of a peace officer. Enforcement officers can carry out inspections to verify compliance with the Act; enter premises, open containers, examine contents and take samples; conduct tests and measurements; obtain access to information (including data stored on computers); stop and detain conveyances; search, seize and detain items related to the enforcement of the Act; secure inspection warrants to enter and inspect premises that are locked and/or abandoned or where entry has been refused; seek search warrants; and arrest offenders.

Enforcement activities are conducted in accordance with the Compliance and Enforcement Policy for CEPA and it is available online.

5.1 COMPLIANCE PROMOTION PRIORITIES

Each year, ECCC develops an annual list of priorities for delivery of compliance promotion activities on issues such as chemical management, air pollutants, and greenhouse gas emissions. Factors that influence the identification of priority activities include the recent publication of new or amended regulatory and non-regulatory instruments, new requirements coming into force, level of compliance, and need to maintain awareness, understanding, or compliance for specific requirements. Resources are aligned with the identified compliance promotion priorities.

In 2018-2019, compliance promotion activities were carried out on 15 priority regulatory and non-regulatory CEPA instruments, namely:

- Code of Practice for the Environmental Management of Road Salts
- Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the use of Cutback and Emulsified Asphalt
- *Concentration of Phosphorus in Certain Cleaning Products Regulations*
- *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*
- *Federal Halocarbon Regulations, 2003*
- *Microbeads in Toiletries Regulations*
- *Multi-Sector Air Pollutants Regulations*
- *New Substances Notification Regulations (Organisms)*
- *Products Containing Mercury Regulations*
- *Prohibition of Asbestos and Asbestos Products Regulations*
- *Prohibition of Certain Toxic Substances Regulations*
- *Renewable Fuels Regulations*
- *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations*
- *Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements Regulations)*
- *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*

ECCC also worked on planning the implementation for 39 new or amended regulatory and non-regulatory instruments published in the *Canada Gazette*, Parts I and II.

5.2 COMPLIANCE PROMOTION ACTIVITIES

Multiple approaches were used to reach the regulated communities, including workshops, information sessions, presentations, information package emails, mail-outs, articles, phone calls, and social media platforms. Many of these activities were carried out in collaboration with provincial and territorial governments, as well as non-governmental organizations and associations.

ECCC was particularly successful with:

- Developing and implementing many shortened and distinct URLs (vanity URL), which were used in targeted and personalized communication and contributed to a better engagement of the regulated communities:
    - A 50% increase in website visits for the *Prohibition of Certain Toxic Substances Regulation*, with 33% of those associated with the vanity URL
    - Advertisement in professional magazines addressed at the retail community had a positive impact on consultation of the webpage related to the *Microbeads in Toiletries Regulations*
- Gathering valuable information on industry practices and compliance barriers through many approaches such as surveying municipalities on the Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the use of Cutback and Emulsified Asphalt and site visits with informal interviews for the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.
- Reporting under the *Products Containing Mercury Regulations* was increased following a blitz to reach importers of lamps that may contain mercury.

In 2018-2019, 31,822 known or potential regulatees received compliance promotion awareness materials; and 4,860 stakeholders contacted compliance promotion officers for clarification of regulatory requirements or additional information. Most inquiries and feedback were received by email, while the remainder came by fax, letter and telephone.

Recognizing that communication efficiency and accuracy is important when reaching the regulated community, extra efforts were made this fiscal year to improve the quality of the compliance promotion activity data. In 2018-2019 alone, ECCC identified over 3,144 new facilities and their contacts, as well as updated information related to an additional 100,793 facilities.

Promoting compliance to Indigenous people and within the federal government

In 2018-2019, ECCC continued to work closely with Indigenous peoples and the federal government by delivering individual communications and individual-instrument and multi-instrument awareness activities for compliance promotion of priority regulatory and non-regulatory instruments. Workshops were delivered to Indigenous peoples throughout Canada and with other federal government departments to increase awareness of their obligations to comply with instruments under CEPA. These activities focused on compliance promotion priority instruments including the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations and Federal Halocarbon Regulations, 2003*.

5.3 ENFORCEMENT PRIORITIES

Each year, ECCC develops a National Enforcement Plan (NEP) that sets out the enforcement activities to be carried out in that fiscal year, including activities to address non-compliance with CEPA. Factors that influence the identification of priority activities include the risk to the environment and human health represented by the regulated substance or activity, governmental and departmental priorities, suspected non-compliance, recent publication of new and amended regulations, and domestic and international commitments and obligations.

In 2018-2019, the NEP gave priority to the following CEPA instruments:

- *Off-Road Compression-Ignition Engine Emission Regulations*
- *Benzene in Gasoline Regulations, Sulphur in Gasoline Regulations, Sulphur in Diesel Fuel Regulations and Renewable Fuels Regulations*
- *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*
- *Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations*

In addition to the planned inspections carried out under the NEP, enforcement activities also include a large number of inspections resulting from responses to complaints, notifications from partners, intelligence or departmental referrals, reported spills and incidents, or other information. Additionally, a number of regulations are identified for focus by specific regions. The focus placed on regulations in each region is influenced by a number of factors, including geography, the prevalence of the regulated sectors, regional issues or concerns, and provincial and territorial environmental sensitivities.

In 2018-2019, ECCC initiated a risk assessment to assess and determine the risk of noncompliance with its laws and regulations - including those under CEPA. This work will inform decision making processes and help better aligning enforcement actions and resources to protect the environment and human health.

5.4 ENFORCEMENT ACTIVITIES

Enforcement activities undertaken between April 1, 2018, and March 31, 2019, are summarized in the following four tables.

- Table 17 provides the number of on-site and off-site inspections for each regulation
- Table 18 provides the breakdown of investigations for each regulation for which at least one investigation occurred or closed
- Table 19 provides the total number of enforcement measures resulting from inspections and investigations that were imposed for each regulation
- Table 20 provides the number of prosecutions for each regulation

5.4.1 Inspections

Inspections are defined as the active process of gathering information to verify compliance with legislation. This may include site visits, examining substances, products or containers, taking samples, and reviewing records. An on-site inspection involves visiting a site, such as a border crossing, an airport or a port of entry, to conduct any activity, operation, or analysis required to verify the regulatee's compliance with a regulation. An off-site inspection is normally undertaken at the officer's place of work or in another location that is not at the regulated site and is usually limited to documentation verification.

Table 17 details the 1,608 inspections under CEPA for fiscal year 2018-2019. The number of inspections relates to the number of times the regulation was inspected for compliance using the start date of the inspection for the reference period.

Table 17. Number of inspections under CEPA from April 1, 2018 to March 31, 2019

	Inspections*		
Instrument	**On-site**	**Off-site**	**Total**
Total	1,151	457	1,608
2-Butoxyethanol Regulations	7	-	7
Benzene in Gasoline Regulations	2	-	2
CEPA - Section(s)	27	44	71
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	19	1	20
Concentration of Phosphorus in Certain Cleaning Products Regulations	1	-	1
Disposal at Sea Regulations	34	23	57
Environmental Emergency Regulations	128	56	184
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	100	6	106
Federal Halocarbon Regulations, 2003	60	135	195
Fuels Information Regulations, No. 1	4	2	6
Gasoline and Gasoline Blend Dispensing Flow Rate Regulations	64	-	64
Interprovincial Movement of Hazardous Waste Regulations	15	1	16
Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations	1	-	1
Multi-Sector Air Pollutants Regulations	3	9	12
Microbeads in Toiletries Regulations	1	1	2
National Pollutant Release Inventory	2	-	2
New Substances Notification Regulations (Chemicals and Polymers)	1	-	1
New Substances Notification Regulations (Organisms)	1	-	1
Off-Road Compression-Ignition Engine Emission Regulations	45	4	49
Off-Road Small Spark-Ignition Engine Emission Regulations	11	-	11
On-Road Vehicle and Engine Emission Regulations	4	-	4
Ozone-depleting Substances and Halocarbon Alternatives Regulations	18	3	21
Ozone-depleting Substances Regulations, 1998	2	-	2
PCB Regulations	179	21	200
Products Containing Mercury Regulations	5	16	21
Prohibition of Certain Toxic Substances Regulations, 2012	20	-	20

	Inspections*		
Instrument	**On-site**	**Off-site**	**Total**
Pulp and Paper Mill Defoamer and Wood Chip Regulations	-	4	4
Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations	2	2	4
Renewable Fuels Regulations	7	[2]	9
Solvent Degreasing Regulations	1	1	2
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	203	21	224
Sulphur in Diesel Fuel Regulations	7	3	10
Sulphur in Gasoline Regulations	3	-	3
Secondary Lead Smelter Release Regulations	-	2	2
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	112	98	210
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	48	2	50
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	13	-	13

* Only those regulations under which an inspection occurred during the time period are listed in this table.

5.4.2 Investigations

An investigation involves gathering, from a variety of sources, evidence and information relevant to a suspected violation. An enforcement officer will conduct an investigation when he or she has reasonable grounds to believe that an offence has been committed under the Act and it has been determined that a prosecution is the appropriate enforcement action.

Table 18 describes the number of investigations under CEPA for fiscal year 2018-2019.

Table 18. Breakdown of investigations from April 1, 2018 to March 31, 2019

	Investigations*		
Instrument**	**Started before 2018-2019 and still ongoing at the end of 2018-2019**	**Started in FY 2018-2019**	**Ended in FY 2018-2019**
Total	64	16	26
CEPA - Section(s)	18	5	9
Disposal at Sea Regulations	6	1	-
Environmental Emergency Regulations	3	1	-
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	2	-	1
Federal Halocarbon Regulations, 2003	1	-	2
Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations	-	-	2
Off-Road Compression-Ignition Engine Emission Regulations	3	6	-
Off-Road Small Spark-Ignition Engine Emission Regulations	1	-	-
On-Road Vehicle and Engine Emission Regulations	2	-	-
PCB Regulations	11	1	4
PCB Waste Export Regulations, 1996	1	-	-
Renewable Fuels Regulations	-	-	2
Sulphur in Diesel Fuel Regulations	1	1	-
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	9	-	2
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	5	1	3
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	1	-	1

*Investigations are tabulated by the number of investigation files, based on the start or end date of the investigation. One investigation may be counted under one or more regulations, therefore the data at the regulation level may not add up to the total at the legislative level.

**Only those regulations under which an investigation occurred during the time period are listed in this table.

5.4.3 Enforcement measures

The following are some responses available to address alleged violations of CEPA and its regulations:

- warnings to bring an alleged violation to the attention of an alleged offender, and if applicable, return to compliance
- directions generally to prevent or eliminate releases of regulated substances
- tickets for certain designated offences, such as failure to submit written reports

- various types of orders, including:
    - environmental protection compliance Orders (EPCOs) – generally to require action to be taken to stop an ongoing violation from continuing, or to prevent a violation from occurring
    - prohibition Orders – to prohibit activity involving a substance new to Canadian commerce
    - recall Orders – to recall regulated substances or products from the marketplace
    - detention Orders for ships
- injunctions
- prosecution at the discretion of a Crown prosecutor
- environmental protection alternative measures aim to return an alleged violator to compliance by way of a negotiated agreement
- administrative monetary penalties (AMP), which provide a financial disincentive to noncompliance

The measures used in 2018 and 2019 are listed in Tables 19 and 20.

Table 19 sets out the number of written warnings, EPCOs, and AMPs issued under CEPA for fiscal year 2018-2019.

Table 19. Number of enforcement measures taken from April 1, 2018 to March 31, 2019

Instrument**	Enforcement Measures* From inspections and investigations			
	Written warnings**	Number of subjects involved in EPCOs***	EPCOs**	AMPs**
Total	228	37	27	146
2-Butoxyethanol Regulations	-	1	1	-
CEPA - Section(s)	17	-	-	38
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	8	-	-	-
Environmental Emergency Regulations	32	2	1	-
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	14	-	-	22
Federal Halocarbon Regulations, 2003	18	-	-	10
Gasoline and Gasoline Blend Dispensing Flow Rate Regulations	5	3	1	-
Interprovincial Movement of Hazardous Waste Regulations	1	-	-	
Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations	1	-	-	-
New Substances Notification Regulations (Organisms)	1	-	-	-
Off-Road Compression-Ignition Engine Emission Regulations	9	-	-	43
Off-Road Small Spark-Ignition Engine Emission Regulations	2	-	-	-
Ozone-depleting Substances and Halocarbon Alternatives Regulations	3	-	-	-
PCB Regulations	17	13	9	-
PCB Waste Export Regulations, 1996	2	-	-	-
Prohibition of Certain Toxic Substances Regulations, 2012	3	1	1	-
Products Containing Mercury Regulations	3	-	-	-
Pulp and Paper Mill Defoamer and Wood Chip Regulations	1	-	-	-

Instrument**	Enforcement Measures* From inspections and investigations			
	Written warnings**	Number of subjects involved in EPCOs***	EPCOs**	AMPs**
Release and Environmental Emergency Notification Regulations	1	-	-	-
Renewable Fuels Regulations	1	-	-	2
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	43	10	8	31
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	40	2	1	-
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	5	2	2	-
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	1	3	3	-

*Enforcement measures that were issued between April 1 2018 and March 31 2019. Therefore it is possible that the initial inspection was conducted in a different fiscal year then when the measure was issued.

