

# Nova Scotia Air Zone Report

2016

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# Acronyms

<b>AQHI</b>	Air Quality Health Index
<b>AQMS</b>	Air Quality Management System
<b>AQU</b>	Nova Scotia Environment's Air Quality Unit
<b>CAAQS</b>	Canadian Ambient Air Quality Standards
<b>CCME</b>	Canadian Council of Ministers of the Environment
<b>CEC</b>	Commission for Environmental Cooperation
<b>CMA</b>	Canadian Medical Association
<b>ECCC</b>	Environment and Climate Change Canada
<b>GLO</b>	Ground Level Ozone
<b>IA</b>	Industrial Approval
<b>IISD</b>	International Institute for Sustainable Development
<b>NAPS</b>	National Air Pollution Surveillance Program
<b>NO</b>	Nitric oxide
<b>NO<sub>2</sub></b>	Nitrogen dioxide
<b>NO<sub>x</sub></b>	Nitrogen oxides (NO + NO <sub>2</sub> = NO <sub>x</sub> )
<b>NSE</b>	Nova Scotia Environment
<b>O<sub>3</sub></b>	Ozone
<b>PM<sub>2.5</sub></b>	Fine particulate matter
<b>ppb</b>	Parts per billion
<b>QA/QC</b>	Quality Assurance/Quality Control
<b>µ/m<sup>3</sup></b>	Micrograms per cubic metre
<b>VOCs</b>	Volatile Organic Compounds
<b>WHO</b>	World Health Organization

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# Introduction to Nova Scotia Environment's Ambient Air Programs

Nova Scotia Environment (NSE) supports and promotes the protection, enhancement, and prudent use of Nova Scotia's air resources through air quality management that includes monitoring ambient air, reporting results, regulating activities that cause air emissions of concern, and doing outreach.

Data are fundamental for effective air quality management, and NSE has a long-standing cooperative agreement with Environment and Climate Change Canada (ECCC), as part of the National Air Pollution Surveillance (NAPS) Program, to collect ambient air quality data.<sup>1</sup> The terms of the agreement are that ECCC provides instruments for monitoring ambient air, and that NSE's Air Quality Unit (AQU) sets up and maintains the stations that monitor air pollution concentrations. Average concentrations for continuously monitored pollutants are calculated each hour and the raw data are directly uploaded to NSE's air quality website.<sup>2</sup>

Environment and Climate Change Canada uses the hourly raw measurements of nitrogen dioxide (NO<sub>2</sub>)<sup>3</sup>, ground-level ozone (GLO) and fine particulate matter (PM<sub>2.5</sub>) to calculate the Air Quality Health Index (AQHI). The AQHI is reported as a number from 1 to 10+, and as a risk category that ranges from "low" to "very-high". Each risk category has a health message to assist individuals in making daily decisions about adjusting their activities to limit exposure to air pollution.<sup>4</sup>

1 <https://www.canada.ca/en/environment-climate-change/services/air-pollution/monitoring-networks-data/national-air-pollution-program.html>.

2 <http://novascotia.ca/nse/airdata/>.

3 Note that a chemical formula provides a short-hand description of what proportions of atoms are present in a chemical compound. In this example, nitrogen dioxide, or NO<sub>2</sub>, consists of one atom of nitrogen and two atoms of oxygen.

4 <https://www.canada.ca/en/environment-climate-change/services/air-quality-health-index/understanding-messages.html>.

The AQU completes quality assurance and quality control (QA/QC) reviews of the raw ambient air quality data and the validated data are periodically updated to NSE's website, and to the NAPS program's national data base.<sup>5</sup>

These data are analysed for trends over time and for associations between monitoring locations. The results of these analyses support actions for protecting and improving air quality. For example, the Air Quality Management System (AQMS), put in place across Canada through the Canadian Council of Ministers of the Environment's (CCME),<sup>6</sup> is a comprehensive approach with four 'mechanisms' that work together to achieve Canadian Ambient Air Quality Standards (CAAQS) that were designed to protect and improve ambient air quality (Fig.1).

The four mechanisms are Base Level Industrial Emissions Requirements, mobile source emissions, airsheds, and air zones.

Provinces and territories use air zones as geographic regions for monitoring, managing, and reporting on ambient concentrations of GLO and PM<sub>2.5</sub> in that area.

This document is NSE's third annual air zone report.<sup>7</sup>

## The Whole AQMS System

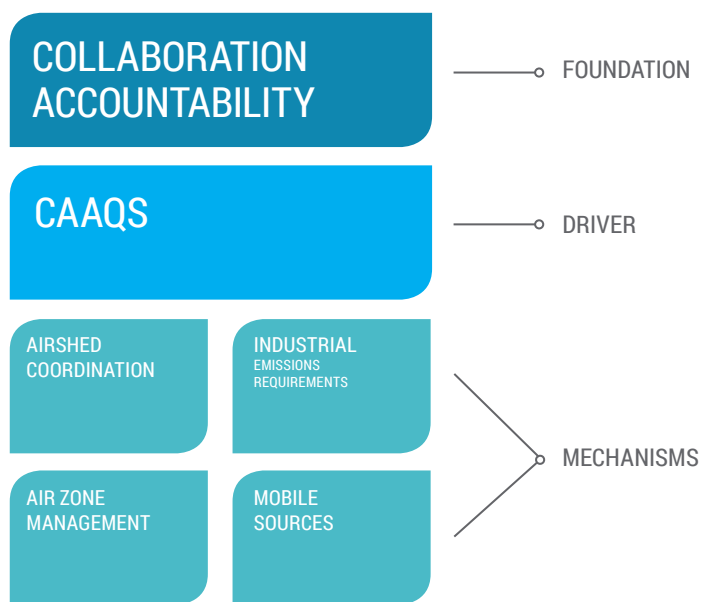


Figure 1. The Air Quality Management Framework.

<sup>5</sup> <http://www.ec.gc.ca/mnsa-naps/default.asp?lang=En&n=8BA86647-1>

<sup>6</sup> <http://www.ccme.ca/en/resources/air/aqms.html>

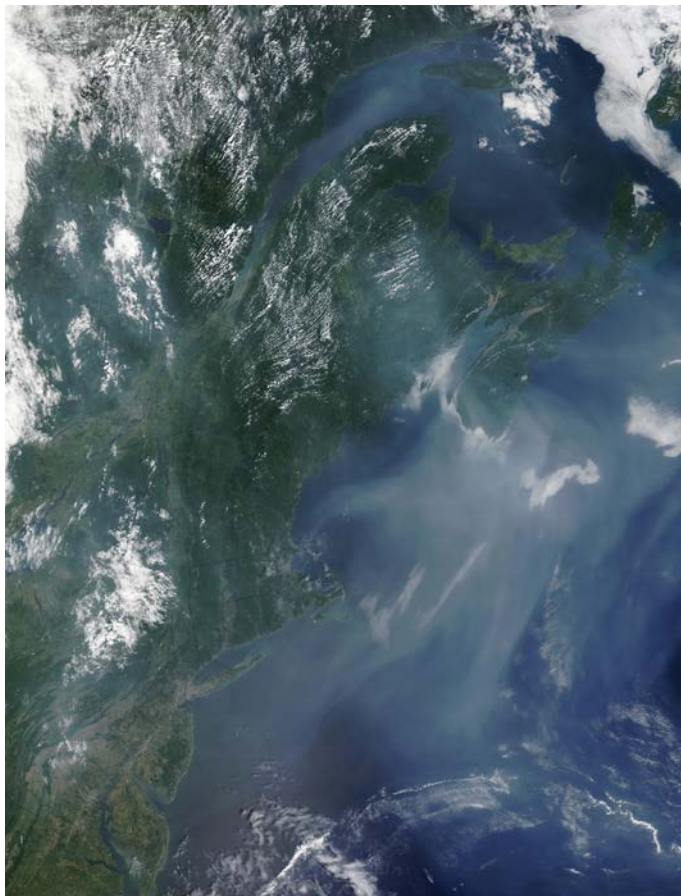
<sup>7</sup> The annual report for 2014 can be accessed at <http://novascotia.ca/nse/air/docs/15-43405%20AirZone%20V3.pdf>, and the 2015 report at [https://www.novascotia.ca/nse/air/docs/16-45114\\_NS\\_Air\\_Zone\\_Report\\_2015.pdf](https://www.novascotia.ca/nse/air/docs/16-45114_NS_Air_Zone_Report_2015.pdf).

# Airsheds and Air Zones

Air zones are geographical areas that fall within the jurisdiction of one province or territory, whereas airsheds are large areas that include many jurisdictions and transboundary air pollution.

