



Environment  
Canada

Environnement  
Canada

[www.ec.gc.ca](http://www.ec.gc.ca)



# Data Sources and Methods for the Weather Warning Index

July 2013

ISBN : En4-144/40-2013E-PDF  
Cat. No.: 978-1-100-22399-5

Information contained in this publication may be reproduced, in part or in whole, and by any means, for personal or public non-commercial purposes, without charge or further permission, unless otherwise specified.

You are asked to:

- Exercise due diligence in ensuring the accuracy of the materials reproduced;
- Indicate both the complete title of the materials reproduced, as well as the author organization; and
- Indicate that the reproduction is a copy of an official work that is published by the Government of Canada and that the reproduction has not been produced in affiliation with or with the endorsement of the Government of Canada.

Commercial reproduction and distribution is prohibited except with written permission from the Government of Canada's copyright administrator, Public Works and Government Services of Canada (PWGSC). For more information, please contact PWGSC at 613-996-6886 or at [droitdauteur.copyright@tpsgc-pwgsc.gc.ca](mailto:droitdauteur.copyright@tpsgc-pwgsc.gc.ca).

Photos: © Environment Canada

© Her Majesty the Queen in Right of Canada represented by the Minister of the Environment, 2012

Aussi disponible en français

# 1 Introduction

The Weather Warning Index is part of the Canadian Environmental Sustainability Indicators (CESI) program (<http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=47F48106-1>), which provides data and information to track Canada's performance on key environmental sustainability issues.

## 2 Description and rationale of the Weather Warning Index

The index provides Canadians with an overview of the state of Environment Canada's severe weather warning program, thereby increasing transparency and allowing the public to understand and track performance of the program. Over time, Canadians will be equipped to track trends in performance of the severe weather warning program.

The index is calculated based on timeliness and accuracy information of six warning types that are representative of Canada's climate: rainfall, snowfall, freezing rain, wind, severe thunderstorm and marine gales.

## 3 Data

### 3.1 Data source

The data sources for the Weather Warning Index include timeliness performance information for the identified six severe weather warning types. This information is compiled by comparing warnings issued by Environment Canada against severe weather reports submitted by the public and data collected by Environment Canada's observation network.

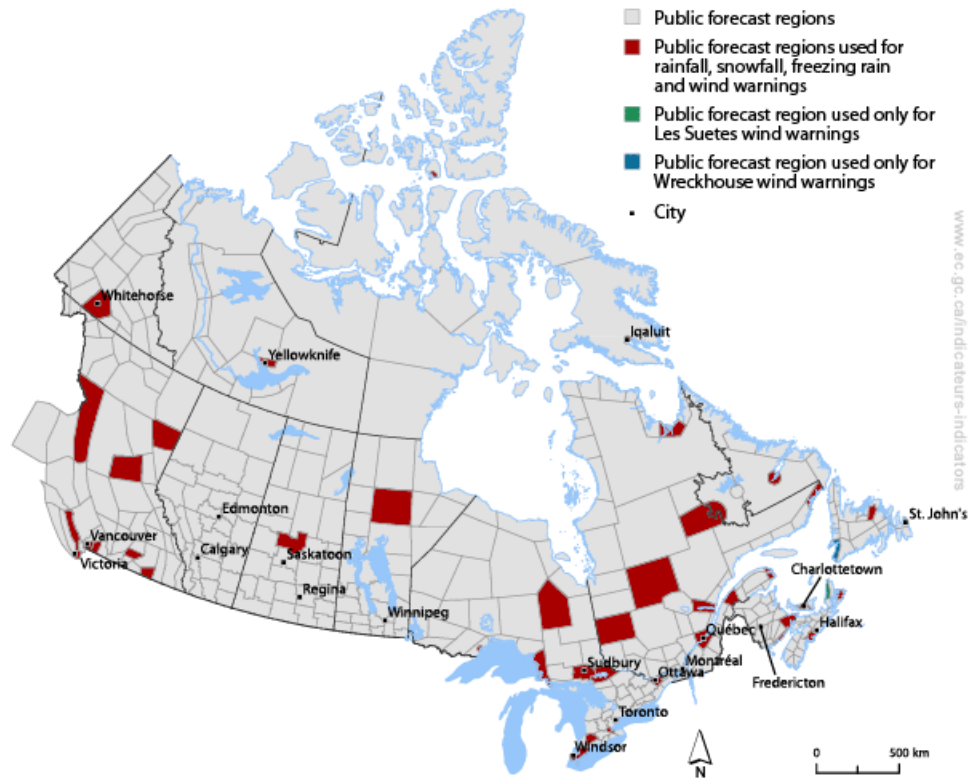
Timeliness statistics reflect the average lead time and target lead time for each of the six warning types, as determined by our warning performance targets. Accuracy statistics reflect the Extremal Dependency Index (EDI), which incorporates the number of hits, misses and false alarms for each of the six warning types.