Written warnings, EPCOs, and AMPs are tabulated by number of measures issued at the regulation level. For example, if one warning was issued for two different regulations the number of warnings would be two. **This is different than previous years where enforcement measures were calculated at the infraction level (i.e. if the outcome of an inspection is the issuance of a written warning that relates to three sections of a given regulation, the number of written warnings is three, even if a single letter was sent to the regulatee and may therefore give the impression that less enforcement has occurred).

***The number of subjects involved in EPCOs is represented by the number of regulatees issued EPCOs, regardless of the number of sections. For example, if one regulatee was issued an EPCO for three sections of the PCB Regulations, the number of subjects involved is one.

5.5 PROSECUTIONS, TICKETS AND EPAMS

Prosecutions

For reporting purposes, prosecutions are all instances in which charges were laid against a person (individual, corporation, or government department). The decision to prosecute ultimately rests with the Director of Public Prosecution (DPP) of Canada or their delegated agent. While reviewing the data, it should be noted that prosecutions often continue through multiple fiscal years, so there may be more counts tabulated during a particular year than actual charges laid.

Tickets

Tickets for offences under CEPA can be issued under the *Contraventions Act*, usually where there is minimal or no threat to the environment or human health. Where an offence has taken place and this offence is designated as ticketable, enforcement officers will issue a ticket, unless they have determined that, in accordance with the criteria of the Compliance and Enforcement Policy for CEPA, another enforcement measure is the appropriate response.

EPAMs

An Environmental Protection Alternative Measure (EPAM) is an agreement that is negotiated with the accused in order to return an alleged violator to compliance with CEPA. It can be used only after a charge has been laid and before the matter goes to trial as an alternative measure to prosecution for an alleged violation of the Act.

Table 20 outlines the number of prosecutions, tickets, and EPAMs under CEPA for fiscal year 2018-2019.

Table 20. Number of prosecutions and new EPAMs from April 1, 2018 to March 31, 2019

Instrument**	Prosecutions				EPAMs****	Tickets
	Charges laid in FY 2018-2019		Concluded in FY 2018-2019			
	Tickets	Counts**	Convicted subjects***	Guilty counts**		
Canadian Environment Protection Act, 1999 - Total	18	91	22	54	0	18
CEPA - Section(s)	7	23	10	10	-	-
Environmental Emergency Regulations	-	-	-	-	-	1
Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations	-	-	1	1	-	-
Off-Road Compression-Ignition Engine Emission Regulations	1	1	-	-	-	-
PCB Regulations	4	19	5	28	-	-
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	2	18	-	-	-	-
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	2	26	5	14	-	17
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	2	4	1	1	-	-

* Prosecuted subjects are the number of subjects charged, where the charge date falls within the reporting period. This means that the number of prosecutions launched is counted, not the number of prosecutions concluded in the reporting year. As well, prosecuted subjects are counted by the number of parties charged. This means that if one case resulted in the prosecution of two different subjects, the number reported would be two. The number of prosecuted subjects does not necessarily correspond to the total at the legislative level, because one prosecution might be related to more than one instrument.

** Counts are the number of sections of legislation or regulations, for which there was a charge or conviction during the reporting period. For example, if one person is charged with two counts under CEPA, this is considered one charge laid against the subject and two counts.

*** Convicted subjects are the number of subjects convicted during the reporting period and are based on date sentenced.

**** EPAMs are counted by the number of charges laid before entering the alternative measures agreement.

5.6 ENFORCEMENT HIGHLIGHTS

In 2018-2019, 22 subjects were convicted and sentenced for offences of contravening CEPA and its regulations, and $2,829,127 in fines was directed to the Environmental Damages Fund (EDF).

The Environmental Damages Fund is a specified purpose account, administered by ECCC, to provide a mechanism for directing funds received as a result of fines, court orders, and voluntary payments to priority projects that will benefit our natural environment.

Below are highlights of prosecutions that occurred under CEPA and its regulations in 2018-2019.

Disposal at sea

On November 7, 2018, Notre Dame Seafoods Inc. was ordered in the Provincial Court of Newfoundland and Labrador to pay $115,000 for contravening the Act. The company pleaded guilty to one count of violating paragraph 124(1)(b) of the Act (disposal at sea provisions). Charges resulted from a May 2017 inspection of the company's fish-processing facility in Comfort Cove-Newstead, Newfoundland and Labrador. During the inspection, officers observed the loading of waste in a manner that was contrary to the conditions of the disposal at sea permit issued by ECCC.

Polychlorinated biphenyls (PCB)

On April 20, 2018, before the Court of Quebec, Distributions Limotrique inc. was fined $ 52,500 after pleading guilty to three counts of contravening the PCB Regulations. The company released PCBs into the environment in a concentration greater than 50mg/kg, processed products containing PCBs in concentrations higher than 50mg/kg, and failed to store PCBs at a storage site and send for destruction.

On July 31, 2018, before the Court of Quebec, Le Holding Sécurité CM Ltée pleaded guilty to four counts of contravening the *PCB Regulations* and one count for failing to comply with an environmental protection compliance Order (EPCO), contrary to the Act. The company was fined $240,000, all of which was paid to the Environmental Damages Fund. An investigation by the Department showed that Le Holding Sécurité CM Ltée failed to comply with an EPCO, discharged PCBs into the environment, failed to report to ECCC about the spill, had illegal equipment containing PCBs, illegally stored PCBs, and failed to submit annual reports within the time prescribed by the Regulations.

On August 15, 2018, FortisAlberta Inc. was ordered by the Provincial Court of Alberta to pay a fine of $300,000 after pleading guilty to one count of violating the PCB Regulations and one count of violating the *Canadian Environmental Protection Act, 1999*. The charges stem from the company's release of PCBs into the environment and its failure to promptly notify an enforcement officer or other designated person of the release.

On August 21, 2018, Collingwood Prime Realty Holdings Corp. and its director, Mr. Issa ElHinn, were sentenced in the Ontario Court of Justice for offences under the Act related to contraventions of the *PCB Regulations*. The court sentenced Mr. El-Hinn to a 45-day jail term, to be served on weekends, for failing to comply with an environmental protection compliance order. The Court also sentenced the corporation and Mr. El-Hinn to pay a combined penalty of $420,000 to be directed to the Environmental Damages Fund. The sentencing has since been appealed and the matter is currently before the courts.

Tetrachloroethylene

On December 10, 2018, GFL Environmental Inc. was sentenced after pleading guilty in the Ontario Court of Justice to violating federal environmental legislation. The company was fined $300,000. After an investigation charges were laid and GFL Environmental Inc. pleaded guilty to two counts of contravening the *Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations* for selling tetrachloroethylene to owners or operators of drycleaning facilities that did not meet regulatory standards.

Volatile Organic Compounds (VOCs)

On September 21, 2018, before the Court of Québec, company 9330-1208 Québec Inc. (operating as Les Produits Prodip.ca) pleaded guilty to one count of contravening the *Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations*. Les Produits Prodip.ca was fined $25,000 to be paid in full to the Environmental Damages Fund. In addition to the fine, the company was ordered to pay $5,145 to cover the cost of destroying the non-compliant paint.

Renewable Fuels

On May 14, 2018, the Canadian National Railway Company (CN) pleaded guilty to one count of violating the Act for importing a fuel that does not meet the requirements of the *Renewable Fuels Regulations*. CN was fined $25,000 and was ordered by the court to pay a sum of $1,101,627 to promote the protection of the environment. The investigation found that between July 1, 2011 and December 31, 2012, CN imported over 224,000,000 litres of diesel fuel. Under the Regulations, 2 percent of that volume should have been renewable fuel unless compliance units were acquired. Despite the compliance units acquired during that period, CN's renewable-fuel deficit was 3,672,090 litres, below the 2 percent requirement. The fine and penalty were directed to the Environmental Damages Fund administered by Environment and Climate Change Canada.

Environmental Offenders Registry and Enforcement Notifications

The Environmental Offenders Registry contains information on convictions of corporations obtained under certain federal environmental laws including CEPA, since June 18, 2009. This tool allows the media and the public to search for corporate convictions using the name of the corporation, its home province, the province where the offence occurred, or the legislation under which the conviction was obtained.

The Enforcement Notifications contain information about successful prosecutions across Canada under the acts and regulations administered by ECCC or involving ECCC enforcement officers (including CEPA).

5.7 INTERNATIONAL ENFORCEMENT COOPERATION

Enforcement-related activities are carried out under various international and domestic agreements and organizations. ECCC actively participates in INTERPOL's Pollution Crime Working Group, which brings together member countries to work collectively on pollution crime issues.

In October 2018, ECCC participated in INTERPOL's Operation 30 Days at Sea, the first-ever global action aimed at combatting maritime pollution crime. During the Operation, ECCC conducted numerous vessel inspections and worked closely with Transport Canada, as well as the United States Coast Guard and the United States Department of Justice. The joint Canadian efforts were also supported by Canada's Department of Justice and the Public Prosecution Service of Canada.

In addition, ongoing bilateral cooperation between the U.S. Environmental Protection Agency and ECCC Enforcement, and trilateral cooperation with Mexico's PROPEPA, under the auspices of the Commission for Environmental Cooperation of North America (CEC) support the three countries' domestic mandates, particularly in the area of cross border environmental crime.

6. REPORT ON RESEARCH

6.1 CHEMICAL SUBSTANCES

ECCC and HC conduct a wide range of research to help inform assessments of the risks associated with various substances to human health or the environment. This research is designed primarily:

- to fill data gaps in risk assessments
- to develop novel methods and approaches to improve risk assessment
- to evaluate the fate and the impact of toxic substances, complex environmental mixtures, and other substances of concern on the environment and human health
- to determine the extent of ecological and human health exposure to contaminants
- to investigate the effects of chemicals on endocrine systems

In addition, HC undertakes research to support the development of regulations, guidelines and air quality objectives with the goal of reducing population exposures to pollutants and improving human health.

During 2018-2019, research on chemicals was carried out by both departments under a number of programs, including the Chemicals Management Plan (CMP), the Northern Contaminants Program (NCP), the Strategic Technology Applications of Genomics in the Environment Program, Genome Canada and the Great Lakes Action Plan.

ECCC Research

The 20 research projects initiated at ECCC under the CMP in 2016 were completed in 2018-2019. These projects, summarized below, have led to the publication of 39 journal articles in 2018-2019 addressing a range of topics related to environmental contaminants, including sources, fate, mode of action, hazard, as well as standard methods development.

Rare Earth Elements and Platinum Group Elements

Study of Rare Earth Elements (REEs) and Platinum Group Elements (PGEs) on aquatic and terrestrial biota (crops, native plants and invertebrates): Implications for ecological risk assessment at contaminated sites

Focus of Research: The effects of soil pH and calcium content on the uptake, accumulation, and toxicity of various REEs, both individually and in mixtures, was examined for terrestrial plants. In addition, the study looked at the impacts of various REEs on aquatic plants and invertebrates. As well, this project examined the effects of PGEs on the physiology of terrestrial plants, with focus on both indicators of water stress and pollen viability and health.

Results: Plant biomass was generally significantly affected by soil pH and REE dose. A significant interaction between soil pH and REE sensitivity was occasionally detected. In low pH soils, the biomass of the plant parts was significantly enhanced with the addition of calcium while in the high pH soils biomass was reduced with higher calcium levels. Many interactions between REE concentrations, calcium, and pH were significant. Some interactions between water stress and PGE dose were present; however, no consistent trend was determined. Cerium was observed to negatively affect pollen germination in all plant species analyzed. Embryos contaminated with REEs had a negative effect on hatching time and success.

Publications: The results of this research were summarized in an internal technical report.

Effect of four rare earth element lanthanides in boreal forest soil on invertebrates and soil microbial community

Focus of Research: The toxicity of four lanthanide rare earth elements (REEs) on invertebrate species and indigenous microorganisms in Canadian boreal forest soil were evaluated. The impact of aging on the toxicity of two lanthanide REEs was also analysed.

Results: Among other findings, this project provided toxicity thresholds for the REES, praseodymium, samarium, neodymium, and yttrium for risk assessment analysis. Results showed that there was no consistent toxicity impact from the aging of the test substances in soil.

Publications: Princz, J.I., Fraser, C., Lemieux, H., Boyd, P., Scroggins, R. 2019. *The effect of aging on toxicity of lanthanides to soil invertebrates in boreal soils*. (In preparation)

Aquatic Ecotoxicology of Lanthanides

Focus of Research: The toxicity of priority rare earth elements (REEs) and mixtures was examined in fish and bivalves and determined their mode of action. The molecular toxicology of certain REEs was analysed to ascertain whether there were similarities and if toxicity could be predicted based on atomic properties.

Results: The toxicity of rare earth chemical elements depends on the type of elements and species under study. For fish, the chemical elements yttrium, samarium, erbium and gadolinium, were considered the most toxic. Providing more details about the effects, the biomarker analysis revealed impacts on protein integrity - essential for organisms health, DNA damage natural repair capacity, and physiological malfunctioning (some enzymes related activity). The studied organisms (mussels and the cnidarian Hydra) revealed similar toxicity effects as fish, although the Hydra species proved to be the most sensitive species compared with others.

