Ministry of Environment and Climate Change Strategy

LOWER FRASER VALLEY AIR ZONE REPORT (2013-2015)

Introduction

This is the third annual quality report for the Lower Fraser Valley (LFV) Air Zone. Annual air zone reporting is a commitment under the national Air Quality Management System (AQMS). This report describes achievement of the Canadian Ambient Air Quality Standards (CAAQS) for ground-level ozone (O_3) and fine particulates ($PM_{2.5}$), the associated management levels and recent actions to improve air quality. A province-wide summary can be found at: http://www.env.gov.bc.ca/soe/indicators/air/.

Background

The AQMS is the national approach to managing air quality in Canada. Under the AQMS, the CAAQS are developed to drive action to protect human health and the environment. Air zones are areas that exhibit similar air quality characteristics, issues and trends, and that form the basis for monitoring, reporting and taking action on air quality. The Lower Fraser Valley (LFV) Air Zone (see Figure 1) is one of seven broad air zones across the province. Under the AQMS, progressively more rigorous actions are expected as air quality approaches or exceeds the CAAQS. The level of action is guided by the Air Zone Management Framework outlined in Table 1.

Figure 1. Lower Fraser Valley Air Zone.

Table 1. Air zone management framework for ground-level ozone and $PM_{2.5}$. The CAAQS define the upper threshold, separating the “red” and “orange” management levels.

Management Level	O_3 (ppb)		$PM_{2.5}$ – Annual ($\mu g/m^3$)		$PM_{2.5}$ - 24h ($\mu g/m^3$)	
	2015	**2020**	**2015**	**2020**	**2015**	**2020**
Red	Actions for Achieving Air Zone CAAQS					
Threshold (CAAQS)	63	62	10	8.8	28	27
Orange	Actions for Preventing CAAQS Exceedance					
Threshold	56		6.4		19	
Yellow	Actions for Preventing Air Quality Deterioration					
Threshold	50		4		10	
Green	Actions for Keeping Clean Areas Clean					

Ozone Levels

Ozone measurements in the LFV Air Zone are summarized in Figure 2. Concentrations ranged from 37 ppb in downtown Vancouver to 64 ppb in Agassiz.[1] All sites achieved the national standard of 63 ppb, with the exception of Agassiz.

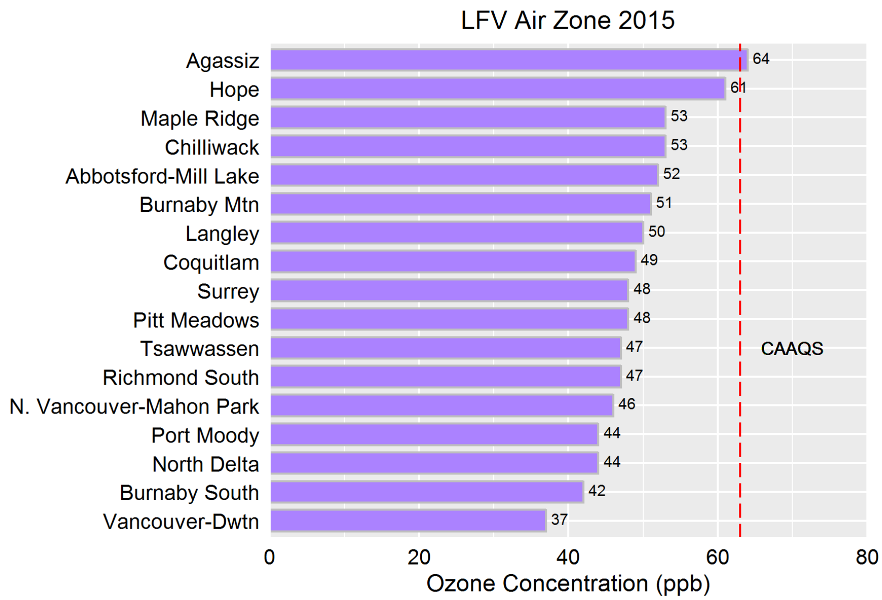

Figure 2. Ozone concentrations in the LFV Air Zone, based on annual 4th highest daily 8-hour maxima, averaged over 2013-2015. Red dashed line identifies the CAAQS of 63 ppb.