## Airsheds

Emissions from vehicles, residential wood burning, industry, and other activities are added to the atmosphere. Weather can carry those pollutants across borders where they add to local, regional, and global air pollution far from where the pollution was generated. How far the pollution is carried depends on seasonal weather patterns and how long the pollutant is stable in the atmosphere. There are large



cities, dense networks of roadways, and numerous industries upwind of Nova Scotia, in the Ohio River Valley, Eastern seaboard of the U.S., and the Québec/Ontario corridor. Emissions from these sources contribute to the formation of Ground-level ozone (GLO) and fine particulate matter (PM<sub>2.5</sub>) that affect Nova Scotia's air quality (Figure 2). A large area of transboundary air pollution is called an airshed, and air quality management in an airshed requires many jurisdictions to work together to improve air quality.

Figure 2. The grey coloured haze in this satellite image is particulate air pollution over the Maritimes that originated in the Eastern United States.

Source: <https://visibleearth.nasa.gov/view.php?id=61010>

## Air Zones

Air zones are geographically smaller than airsheds and are used to manage local air quality inside provincial and territorial borders. Nova Scotia is divided into four air zones (Fig. 3). Each air zone shares common terrain, meteorology, and other factors that interact with air pollutant emissions to influence ambient air quality in the air zone. The AQU collects data from ambient air monitoring stations in each air zone.<sup>8</sup> The data are used to calculate achievement of the CAAQS, and an air zone management framework is used to help determine what management actions may be best suited to each air zone.

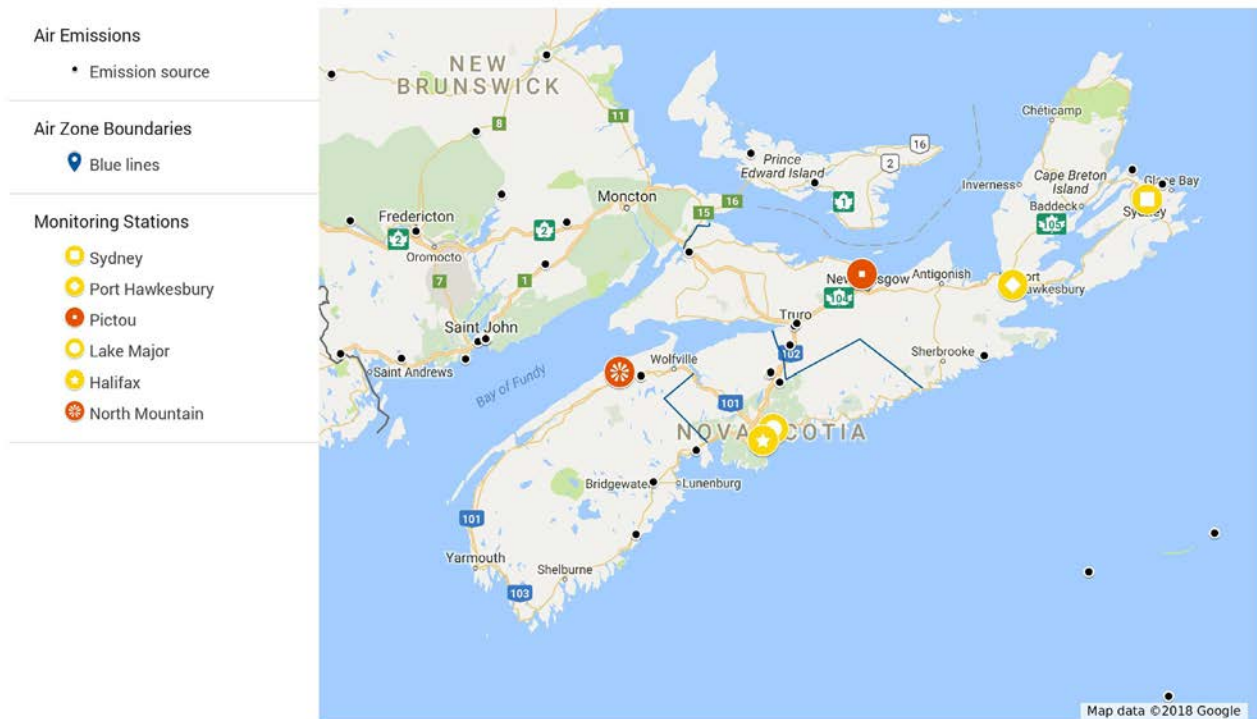


Figure 3. Nova Scotia's four air zones, with the locations of ambient air monitoring stations indicated by large circles. The black dots are locations of operations that report air contaminant emissions to the National Pollutant Release Inventory (NPRI).

<sup>8</sup> Nova Scotia's ambient air monitoring stations tend to be located near populated centres with industrial development. However, the stations are not used to demonstrate any industrial emitter's compliance with their Industrial Approvals (IA). Rather, IA holders that have requirements in their approval to monitor ambient air must monitor the ambient air near their facilities and demonstrate that their emissions do not contribute to pollution that exceeds maximum permissible ground level concentrations for several pollutants that are listed in the Nova Scotia Air Quality Regulations. The IA holders are required to report results to NSE and demonstrate compliance with limits in their approvals.

# Canadian Ambient Air Quality Standards (CAAQS)

Ground level ozone and PM<sub>2.5</sub> are two of the most common elements of ambient air pollution, and CAAQS for these two pollutants are the current drivers for action in the AQMS.<sup>9</sup>

## Ground Level Ozone

Ozone higher up in the atmosphere, from between about 15 to 50 km above the surface of the Earth, is formed through natural processes and makes up a region in the stratosphere called the 'ozone layer.' The ozone layer is beneficial to human health and the environment by preventing harmful ultraviolet rays from reaching the Earth's surface. On the other hand, ground level ozone is harmful to human health and the environment. Inhalation of ozone can cause airway inflammation and reduced breathing capacity, and this is particularly noticeable in people with pre-existing disease such as asthma. Recent research suggests that there is also a connection between exposure to GLO and cardiovascular mortality.<sup>10</sup>

Ninety percent of the atmosphere's ozone is found in the stratosphere and the rest is found in the lower atmosphere – the troposphere.<sup>11</sup> Unlike stratospheric ozone, ground-level ozone is mostly the result of sunlight reacting with nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs) that are emitted from activities such as electric power generation, the natural gas industry, wood burning, manufacturing and transportation.<sup>12</sup> There is some ozone in the troposphere that is the result of "natural events, such as wildfires or stratospheric intrusions, or from man-made pollution from [transboundary] sources".<sup>13</sup> It is estimated that Canada's average annual baseline concentrations of GLO range from 23 and 34 ppb.<sup>14</sup> It has also been modelled that if all of North America's emissions of pollutants that participate in GLO formation were turned off, the fourth highest 8-hour value in Nova Scotia between March 1 and August 31 would be about 50 ppb.<sup>15, 16</sup> The 2016 CAAQS results for GLO, which is the 3-year average of the annual 4<sup>th</sup>-highest daily maximum 8-hour average concentrations, ranges between 45 and 57 ppb in Nova Scotia's air zones.

<sup>9</sup> As part of the continuous improvement and implementation of the AQMS, the CCME has put in place a new CAAQS for sulphur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>) that will take effect in 2020.

<sup>10</sup> See, for example, Day, Drew B. *et al.* (2017). Association of ozone exposure with cardiorespiratory pathophysiologic mechanisms in healthy adults. *Journal of the American Medical Association (JAMA) Internal Medicine*. Pp. E1-E10. DOI: 10.1001/jamainternmed.2017.2842.

<sup>11</sup> Jet Propulsion Laboratory (2015). *NASA: Background ozone a major issue in U.S. West*. <https://www.jpl.nasa.gov/news/news.php?feature=4723>.

<sup>12</sup> <http://www.ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En>

<sup>13</sup> U.S. EPA (2015). *Tools for addressing background ozone*. [https://www.epa.gov/sites/production/files/2015-10/documents/20151001\\_background\\_ozone.pdf](https://www.epa.gov/sites/production/files/2015-10/documents/20151001_background_ozone.pdf).

<sup>14</sup> Vingarzan, R. (2004). A review of surface ozone background levels and trends. *Atmospheric Environment*, 38, p. 3439.

<sup>15</sup> Chan, E. and Vet, R.J. (2010). Baseline levels and trends of ground level ozone in Canada and the United States. *Atmospheric Chemistry and Physics*, (10), pp. 8629-8647. Doi: 10.5194/acp-10-8629-2010.

<sup>16</sup> Fiore, A.M. *et al.* (2014). Estimating North American background ozone in U.S. surface air with two independent global models: Variability, uncertainties, and recommendations. *Atmospheric Environment*, 96, p. 297.





Ground level ozone is a key pollutant in determining the AQHI and providing near real-time advice on reducing exposure. In addition, the *Nova Scotia Air Quality Regulations* contain a maximum permissible 1-hour concentration for GLO of 82 ppb, and one hour data are used to understand the daily, seasonal and yearly trends of GLO. The CAAQS for GLO, used for air zone management, is 63 ppb (Table 1).