Publications: Dubé, M., Auclair J., Hanana, H., Turcotte, P., Gagnon, C., Gagné, F. 2019. *Gene expression changes and toxicity of selected rare earth elements in rainbow trout juveniles*. Comp Biochem Physiol C Toxicol Pharmacol. 2019 Sep;223:88-95

Hanana, H; Turcotte, P; Dubé, M; Gagnon, C; Gagné, F. 2018. *Response of the freshwater mussel, Dreissena polymorpha to sub-lethal concentrations of samarium and yttrium after chronic exposure*. Ecotoxicol Environ Saf. 2018 Dec 15;165:662-670

Blaise, C; Gagné, F; Harwood, M; Quinn, B; Hanana, H. 2018. *Ecotoxicity responses of the freshwater cnidarian Hydra attenuata to 11 rare earth elements*. Ecotoxicol Environ Saf. 2018 Nov 15; 163:486-491

Organic flame retardants, benzotriazole, benzothiazole and other priority substances

Evaluation of estrogenic and thyroid-disrupting activities of targeted CMP3 priority substances: benzotriazole, thiocarbamate, hindered phenols and a brominated organophosphate flame retardant

Focus of Research: The study evaluated the impact of these substances on the hormone processes involved in the metamorphosis of tadpoles to frogs. These substances were assessed for their effects on time to metamorphosis, growth, gender, expression of genes involved in development and sexual differentiation, and histology of thyroid and gonadal tissue.

Results: Chronic exposures to the tested hindered phenol (CAS 96-76-4), benzotriazole (CAS 3147759) and the brominated organophosphate flame retardant (CAS 19186-97-1) did not affect the hormone processes of *Lithobates pipiens tadpoles*. Tested hindered phenols with CAS 96-69-5 and CAS 61788-44-1 were highly toxic at all concentrations tested for *Lithobates pipiens* tadpoles exposed.

Publications: This project permitted the preparation and publication of several articles, amongst which was a publication on the toxicity of various solvents on native amphibians early life stages.

Using a multi-tiered screening approach and the adverse outcome pathway (AOP) framework to determine the effects of new and existing priority CMP3 substances, primarily organic flame retardants, on key neuroendocrine pathways

Focus of Research: Since there is an urgent need for novel testing approaches that can help overcome some of the acknowledged limitations and cost of traditional ecological risk assessment, ten organic flame retardants and five BPA alternatives were analyzed for their toxicity to birds with both novel and regular *in vitro* screening methods. ToxChip polymerase chain reaction (PCR) arrays were used to determine the transcriptomic responses of the CMP3 substances. Chemicals which elicited a strong response were tested by in *ovo* egg injection method to determine the adverse effects of mechanistic exposure at an organismal level.

Results: Among other things, results showed that two organic flame retardants elicited negative effects on cell viability, and all five BPA alternative substances tested decreased cell viability. In addition, the research resulted in the development of a novel cell-culture method to allow screening in wild avian species.

Publications: Basu, N., Crump, D., Head, J., Hickey, G., Hogan, N., Maguire, S., Xia, J., Hecker, M. 2019. *EcoToxChip – A Next-Generation Toxicogenomics Tool for Chemical Prioritization and Environmental Management*. Environ. Toxicol. Chem. 38(2): 279-288. DOI: 10.1002/etc.4309

Environmental Transformation Processes and Bioaccumulation, Fate and Effects of CMP3 Priority Organic Flame Retardants (OFRs) in Wildlife and Fish within an Adverse Outcome Pathway (AOP) Framework

Focus of Research: This study addressed the limited understanding of CMP3 priority OFRs and the role of degradation, metabolism and transformation in wildlife and fish. The project assisted with the challenges and concerns for scientists, risk assessors, and managers as to OFR sources, bioavailability and ecosystem behaviour and ultimately their potential toxicology and health impacts on exposed biota.

Results: This allowed the characterization of the fate and metabolism of these CMP3 priority OFRs in avian species at multiple biological scales, feeding into an Avian AOP Framework.

Publications: Zhang, Y., Su, G. G., Li, M., Li, S., Wang, Q., Zhu, G., Letcher, R.J., Liu, C. 2018. *Chemical and biological transfer: Which one is responsible for the maternal transfer toxicity of tris(1,3-dichloro-2-propyl) phosphate in zebrafish?* Environ. Pollut. 243:1376-1382. DOI: 10.1016/j.envpol.2018.09.114

Exposure, Uptake and Adverse Effects on Birds exposed to New and Existing CMP3-Priority Organic Flame Retardants: identifying in vivo changes within an Avian Adverse Outcome Pathway

Focus of Research: An adverse outcome pathway approach was used to determine the effects of organic flame retardants on wild and captive avian species. Wild birds' blood was analysed to determine the presence and concentration of chemicals. In captive birds, the metabolism of these chemicals and their toxicological effects on physiology, behaviours, and the thyroid system were identified.

Results: Among other findings, this project showed that the resting metabolic rate and growth of *Coturnix japonica* was significantly reduced when exposed to triphenyl phosphate (TPHP). Embryonic exposure to TPHP had no effects on fear response or exploratory behaviour in *Coturnix japonica* chicks.

Publications: Tongue, A.D.W., Reynolds, S.J., Fernie, K.J., Harrad, S. 2019. *Flame retardant concentrations and profiles in wild birds associated with landfill*: *A critical review*. Environ. Pollut. 248 :646-658. DOI: 10.1016/j.envpol.2019.01.103

Atmospheric Fate Studies on CMP Priority Chemicals

Focus of Research: The research was designed to assess sources of flame retardant emissions into the environment, their transport through the environment, and pathways of human exposure.

Results: There are a multitude of sources of flame retardants to air across cities and regions, and the research has increased understanding of OPEs emitted to the atmosphere and their transport and deposition into water bodies. It has also found that handheld electronic devices, notably cell phones, may either be sources or indicators of OPE exposure through hand-to-mouth and/or dermal uptake.

Publications: Saini, A., Clarke, J., Jariyasopit, N., Rauert, C., Schuster, J. K., Halappanavar, S., Evans, G., Su, Y., Harner, T. 2019. *Flame retardants in urban air: A case study in Toronto targeting distinct source sectors*. Environ. Pollut. 247, 89-97. DOI: 10.1016/j.envpol.2019.01.027

Rodgers, T.F.M., Truong, J.W., Jantunen, L.M., Helm, P.A., Diamond, M.L., Organophosphate *Ester Transport, Fate, and Emissions in Toronto, Canada, Estimated Using an Updated Multimedia Urban Model*. Environ. Sci. Technol., 2018, 52 (21), pp 12465–12474, DOI: 10.1021/acs.est.8b02576

Yang, C. , Harris, S., Jantunen, L., Siddique, S., Kubwabo C., Tsirlin, D., Latifovic, L., Fraser, B., St-Jean, M., De La Campa, R., You, H., Kulka, R., Diamond, M. *Are cell phones an indicator of personal exposure to organophosphate flame retardants and plasticizers?*, Vol.122, 104-116, Jan. 2019, https://doi.org/10.1016/j.envint.2018.10.021

Long range transport of organophosphate ester (OPE) flame retardants

Focus of Research: OPEs are believed to be arriving in the Arctic on ocean currents and via air transport. In this study, water samples were collected throughout the Canadian Arctic over several years to assess the levels and distribution of OPEs.

Results: OPEs were found in all abiotic environmental compartments in the Canadian North at higher levels than other contaminants including other flame retardants and pesticides. Levels of OPEs were found to be lower in the eastern Canadian Arctic than in the western Arctic.

Publications: Jantunen, L., Bernstein, S., Stern, G., Burt, A. *Organophosphate Esters Flame Retardants and Plasticizers in the Canadian Arctic Waters*. Society of Environmental Toxicology and Chemistry. Sacramento, California, USA, November 2018

First steps towards characterization of halogenated alkene flame retardants

Focus of Research: Mass spectrometry techniques were used to determine the molecular composition of two halogenated alkenes, which are widely used as flame retardant additives and plasticizers but poorly understood.

Results: The results showed that the composition of the substance was quite different from what was assumed in an initial screening risk assessment conducted by the department. These new data will further inform ecological risk assessment of the substances.

Publications: Chibwe, L., Myers, AL., De Silva, AM., Reiner, EJ., Jobst, K., Muir, D., Yuan, B. C12-30 αBromo-Chloro "Alkenes": Characterization of a Poorly Identified Flame Retardant and Potential Environmental Implications, which has been published in *Environmental Science & Technology*

Chronic toxicity of thiocarbamate, benzotriazole, and benzothiazole compounds to survival, growth, and reproduction of freshwater invertebrates

Focus of Research: Chemicals from three groupings (thiocarbamates, benzotriazoles, and benzothiazoles) were assessed for their toxicity to aquatic invertebrates and bacteria living in sediments. The survival, growth, and reproduction of these organisms were analysed to determine the risk these chemicals pose to aquatic ecosystems.

Results: Thiocarbamates, benzotriazoles and benzothiazoles caused limited toxicity to aquatic invertebrates. Observed effects occurred at concentrations well above those measured in the environment for benzotriazoles. However, thiocarbamates and benzothiazoles were difficult to measure and there are limited data on environmental concentrations; therefore, more information is needed to assess the risks of these compounds to aquatic ecosystems.

Publications: Bartlett, A., Frank, R., Brown, L., Hedges, A., Vucic, J., Campbell, S., Rudy, M., Vanderveen, R., Shires, K. 2018. *Chronic toxicity of thiocarbamate compounds to survival, growth, and reproduction of freshwater invertebrates*. Environmental Toxicology and Chemistry. (In preparation)

Environmental Fate and Deposition of CMP3 Priority Polar Organic Substances

Focus of Research: Trophic magnification of CMP3 priority substances (hindered phenol antioxidants (HPs), organophosphate ester plasticizers/flame retardants (OPEs), and benzotriazoles UV stabilizers (BZT-UVs)) in an urban, industrial aquatic food web and a remote, reference aquatic food web were investigated. Usage and release of selected substances (HPs and OPEs) were also explored by analyzing wastewater influent and effluent. Additionally, transformation products of HPs in wastewater and biota were investigated. This research was conducted to support toxic effects research via chemical analyses.

Results: The study generated the first data in water, sediment, biota and wastewater of CMP3 substances (such as hindered phenol antioxidants, organophosphate esters, and benzotriazole UV stabilisers) in the Canadian environment and contributed to the understanding of exposure, long-range transport, and food web biomagnification. As well, it contributed to the understanding of usage and persistence of these substances by measuring wastewater treatment plant influent, as well as emissions of these substances by investigating concentrations in effluent.

Publications: Lu, Z., De Silva, A.O., Provencher, J.F., Mallory, M.L., Kirk, J.L., Houde, M., Stewart, C., Braune, B.M., Avery-Gomm, S., Muir, D.C.G. 2019. *Occurrence of substituted diphenylamine antioxidants and benzotriazole UV stabilizers in Arctic seabirds and seals*. Science of the Total Environment. 663: 950–957

Lu, Z., Smyth, S.A., De Silva, A.O. 2019. Distribution and fate of *synthetic phenolic antioxidants in various wastewater treatment processes in Canada*. Chemosphere. 219, 826-835

Lu, Z., De Silva, A.O., Zhou, W., Tetreault, G.R., de Solla, S.R., Fair, P.A., Houde, M., Bossart, G., Muir, D.C.G. 2019. *Substituted diphenylamine antioxidants and benzotriazole UV stabilizers in blood plasma of fish, turtles, birds and dolphins from North America*. Science of the Total Environment. 647: 182-190

Chronic toxicity and modes of action of benzotriazoles and flame retardants in aquatic organisms

Focus of Research: The presence of benzotriazoles (BZTs) and BZT-UV stabilisers (BZT-UVs) in environmental samples were analyzed in order to better understand their fate and transport. The toxicity of these substances was also evaluated on model species of fish, algae, and invertebrate. As well, flame retardants (FRs) in environmental samples were determined and the chronic toxicity and molecular modes of action of three FRs were examined on freshwater invertebrates.

Results: Few chronic effects were observed for the selected BZT substances at environmentally relevant concentrations. Results indicate that exposure to the flame retardant substances studied affects important biological pathways at the molecular and protein levels, and could lead to long-term endocrine disruption through multiple generation.

Publications: Lu, Z., De Silva, A.O., Provencher, J.F., Mallory, M.L., Kirk, J.L., Houde, M., Stewart, C. Braune, B.M., Black, A., Muir, D.C.G. 2019. *Accumulation of substituted diphenylamine antioxidants and benzotriazole UV stabilizers in Arctic seabirds and seals*. Science of the Total Environment 663:950-957. DOI: 10.1016/j.scitotenv.2019.01.354

Survival, developmental toxicity, and tumour inducing potency of a model benzotriazole/benzothiazole (e.g. 2-mercaptobenzothiazole) in fish – as a step towards an adverse outcome pathway (AOP) for this class of compounds

Focus of Research: The tumour-inducing potency of a model benzothiazole (2-mercaptobenzothiazole (2-MBTH)) was assessed in fish.

Results: Molecular level responses of fish that had been exposed to 2-MBTH were used to establish an adverse outcome pathway that extends from exposures of fish cells in vitro, to exposures of fish eggs, to tumor assessment in year old fish. Adverse outcome pathways can be used to aid risk assessments of other benzothiazoles in fish.

Publications: The results of this research were summarized in an internal technical report.