Trends in ozone levels are shown in Figure 3.[2] The 2015 levels in Hope and Chiliwack were higher than measured in the previous five years. A very warm, sunny summer and periodic wildfire smoke events contributed to the higher than expected levels in 2015 (see Appendix I and II for more information).

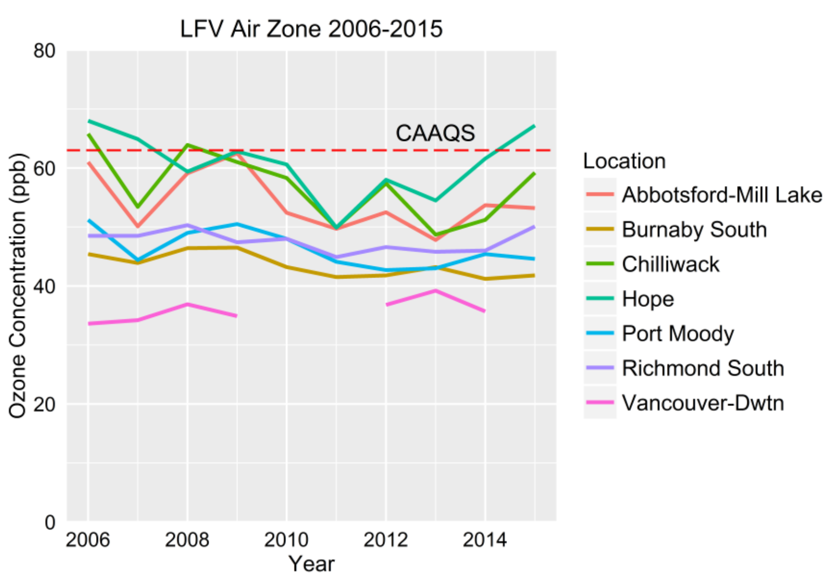

Figure 3. Trends in ozone concentrations (2006-2015), based on annual 4th highest daily 8-hour maxima for a single year. Red dashed line identifies CAAQS of 63 ppb.

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[1] Concentrations based on 4th highest daily 8-hour maximum, averaged over three years (2013-2015).
[2] Concentrations based on 4th highest daily 8-hour maximum, averaged over a single year.

$PM_{2.5}$ Levels

$PM_{2.5}$ refers to inhalable particles up to 2.5 micrometres in diameter. $PM_{2.5}$ measurements are summarized in Figure 4. All measurements for this reporting period were based on the Federal Equivalent Method (FEM), which provides a more complete measure of $PM_{2.5}$ than the older TEOM instruments.

Daily concentrations (upper plot) ranged from 12 to 20 $\mu g/m^3$.[3] All sites achieved the national standard of 28 $\mu g/m^3$. Annual concentrations (lower plot) ranged from 4.7 to 6.9 $\mu g/m^3$.[4] All monitoring sites achieved the national standard of 10 $\mu g/m^3$. For both measures, the highest concentrations were observed in Langley and Abbotsford.

Trends in annual mean concentrations between 2006 and 2015 are shown in Figure 5 for a subset of these sites.[5] A shift to higher reported concentrations is seen with the change from TEOM to FEM instruments from 2013 onward but concentrations have remained below the CAAQS level.