These statistics are compiled by Environment Canada from available meteorological observations, archived warning bulletins and existing verification procedures. This information is available in the quarterly and annual reports from the Meteorological Service of Canada (MSC) warning program prepared by the Performance Management Division of the Business Policy Directorate.

### 3.2 Spatial coverage

Information reported in selected geographic regions for each warning group is used in calculating the index. These selected geographic regions are representative of Canada's climate and are areas that regularly have sufficient event data against which to compare severe weather warnings.

Public forecast regions with those used in the Weather Warning Index highlighted - rainfall, snowfall, freezing rain and wind warnings



**Note:** Some public forecast regions are not visible at the national scale. See Table 1 for the complete list.

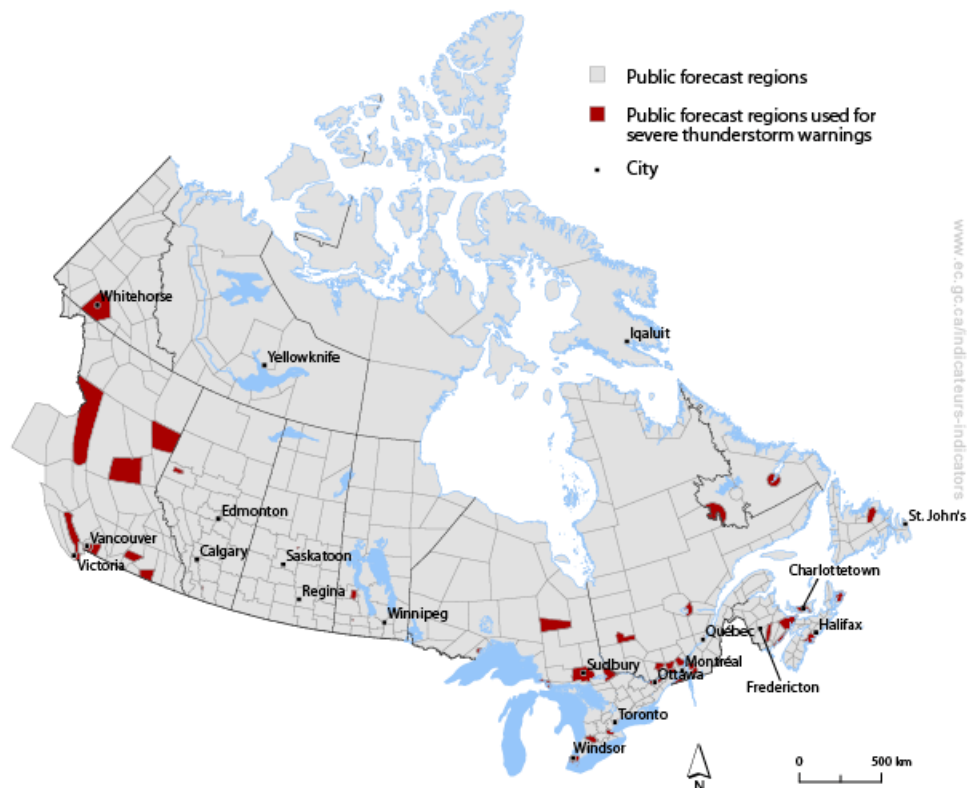
**Source:** Environment Canada (2013) Public Forecast Regions of Canada. Meteorological Service of Canada - Performance Management Systems Division. Available from: <http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=E5A4F19C-1>

**Table 1: Public forecast regions used in the Weather Warning Index for rainfall, snowfall, freezing rain and wind warnings**

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
Metro Vancouver	City of Winnipeg	Windsor - Essex - Chatham-Kent	Metro Montréal - Laval	Saint John and County
Fraser Valley-West including Abbotsford	Thompson - Nelson House - Split Lake	London - Middlesex	Québec	Moncton and Southeast New Brunswick
East Vancouver Island	City of Regina	City of Hamilton	Saguenay	Halifax Metro and Halifax County West
Greater Victoria	City of Saskatoon	City of Toronto	Rimouski - Mont Joli	Charlottetown (Queens County P.E.I.)