## Fine Particulate Matter

Fine particulate matter are solid or liquid particles in the atmosphere that are less than or equal to 2.5 micrometres in diameter (a micrometre is 1/1,000,000 of a metre). Fine particulate matter is made up of many different chemicals that originate from natural emission sources such as forest fires, wind-blown dust, sea salt and marine algae, and from human activities such as wood burning, transportation, agriculture, power plants and factories.<sup>17</sup> Globally, PM<sub>2.5</sub> affects more people than any other air pollutant<sup>18</sup> and exposure to PM<sub>2.5</sub> leads to increased health issues. Health outcomes are correlated to the mass of PM<sub>2.5</sub> in a volume of air, and instruments in each Nova Scotia's air zones measure 1-hour average mass concentrations (in micrograms per cubic metre of air, or µg/m<sup>3</sup>). These raw data are used to help calculate the AQHI that provides near real-time advice on reducing exposure.

The validated 1-hour data, that have passed QA/QC, are used to understand daily, seasonal and yearly trends, and a 24-hour average and an annual mass concentration per volume are used to determine CAAQS for air zone management, determined by the 3-year average of the annual 98<sup>th</sup> percentile of the daily 24-hour average and 3-year average of the annual average, respectively (Table 1).

Pollutant	Averaging time	Standards (numerical values)		Metric
		2015	2020	
PM <sub>2.5</sub>	24-hour (calendar day)	28 µg/m <sup>3</sup>	27 µg/m <sup>3</sup>	The 3-year average of the annual 98 <sup>th</sup> percentile of the daily 24-hour average concentrations.
PM <sub>2.5</sub>	Annual (calendar year)	10.0 µg/m <sup>3</sup>	8.8 µg/m <sup>3</sup>	The 3-year average of the annual average concentrations.
Ground-level Ozone	8-hour	63 ppb	62 ppb	The 3-year average of the annual 4 <sup>th</sup> -highest daily maximum 8-hour average concentrations.

Table 1. The Canadian Ambient Air Quality Standards (CAAQS).

<sup>17</sup> <http://www.ec.gc.ca/inrp-npri/donnees-data/ap/index.cfm?lang=En>

<sup>18</sup> World Health Organization. <http://www.who.int/mediacentre/factsheets/fs313/en/>.



## Air Zone Management Framework

Although the CAAQS are achieved in all Nova Scotia's air zones, an air zone management framework is used to work towards continuous improvement because the health for some portion of the population continues to be affected when ambient concentrations of GLO and PM<sub>2.5</sub> are very low.<sup>19, 20</sup> For example, the World Health Organization (WHO) ranked Canada to have the third best air quality in the world,<sup>21</sup> but the Canadian Medical Association (CMA) estimated that in 2008 there were 2,682 premature deaths in Canada from air pollution (69 in Nova Scotia) and total economic damages of about \$8 billion (\$200 million in Nova Scotia).<sup>22</sup> More recently, the International Institute for Sustainable Development (IISD) estimates that "7,712 deaths were attributable to PM<sub>2.5</sub> and ground-level ozone in Canada in 2015"<sup>23</sup> and "direct welfare cost of [GLO and PM<sub>2.5</sub>] is estimated to have been \$36 billion in 2015".<sup>24</sup> The majority of these cumulative effects occur on days that are normally regraded as having good air quality.<sup>25</sup>

The air zone management framework has four air management levels, represented by colour, and provides guidance on management actions for each level (Table 2). Numerical values of GLO and PM<sub>2.5</sub> in the form of the CAAQS are calculated from the data measured at each monitoring station. The values are compared to threshold values and the highest CAAQS value in an air zone sets the air zone's management level. Management levels have continuous improvement as a priority and require more stringent management actions as the numerical form of the air pollutant measurements approach the CAAQS limits. There is one management level (Red) that requires actions to be implemented for achieving CAAQS if the CAAQS are exceeded. There are three management levels (green, yellow and orange) that require action to 'keep clean areas clean' or prevent degradation of air quality when the CAAQS are achieved.

<sup>19</sup> For example, see: Bell, M. L., Peng, R. D., and Dominici, F. (2006). The Exposure-Response Curve for Ozone and Risk of Mortality and the Adequacy of Current Ozone Regulations. *Environmental Health Perspectives*. <http://dx.doi.org/10.1289/ehp.8816>.

<sup>20</sup> Government of Canada (2012). *Canadian smog assessment – Highlights and key messages*. Environment Canada. Retrieved from <http://publications.gc.ca/site/eng/9.694820/publication.html>. Page 4.

<sup>21</sup> World Health Organization (2011). Urban outdoor air pollution database. [http://www.who.int/phe/health\\_topics/outdoorair/databases/OAP\\_database\\_8\\_2011.xls](http://www.who.int/phe/health_topics/outdoorair/databases/OAP_database_8_2011.xls). Accessed from, CBC News. *Canada's air quality 3rd best in world*, <http://www.cbc.ca/news/health/canada-s-air-quality-3rd-best-in-world-1.980695>.

<sup>22</sup> Canadian Medical Association (2008). No breathing room: National illness costs of air pollution.

<sup>23</sup> International Institute for Sustainable Development (2017). *Costs of pollution in Canada: Measuring the impacts on families, businesses and governments*. Page 26.

<sup>24</sup> Ibid. Page viii.

<sup>25</sup> Government of Canada (2012). <http://publications.gc.ca/site/eng/9.694820/publication.html>, pp. 4-5.





Management Level	Management Actions	Air Management Threshold Values		
		Ozone 8-hour (ppb)	PM <sub>2.5</sub> 24-hour (µg/m <sup>3</sup> )	PM <sub>2.5</sub> Annual (µg/m <sup>3</sup> )
 <b>Red<sup>††</sup></b>	Actions for <b>Achieving</b> Air Zone CAAQS	63	28	10
 <b>Orange</b>	Actions for <b>Preventing</b> CAAQS Exceedance	56	19	6.4
 <b>Yellow<sup>*</sup></b>	Actions for <b>Preventing</b> air quality <b>Deterioration</b>	50	10	4
 <b>Green</b>	Actions for <b>Keeping Clean Areas Clean</b>	0	0	0

Table 2. The Air Quality Management Framework and associated threshold values.

†† The threshold values for the “red” management level are equal to the numerical values of the Canadian Ambient Air Quality Standards (CAAQS).

\* The CAAQS thresholds between the green and yellow management levels are based on estimated baseline concentrations in ambient air.<sup>26</sup>

## Air Zone Results for Nova Scotia at a Glance

### Results for 2016

In 2016, the CAAQS were achieved in all four of Nova Scotia’s air zones. The management level in the Central and Eastern Air Zones is ‘yellow’ and the management level for the Northern and Western air zones is ‘orange’ (Table 3).

NOVA SCOTIA AIR ZONE MANAGEMENT LEVELS AND CAAQS ACHIEVEMENT RESULTS FOR 2016 (2014–2016 AVERAGE)

















Air Zone	Management Level	Management Actions	Results		
			Ozone 8-hour (ppb)	PM <sub>2.5</sub> 24-hour (µg/m <sup>3</sup> )	PM <sub>2.5</sub> Annual (µg/m <sup>3</sup> )
<b>Central</b>	 <b>Yellow</b>	Actions for Preventing AQ Deterioration	 <b>51</b>	 <b>11</b>	 <b>4.6</b>
<b>Eastern</b>	 <b>Yellow</b>	Actions for Preventing CAAQS Exceedance	 <b>48</b>	 <b>13</b>	 <b>6.0</b>
<b>Northern</b>	 <b>Orange</b>	Actions for Preventing CAAQS Exceedance	 <b>45</b>	 <b>18</b>	 <b>6.6</b>
<b>Western</b>	 <b>Orange</b>	Actions for Preventing CAAQS Exceedance	 <b>57</b>	 <b>12</b>	 <b>5.7</b>

Table 3. CAAQS achievement and management level results for air zone monitoring in Nova Scotia for the 2016 reporting year.

<sup>26</sup> CCME (2012). *Guidance document on air zone management*, pages 12-14. [http://www.ccme.ca/files/Resources/air/aqms/pn\\_1481\\_gdazm\\_e.pdf](http://www.ccme.ca/files/Resources/air/aqms/pn_1481_gdazm_e.pdf)

YEAR-TO-YEAR COMPARISON OF AIR ZONE MANAGEMENT LEVELS

















	Multi-Year Air Zone Management Levels			
	Central	Eastern	Northern	Western
2013	Yellow 	Yellow 	Orange 	Orange 
2014	Yellow 	Yellow <sup>†</sup> 	Orange 	Orange 
2015	Yellow 	Yellow 	Orange 	Orange 
2016	Yellow 	Yellow 	Orange 	Orange 

Table 4. Year-to-year comparison of the air zones' management levels.