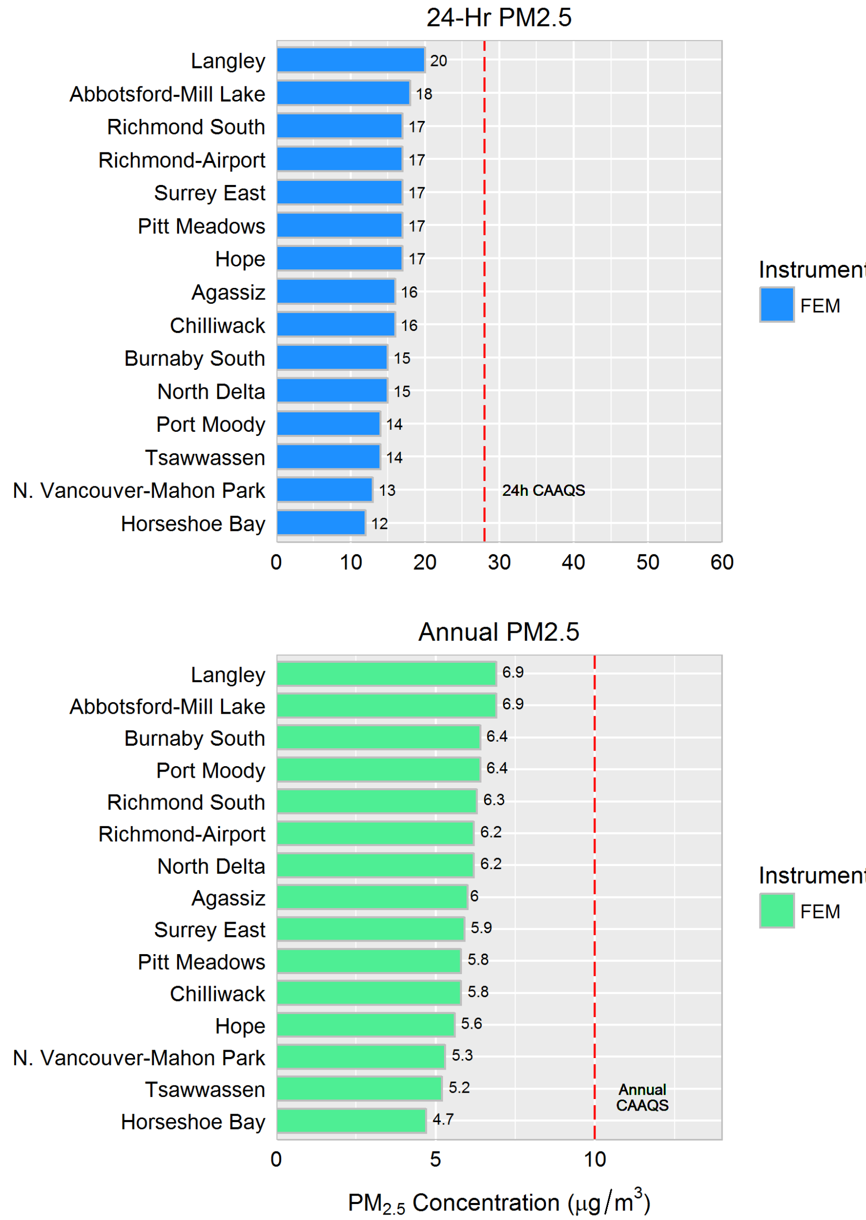

Figure 4. $PM_{2.5}$ concentrations in the LFV Air Zone. Upper plot based on 24-hour concentration (annual 98th percentile, averaged over 2013-2015). Lower plot based on annual mean concentration (averaged over 2013-2015). The red dashed lines identify CAAQS of 28 $\mu g/m^3$ (upper plot) and 10 $\mu g/m^3$ (lower plot).

[3] Concentrations based on the annual 98th percentile of 24-hour values, averaged over three years (2013-2015).
[4] Concentrations based on the annual average of 24-hour values, averaged over three years (2013-2015).
[5] Concentrations based on the annual average of 24-hour values over single year.