Other publications dealing with flame retardants:

- Yang, C., Harris, S.A., Jantunen, L.M., Siddique, S., Kubwabo, C., Tsirlin, D., Latifovic, L., Fraser, B., St-Jean, M., De La Campa, R., You, H., Kulka, R., Diamond, M.L. *Are cell phones an indicator of personal exposure to organophosphate flame retardants and plasticizers? Environment International*. 2019. 122:04-116.
- Okeme, J.O., Rodgers, T.F.M., Jantunen, L.M., Diamond, M.L. *Examining the Gas-Particle Partitioning of Organophosphate Esters: How Reliable Are Air Measurements?* Environ. Sci. Technol. 2018, 52, 23, 13834-13844
- Rodgers, T.F.M., Troung, J.W., Jantunen, L.M., Helm, P.A., Diamond, M.L. *Organophosphate Ester Transport, Fate, and Emissions in Toronto, Canada, Estimated Using an Updated Multimedia Urban Model*. Environ. Sci. Technol. 2018, 52, 21, 12465-12474

Nanomaterials

Understanding the Atmospheric Fate and Toxicity of Engineered Nanoparticles through Transformation Studies

Focus of Research: The impact on the overall toxicity of airborne nanomaterials such as titanium oxide and silicon oxide when coated with secondary organic material found in the atmosphere, was investigated through laboratory studies.

Results: The results indicated that organic coatings on nanomaterials, as would occur in the atmosphere, significantly reduces the overall particle toxicity. This will be used to inform improvements to the risk assessment of nanomaterials released into the air.

Publications: Liu, Q., Liggio, J., Breznan, D., Thomson, E.M., Kumarathasan, P., Vincent, R., Li, K., Li, S. 2019. *Oxidative and Toxicological Evolution of Engineered Nanoparticles with Atmospherically Relevant Coatings*. Environ. Sci. Technol. 53, 3058-3066. DOI: 10.1021/acs.est.8b06879

Aquatic Nanotoxicology

Focus of Research: The impact of different types of freshwater on copper oxide nanoparticle toxicity was investigated.

Results: The toxicity of silver, zinc and copper nanoparticles were compared with the dissolved form in water and revealed that in general the nanoparticles were less toxic as particles. Additional testing was done on different sources of surface waters as green water (Great Lakes), brown water (Laurentian shield), urban (diluted municipal effluent in green water) and tap water (treated green water) looking at nanoparticles bioavailability and toxicity revealed that nanoparticles were generally more bioavailable in green water showing a potentially higher toxicity risk associated with Great Lakes sources.

Publications: Gagné, F., Auclair, J., Turcotte, P., Gagnon, C., Peyrot, C., Wilkinson, K. 2018. *The influence of surface waters on the bioavailability and toxicity of zinc oxide nanoparticles in freshwater mussels*. Comp Biochem Physiol C Toxicol Pharmacol.;219:1-11. DOI: 10.1016/j.cbpc.2019.01.005

Auclair J, Turcotte P, Gagnon C, Peyrot C, Wilkinson KJ, Gagné F.2019. *The influence of surface coatings on the toxicity of silver nanoparticle in rainbow trout*. Comp Biochem Physiol C Toxicol Pharmacol. 2019 Dec;226:108623

Fate, transformation and bioaccumulation of silver nanoparticles (nAg) and metal oxide nanoparticles (nCeO2, nCuO, nZnO) in the aquatic environment

Focus of Research: The fate and transformation of silver and metal oxide nanoparticles was analyzed based on their size, synthetic coating, and surrounding organic matter. The transformation products, bioavailability and bioaccumulation in aquatic organisms were evaluated.

Results: Natural transformation processes, such as aggregation or degradation, control the environmental fate and behavior of nanoparticles released into the environment. Particle size distributions change significantly under different natural conditions where most material was found in coarse colloidal fractions. The presence of natural humic substances slowed degradation of nanoparticles, which is characterized by the increase of small ion complexes and the detection of small colloids. Half-life values for silver nanoparticles were generally estimated to be less than 12 days under natural conditions, indicating transformation by-products must be considered in risk assessment studies.

Publications: Gagnon C. 2018. *Silver nanoparticles in municipal wastewaters and environmental fate*. Nano Res. Appl. 4 : 53. DOI : 10.21767/2471-9838-C3-013

Fate and effects of nanotechnology in bacterial cultures and complex communities

Focus of Research: Selected metal, carbon and silica nanomaterials were evaluated for their ecotoxicological potential focusing on microorganisms, using pure cultures and aquatic microbial communities. Multiple endpoints were studied including diversity, activity, biomass, ratios of live:dead cells, and reactive oxygen species production. As well, parallel studies based on transcriptomic and proteomic analyses were conducted.

Results: Frameworks were elaborated to inform the utilization of read-across approaches for the fate and effects of different nanomaterials.

Publications: Lawrence, J.R., Swerhone, G.D.W., Roy, J., Paule, A., Chekabab, S., Korber, D.R. 2019. *Comparative molecular, genomic and microscale analysis of the effects of nanocrystalline cellulose on the structure and function of river biofilm communities*. Ecotoxicology. (Submitted)

Environmental Fate, Effects and Bioaccumulation of Priority Nanomaterials in Soil

Focus of Research: The effect of metal nanomaterials (nano copper (II) oxide and nano cerium (IV) oxide) on soil invertebrate species and indigenous microorganisms in agricultural soil were examined, with and without biosolid amendment. This also included an evaluation of the bioaccumulation potential in earthworms over time at sublethal levels.

Results: Among other findings, this project determined the conditions and concentrations at which selected metal nanomaterials exert adverse effects on soil microbial growth, activity and diversity.

Publications: Samarajeewa, A., Velicogna, J., Schwertfeger, D., Jesmer, A., Subasinghe, R., Princz, J., Scroggins, R., Beaudette, L. 2019. *Assessment of the soil microbial community in a sandy loam soil amended with biosolids containing nano-silver particles*. NanoImpact 14:100157. DOI: 10.1016/j.impact.2019.100157

Other

The environmental fate, distribution and effects of naphthalene sulfonic acids (NSAs): Developing analytical methods, investigating toxicity, and evaluating bioaccumulation

Focus of Research: Analytical methods were developed for the determination of Naphthalene Sulfonic Acids and Salts (NSAs) in water, wastewater (effluent and influent), sediments, and tissues (worms, freshwater mussels, frogs and snapping turtle). The analytical methods were used to support investigations of NSA toxicity to and bioaccumulation in a variety of indicator species. In addition, the environmental mobility and bioavailability of NSAs and their environmental fate and distribution was studied.

Results: Analytical methods were developed for three NSAs (dinonylnaphthalenedisulfonic acid, DNDS; Calcium bis(2,3-dinonylnaphthalene-1-sulfonate), CaDNS; and Barium bis(2,3-dinonylnaphthalene-1-sulfonate), BaDNS). CaDNS and BaDNS appear to bind irreversibly to sediments and sand, while DNDS does not, suggesting that CaDNS and BaDNS are less mobile in the environment. Acute toxicity tests conducted with H. *azteca*, P. *pilsbryi,* L. *cardium*, and L. *siliquoidea* showed toxicity: CaDNS ~ BaDNS > DNDS. Chronic toxicity tests conducted with H. *azteca* and T. *tubifex* showed toxicity: CaDNS ~ BaDNS > DNDS, with sediment having a protective effect, consistent with findings in mobility experiments. Toxicity tests conducted with S. tropicalis revealed deformation and developmental delays in metamorphosis.

Publications: Matten, K.J. *Toxicity of dinonylnaphthalene sulfonates in overlying water on the pelagic Pimephales promelas, larval freshwater mussels, and epibenthos*. (In preparation)

Source, Environmental Fate and Toxicity of Synthetic Musks in Canada

Focus of Research: The levels of synthetic musk compounds (SMCc) in air, water, and sediment in the environment were assessed to determine how their usage and releases have changed over the last decade. Urban sources of SMCs were investigated through the analysis of air, soils and surface water samples from a wide array of land-use types and urban densities. The release of synthetic musk compounds from wastewater treatment plants to air and aquatic environments was assessed, as well as their levels in the Great Lakes Basin and whether they can be carried by air currents to the remote Arctic were also examined.

Results: Polycyclic musks were found to be the most abundant musk compounds in urban areas. Their sources to the outdoor environment originated from releases from indoor air and volatilization from wastewater treatment plants during the treatment process. SMCs were not found in remote Arctic air indicating low potential for long-range atmospheric transport. Results will be used to improve the risk assessment of SMCs in the urban environment.

Publications: Wong, F., Robson, M., Melymuk, L. Shunthirasingham, C. Alexandrou, N., Shoeib, M., Luk, E., Helm, P., Diamond, M. L., Hung, H. 2019. *Urban sources of synthetic musk compounds to the environment*. Environ. Sci.: Processes Impacts, 21, 74. DOI: 10.1039/C8EM00341F

Fate of microplastics in the Arctic environment

Focus of Research: The research aimed to determine the extent of microplastic contamination across the Canadian Arctic archipelago and Hudson Bay marine systems, and to evaluate sources and transport pathways of the microplastics.

Results: Microplastics were found in the arctic snow, water sediment and zooplankton. They are ubiquitous and consist mostly of small fibres. These results provide insight into the source, transport, fate and entry of microplastics into the Arctic food chain.

Publications: Adams, J., Jantunen, L., Diamond, M. L., Finkelstein, S. A., Rochman, C. M., Bernstein, S., Stern, G., *Understanding sources and transport of microplastic pollution to the Canadian Arctic*, SETAC Europe, Helsinki Finland, May 2019

Health Canada Research

HC funded 26 CMP research projects in 2018-2019. These projects address departmental and international priorities and cover a number of subjects such as characterization of nanomaterials, toxicological response to nanomaterials, carcinogenic potential of chemicals, genetic toxicity assessment, hazard characterization and identification of biotechnology microbes.

In vitro to in vivo extrapolation (IVIVE) Toxicokinetics of CMP Chemicals

Focus of research: The goal of this research is to develop better in-vitro toxicokinetic (TK) data and consistent biological extrapolation models to predict realistic doses in-vivo where potential toxicological effects would be anticipated based on measures from high throughput in-vitro assay toxicity databases. Tests and models focus on substances recently used as replacements for plasticizers, flame retardants and perfluorinated chemicals.

Results: The project resulted in the development of a new software platform to screen and model high throughput screening (HTS) data. This software, named DREAM-TK, allows data users to analyze and visualize HTS toxicity and in-vitro TK data. This tool helps in identifying chemicals considered safe and/or to trigger additional testing.

Publications: This research has provided information for the preparation of new draft documents for various international collaborations such as those facilitated by the Organisation for Economic Cooperation and Development (OECD) chemical safety programs.

The impact of dissolution behaviour of metal oxide nanomaterials on toxicological response

Focus of research: Health Canada is responsible for assessment and management of risks associated with engineered nanomaterials (materials in a size range of 1-100 nanometers). The toxicological behavior of nanomaterials (NMs) is closely associated with their distinct physical-chemical properties. This research is investigating the influence of dissolution behaviour of NMs on their toxic potential.

Results: The results of this research resulted in the development of a method that made a significant contribution to the understanding of lung bioaccessibility of platinum group elements in the thoracic fraction of re-suspended road dust. The results will inform HC risk assessments and will help HC meet its 2017-2021 commitments associated with the OECD Working Party on Manufactured Nanomaterials (WPMN).

Publications: Avramescu, M-L., Chénier, M., Gardner, HD., Rasmussen, P.E. (2019) *Solubility of metal oxide nanomaterials: observations on method development*. Journal of Physics Conference Series, 1323:1

Characterization of Residential Exposures to CMP Metals and Organics-Creation of a data repository for the Canadian House Dust Study (CHDS)

Focus of research: The objective of this research is to provide information on indoor environmental exposures (metals and synthetic organic compounds) using nationally representative house dust samples. The study focuses primarily on childhood exposures to house dust through normal hand-to-mouth ingestion behavior but looks also at potential inhalation exposures by characterizing re-suspended dust in carpeted versus non-carpeted homes.

Results: The results showed that metal concentrations in settled house dust are often correlated with those in the personal breathing zone. Therefore, settled dust data are useful for estimating indoor and personal exposures by inhalation, in addition to exposure via ingestion. Results were used to support Health Canada's risk assessment and management activities, with particular focus on mitigation of childhood residential exposures to chemical substances.

Publications: Rasmussen, P., Levesque, C., Chénier, M., and Gardner, H.D. *Contribution of metals in resuspended dust to indoor and personal inhalation exposures: Relationships between PM_{10} and settled dust*. Building and Environment. Volume 143, 1 October 2018, Pages 513-522. DOI:10.1016/j.buildenv.2018.07.044

Shang, H., Fan, X., Kubwabo, C., Rasmussen, P.E. Short-chain and Medium-chain Chlorinated Paraffins in Canadian House Dust and NIST SRM 2585. Environmental Science and Pollution Research, 2019

Development and validation of rapid methods to assess endocrine toxicity

Focus of research: There are growing concerns that exposures to commercial chemicals cause harm by interfering with the hormonal control of growth and development of the brain, reproductive tract and lead to metabolic and stress-related problems. Developing rapid methods to identify chemicals posing these hazards is a critical need for safety assessment. This project will 1) identify and characterize the molecular target(s) mediating toxicity of organophosphate flame retardants and 2) establish methods to screen for molecules that impair thyroid hormone signaling.