† The management level for the Eastern Air Zone was reported as "Orange" in the 2014 Air Zone Report. It was later discovered that an instrument used for measuring PM<sub>2.5</sub> had a technical issue to cause the readings to be incorrect. The data have been adjusted to account for the issue and the air zone management level has been revised to "Yellow."



# A Closer Look at the Air Zone Results for Nova Scotia

## Central Air Zone

Population density is correlated with air emissions because transportation, housing, and commercial activities that support population also generate emissions. The central air zone has the greatest population density of Nova Scotia's four air zones. There are two ambient air monitoring stations in the central air zone. One is located in Downtown Halifax and the other is located at Lake Major, which is downwind from Halifax, in area with less population, traffic, and commercial density (Fig. 4).

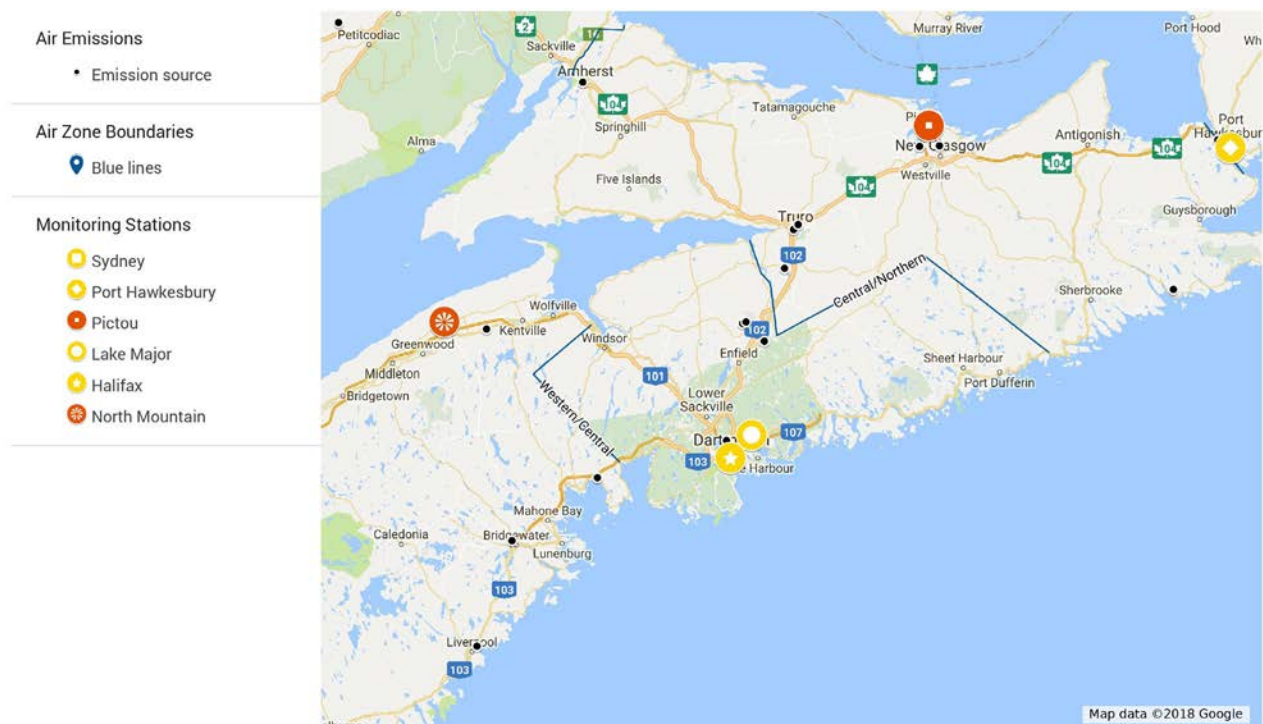


Figure 4. The central air zone, showing road ways, monitoring stations (large yellow circles), and emission sources (black dots) that are reported to the NPRI.

The  $PM_{2.5}$  measurements in the central air zone in 2016, as in previous years, fall in the 'yellow' management level and are not statistically different from Nova Scotia's other air zones (except for the northern air zone, which is significantly higher than all other air zones). GLO in downtown Halifax is 'green,' and 'yellow' in Lake Major (Table 5).

## CENTRAL AIR ZONE



















Reporting Year	Ozone 8-hour (ppb)		PM <sub>2.5</sub> 24-hour (µg/m <sup>3</sup> )		PM <sub>2.5</sub> Annual (µg/m <sup>3</sup> )	
	Lake Major	Downtown Halifax	Lake Major	Downtown Halifax	Lake Major	Downtown Halifax
2013	 52	 42	 15	*	 6.0	*
2014	 52	 41	 14	*	 6.0	*
2015	 51	 42	 15 <sup>†</sup>	 11	 6.3 <sup>†</sup>	 4.6
2016	 51	 41	*	 11	*	 4.6

Table 5. Year-to-year comparison of the central air zone's management levels and CAAQS measured at each monitoring station.

<sup>†</sup> Result is based on two-years of data. Data must pass QA/QC and completeness tests to be acceptable for calculating CAAQS. More information can be found at [http://www.ccme.ca/files/Resources/air/aqms/pn\\_1483\\_gdad\\_eng.pdf](http://www.ccme.ca/files/Resources/air/aqms/pn_1483_gdad_eng.pdf).

\* Station data did not pass quality assurance tests and are not used to calculate the CAAQS.

## Central Air Zone GLO

Transportation is the main source of pollutants that contribute to the formation of GLO. When fuel is burned with air at high temperature, nitrogen (N<sub>2</sub>) and oxygen (O<sub>2</sub>) gases in the air are split and combine to form nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). These undergo chemical reactions when exposed to sunlight to form N<sub>2</sub> and ozone (O<sub>3</sub>) molecules. Emissions of NO also combine with O<sub>3</sub> molecules already present in the atmosphere near the emission source to reduce the ambient concentration of GLO. However, as the air moves away from the emission source and the pollutants continue to react in the presence of sunlight, the result is an excess of ozone. The effect of NO reacting with GLO and reducing concentrations near the emission source is evident in measurements taken at downtown Halifax. Average 1-hour NO measured at Downtown Halifax is represented in Figure 5. The ambient concentrations of NO are greatest at two times during the day, and these times correspond with morning and afternoon 'rush-hours' when traffic density is at its highest. Further illustrating the traffic effect is that concentrations are lower during the weekend when fewer cars are on the streets. Figure 6 shows a similar pattern for GLO, but ambient concentrations are lowest at those times of day when NO concentrations are at their highest.

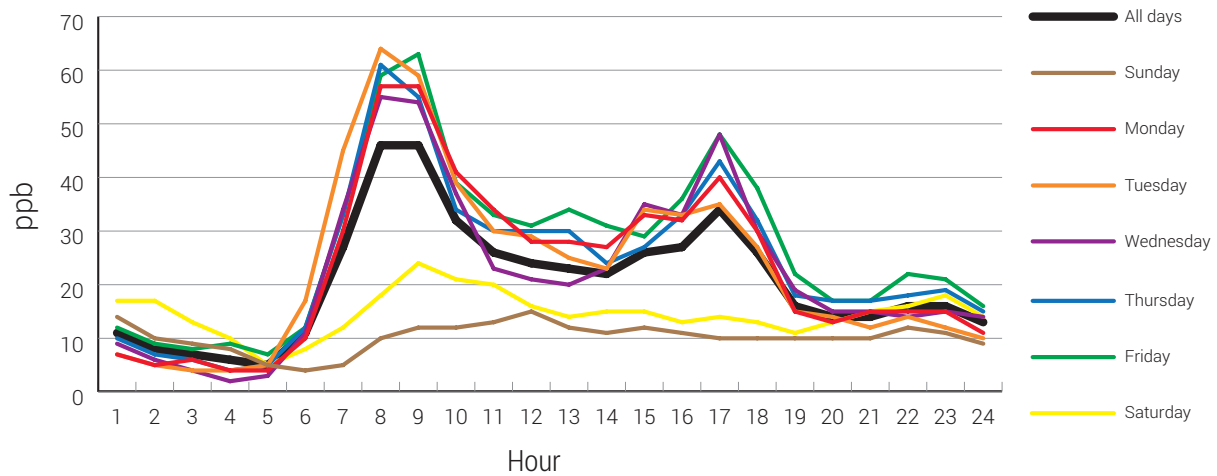


Figure 5. Daily patterns of ambient concentrations of nitrogen oxide (NO) at Downtown Halifax.