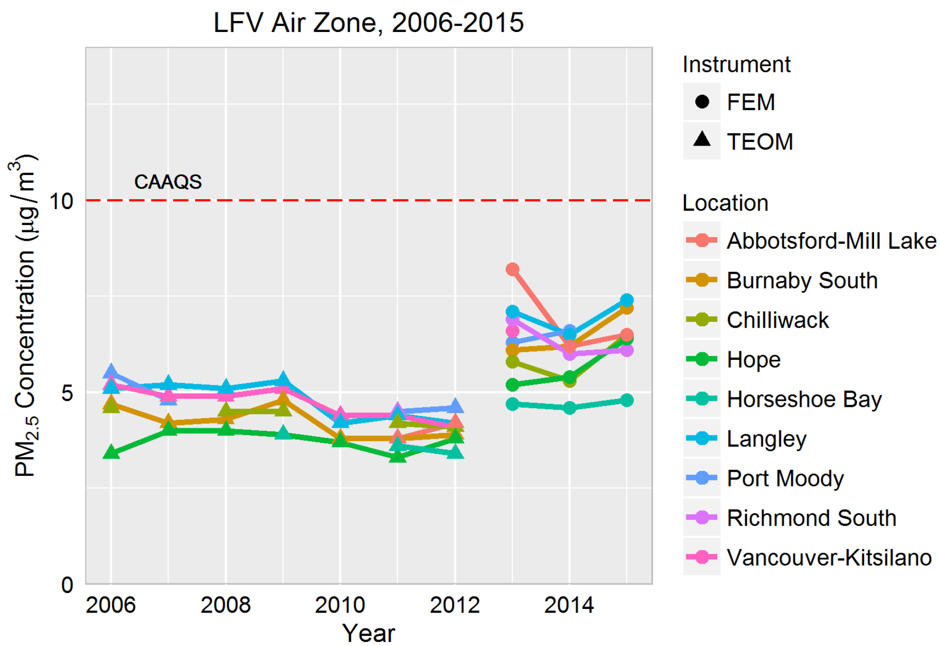

Figure 5. Trends in $PM_{2.5}$ concentrations (2006-2015), based on annual mean concentrations from a single year. The CAAQS value of 10 µg/m^3 is shown by the dashed line. $PM_{2.5}$ measurements prior to 2011 are reported at 25^{o}C and 1 atm. From 2011 onward, measurements are reported at local conditions.

Air Zone Management Levels

Air zone management levels are assigned on the basis of the highest concentrations within an air zone, excluding contributions from transboundary flows (TF) and exceptional events (EE) such as wildfires. This is done so that long-term management strategies are not developed on the basis of events that are beyond local or provincial control.

Across B.C., wildfires are the primary contributor to TF/EE. The methodology for identifying wildfire-influenced data is provided in Appendix I and excluded data are summarized in Appendix II, along with information on specific wildfire influences. Air quality in the LFV Air Zone was particularly affected by wildfire smoke during the summer 2015. Hot, dry conditions and fires burning to the north of the region and in Washington State led to periods of degraded air quality in several communities across the air zone.

Table 2 summarizes ozone concentrations as measured and after TF/EE influences have been considered. As described in Appendix II, wildfire smoke is believed to have boosted ozone concentrations above 63 ppb on at least two days at the Agassiz site. Following exclusion of the wildfire-influenced data, Agassiz is assigned an “orange” management level. Because air zone management levels are preferentially based on sites with three complete years of data, the LFV Air Zone is assigned an “orange” management level based on ozone levels in Hope.

Table 2. Summary of ozone concentrations as measured and air zone management levels for the LFV Air Zone (based on 2013-2015 data).