Results: Enzyme targets of flame retardant toxicity were identified in all affected organs. Detailed structure activity studies of enzyme inhibition have been completed for liver target and for human homolog enzyme. This project contributes to a global initiative to characterize the molecular targets influenced by hazardous substances and to develop validated, high throughput methods to rapidly screen chemicals for toxicity and to set priorities for further assessment.

Publications: Dong, H., Atlas, E., Wade, MG. 2019. *Development of a non-radioactive screening assay to detect chemicals disrupting the human sodium iodide symporter activity*. Toxicol. In Vitro. 57:39-47. doi: 10.1016/j.tiv.2019.01.021

GeneTox21 - An Integrated, High-throughput (HT) Platform for In Vitro Genetic Toxicity Assessment of New and Existing Chemicals

Focus of research: Genetic damage is associated with numerous human diseases, and chemical screening programs routinely assess a chemical's ability to damage DNA (i.e., genetic toxicity). Traditional assessment tools (i.e., bioassays) are laborious and not conducive to high-throughput (HT), high-content chemical screening using tools that employ cultured cells (i.e., in vitro bioassays). This project is developing an integrated, multi-assay, high(er) throughput (HT) platform for the assessment of chemically-induced genetic toxicity.

Results: The results showed advancement towards validation of the cell in vitro transgene mutagenicity assay, and the establishment of an in vitro mutagenicity assay. For the former, a miniaturized protocol was developed to assess the effects of various treatment times and post-exposure sampling times. The HT platform, which is called GeneTox21, will be internationally promoted to encourage its adoption for robust genetic toxicity assessment of new and existing substances.

Publications: Cox, J.A., Zwart, E., Luijten, M. 2018. *The development and pre-validation of an in vitro mutagenicity assay based on MutaMouse primary hepatocytes, Part I: Isolation, structural, genetic and biochemical characterization*. Environmental and Molecular Mutagenesis 60:331-347

Cox, J.A., Zwart, E., Luijten, M. 2019. *The development and pre-validation of an in vitro mutagenicity assay based on MutaMouse primary hepatocytes, Part II: Assay performance for the identification of mutagenic chemicals*. Environmental and Molecular Mutagenesis. 60:348-360

Refining and Deploying a Quantitative Framework for the Analysis and Regulatory Interpretation of Genetic Toxicity Dose-Response Data

Focus of research: This project is using dose-response data from the scientific literature to determine the levels of genotoxic effects (e.g., DNA damage or genetic mutations) that should be considered adverse. As a follow-up, the work is conducting case studies of selected chemicals to evaluate the ability to use analyses of dose-response data to assess the risk of adverse human health effects; i.e., adverse effects on the genome.

Results: Procedures were developed and implemented to effectively and efficiently analyze large amounts of dose-repose data generated using a cell-based genetic toxicity bioassay known as the ToxTracker assay. The dose-response data were also adjusted for levels of cytotoxicity. Additionally, the scope of several case studies to evaluate the risk of adverse human health effects was expanded. The results obtained will be used to develop a framework for routine quantitative use of genetic toxicity data for regulatory evaluations of new and existing chemicals. Interactions with stakeholders will permit an evaluation of the proposed framework, and international promotion of quantitative methods for regulatory evaluations of genotoxic chemicals.

Publications: White, P.A., Zeller, A., Pfuhler, S., Johnson, G.E. 2019. R e: Gi et al. 2018, *In vivo positive mutagenicity of 1,4-dioxane and quantitative analysis of its mutagenicity and carcinogenicity in rats*. Archives of Toxicology 92:3207-3221. Arch Toxicol 93:211-212

Relative toxic potency of silica and titanium dioxide nanoparticle variants

Focus of research: The objective is to assess composition, size and surface coating characteristics of nanomaterial (NMs), and test toxicity in lung cells including cells from biopsy samples from healthy lungs and those affected by pulmonary diseases (e.g., cystic fibrosis).

Results: From early findings, macrophages exposed to silica nano particles (SiNPs) showed different responses based on size and surface-modification. Also, SiNPs were relatively more cytotoxic than titanium oxide nanoparticles, and atmospheric changes appeared to alter these toxicities. Furthermore, internalization of nanoparticles into exposed cells and changes in cellular organelles were noticed with size- and surface-modification appearing to play key roles in influencing these biological responses (e.g., oxidative stress). This work will advance our understanding on the health consequences of exposure to NMs, and assist in the design of less toxic NMs.

Publications: Liu, Q., Liggio, J., Breznan, D., Thomson, EM., Kumarathasan, P., Vincent, R., Li, K., Li, SM. *Oxidative and Toxicological Evolution of Engineered Nanoparticles with Atmospherically Relevant Coatings*. Environ Sci Technol. (Accepted in 2018). 2019 Mar 19;53(6):3058-3066. doi: 10.1021/acs.est.8b06879

Breznan D, Das DD, MacKinnon-Roy C, Bernatchez S, Sayari A(1), Hill M, Vincent R, Kumarathasan P. *Physicochemical Properties Can Be Key Determinants of Mesoporous Silica*. Nanoparticle Potency in Vitro. ACS Nano. 2018 Dec 26;12(12):12062-12079

An integrated testing strategy to assess somatic and germ cell mutations using the OECD's transgenic rodent test guideline TG 488 and the MutaMouse model

Focus of research: The objective is to harmonize the experimental design to identify somatic and germline mutations at a single time point. This integrated approach will significantly reduce the number of animals that are needed for the testing of chemicals for regulatory purposes.

Results: Data generated by this project have been used by the Organisation for Economic Cooperation and Development (OECD) to update the recommended experimental design in one test guideline that is routinely used to assess the ability of chemicals to induce mutations (i.e., changes in the sequence of the DNA).

Publications: Marchetti F., Aardema, M., Beevers, C., van Benthem, J., Godschalk, R., Yauk, CL., Young, B., Williams, A., Douglas, GR. (2018) *Identifying germ cell mutagens using OECD test guideline 488 (transgenic rodent somatic and germ cell mutation assay*) and integration with somatic cell testing. Mutation Research, 832:7-18. Epub: May 29, 2018

6.2 LIVING ORGANISMS

Government research on living organisms focuses on developing novel and contemporary methods for determining the hazardous characteristics and the pathogenicity potential of various existing and emerging biotechnology microbes in order to support regulatory risk assessments. The research is jointly coordinated between regulators at HC and ECCC.

Research in 2018-2019 continued on a number of subjects, and five laboratory protocols to assess pathogenicity were provided to regulators as a reference for notifiers.

6.3 AIR POLLUTANTS AND GREENHOUSE GASES

Air quality research efforts help quantify priority air pollutants and determine trends, improve and validate air quality predictions both in the near term and into the future within the national and global context. These efforts also enhance understanding of the impacts of air pollution on Canadians and the environment. The research also tackles emerging issues and underpins and informs evidence-based policy and regulatory development.

ECCC Research

Ongoing research continued on a wide range of air pollutants, including short lived climate pollutants, ammonia, nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic compounds (VOCs), ozone, and particulate matter/aerosols. It also included utilizing surface and satellite observations; measuring the impact of ship emissions and the formation of secondary species formed in the Arctic environment. Over 67 research papers were published in peer-reviewed scientific journals in 2018-2019. The following are representative examples of that important body of work.

Satellite-based measurement of emissions of ammonia and nitrogen oxides

Focus of Research: The derivation of emissions of ammonia and nitrogen oxides from various sources, including wildfires, using satellite data.

Results: The research found there was good agreement between the satellite measurements, model predictions and emissions inventories, suggesting that satellite data can contribute to improved understanding and quantification of air pollutant emissions.

Publications: Adams, C., McLinden, C.A., Shephard, M.W., Dickson, N., Dammers, E., Chen, J., Makar, P., Cady-Pereira, K.E., Tam, N., Kharol, S.K., Lamsal, L.N., Krotkov, N.A., *Satellite-derived emissions of carbon monoxide, ammonia, and nitrogen dioxide from the 2016 Horse River wildfire in the Fort McMurray area*, Atmos. Chem. Phy., Vol. 19, 4, Feb. 2019, 2577-2599, 10.5194/acp-19-2577-2019

Zhang, X., Jones, D.B.A., Keller, M., Walker, T.W., Jiang, Z., Henze, D.K., Worden, H.M., Bourassa, A.E., Degenstein, D.A., Rochon, Y.J., *Quantifying Emissions of CO and NOx Using Observations From MOPITT, OMI, TES, and OSIRIS,* Journal of Geophysical Research: Atmospheres, Vol. 214, 2, Jan. 2019, 1170-1193,https://doi.org/10.1029/2018JD028670

Griffin, D., Zhao, X., McLinden, C.A., Boersma, F., Bourassa, A., Dammers, E., Degenstein, D., Eskes, H.,Fehr, L., Fioletov, V., Hayden, K., Kharol, S.K.a, Li, S.-M.a, Makar, P., Martin, R.V., Mihele, C., Mittermeier, R.L., Krotkov, N., Sneep, M., Lamsal, L.N., Linden, M.T., Geffen, J.V., Veefkind, P., Wolde, M., *High-Resolution Mapping of Nitrogen Dioxide With TROPOMI: First Results and Validation Over the Canadian Oil Sands*, Geophysical Research Letters, 46, 3, Dec. 2018

Global and regional trends of sulphur dioxide and nitrogen

Focus of study: An assessment of global and regional trends of sulphur in the atmosphere was conducted, and exceedances of ecosystem critical loads for acidifying deposition of nitrogen and sulphur in Alberta and Saskatchewan were identified.

Results: The research provided insights into where global sulphur emissions have increased or decreased between 1990 and 2015, and included the identification of nearly 40 emissions sources not previously captured in global emissions inventories. The related critical loads work identified that ecosystems in portions of Alberta and Saskatchewan have exceeded their ability to buffer acid deposition.

Publications: Aas, W., Mortier, A., Bowersox, V., Cherian, R., Faluvegi, G., Fagerli, H., Hand, J., Klimont, Z., Galy-Lacaux, C., Lehmann, C.M.B., Myhre, C.L., Myhre, G., Olivié, D., Sato, K., Quaas, J., Rao, P.S.P., Schulz, M., Shindell, D., Skeie, R.B., Stein, A., Takemura, T., Tsyro, S., Vet, R., Xu, X., *Global and regional trends of atmospheric sulfur*, Scientific Reports, Vol. 9, 11, Jan. 2019, 9533

Liu, F., Choi, S.B,, Li, C., Fioletov, V.E., McLinden, C.A., Joiner, J., Krotkov, N.A., Bian, H., Janssens-Maenhout, G., Darmenov, A.S., Da Silva, A.M. *A new global anthropogenic SO_2 emission inventory for the last decade: A mosaic of satellite-derived and bottom-up emissions*, Atm. Chem Phys., Vol 18, Issue 22, 22 November 2018, Pages 16571-16586

Makar, P. A., Akingunola, A., Aherne, J., Cole, A. S., Aklilu, Y.-A., Zhang, J., Wong, I., Hayden, K., Li, S.-M., Kirk, J., Scott, K., Moran, M. D., Robichaud, A., Cathcart, H., Baratzedah, P., Pabla, B., Cheung, P., Zheng, Q., Jeffries, D. S. (2018) *Estimates of exceedances of critical loads for acidifying deposition in Alberta and Saskatchewan*, Atmos. Chem. Phys., 18, 9897-9927

Monitoring of atmospheric ozone and ultraviolet radiation

Focus of Research: The measurement of atmospheric ozone, aerosol and water vapour using an ECCC-developed lidar (Light Detection and Ranging) instrument was validated, and ECCC scientists contributed to an international assessment of ozone in the layer of the atmosphere nearest the surface of the Earth.

Results: The assessments of new lidar and of established satellite measurement technologies demonstrated that both remote sensing techniques are highly useful and efficient methods to collect data. Analysis of satellite measurements of tropospheric ozone did not identify any clear trends in the global levels; the analysis of ultraviolet radiation trends found that levels at various locations in the Northern Hemisphere over the past 25 years vary considerably due mainly to the variations in airborne aerosols and total ozone, but the relationship between these factors requires further research.