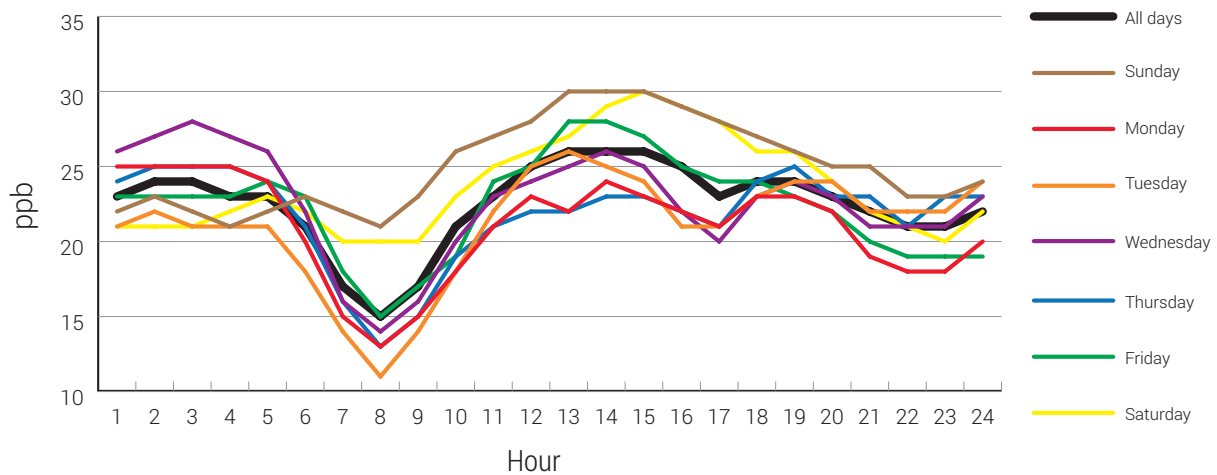


Figure 6. Daily patterns of ambient concentrations of ground-level ozone (GLO) at Downtown Halifax.

The GLO, in the form of the CAAQS measured at Downtown Halifax in 2016, is 41 ppb. The GLO, in the form of the CAAQS, measured downwind of Halifax is 51 ppb. The difference between the two stations is statistically significant. It is thought that as the air moves away from Downtown Halifax, chemical reactions continue to take place and excess ozone is formed. The highest measurement is used to report on CAAQS achievement for the central air zone.

## Central Air Zone PM<sub>2.5</sub>

Long-range transport of PM<sub>2.5</sub> from outside Nova Scotia is a significant contributor of PM<sub>2.5</sub> measured at Halifax, and local sources include vehicles, ships, woodsmoke and others.<sup>27</sup> The PM<sub>2.5</sub> measured at Downtown Halifax, in the form of the 24-hr and annual CAAQS, tends to be lower than the measurements taken at Lake Major. The difference (based on available data) is statistically significant. This difference requires further investigation, but the Lake Major station is located downwind of Halifax and may be influenced by a greater number of sources than the downtown station, and there may be more localised emission sources from residential fuel wood burning in the suburban area of Lake Major.

## Eastern Air Zone

The eastern air zone has Nova Scotia's second largest population centre, but the population density of the air zone is only about one quarter of the central air zone's population density. There are two monitoring stations in the air zone, located in the areas with the highest concentrations of population and industry (Figure 7). Industries that report air emissions to the National Pollutant Release Inventory (NPRI) that are relevant to the CAAQS include three coal-fired power plants, a biomass-fired generating facility, a thermal mechanical pulping paper mill, and several other smaller activities and commercial facilities.

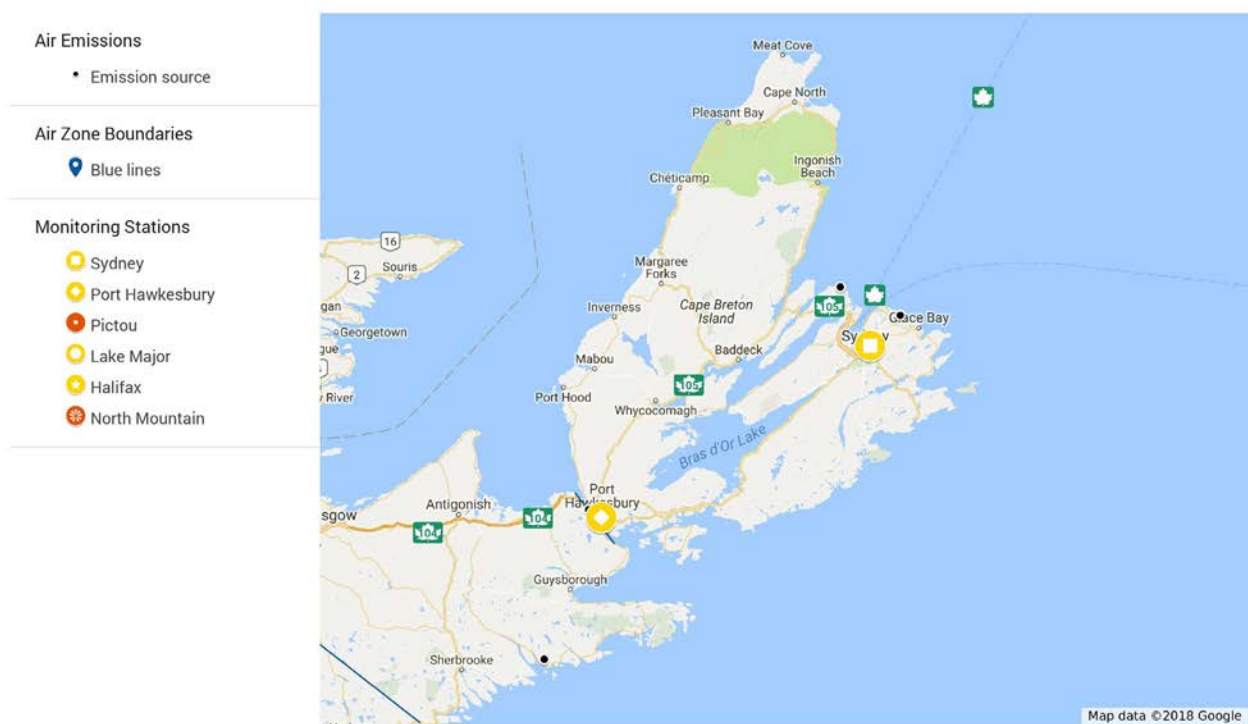


Figure 7. The eastern air zone, showing road ways, monitoring stations (large yellow circles), and emission sources (black dots) that are reported to the NPRI.

<sup>27</sup> Gibson, M. D., et al. (2013). Identifying the sources driving observed PM<sub>2.5</sub> temporal variability over Halifax, Nova Scotia during BORTAS-B. *Atmospheric Chemistry and Physics*, (13), pp. 7199-7213. Doi: 10.5194/acp-13-7199-2013.



The PM<sub>2.5</sub> measurements in the eastern air zone in 2016, as in previous years, fall in the 'yellow' management level (Table 6) and are not statistically different from Nova Scotia's other air zones (except for the northern air zone, which is significantly higher than all other air zones). Ozone measurements fall in the 'green' management level, just below the 50 ppb threshold for 'yellow' that is based on estimated baseline concentrations in ambient air. Both the 24-hour and annual PM<sub>2.5</sub> CAAQS measured at the Port Hawkesbury monitoring station tend to be greater than what is measured at Sydney; however, the difference is not statistically significant.

#### EASTERN AIR ZONE

























Reporting Year	Ozone 8-hour (ppb)		PM <sub>2.5</sub> 24-hour (µg/m <sup>3</sup> )		PM <sub>2.5</sub> Annual (µg/m <sup>3</sup> )	
	Port Hawkesbury	Sydney	Port Hawkesbury	Sydney	Port Hawkesbury	Sydney
2013	 47	 49	 16	 13	 6.3	 5.0
2014	 47	 50	 15	 14	 6.1	 5.4
2015	 46	 49	 15	 14	 6.1	 5.9
2016	 48	 48	 13	 13	 5.7	 6.0

Table 6. Year-to-year comparison of the eastern air zone's management levels and CAAQS measurements.

## Western Air Zone

The western air zone, Nova Scotia's largest air zone, is mostly rural but does have industrial air emissions sources that report to the NPRI. These include food processing facilities, manufacturing plants, and other institutions. Key geographic features include the North and South Mountains and the Annapolis Valley. It is also dominated by the Southwest Nova Scotia Uplands Ecoregion that is, "marked by warm summers and mild winters [and is] strongly influenced by the Atlantic Ocean and is one of the most humid parts of the Maritime provinces."<sup>28</sup> One of the most densely populated and commercially active centres is found in the Annapolis Valley. The area has an airport, some commercial facilities, and a high concentration of agricultural activity (Figure 8).

<sup>28</sup> Webb and Marshall (1999). *Ecoregions and ecodistricts of Nova Scotia*. Agriculture and Agri-Food Canada & Environment Canada. Accessed at [http://sis.agr.gc.ca/cansis/publications/surveys/ns/nsee/nsee\\_report.pdf](http://sis.agr.gc.ca/cansis/publications/surveys/ns/nsee/nsee_report.pdf).