Location	No. Valid Years	4th Highest Daily 8-hour Maxima		Air Zone Management Level
		As Measured	TF/EE Influences Removed	
Abbotsford-Airport	3	50	50	**Goal: Preventing CAAQS Exceedane**
Abbotsford-Mill Lake	3	52	52	
Agassiz	2	64	63	
Burnaby Mtn	3	51	51	
Burnaby South	3	42	42	
Burnaby-Kensington	3	44	44	
Chilliwack	3	53	53	
Coquitlam	3	49	49	
Hope	3	61	61	
Langley	3	50	50	
Maple Ridge	3	53	53	
N. Vancouver-2nd Narrows	3	41	41	
N. Vancouver-Mahon Park	3	46	46	
North Delta	3	44	44	
Pitt Meadows	3	48	48	
Port Moody	3	44	44	
Richmond South	3	47	47	
Richmond-Airport	3	45	45	
Surrey	3	48	48	
Tsawwassen	3	47	47	
Vancouver-Dwtn	2	37	37	

Table 3 summarizes $PM_{2.5}$ concentrations as measured and with TF/EE influences removed for each monitoring site. Overall, the LFV Air Zone is assigned an “orange” management level based on $PM_{2.5}$ concentrations in Langley and Abbotsford, with “yellow” management levels identified elsewhere in the air zone. This indicates that $PM_{2.5}$-related actions should focus on actions to prevent CAAQS exceedances.

Table 3. Summary of $PM_{2.5}$ concentrations as measured and air zone management levels for the LFV Air Zone (based on 2013-2015 data).

Location	Monitor Type	No. Valid Years	Daily Mean (98th Percentile)		Annual Mean		Air Zone Management Level
			As Measured	TF/EE Removed	As Measured	TF/EE Removed	
Abbotsford-Airport	FEM	3	18	17	6.4	6.3	Goal: Preventing CAAQS Exceedance
Abbotsford-Mill Lake	FEM	3	18	18	6.9	6.9	
Agassiz	FEM	2	16	15	6	5.9	
Burnaby South	FEM	3	15	15	6.4	6.3	
Burnaby-Kensington	FEM	2	15	15	6.5	6.2	
Chilliwack	FEM	3	16	15	5.8	5.7	
Hope	FEM	3	17	16	5.6	5.4	
Horseshoe Bay	FEM	3	12	11	4.7	4.5	
Langley	FEM	3	20	20	6.9	6.8	
N. Vancouver-2nd Narrows	FEM	3	15	14	6.4	6.3	
N. Vancouver-Mahon Park	FEM	3	13	13	5.3	5.2	
North Delta	FEM	3	15	15	6.2	6.1	
Pitt Meadows	FEM	2	17	17	5.8	5.7	
Port Moody	FEM	3	14	14	6.4	6.2	
Richmond South	FEM	3	17	17	6.3	6.2	
Richmond-Airport	FEM	2	17	17	6.2	6.2	
Surrey	FEM	3	17	16	5.9	5.8	
Tsawwassen	FEM	3	14	14	5.2	5.2	

Actions to Protect Air Quality

Through delegated authority under the *Environmental Management Act*, Metro Vancouver has responsibility for managing air emissions within its boundaries.

Metro Vancouver developed an Integrated Air Quality Management and Greenhouse Gas Management Plan in 2011.[6] This plan contains 12 strategies, 81 actions and 10 performance measures. It seeks to reduce levels of $PM_{2.5}$, ground-level ozone, and other priority pollutants to protect human health and the environment, improve visual air quality and minimize contributions to climate change. The first progress report on plan implementation was released in 2014.[7] More information on air quality-related

[6] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf
[7] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/2014IAQGGMPProgressReport.pdf

activities in Metro Vancouver can be found at: http://www.metrovancouver.org/services/air-quality/Pages/default.aspx.

The Fraser Valley Regional District is in the process of updating its Air Quality Management Plan that was first developed in 1998.[8] This plan highlights several air quality issues, including ground-level ozone and $PM_{2.5}$.

Regional air quality agencies including Metro Vancouver and the Fraser Valley Regional District developed a Regional Ground-Level Ozone Strategy in 2014.[9] This strategy identifies goals and strategic policy direction for the LFV. The strategy is currently in the implementation phase.

A description of other activities underway in B.C. air zones can be found in the “Air Zone Management Response for British Columbia” (see: www.gov.bc.ca/bcairquality).