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
North Coast - Inland Sections	Prince Albert - Shellbrook - Spiritwood - Duck Lake	City of Ottawa	Forillon National Park - Gaspé - Percé	Sydney Metro and Cape Breton County
Central Okanagan - including Kelowna	City of Calgary	North Bay - West Nipissing	Abitibi	Inverness County (Les Suetes Wind only)
West Kootenay	City of Edmonton	Greater Sudbury and Vicinity	Chibougamau	St. Georges (Wreckhouse Wind only)
Prince George	Yellowknife Region	Sault Ste. Marie - St. Joseph Island	Sept-Îles - Port-Cartier	Gander and Vicinity
BC North Peace River	Resolute	City of Thunder Bay	Blanc Sablon	St. John's and Vicinity
Whitehorse	Iqaluit	Kapuskasing - Hearst	Fermont	Goose Bay and Vicinity
			Kuujuuaq	Labrador City and Wabush

Public forecast regions with those used in the Weather Warning Index highlighted - severe thunderstorm warnings



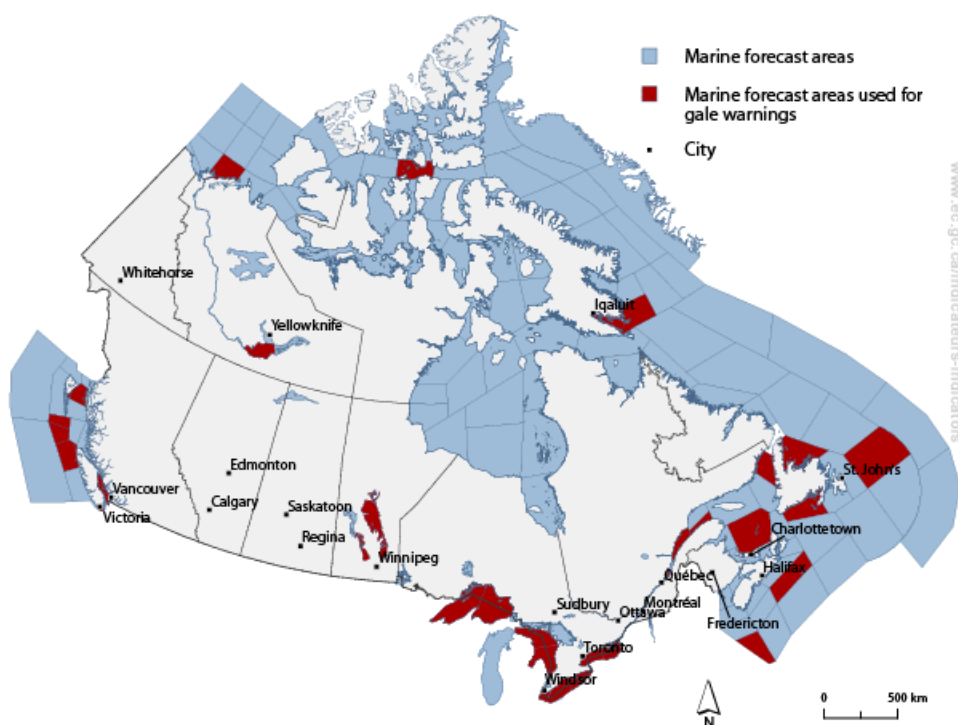
**Note:** Some public forecast regions are not visible at the national scale. See Table 2 for the complete list.  
**Source:** Environment Canada (2013) Public Forecast Regions of Canada. Meteorological Service of Canada - Performance Management Systems Division. Available from: <http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=E5A4F19C-1>