Publications: Strawbridge, K.B., Travis, M.S. Firanski, B.J., Brook, J.R., Staebler, R., Leblanc, T., *A fully autonomous ozone, aerosol and nighttime water vapor lidar: A synergistic approach to profiling the atmosphere in the Canadian oil sands region*, Atoms. Environ, Volume 11, Issue 12, 19 December 2018, Pages 6735-6759, doi:10.5194/amt-11-6735-2018

Gaudel, A.. Cooper, O. R., Ancellet, G., Barret, B., Boynard, A., Burrows, J. P., Clerbaux, C., Coheur, P.F,. Cuesta, J., Cuevas, E., Doniki, S., Dufour, G., Ebojie, F., Foret, G., Garcia, O., Granados Muños, M. J., Hannigan, JW., Hase, F., Huang, G., Hassler, B., Hurtmans, D., Jaffe, D., Jones, N., Kalabokas, P., Kerridge, B., Kulawik, S. S., Latter, B., Leblanc, T., Le Flochmoën, E., Lin, W., Liu, J., Liu, X., Mahieu, E., McClure-Begley, V., Neu, J. L., Osman, M., Palm, M., Petetin, H., Petropavlovskikh, I., Querel, R., Rahpoe, N., Rozanov, A., Schultz, M. G., Schwab, J., Siddans, R., Smale, D., Steinbacher, M., Tanimoto, H., Tarasick, D. W., Thouret, V., Thompson, A. M., Trickl, T., Weatherhead, E., Wespes, C., Worden, H. M., Vigouroux, C., Xu, X., Zeng, G., and Ziemke,J. *Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation*. Elem Sci Anth 2018; 6 (1): 39, doi: 10.1525/elementa.291

Fountoulakis, I., Zerefos, C.S., Bais, A.F., Kapsomenakis, J., Koukouli, M.-E., Ohkawara, N., Fioletov, V., De Backer, H., Lakkala, K., Karppinen, T., Webb, A.R., *Twenty-five years of spectral UV-B measurements over Canada, Europe and Japan: Trends and effects from changes in ozone, aerosols, clouds, and surface reflectivity*, Comptes Rendus Geoscience External Geophysics, Climate, 350,7, Nov 2018, 393-402, 10.1016/j.crte.2018.07.011

Regional and global sources of aerosols and particulate matter

Focus of Research: ECCC scientists participated in a study of global sources of fine particulate matter, conducted studies on the impacts of wildfire smoke on ecosystems, and conducted an extensive overview of recent advances in understanding the sources and chemical processes affecting particulate matter in the Arctic and their effect on Arctic climate.

Results: Fine particulate matter was found to originate from a variety of sources - just over half coming from residential energy use, industry and power generation. Dense wildfire smoke negatively impacts the ability of forests to absorb carbon from the atmosphere, leading them to become net sources of carbon instead.

Publications: In 2018-2019, ECCC scientists contributed to many publications related to aerosols and fine particulate matter; a few examples include:

Weagle, C.L., Snider, G., Li, C., Van Donkelaar, A., Philip, S., Bissonnette, P., Burke, J., Jackson, J., Latimer, R., Stone, E., Abboud, I., Akoshile, C., Anh, N.X., Brook, J.R., Cohen, A., Dong, J., Gibson, M.D., Griffith, D., He, K.B., Holben, B.N., Kahn, R., Keller, C.A., Kim, J.S., Lagrosas, N., Lestari, P., Khian, Y.L., Liu, Y., Marais, E.A., Martins, J.V., Misra, A., Muliane, U., Pratiwi, R., Quel, E.J., Salam, A., Segev, L., Tripathi, S.N., Wang, C., Zhang, Q., Brauer, M., Rudich, Y., Martin, R.V., *Global Sources of Fine Particulate Matter: Interpretation of PM2.5 Chemical Composition Observed by SPARTAN using a Global Chemical Transport Model*, Environ. Sci. Technol., 2018, 52 (20), pp 11670–11681. DOI: 10.1021/acs.est.8b01658

McKendry, I. G., Christen, A., Lee, S.-C., Ferrara, M., Strawbridge, K. B., O'Neill, N., Black, A.: *Impacts of an intense wildfire smoke episode on surface radiation, energy and carbon fluxes in southwestern British Columbia, Canada*, Atmos. Chem. Phys., 19, 835-846, https://doi.org/10.5194/acp-19-835-2019, 2019

Abbatt, J.P.D., Leaitch, R., W., Aliabadi, A.A., Bertram, A.K., Blanchet, J.-P., Boivin-Rioux, A., Bozem, H., Burkart, J., Chang, R.Y.W., Charette, J., Chaubey, J.P., Christensen, R.J., Cirisan, A., Collins, D.B., Croft, B., Dionne, J., Evans, G.J., Fletcher, C.G., Gali, M., Ghahremaninezhad, R., Girard, E., Gong, W., Gosselin, M., Gourdal, M., Hanna, S.J., Hayashida, H., Herber, A.B., Hesaraki, S., Hoor, P., Huang, L., Hussherr, R., Irish, V.E., Keita, S.A., Kodros, J.K., Köllner, F.g,, Kolonjari, F., Kunkel, D., Ladino, L.A., Law, K., Levasseur, M., Libois, Q., Liggio, J., Lizotte, M., MacDonald, K.M.,Mahmood, R., Martin, R.V., Mason, R.H., Miller, L.A., Moravek, A., Mortenson, E., Mungall, E.L., Murphy, J.G., Namazi, M., Norman, A.-L., O'Neill, N.T., Pierce, J.R., Russell, L.M., Schneider, J., Schulz, H., Sharma, S., Si, M., Staebler, R.M., Steiner, N.S., Thomas, J.L., Von Salzen, K., Wentzell, J.J.B., Willis, M.D, Wentworth, G.R., Xu, J.-W., Yakobi-Hancock, J.D., *Overview paper: New insights into aerosol and climate in the Arctic*, Atoms. Chem. Phy., vol. 19, 4, Feb. 2019, 2527-2560, 10.5194/acp-19-2527-2019

Air pollution from the transportation sector

Focus of research: Studies were conducted to improve the measurement of black carbon (BC) emitted by small marine engines and diesel vehicles, examine air pollution near roadways, and assess the impact of air pollutant emissions from marine shipping in the Canadian Arctic.

Results: The research on small marine engines indicated that differences in measured BC emissions relate to engine characteristics, loads and the fuel used. The near-roadway study indicated that larger vehicles are the most influential factor affecting the level of the measured pollutants. Research showed that the properties of BC particles depend greatly on particle size. Marine shipping was found to be a small contributor of ozone and particulate matter, but a significant contributor of nitrogen dioxide and sulphur dioxide over Arctic shipping channels.

Publications: Jiang, Y., Yang, J., Gagné, S., Chan, T.W., Thomson, K., Fofie, E., Cary, R.A., Rutherford, D., Comer, B., Swanson, J., Lin, Y., Rooy, P.V., Asa-Awuku, A., Jung, H., Barsanti, K., Karavalakis, G., Cocker, D., Durbin, T.D., Miller, J.W., Johnson, K.C. (2018) *Sources of variance in BC mass measurements from a small marine engine: Influence of the instruments, fuels and loads*. Atmospheric Environment 182: 128-137. doi.org/10.1016/j.atmosenv.2018.03.008

Wang, J.M., Jeong, C.-H., Hilker, N., Shairsingh, K.K., Healy, R., Sofowote, U., Debosz, J., Su, Y., McGaughey, M., Doerksen, G., Munoz, T., White, L., Herod, D., Evans, G.J. *Near-Road Air Pollutant Measurements: Accounting for Inter-Site Variability using Emission Factor*s, Env. Sci. & Tech., 2018 52 (16), 9495-9504, DOI: 10.1021/acs.est.8b01914

Gong, W., Beagley, S.R., Cousineau, S., Sassi, M., Munoz-Alpizar, R., Ménard, S., Racine, J., Zhang, J., Chen, J., Morrison, H., Sharma, S., Huang, L., Bellavance, P. , Ly, J., Izdebski, P., Lyons, L., Holt, R., *Assessing the impact of shipping emissions on air pollution in the Canadian Arctic and northern regions: Current and future modelled*

scenarios, Atoms. Chem. Phys., Volume 18, Issue 22, 26 November 2018, Pages 16653-16687, 10.5194/acp-18-16653-2018

Emissions from oil sands activities

Focus of Research: Under the Oil Sand Monitoring program (OSM), ECCC scientists assessed the contribution of oil sands operations to regional emissions of air pollutants and GHGs using aircraft-based measurements.

Results: ECCC research contributed to improvement in the quantification of emissions from oil sands activities in Canada.

Publications: Stroud, C. A., Makar, P. A., Zhang, J., Moran, M. D., Akingunola, A., Li, S.-M., Leithead, A., Hayden, K., Siu, M.: *Improving air quality model predictions of organic species using measurement-derived organic gaseous and particle emissions in a petrochemical-dominated region*, Atmos. Chem. Phys., 18, 13531-13545, https://doi.org/10.5194/acp-18-13531-2018, 2018

Baray, S., Darlington, A., Gordon, M., Hayden, K. L., Leithead, A., Li, S.-M., Liu, P. S. K., Mittermeier, R. L., Moussa, S. G., O'Brien, J., Staebler, R., Wolde, M., Worthy, D., McLaren, R.: *Quantification of methane sources in the Athabasca Oil Sands Region of Alberta by aircraft mass balance*, Atmos. Chem. Phys., 18, 7361-7378, https://doi.org/10.5194/acp-18-7361-2018, 2018

Enhanced methane emissions from a warming Canadian Arctic

Focus of Research: ECCC scientists looked at methane measurements from four monitoring stations in the Canadian sub-Arctic and used computer models to determine the relative contributions to atmospheric methane concentrations from wetland and forest fire sources.

Results: This study showed a correlation with warmer summer conditions resulting in higher methane emissions from wetlands at the sub-Arctic sites studied. ECCC scientists are conducting a similar study using data from additional measurement sites across Canada to understand methane emissions from wetlands on the national scale.

Publications: Ishizawa, M., Chan, D., Worthy, D., Chan, E., Vogel, F., Maksyutov, S. (2019): Analysis of atmospheric CH4 in Canadian Arctic and estimation of the regional CH4 fluxes, Atmospheric Chemistry and Physics, 19, 4637–4658, https://doi.org/10.5194/acp-19-4637-2019

Health Canada research

In 2018-2019, HC continued to conduct research on human exposure to indoor and outdoor air pollutants and their health impacts in order to guide actions to address air pollution by governments, industries, other organizations and individuals. HC scientists published approximately 44 articles in peer reviewed scientific journals. These addressed issues such as global estimates of mortality associated with air pollution exposure, risk factors that contribute to the estimation of the global burden of disease, gene environment interactions as they relate to air pollution, the effect of air pollution on birth outcomes, the benefits of kitchen exhaust fans in improving indoor air quality, and studies of the relationship between air pollution exposure and hypertension, diabetes and Parkinson's disease. Others studies investigated determinants of air pollution exposure in various environments and provided information of use to local air quality management and population health studies.

Twenty-one HC research projects on air quality were ongoing in 2018-2019 and three new research projects were initiated. The new studies included investigations of aeroallergens and air pollution, ultrafine particles and cancer, and the effect of biomass burning emissions on children's health. The following presents some of the projects in which Health Canada was engaged during 2018-2019.

ATOUSSA – Assessing Toxicity of Organics in Urban Source Sectors for Air

Focus of research: This study investigates potential human health risks associated with exposure to chemical mixtures in urban air. The objective is to identify various toxic organics and characterise their relative concentrations at different sites in urban Toronto influenced by different types of emission sources.

Results: The project generated knowledge of the chemical composition of eight different sites indicative of different sources in the Toronto urban area and how the chemical composition changes from season to season. Several toxicity assays were optimised to determine the most sensitive assays that will enable differentiation of site-specific responses that can be linked to specific chemical components and their respective concentrations in the mixtures. The current study provided a level of comparison with and between various sources in the Toronto region.

Publications: Saini, A., Clarke, J., Jariyasopit, N., Rauert, C., Schuster, J.K., Halappanavar, S., Evans, G.J., Su, Y., Harner, T. Flame Retardants in Urban Air: A Case Study in Toronto Targeting Distinct Source Sectors. Environmental Pollution; Volume 247, April 2019, Pages 89-97

Analysis of indoor air VOC data collected in Canadian Health Measures Survey: National estimates of indoor air VOCs and determinants of indoor air VOCs

Focus of research: Under the Canadian Health Measures Survey (CHMS), a population-based national indoor air survey (NIAS) was conducted for the presence of volatile organic compounds (VOCs) in the indoor air of Canadian homes. The goal is to examine associations between levels of indoor air VOCs and housing type (houses vs. apartments), lifestyle (smoking vs. non-smoking) and seasons (monthly variation).

Results: About two-thirds of the 88 VOCs measured in the cycle 3 of the CHMS were detected in more than half of the homes, and that VOC levels are comparable to those of cycle 2 for the majority of measured VOCs. Information on indoor air VOCs can be used to assess human inhalation exposure to these chemicals and to inform the development of residential indoor air quality guidelines for individual VOCs.

Publications: Li, Y., Cakmak, S. Zhu, J. *Profiles and monthly variations of selected volatile organic compounds in indoor air in Canadian homes: results of Canadian national indoor air survey* 2012-2013. Environment International (2019), 126, 134–144

The role of non-chemical stressors and stress susceptibility in modifying the effects of air pollutants on health

Focus of research: Non-chemical stressors are important determinants of health that may also modify or contribute to the adverse health effects associated with air pollution. The objective is to assess the extent to which non-chemical stressors and inter-individual differences in stress response modify health effects of air pollution.

Results: The study produced the first evidence that individual differences in stress reactivity are associated with differential sensitivity to pulmonary impacts of ozone. The first national profile of allostatic load, a measure of cumulative physiological dysfunction associated with chronic exposure to stressors, was published. There was a spatial association identified between psychological distress and ambient air pollution levels in Canada.

This work provides insight into factors governing susceptibility to inhaled pollutants. The allostatic load profile provides a tool for assessing combined and cumulative impacts of exposure to multiple stressors.