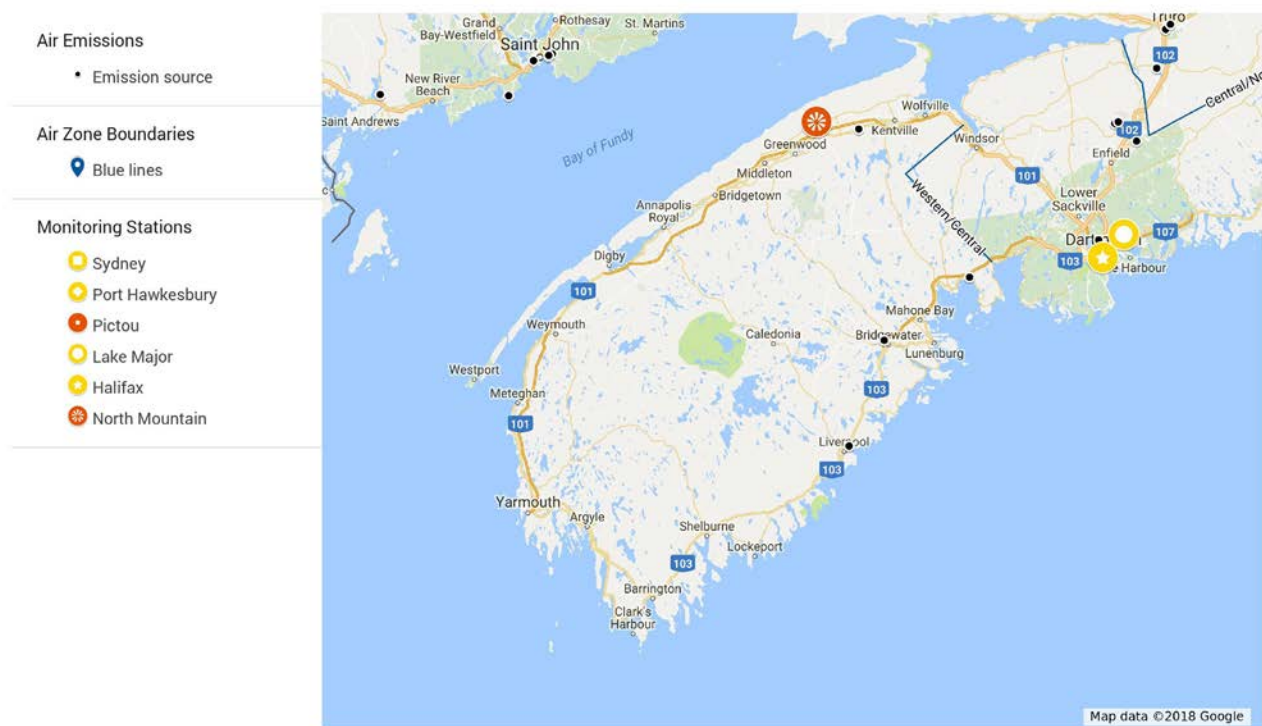


Figure 8. The western air zone of Nova Scotia. There was one monitoring station operational for this reporting period (large orange circle). An additional station has been installed at Kentville and will be included in future reports when sufficient data have been collected. The black dots represent emission sources that report to the NPRI.

There is currently one station in the western air zone used for calculating CAAQS, located on the North Mountain near Aylesford. A second monitoring station for the western air zone, located in Kentville, was put into service in 2016. Because CAAQS are based on three-year averages, it is anticipated that first reporting for CAAQS from the Kentville station will be calculated from the data averaged for 2016 to 2018.

The  $PM_{2.5}$  measurements in the western air zone in 2016, as in previous years, fall in the 'yellow' management level and are not statistically different from Nova Scotia's other air zones (except for the northern air zone, which is significantly higher than all other air zones). Ground level ozone measurements fall in the 'orange' management level (Table 7) and are the highest in Nova Scotia.

#### WESTERN AIR ZONE

Reporting Year	Ozone 8-hour (ppb)	$PM_{2.5}$ 24-hour ( $\mu\text{g}/\text{m}^3$ )	$PM_{2.5}$ Annual ( $\mu\text{g}/\text{m}^3$ )
2013	60	12	4.4
2014	59	12	4.8
2015	59	14	5.3
2016	57	12	5.7

Table 7. Year-to-year comparison of the western air zone's management levels and CAAQS measurements at the North Mountain monitoring station.

## Western Air Zone GLO

Ground level ozone is formed when sunlight reacts with 'precursor' pollutants, such as  $\text{NO}_x$  and VOCs. The potential for ozone formation depends on if the environment is saturated or limited in  $\text{NO}_x$ . Rural environments, like that of the western air zone, tend to be limited in  $\text{NO}_x$ , and further reductions of  $\text{NO}_x$  will result in reduced concentrations of GLO. Environments that are saturated with  $\text{NO}_x$ , like downtown Halifax, will experience an increase in GLO concentrations when  $\text{NO}_x$  is decreased.

Air pollution that is created in one jurisdiction and travels across borders to another jurisdiction is called transboundary pollution. Weather patterns in eastern North America generally carry air pollution from the south-west to the north-east, and because of its location, the western air zone it is generally the first region of Nova Scotia to receive long-range air pollutants that originate in the Eastern United States. Coal-fired power plants and transportation are important sources of  $\text{NO}_x$  and there are many coal-fired power plants downwind of Nova Scotia (Figure 9).

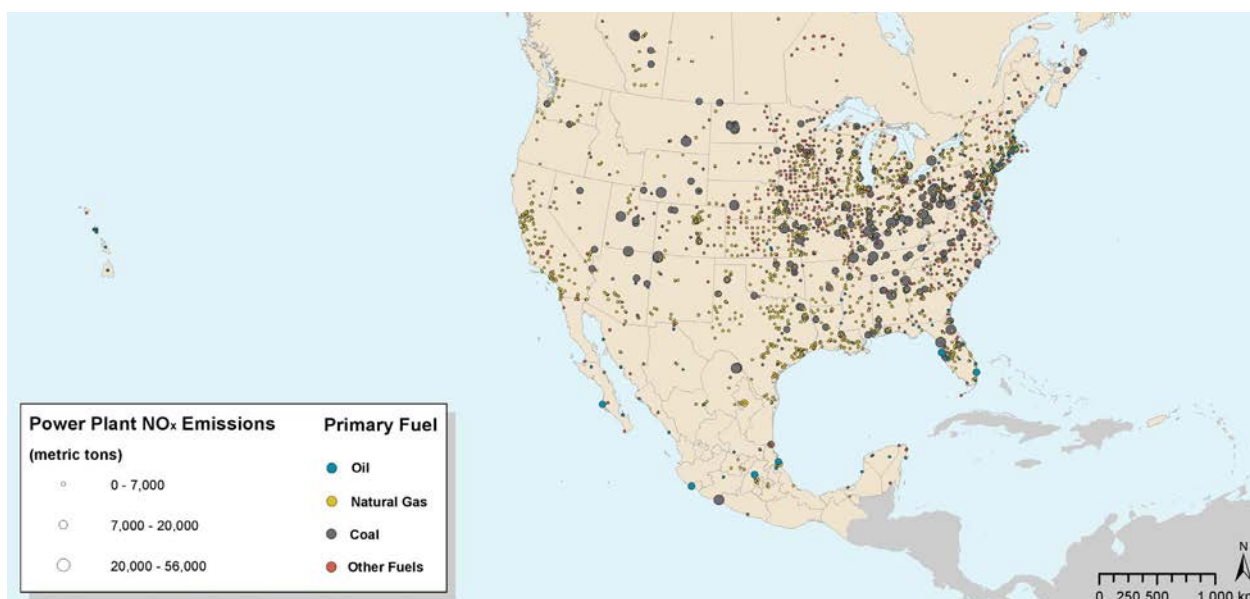


Figure 9. This map identifies the locations of North American coal-fired power plants and the relative size of their  $\text{NO}_x$  emissions.<sup>29</sup> In a typical meteorological setup for transboundary air pollution, a high pressure system sets up over Bermuda and is large enough so that its leading edge is over Eastern North America. A high pressure system in the Northern Hemisphere rotates in a clockwise direction, and this movement carries emissions from the Eastern United States into Nova Scotia.<sup>30</sup>

Analysis of the long-term GLO monitoring data from the western air zone show that  $\text{NO}_2$  emission reductions from coal-fired power plants in the Ohio River Valley, beginning in 1999, are correlated with reduced summertime GLO concentrations in Nova Scotia (Figure 10).

<sup>29</sup> Data are taken from the Commission for Environmental Cooperation of North America (CEC) power plant emissions project <http://www.cec.org/sites/default/napp/en/north-american-emissions/north-american-emissions.php>.