**Table 2: Public forecast regions used in the Weather Warning Index for severe thunderstorm warnings**

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
Metro Vancouver	City of Winnipeg	Windsor - Essex - Chatham-Kent (Windsor - Leamington - Essex County)	Montréal métropolitain - Laval (l'île de Montréal)	Saint John and County
Fraser Valley-West including Abbotsford	Brandon - Carberry - Treherne (City of Brandon)	London - Middlesex (London - Parkhill - Eastern Middlesex County)	Vaudreuil - Soulanges - Huntingdon (Huntingdon)	Moncton and Southeast New Brunswick
East Vancouver Island	Dauphin - Roblin - Winnipegosis (R.M. of Dauphin including Sifton and Valley River)	City of Hamilton	Vallée du Richelieu - Saint-Hyacinthe (Saint-Hyacinthe - Acton Vale)	Halifax Metro and Halifax County West
Greater Victoria	City of Regina	City of Toronto	Lanaudière (Rawdon - Joliette)	Charlottetown (Queens County P.E.I.)
North Coast - Inland Sections	City of Saskatoon	City of Ottawa (Ottawa North - Kanata - Orléans)	Lachute - Saint-Jérôme (Lachute)	Sydney Metro and Cape Breton County
Central Okanagan - including Kelowna	Prince Albert - Shellbrook - Spiritwood - Duck Lake (City of Prince Albert)	North Bay - West Nipissing (North Bay - Powassan - Mattawa)	Laurentides (Mont-Tremblant - Sainte-Agathe)	Oromocto and Sunbury County
West Kootenay	City of Calgary	Greater Sudbury and Vicinity	Haute-Gatineau - Lièvre - Papineau (Reserve Papineau-Labelle)	Gander and Vicinity
Prince George	City of Edmonton	Sault Ste. Marie - Superior East (Sault Ste. Marie - St. Joseph Island)	Abitibi (Val D'Or - Louvicourt)	St. John's and Vicinity
BC North Peace River	Lethbridge - Taber - Milk River (City of Lethbridge)	City of Thunder Bay	Estrée (Granby - Waterloo)	Goose Bay and Vicinity
Whitehorse	Grande Prairie - Beaverlodge -	Kapuskasing - Hearst	Québec	Labrador City and Wabush

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
	Valleyview (Co. of Grande Prairie near Grande Prairie and Wembley)	(Kapuskasing - Hearst - Smooth Rock Falls)		
			Lac Saint-Jean (Alma - Desbiens)	

Marine forecast areas with those used in the Weather Warning Index highlighted - gale warnings



**Note:** Some marine forecast areas are not visible at the national scale. See Table 3 for the complete list.  
**Source:** Environment Canada (2013) Meteorological Service of Canada - Performance Management Systems Division.

**Table 3: Marine forecast areas used in the Weather Warning Index for gale warnings**

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
Strait of Georgia - south of Nanaimo	Great Slave Lake Basin	Western Lake Superior	Donnacona to Isle-aux-Coudres	Georges Bank
Strait of Georgia - north of Nanaimo	Tuktoyaktuk	Eastern Lake Superior	Tadoussac to Pointe-des-Monts	Sable
Juan de Fuca Strait - East Entrance	Frobisher Bay	Northern Lake Huron	Pointe-des-Monts to Anticosti - southern half	Gulf - Magdalen

Pacific and Yukon	Prairie and Northern	Ontario	Quebec	Atlantic
West Vancouver Island North	West Brevoort - southern half	Southern Lake Huron		Northeast Gulf
Queen Charlotte Sound - western half	Barrow	Western Lake Erie		Southwest Coast
Hecate Strait - Northern Half	Lake Manitoba	Eastern Lake Erie		Northeast Coast
	Lake Winnipeg - South Basin	Western Lake Ontario		Northern Grand Banks
	Lake Winnipeg - North Basin	Eastern Lake Ontario		

### 3.3 Temporal coverage

To reduce volatility from year to year, a three-year moving average is used for reporting purposes. The index uses data from calendar years 2010, 2011 and the most recent year 2012. This is the second iteration of the index. The first iteration calculated a three-year moving average using data from 2009, 2010 and 2011. The index is updated annually. Each spring, a value is calculated for the previous calendar year using available information.

### 3.4 Data completeness

Data for selected geographic regions for each warning type are used in calculating the index. These regions are representative of Canada's climate and are areas that regularly have sufficient event data against which to compare severe weather warnings.