Publications: Thomas, J., Guénette, J., Thomson, EM. *Stress axis variability is associated with differential ozone-induced lung inflammatory signaling and injury biomarker response*. Environ Res. 2018 Sep 8. pii: S0013-9351(18)30496-1. doi: 10.1016/j.envres.2018.09.007

Thomas J, and Thomson EM. Dec 2018. *Corticosterone determination in bronchoalveolar lavage fluid and its relationship to free and total plasma corticosterone*. Anal Biochem. 2019 Feb 15;567:27-29. doi:10.1016/j.ab.2018.12.005

Air Quality Health Index (AQHI) panel and intervention studies oxidative stress markers and additional data analysis

Focus of research: This project proposed to analyze oxidative stress markers for Prince George 2015 and London 2015, to analyze associations between the AQHI and individual pollutants and cardiorespiratory measures in the London 2015 data, and to conduct additional analyses of panel and intervention study data, including subgroup analyses and alternative weightings of pollutants in the AQHI formulation.

Results: The study found short term adverse effects on heart and lung function with increases in the AQHI, as well as benefits to the heart and lungs over the duration of the study from daily outdoor physical activity. These findings suggest that older adults living in smaller cities and rural areas benefit from daily light outdoor physical activity in winter, but may also benefit from reducing outdoor activity when the AQHI is particularly high in order to reduce short-term adverse effects on the heart and lungs.

Publications: Stieb, DM., Shutt, R., Kauri, LM., Szyszkowicz, M., Dobbin, NA, Chen, L., Rigden, M., Van Ryswyk, K., Kulka, R., Jovic, B., Mulholland, M., Green, MS, Liu, L., Pelletier, G., Weichenthal, SA., Dales, RE. "*Cardiorespiratory effects of air pollution in a panel study of winter outdoor physical activity in older adults*." Journal of occupational and environmental medicine 60.8 (2018): 673-682

Oxidative stress, inflammation and cardiovascular changes associated with oxidative potential of ambient coarse, fine and ultrafine particulate matter

Focus of research: Particulate Matter (PM) in ambient air is a complex mixture of various sizes and constituents. Oxidative stress/inflammation is thought to be an important pathway leading to PM-associated disease status. This has led to a hypothesis that oxidative potential (OP) may be an integral property of PM that initiates oxidative stress/inflammation in the body. This project will provide evidence as to how reactive constituents of ambient PM of different size fractions/sources may affect human health differently.

Results: Exposure to various metals and oxidative potential was significantly associated with increased levels of various blood or urinary biomarkers. Metals and reactive oxidants in ambient particles may influence biomarker levels that reflect systemic inflammation, oxidative stress, perturbations of blood-brain barrier integrity and body stress response. These results may help interpret previously published epidemiology findings showing associations between short-term exposure to air pollution and hospitalizations and emergency room visits for cardiovascular, respiratory and neuro-psychological illness.

Publications: Liu, L., Urch, B., Szyszkowicz, M. Speck, M., Van Huang, A., Leingartner, K., Shutt, R., Pelletier, G., Gold, G.R., Brook, J.R., Pollitt, K.G., Silverman, F.S. *Metals and oxidative potential in urban particulate matter influence systemic inflammatory and neural biomarkers: A controlled exposure study*. Environment International. October 2018

An intervention study on the effectiveness of the Air Quality Health Index (AQHI) advice in a panel of patients with implanted cardioverter defibrillators in Toronto

Focus of research: The AQHI is a risk communication tool intended to provide information to the public on current and forecasted air quality conditions. Although the AQHI has been used extensively for several years, little research has been done to characterize the benefits that may be achieved by following AQHI advice. The primary objective is to evaluate the actual effectiveness of the AQHI as an intervention in reducing health risks of patients wearing implantable cardioverter defibrillator (ICD). The secondary objective is to study the associations between daily exposure to outdoor O3, NO2 and PM2.5 as well as AQHI and variations in arrhythmia parameters and other cardiovascular outcomes in this panel of cardiac patients.

Results: The results suggest that air pollution was associated with adverse changes in cardiovascular measures in ICD patients. Advice to avoid exposure to outdoor air pollution based on AQHI may help reduce adverse impacts on cardiovascular measures. Daily mild exercise may benefit cardiovascular function in this cohort of ICD patients.

Publications: Liu, L., Urch, B., Nanthakumar, K., Chen, L., Smith-Doiron, M., Brook, J.R., Speck, M., Silverman, F., Stieb, D.M. *Air pollution, physical activity and cardiovascular function of patients with implanted cardioverter defibrillators: A randomized controlled trial of indoor versus outdoor activity*. Journal Occup. Environ. Med. (under review)

Methods to Pool Non-Linear Concentration-Response Models

Focus of research: New evidence is emerging that relationships between outdoor concentrations of air pollutants and health may not all be best characterized by linear risk models. This project will develop mathematical methods to combine results from several studies with non-linear associations between air pollution exposure and health.

Results: This study resulted in the development of a method pooling non-linear risk functions named the Global Exposure Mortality Model (GEMM) for non-accidental deaths. This new approach is used worldwide to determine the impact of fine particulate matter on mortality.

Publications: Szyszkowicz, M., Thomson, E.M., Colman, I., Rowe, B.H. *Ambient air pollution exposure and emergency department visits for substance abuse*. PLoS ONE 13(6): e0199826. https://doi.org/10.1371/journal.pone.0199826

Outdoor Pollution Exposure Risk Assessment (OPERA)

Focus of research: Outdoor Pollution Exposure and Risk Assessment (OPERA) represents a new paradigm in how to conduct burden of disease studies to support evidence-based decision making in climate and air quality management. The project consists of two main components: construction of multi-pollutant concentration response functions for different health outcomes; and estimation of disease burden by source of pollution and geographic area.

Results: Improved air pollution exposure methodologies were applied to Canadian and global cohorts and found associations between air pollution exposure for a range of health outcomes including diabetes, preterm birth and mortality. A large international collaboration has made a significant contribution to the estimation of the global burden of disease associated with air pollution.

Publications: Burnett, R., Chen, H., Szyszkowicz, M., Fann,N., Hubbell, B., Pope III, A.C., Apte, J.S., Brauer, M., Cohen, A., Weichenthal, S., Coggins, J., Di, Q., Brunekreef, N., Frostad, J., Lim, S., Kan, H., Walker, K.D., Thurston, G.D., Hayes, R.B., Lim, C.C., Turner, M.C., Jerrett, M., Krewski, D., Gapstur, S.M., Diver, R.W., Ostro, B., Goldberg, D., Crouse, L.D., Martin, R.V., Peters, P., Pinault, L., Tjepkema, M., van Donkelaar, A., Villeneuve, P.J., Miller, A.B., Yin, P., Zhou, M., Wang, L., Janssen, N.A.H., Marra, M., Atkinson, R.W., Tsang, H., Thach, T.Q., Cannon, J.B., Allen, R.T., Hart, J.E., Laden, F., Cesaroni, G., Forastiere, F., Weinmayr, G., Jaensch, A., Nagel, G., Concin, H., Spadaro, J.V. *Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter*. 2018. Proceedings of National Academy of Sciences

Stieb DM, Lavigne E, Chen L, Pinault L, Gasparrini A, Tjepkema M. *Air pollution in the week prior to delivery and preterm birth in 24 Canadian cities: a time to event analysis. Environ Health*. 2019 Jan 3;18(1):1. doi: 10.1186/s12940-018-0440-8

Meng, J., Martin, R.V., Li, C., van Donkelaar,A., Tzompa-Sosa, Z.A., Yue, X., Xu, J.W., Weagle, C.L., Burnett, R.T.. Source Contributions to Ambient Fine Particulate Matter for Canada. Environ. Sci. & Tech. 2019, 53, 17, 10269-10278

Modification of the air pollution-lung cancer mortality relationship by synoptic-scale weather types: a Canadian national-level cohort study

Focus of research: This study examines the modifying effect of weather type on the associations between air pollution (nitrogen dioxide (NO_2), particulate matter (PM) and ozone (O3)) and human health in a Canadian national cohort, using lung cancer mortality rates and adjusting for socio-economic factors which can affect the air pollution-related risk estimate. It will also assess the relationship between local road length, proximity to primary highways, and cause-specific mortality in the 1991 Canadian Census Health and Environment Cohort (CanCHEC). The CanCHEC study comprises 2.6 million people who were enrolled in 1991 and followed-up through to 2009.

Results: The effects of long-term traffic exposure on diabetes, cerebrovascular disease, lung cancer, ischemic heart disease (IHD), and Chronic Obstructive Pulmonary Disease (COPD) mortality differ by climate zones. The results suggest that exposure to higher road density and proximity to major traffic roads was associated with increased mortality risk from cerebrovascular and cardiovascular disease, ischemic heart disease, COPD, respiratory disease, and lung cancer.

Publications: Cakmak, S., Hebbern, C., Vanos, J., Crouse, D.L., Tjepkema, M. *Exposure to traffic and mortality risk in the 1991–2011 Canadian Census Health and Environment Cohort* (CanCHEC). Environment International 124 (March 2019) 16-24

Benefits of kitchen exhaust fans in improving indoor air quality

Focus of Research: This pilot study examines the use of different flow rate fans during cooking and tests whether continuing to run the fan after cooking significantly improves pollutant removal rates and integrated exposures.

Results: Fan flow rate and physical characteristics of the exhaust fan used during cooking were the most important determinants of exposures following cooking. This information will inform Health Canada guidance to Canadians on reducing exposure to cooking-related air pollutants in homes.

Publications: Sun, L., Wallace, L.A., Dobbin, N.A., You, H., Kulka, R., Shin, T., St-Jean, M., Aubin, D., Singer, B.C. "*Effect of venting range hood flow rate on size-resolved ultrafine particle concentrations from gas stove cooking.*" Aerosol Science and Technology 52.12 (2018): 1370-1381

Dobbin, N.A., Sun, L., Wallace, L.A., You, H., Kulka, R., Shin, T., St-Jean, M., Aubin, D., and Singer, B.C."*The benefit of kitchen exhaust fan use after cooking-An experimental assessment.*" Building and Environment 135 (2018): 286-296

Canadian Atlantic Marine Air Pollution study

Focus of Research: This study investigates the impact that lower-sulphur marine fuel regulations have had on air pollution exposures for Canadians living in Halifax, Nova Scotia.

Results: Findings to date indicate that the low-sulphur marine fuel Regulations have substantially reduced ambient exposures to SO2 and contributed to a moderate improvement in Halifax particulate air quality. Source apportionment modeling will be applied to quantify pre- and post-regulatory marine sector emission contributions to ambient $PM_{2.5}$ and $PM_{2.5}$-associated air toxics (e.g., heavy metals) relative to other transport and non-transort source types.

Publications: A scientific article outlining the efficacy of the lower-sulphur marine fuel regulations will be published in 2019.

Acute and chronic health effects of ambient $PM_{2.5}$ oxidative potential

Focus of Research: Particulate matter oxidative potential measurements have been proposed as a promising integrated measure of overall particle toxicity. These studies investigate exposure to $PM_{2.5}$ oxidative potential at different scales and apply this data to epidemiological investigations.

Results: Spatial characterization of $PM_{2.5}$ oxidative potential has been conducted at the scale of both between-cities (Canada wide) and within-cities (Toronto) revealing significant distinctions from the signal observed from PM mass. Associations between oxidative potential and various health outcomes including birth outcomes have been observed. Scientific articles focusing on $PM_{2.5}$ oxidative potential and development of childhood asthma and pediatric cancers will be published in 2019 with additional publications in subsequent years.

Publications: Weichenthal, S., Shekarrizfard, M., Traub, A., Kulka, R., Al-Rijleh, K., Anowar, S., Evans, G., Hatzopoulou, M. *Within-City Spatial Variations in Multiple Measures of $PM_{2.5}$ Oxidative Potential in Toronto, Canada*. Environmental science & technology 53.5 (2019): 2799-2810.

Lavigne, É., Burnett RT., Weichenthal, S. *Association of short-term exposure to fine particulate air pollution and mortality: effect modification by oxidant gases*. Scientific reports 8.1 (2018): 16097

Weichenthal, S., Shekarrizfard, M., Kulka, R., Pascale, S., Lakey, S., Al-Rijleh, K., Anowar, S., Shiraiwa, M., Hatzopoulou, M. *Spatial variations in the estimated production of reactive oxygen species in the epithelial lung lining fluid by iron and copper in fine particulate air pollution*. Environmental Epidemiology 2.3 (2018): e020

Lavigne, É., Burnett, RT., Stieb, D.M., Evans, G.J., Godri Pollitt, K.J., Chen, H., van Rijswijk, D., Weichenthal, S. *Fine particulate air pollution and adverse birth outcomes: effect modification by regional nonvolatile oxidative potential*. Environmental health perspectives 126.07 (2018): 077012

Characterizing woodsmoke impacts in British Columbia communities

Focus of Research: In a number of British Columbia (BC) communities where wood burning is common, levels of $PM_{2.5}$ may exceed the Canadian Ambient Air Quality Standards. Woodsmoke is believed to be a major contributor, but this has not been confirmed due to challenges in differentiating the portion of $PM_{2.5}$ that originates from woodsmoke. In this study, investigators employed an innovative continuous mobile monitor to detect woodsmoke in six BC communities: Whistler, Pemberton, Courtney, Cumberland, Vandehoof, and Fraser Lake in the winter of 2017.