<sup>30</sup> For more information, see *Case study of a trans-boundary air pollution event in Nova Scotia* <https://novascotia.ca/nse/air/docs/NovaScotiaTransboundaryEvent2004.pdf>

## WESTERN AIR ZONE GLO AND THE OHIO RIVER VALLEY'S AMBIENT NO<sub>2</sub> AND NO<sub>2</sub> EMISSIONS\*

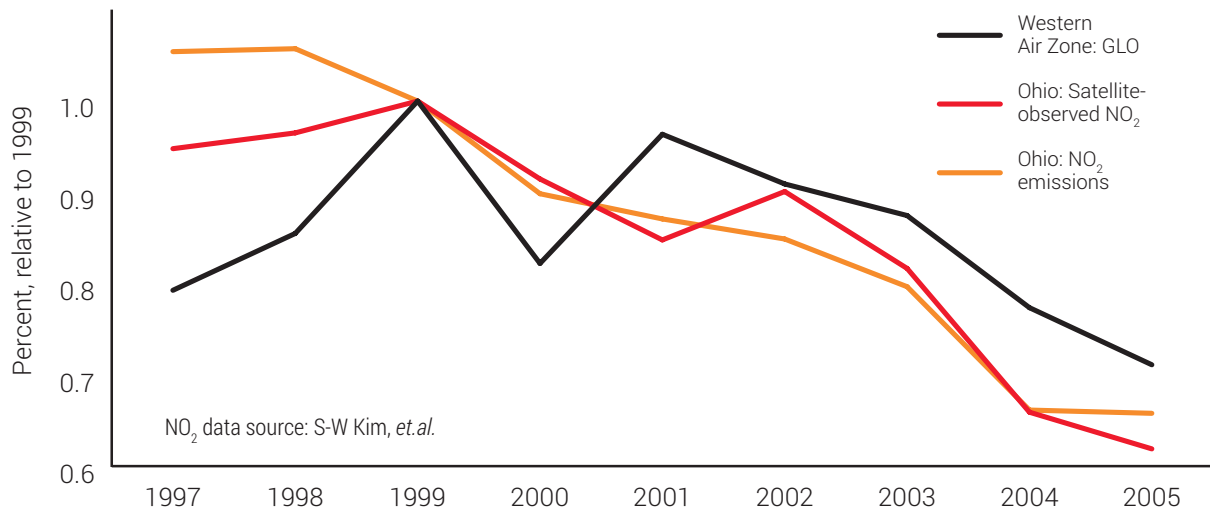


Figure 10. Summertime ambient NO<sub>2</sub> concentrations in the Ohio River Valley are correlated with strategies to reduce NO<sub>2</sub> emissions from coal-fired power plants in the region.<sup>31</sup> The summertime GLO concentrations measured in Nova Scotia's western air zone are also correlated with emission reductions of NO<sub>2</sub> in the Ohio River Valley.

The CAAQS for GLO is achieved in the western air zone, but the results are in the "orange" management level. To determine the effects of transboundary pollution and past emission reduction strategies on the CAAQS, the long-term GLO data from the Western Air Zone were converted to the numeric form of the CAAQS and it is found that the CAAQS for GLO may not have been achieved without the emission reduction strategies implemented in the Ohio River Valley by the Government of the United States (Figure 11).

<sup>31</sup> S-W Kim, *et. al.* 2006. Satellite-observed U.S. power plant NO<sub>x</sub> emission reductions and their impact on air quality. *Geophysical Research Letters*, VOL. 33, L22812.

## WESTERN AIR ZONE 3-YEAR MOVING AVERAGE OF 4TH HIGHEST, 8-HOUR AVERAGE GLO, 2000–2016

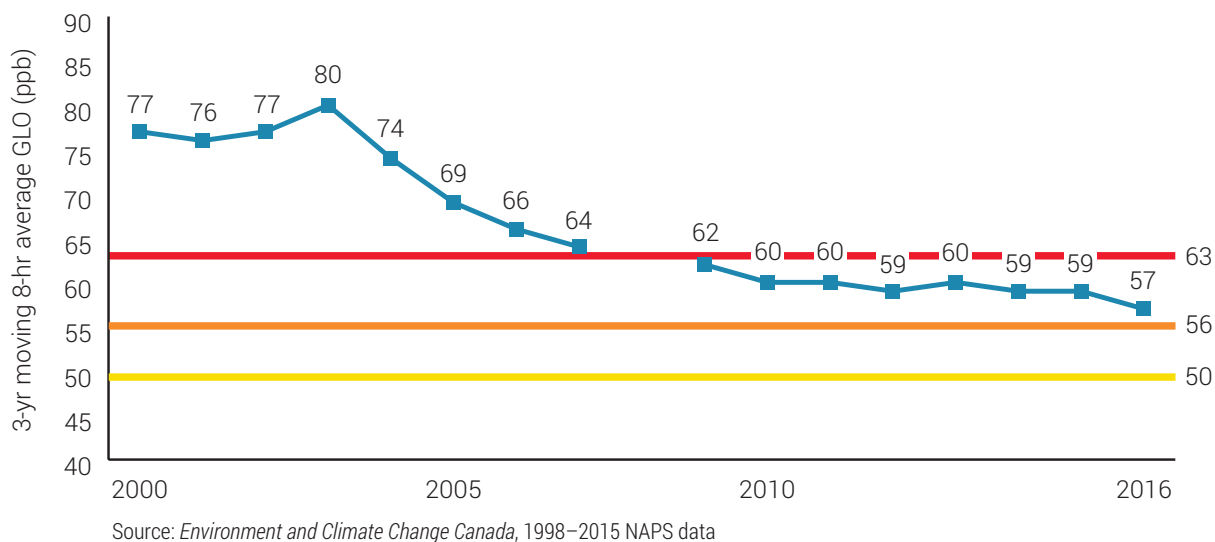


Figure 11. The CAAQS for GLO came into force in 2015, but the long-term GLO measurements from the western air zone were converted to the numeric form of the CAAQS for comparison with the standard and management level thresholds. The results show that the values prior to 2009 were greater than the CAAQS threshold for achievement. There is evidence that GLO transported from the Ohio River Valley in the United States contributed to GLO measured in the Western Air Zone, and that reduction strategies in the US have beneficial results for Nova Scotia.

In addition to pollution that comes from the coal-fired power plants of the Ohio River Valley, pollution also arrives in the western air zone from the eastern seaboard of the United States, where transportation produces most of the  $\text{NO}_x$  emissions that contribute to the formation of GLO. Strategies to reduce  $\text{NO}_x$  emissions from transportation in the eastern United States, and Nova Scotia, would likely result in further reductions in ambient GLO concentrations in the  $\text{NO}_x$ -limited environment of the western air zone. This supports the need for continued cooperation to improve air quality at the airshed level.

## Northern Air Zone

The Cobequid Mountains are a prominent geographical feature of the northern air zone, and the air zone is dominated by the Nova Scotia Highlands ecoregion. It also includes the Maritime Lowlands ecoregion to the north of the Cobequid Mountains that is characterised by having, “the lowest precipitation levels in the Maritime provinces.”<sup>32</sup> A coal-fired power plant, tire manufacturing plant, and pulp and paper plant are in this region, near the Town of Pictou. An air monitoring station is located in Pictou (Figure 12). The northern air zone’s management level is “orange” (Table 8).

### Northern Air Zone $\text{PM}_{2.5}$

Long-term  $\text{PM}_{2.5}$  data exhibit patterns of local, distant, natural and human-caused sources of  $\text{PM}_{2.5}$  pollution, and a pulp and paper mill in the northern air zone reported  $\text{PM}_{2.5}$  emissions greater than those reported by any other facility in Nova Scotia.<sup>33</sup> Actions have been taken to reduce emissions from this source and a

<sup>32</sup> Webb and Marshall (1999). *Ecoregions and ecodistricts of Nova Scotia*. Agriculture and Agri-Food Canada & Environment Canada. Accessed at [http://sis.agr.gc.ca/cansis/publications/surveys/ns/nsee/nsee\\_report.pdf](http://sis.agr.gc.ca/cansis/publications/surveys/ns/nsee/nsee_report.pdf).

significant reduction in the ambient concentrations of  $PM_{2.5}$  is observed beginning in mid-2015 (Figure 13 and Figure 14). The hourly average  $PM_{2.5}$  measured at Pictou now closely tracks with  $PM_{2.5}$  measured at other locations in the province, but because the CAAQS are based on a 3-year average of the 98<sup>th</sup> percentile of 24-hour averages, and the 3-year average of the annual average, the air zone’s management level will remain statistically higher than what is observed in other air zones for a delayed period.