### 3.5 Data timeliness

Data are available for each calendar by the end of February of the following year. The index will be updated each year in the spring with these data.

## 4 Methods

### 4.1 Definitions

There are several definitions of note with regard to the index, indicated below.

An **event** is an individual instance of a weather or environmental hazard that meets hazard criteria thresholds.

The **event time** is the time at which the criteria threshold is first met for an event. For alerts where the criteria thresholds are accumulated precipitation, the event time is the time at which the accumulated precipitation total first equals or exceeds the criteria amount.

The **issue time** is the time at which the alert has been transmitted by the Environment Canada forecaster.

The **lead time** is the difference between the time that an alert is issued and the event time. For example, if an alert is issued at 09:00 and the event time is 09:30, the lead time is 30 minutes.



The **target lead time** is Environment Canada’s performance goal for the timeliness of alerts. The target lead time is intended to provide adequate time for the public to take appropriate action when alerted of a predicted event. Other factors such as the predictability of an event and the ability of the public and media to receive notice of the message may influence the actual lead times provided.

Each of the six severe weather warnings that comprise the index has an associated performance target lead time, in terms of issuance of a warning. The target lead times for the six warning types are as indicated below in Table 4.

**Table 4: Target lead time by severe warning type (Warning Performance Target)**

Severe weather warning type		Target lead time
Land components	rainfall	greater than or equal to 12 hours
	freezing rain	greater than or equal to 6 hours
	wind	greater than or equal to 12 hours
	snowfall	greater than or equal to 18 hours
	severe thunderstorm	greater than or equal to 30 minutes
Marine component	gale	greater than or equal to 18 hours

A **hit** is defined as “a warning event was forecast and it occurred.”

A **miss** is defined as “a warning event occurred but there was no advance warning provided or no alert was issued.”

A **false alarm** is defined as “a warning event was forecast but conditions did not reach warning criteria.”

A **correct negative** is defined as “no warning was issued and no event was reported.”

## 4.2 Methodology

The index ranges from 0 to 10 and is constructed by taking a weighted mean of timeliness and accuracy statistics. To reduce volatility from year to year, a three-year moving average is used for reporting purposes.

### Weighting

The index considers demographic and recreational statistics in its calculations. More specifically, given the statistic that 20 percent of Canadians engage in marine activities,<sup>1</sup> a 20 percent weight is assigned to the marine gale component of the index. The remaining severe weather warning types (severe thunderstorm, wind, rainfall, snowfall and freezing rain) are assigned a combined 80 percent weight in the index. In addition, each of these land components is weighted based on its frequency of occurrence during the reporting periods, which also reflects its impact on the overall population.

---

<sup>1</sup> Discover Boating Canada (2007) The economic impact of recreational boating in Canada: 2006 summary report. National Marine Manufacturers Association (NMMA) Canada.

### Timeliness factors

To calculate the average lead time for each warning component, the warning issue time is subtracted from the time when the warning event occurred. The lead times so obtained are then averaged over the year to obtain the “average lead time”. Missed events are assigned 0 lead time. This value is then compared to the target lead time for the specific warning type. The resultant value represents the “timeliness” aspect of the index.

### Accuracy factors

The number of successfully detected events (hits), the number of missed events and the number of false alarms represents the “accuracy” aspect of the index. These values are used to calculate the Extremal Dependency Index (EDI).

$$EDI = \frac{\log(\text{False Alarm Rate}) - \log(\text{Hit Rate})}{\log(\text{False Alarm Rate}) + \log(\text{Hit Rate})}$$

The Hit Rate is calculated using the number of hits and misses, and the False Alarm Rate is based on the number of false alarms and number of correct negatives (Non-events). This requires an estimation of the number of periods of time during the year that no warning would be required (non-events). Since the EDI is a ratio of logarithms, it does not matter which base is used.