Results: The collected data is being used to develop woodsmoke concentration maps, which have been presented to the participating communities and other stakeholders. Currently the method is being refined for use by community groups.

Publications: A draft manuscript has been developed and will be submitted to a journal in 2020.

Health effects of exposure to ultrafine particles (UFPs)

Focus of Research: This study investigates long-term exposure to UFPs on the risk of developing lung, breast and prostate cancers using data from three case-control studies. As well, it investigates pregnancy exposure to UFPs on the risk of term low birth weight (<2,500g), preterm birth and small for gestational age using a provincial birth registry in Ontario for births in the city of Toronto.

Results: Three scientific manuscripts have been published based on findings relating UFPs and prostate and breast cancer. A scientific paper on UFPs and childhood asthma was published in 2018, with additional analyses expected for 2019.

Publications: Goldberg, MS., Weichenthal, S. Labrèche, F., Lavigne, É. *Number concentrations of ultrafine particles and the incidence of postmenopausal breast cancer*. Environmental Epidemiology 2.1 (2018): e006

Shekarrizfard, M., Valois, M.F., Weichenthal, S., Goldberg, M., Fallah-Shorshani, M., Cavellin, L.D., Crouse, D., Parent, M.E., and Hatzopoulou, M.. *Investigating the effects of multiple exposure measures to traffic-related air pollution on the risk of breast and prostate cancer*. Journal of Transport & Health 11 (2018): 34-46

Lavigne, É., Donelle, J., Hatzopoulou, M., Van Ryswyk, K., van Donkelaar, A., Martin, RV., Chen, H., Stieb, DM., Gasparrini, A., Crighton, E., Yasseen, AS., Burnett, RT., Walker, M., Weichenthal, S. *Spatiotemporal variations in ambient ultrafine particles and the incidence of childhood asthma*. American journal of respiratory and critical care medicine 199.12 (2019): 1487-1495

Spatial modelling to support health studies

Focus of Research: Health Canada carries out intensive ambient air pollution monitoring, and develops land-use regression (LUR) models that allow for the prediction of concentrations of pollutants at a neighbourhood or household level. LUR models are being used to support local- and national-scale health studies investigating air pollution impacts on respiratory, cardiovascular (e.g. stroke), developmental (e.g. birth outcomes, gestational diabetes), autoimmune diseases and cancer outcomes.

Results: Land-Use Regression models and other exposure data developed by Health Canada's Air Program are now available through several venues including The Canadian Urban Environmental Health Research Consortium (CANUE).

Publications: Brook, J.R., Setton, E.M., Seed, E., Shooshtari, M., Doiron, D. *The Canadian Urban Environmental Health Research Consortium–a protocol for building a national environmental exposure data platform for integrated analyses of urban form and health*. BMC public health 18.1 (2018): 114

Time-dependent vulnerability to air pollution in a pregnancy cohort

Focus of Research: This study applies an emerging novel approach (multilevel Bayesian modeling) to identify periods of susceptibility to air pollution during fetal development in the Maternal-Infant Research on Environmental Chemicals (MIREC) cohort. Air pollution exposures is estimated using coupled satellite remote sensing and National Air Pollution Surveillance Program (NAPS) data, an approach that Health Canada researchers have previously validated in Windsor, Ontario.

Results: The study results suggest that exposure to ambient air pollution during critical periods of pregnancy were associated with lower birth weight among term infants.

Publications: A manuscript is expected for submission to a journal in 2019.

Central Experimental Farm Greenspace Effects

Focus of Research: Air pollution, traffic related noise and local temperatures are all influenced by features of the urban built environment. In Ottawa, the Central Experimental Farm (CEF) likely plays a prominent role in influencing these exposures, but to date there have been few efforts to evaluate these impacts. The purpose of this study was to characterize air pollution, noise and ambient temperature on and around the CEF, and to determine if the farm has a mitigating impact on these exposures.

Results: Three seasonal sampling campaigns were conducted in and around the CEF. The spatial variability of nitrogen dioxide, fine particulate matter, ultra-fine particles, black carbon, volatile organic compounds, ambient temperature, and noise within this area was characterized. The study produced evidence that this large green space can mitigate levels of heat and air pollution in the surrounding area.

Publications: A manuscript was submitted to a journal for publication in 2019.

Joint effects of exposure to aeroallergens and outdoor air pollution in the urban environment

Focus of Research: Little is known regarding the joint exposures of aeroallergens and air pollution among children. A land-use regression (LUR) model approach based on environmental determinants has been developed for predicting the variability of pollen concentrations at fine spatial scales in the city of Toronto. Using the Canadian Healthy Infant Longitudinal Development (CHILD) study, the combined effects of exposure to outdoor air pollution and aeroallergens on asthma incidence among Canadian children is being evaluated.

Results: A scientific paper based on the characterization of aeroallergens in Canada was published in 2018. Results of joint effects of aeroallergens and air pollution on atopic disease development using the CHILD Study will be available in 2019.

Publications: Sierra-Heredia C., North M., Brook J., Daly C., Ellis A.K., Henderson D., Henderson S.B., Lavigne É., Takaro T.K. Aeroallergens in Canada: Distribution, public health impacts, and opportunities for prevention. International Journal of Environmental Research and Public Health 15: 8, 1577

Air Quality and Health Impacts of Freight Modal Shifts

Focus of Research: The overall goal of this study is to identify and characterize the potential of modal shifts in freight transport for mitigating air pollutant emissions, air pollutant concentrations, population exposure to air pollutants, and health impacts.

Results: The results indicated that there is limited evidence that road-to-rail, road-to-marine, and rail-to-marine modal shifts could reduce pollutant and GHG emissions. There was insufficient evidence on modal shifts involving the pipeline mode, and on the air quality, population exposure, and health impacts related to any modal shift.

Publications: Ramani, T., Jaikumar, R., Khreis, H., Rouleau, M., Charman, N. *Air Quality and Health Impacts of Freight Modal Shifts: Review and Assessment*. Transportation Research Record 2673.3 (2019): 153-164

6.4 WATER QUALITY

Both ECCC and HC continued their water quality research activities.

ECCC's research related to water quality included the following:

Method development for analytes in wastewater treatment plant influent and effluent

Focus of Research: To assess changes in the levels and trends of synthetic musk compounds and Organophosphorus Esters (OPEs) in both influent and effluent wastewater in the Great Lakes Basin (musks) and across Canada (OPEs).

Results: New GC/MSMS based methods for determination of 21 nitro, polycyclic and macrocyclic musk compounds were developed. A comparison to results reported by Smyth et al. in 2008 from the same sampling sites indicated a major reduction in levels of nitro musk compounds. Levels of musk ketone have dropped by a factor of eight, while levels of musk xylene have dropped by a factor of 26 during cold sampling periods and 130 for samples collected during warm periods. Removal efficiency for musk compounds ranged between 60% and 100%. For OPEs, removal efficiencies from the liquid waste stream were > 80% in secondary and advanced treatment and as high as 60% in primary treatment.

Publications: McDonough, C.A., De Silva, A.O., Sun, C., Cabrerizo, A., Adelman, D., Soltwedel, T., Bauerfeind, E., Muir, D.C.G., Lohmann, R. 2018. Dissolved organophosphate esters and PBDEs in remote marine environments: Fram Strait depth profiles and Arctic surface water distributions. Environ. Sci. Technol. 52(11): 6208-6216

Organophosphorus flame retardants in a variety of environmental compartments

Focus of Research: The goal of this project was to analyze organophosphate ester (OPE) flame retardants and plasticizers in environmental samples, focusing on 23 individual OPE congeners representing alkyl-, phenyl-, and halogen- substituted OPEs.

Results: OPEs were analyzed in sediment and water from an urban, industrial environment (Hamilton Harbour) and a rural site in Georgian Bay. OPEs in sediment and water were generally lower in Georgian Bay than the Hamilton Harbour site. Furthermore, OPEs were measured in influent, effluent, and biosolids from 8 wastewater treatment plants in Canada, representing treatment technologies such as facultative lagoon, aerated lagoon, chemically assisted primary treatment, secondary activated sludge treatment and advanced biological nutrient removal. Removal efficiencies from the liquid waste stream were > 80% in secondary and advanced treatment and as high as 60% in primary treatment.

Publications: McDonough, C.A., De Silva, A.O., Sun, C., Cabrerizo, A., Adelman, D., Soltwedel, T., Bauerfeind, E., Muir, D.C.G., Lohmann, R. 2018. *Dissolved organophosphate esters and PBDEs in remote marine environments: Fram Strait depth profiles and Arctic surface water distributions*. Environ. Sci. Technol. 52(11): 6208-6216

Biological impacts of municipal effluents on fish in the St. Lawrence River

Focus of Research: To identify the presence of emerging chemicals in fish residing in effluent-impacted waters and investigate the potential effects of these complex mixtures of the biology of fish.

Results: Fish were collected in regions of the St. Lawrence River impacted by urban effluents and the health of the animals were evaluated. Juvenile fish exposed in cages for six weeks to municipal effluents and contaminants have been assessed in tissues, as well as biological markers. Finally, methods have been developed to screen for chemicals of potential interest in tissues of top predator fish.

Publications: Tian, L., Verreault, J., Houde, M., Bayen, S. 2019. *Suspect screening of plastic-related chemicals in northern pike (Esox lucius) from the St. Lawrence River, Canada*. Environmental Pollution 255, 113223. https://doi.org/10.1016/j.envpol.2019.113223

Lacaze, E., Gendron, A., Miller, J., Sherry, J., Colson, T.-L., Sherry, J.P., Giraudo, M., Marcogliese, D. Houde, M. 2019. *Cumulative effects of municipal effluent and parasite infection in yellow perch: a field study using high-throughput RNA-sequencing*. Science of the Total Environment 665:797-809

Toxicity of pesticides to non-target freshwater species

Focus of Research: Neonicotinoid insecticides were assessed for their toxicity to non-target freshwater invertebrates, specifically amphipod crustaceans and mayfly larvae. The survival, growth, and behaviour of these organisms were analysed to determine the risks that neonicotinoids pose to aquatic ecosystems.

Results: Neonicotinoids caused negative effects on the survival, growth, and behaviour of freshwater species. The concentrations at which these effects were observed were within the range of environmental concentrations for some compounds, indicating that non-target aquatic species may be adversely affected by some neonicotinoids. The toxicity of neonicotinoids varied between compounds, and therefore the effects caused by one neonicotinoid cannot necessarily be extrapolated to others.

Publications: Bartlett, A.J., Hedges, A.M., Intini, K.D., Brown, L.R., Maisonneuve, F.J., Robinson, S.A., Gillis, P.L., de Solla, S.R.. 2018. *Lethal and sublethal toxicity of neonicotinoid and butenolide insecticides to the mayfly, Hexagenia spp*. Environ Pollut 238:63-75

Bartlett, A.J., Hedges, A.M., Intini, K.D., Brown, L.R., Maisonneuve, F.J., Robinson, S.A., Gillis, P.L., de Solla, S.R. 2019. *Acute and chronic toxicity of neonicotinoid and butenolide insecticides to the freshwater amphipod, Hyalella azteca.* Ecotoxicol Environ Saf 175:215-223

Environmental fate of selected human and veterinary use pharmaceuticals

Focus of Research: The aquatic toxicity, bioaccumulative potential and environmental fate of selected pharmaceuticals for human and veterinary use was examined using a variety of species (bacteria, algae, yeast, invertebrates and fish) in order to derive safe concentrations for the aquatic environment.

Results: The toxicity of 20 pharmaceutical compounds likely to be released by municipal wastewaters and agriculture wastewater runoffs (manure) were examined using multitrophic biotests involving bacteria, yeast, algae, invertebrates and fish. Though the analysis is still on-going, it seems that the antibiotic products are more toxic for bacteria and algae while other pharmaceutical products having an endocrine disruption effect were more toxic to fish. Sub-lethal effects studies using the collected samples are planned in the following years.

Publications: Data shared with Health Canada for risk assessment.

Effect of salt-laden winter road runoff on aquatic organisms

Focus of Research: The effect of salt-laden winter road runoff on sensitive aquatic organisms was examined to determine if winter road runoff poses a risk to aquatic ecosystems, including freshwater mussel species at risk.

Results: Winter melt waters collected from bridges and runoff waters entering streams during a January thaw were acutely toxic to freshwater mussel larvae, most likely due to high levels of salt. However, water collected from streams receiving the melt waters was not acutely toxic to early life stage mussels. Investigations are ongoing to determine how multiple pulses of salt-laden winter runoff water affects sensitive aquatic organisms.

Publications: Conference presentation Gillis, .PL., Salerno, J., McKay, V., Bennett, C.J., Pratt, A., Rochfort, Q., Prosser, R.S. *The sensitivity of freshwater mussels to salt-laden winter bridge runoff; implications for mussel species at risk*. Society of Environmental Toxicology and Chemistry North America, Sacramento, CA, November 2018

7. ADDITIONAL INFORMATION

Further information on CEPA and related activities can be found online:

- CEPA Environmental Registry
- Environment and Climate Change Canada
- Health Canada
- CMP chemical substances section of the Canada.ca

For more information or to obtain publications contact the Environment and Climate Change Canada's Inquiry Centre.

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The following media relations contacts are also available to provide information.

Environment and Climate Change Canada
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Health Canada
Telephone: 613-957-2983