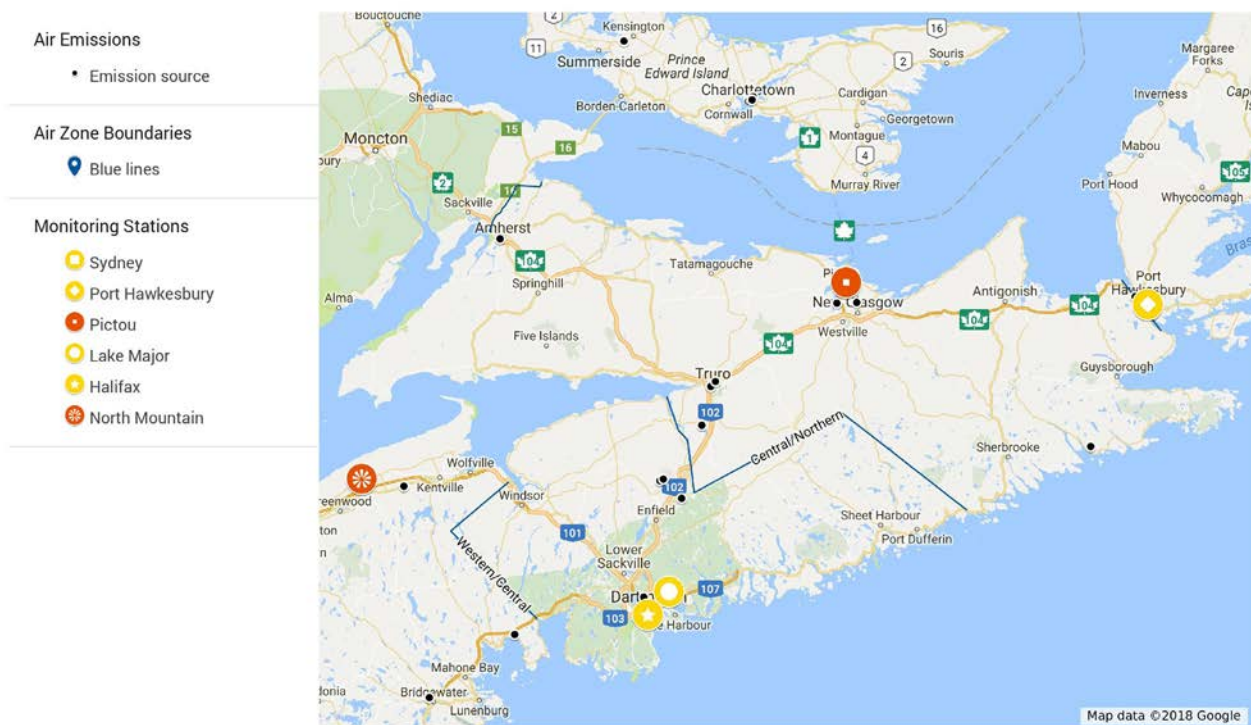


Figure 12. The northern air zone, showing road ways, monitoring station (large orange circle), and emission sources (black dots) that are reported to the NPRI.

#### NORTHERN AIR ZONE

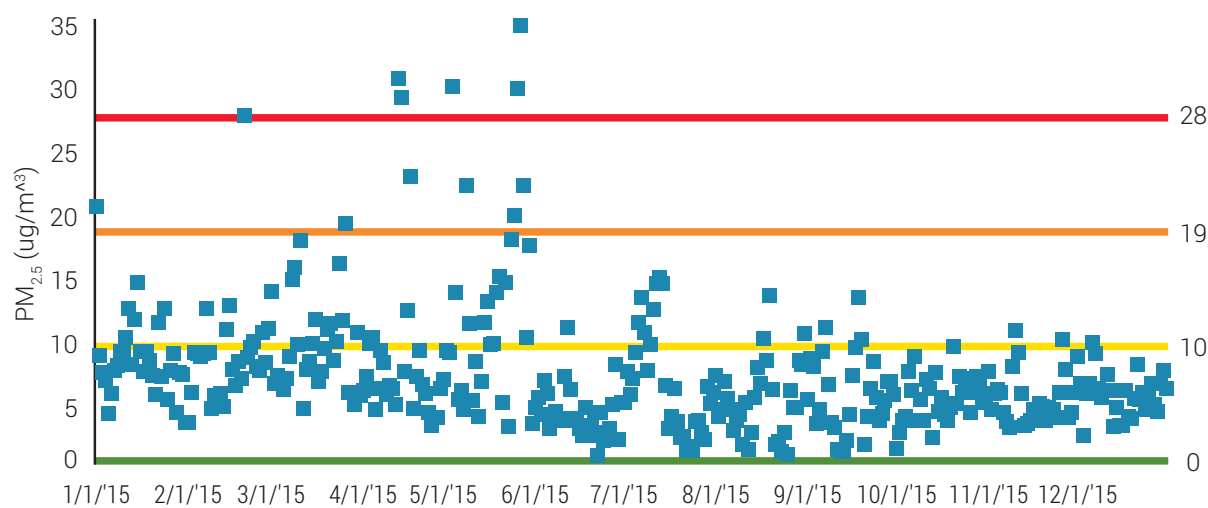
Reporting Year	Ozone 8-hour (ppb)	$PM_{2.5}$ 24-hour ( $\mu\text{g}/\text{m}^3$ )	$PM_{2.5}$ Annual ( $\mu\text{g}/\text{m}^3$ )
2013	46	18	6.9
2014	45	21	7.5
2015	45	23 <sup>†</sup>	7.6 <sup>†</sup>
2016	45	18	6.6

Table 8. Year-to-year comparison of the northern air zone’s management levels and CAAQS measurements at the Pictou monitoring station.

<sup>†</sup> Result is based on two-years of data. Data must pass quality assurance/quality control and completeness tests to be acceptable for calculating CAAQS. More information can be found at [http://www.ccme.ca/files/Resources/air/aqms/pn\\_1483\\_gdad\\_eng.pdf](http://www.ccme.ca/files/Resources/air/aqms/pn_1483_gdad_eng.pdf).

<sup>33</sup> <http://www.ec.gc.ca/inrp-npri/donnees-data/index.cfm?lang=En>

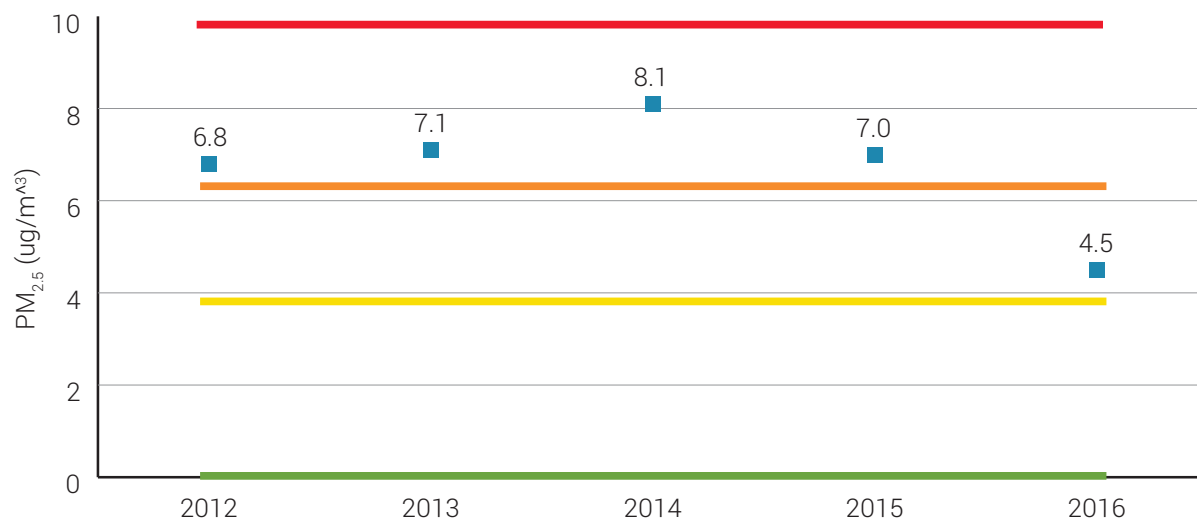
### NORTHERN AIR ZONE, 2015, 24-HOUR DAILY AVERAGE PM<sub>2.5</sub>



Note: These are 24-hour daily averages, not CAAQS values

Figure 13. For comparison purposes, peak values of 24-hour average ambient PM<sub>2.5</sub> in the Northern Air Zone are compared to the CAAQS thresholds over the period during which a pulp and paper mill in the air zone shutdown for repairs and resumed operations with new pollution control equipment to reduce PM<sub>2.5</sub> emissions.

### NORTHERN AIR ZONE, MEAN ANNUAL PM<sub>2.5</sub> COMPARED TO CAAQS THRESHOLDS



Note: These are annual mean values, not CAAQS values

Figure 14. The annual average PM<sub>2.5</sub> in the Northern Air Zone for 2015 showed a reduction from the previous two years. It is expected that future annual averages will be lower because a local pulp and paper mill installed emissions control equipment in mid-2015 and continues to operate with significantly reduced emissions.

# Contact Us

For more information on ambient air quality monitoring, the AQMS, ambient air quality data or related products visit [novascotia.ca/nse/air/](http://novascotia.ca/nse/air/) or contact us at **902-424-3600**.