Hit Rate = Hits / (Hits + Misses)

False Alarm Rate = False Alarms / (False Alarms + Non-events)

### Weather Warning Index calculation

The index ranges between zero and ten. It would attain a value of ten if all component warnings meet warning criteria and there are no missed events or false alarms. The scoring formula for each warning component is as follows:

#### Case 1

If the Average Lead Time is equal to or greater than the Target Lead Time ( $ALT \geq TLT$ ), the index component score becomes

$$[EDI + (0.5 \times (\text{AverageLeadTime} / \text{TargetLeadTime} - 1) \times (1 - EDI))] \times 10$$

#### Case 2

If the Average Lead Time is less than the Target Lead Time ( $ALT < TLT$ ), the index component score becomes

$$EDI \times (\text{AverageLeadTime} / \text{TargetLeadTime}) \times 10$$

#### Assumptions

- All lead times are greater than or equal to zero.
- Individual lead times greater than twice the target lead time are assigned a value of twice the target lead time.

**Table 5: Weather Warning Index Calculation, timeliness and accuracy statistics, 2010, 2011 and 2012**

2010-2011-2012	Rain	Snow	Freezing rain	Wind	Severe thunderstorm	Marine gale
Hits	195	275	133	292	146	2064
Misses	88	105	58	99	71	464
False alarms	138	170	72	177	939*	723
Correct negatives	6779	9575	3787	19682	27194	4849
<b>TOTAL</b>	<b>7200</b>	<b>10125</b>	<b>4050</b>	<b>20250</b>	<b>28350</b>	<b>8100</b>
Hit rate	0.69	0.72	0.70	0.75	0.67	0.82
False alarms rate	0.02	0.02	0.02	0.01	0.03	0.13
Extremal Dependency Index (EDI)	0.83	0.85	0.83	0.88	0.79	0.82
Average lead time (in hours)	13.92	15.42	5.71	12.72	0.37	19.30
Target lead time (in hours)	12	18	6	12	0.5	18
Weight	15%	21%	10%	22%	12%	20%
Weather Warning Index component score	8.40	7.30	7.93	8.87	5.80	8.26
Individual weighted Weather Warning Index component score	1.30	1.52	0.83	1.90	0.69	1.65
Change with respect to 2009-2011 individual weighted Weather Warning Index	+0.09	-0.02	+0.25	+0.02	-	-0.01
<b>Weather Warning Index is the sum of the individual weighted Weather Warning Index component scores: 7.89</b>						

\* False alarms are not available for severe thunderstorm alerts. A convective warning bias of 5 is used to estimate the number of false alarms, where:

$$\text{False alarms} = \text{Convective Warning Bias} \times (\text{hits} + \text{misses}) - \text{hits}$$

## 5 Caveats and limitations

This is only the second iteration of the Weather Warning Index, making trend analysis difficult to perform at this time. As more data become available over time it may be possible to track trends in the performance of Environment Canada's severe weather warning program.

Calculation of the index does not consider when weather warnings are received by Canadians, as this factor varies considerably depending upon how warnings are received (for example, via a media outlet or via a website).

The index does not represent all forecast regions in Canada; instead, it represents areas that regularly have sufficient event data against which to compare severe weather warnings.

## 6 References and further reading

Discover Boating Canada (2007) The economic impact of recreational boating in Canada: 2006 summary report. National Marine Manufacturers Association (NMMA) Canada.

Environment Canada (2013) Marine warnings and watches. Retrieved on 12 April, 2013. Available from: <http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=2EC4EC51-1&offset=10&toc=show>

Environment Canada (2013) Public alerting criteria Retrieved on 12 April, 2013. Available from: <http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=D9553AB5-1>

Ferro C *et al.* (2011) Extremal Dependence Indices: Improved Verification Measures for Deterministic Forecasts of Rare Binary Events. *Weather and Forecasting* 26(5):699-713.

Wilson L (2012) A new index for the verification of accuracy and timeliness of weather warnings. Environment Canada, Meteorological Service of Canada - Performance Management Systems Division. Available from Nelson Shum: [nelson.shum@ec.gc.ca](mailto:nelson.shum@ec.gc.ca).

**[www.ec.gc.ca](http://www.ec.gc.ca)**

Additional information can be obtained at:

Environment Canada

Inquiry Centre

10 Wellington Street, 23<sup>rd</sup> Floor

Gatineau, QC K1A 0H3

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

Fax: 819-994-1412

TTY: 819-994-0736

Email: [Enviroinfo@ec.gc.ca](mailto:Enviroinfo@ec.gc.ca)