[8] http://www.fvrd.ca/assets/Services/Documents/FVRD%20AQManagementPlan.pdf
[9] http://www.metrovancouver.org/services/air-quality/AirQualityPublications/RGLOS2014.pdf

Appendix I – Approach to Identify Wildfire-influenced Data

Summertime air quality in British Columbia is periodically influenced by wildfire smoke – from local fires as well as long-range transport from outside of the province. The wildfire season in B.C. typically occurs between May and September, when warm and dry conditions prevail.

A myriad of different pollutants are emitted from wildfires. These include $PM_{2.5}$ and gases such as nitrogen oxides and volatile organic compounds that can react in the atmosphere to form ground-level ozone and additional $PM_{2.5}$.

Given that smoke-affected areas may be extensive, and that smoke may linger for days before being fully dispersed from an airshed, the current analysis has focussed on those periods when wildfire smoke may have contributed to an exceedance of the CAAQS levels for ground-level ozone or $PM_{2.5}$ levels. Criteria used to flag and evaluate wildfire-influenced data included the following:

- 24-hour $PM_{2.5}$ concentrations exceeded the CAAQS level of 28 $\mu g/m^3$ or 8-hour daily maximum ozone concentrations exceeded the CAAQS level of 63 ppb between May and September,
- Wildfires of interest were identified based on data from B.C. Wildfire Management Branch,
- Wildfire smoke advisories had been issued by Metro Vancouver during the period of interest,
- MODIS satellite images indicated smoke impacts over the region,
- Multiple monitoring sites in the area of concern exhibited similar air quality characteristics, suggesting a common source or contributing source, and
- Modelling studies identify enhanced pollutant concentrations due to wildfire smoke.

Wildfire-influenced data were excluded from the calculation of air zone management levels. Excluded data are described in Appendix II, along with additional information on specific wildfire influences.

Appendix II – Wildfire-influenced Data in the LFV Air Zone (2013-2015)

Ground-level Ozone

Wildfire smoke plumes are known to contribute to or "enhance" ozone concentrations.[10] Due to the number of complex chemical reactions involved in ozone formation, ozone enhancements are typically estimated using photochemical modelling. Such modelling was not available for this analysis. Other supporting evidence, including the presence of wildfire smoke and meteorological conditions conductive to ozone formation in the LFV are considered here.

Based on 2013-2015 data, Agassiz was the only site in the LFV Air Zone to have exceeded the ozone CAAQS. Elevated ozone concentrations were observed in late June and early July, 2015 (see Figure II-1 and Table II-1), when 1-hour concentrations reached a maximum of 90 ppb and 8-hour concentrations reached a high of 78 ppb. During this period, a number of notable wildfires burned to the north of the region (see Table II-2). Smoke from these fires and resultant high $PM_{2.5}$ concentrations prompted Metro Vancouver to issue an air quality advisory from July 5-10, 2015. On July 8 and 9, 8-hour average ozone concentrations exceeded 75 ppb.

Ozone production is typically reliant on photochemical reactions in the atmosphere. For this reason, temperature is often used as a predictor for high ozone levels. Historically, ozone concentrations in excess of 75 ppb in the Eastern Fraser Valley have occurred on days in which the maximum temperature has reached at least 31^{o}C.[11] However, on July 8 and 9, maximum temperatures peaked below 31^{o}C. MODIS satellite images (Figure II-2) show smoke filling north-south tributary valleys to the Fraser, including Harrison Lake that lies immediately north of Agassiz. These images, together with elevated $PM_{2.5}$ levels at Agassiz, indicate the presence of wildfire smoke. Lower temperature measurements than normally associated with peak ozone events suggest the likely enhancement of ozone levels due to this smoke.

Excluding Agassiz ozone data from July 8 and 9, 2015, the re-calculated annual 4th highest ozone concentration for 2015 becomes 65.9 ppb (July 4, 2015) and the corresponding CAAQS value averaged over 2013-2015 becomes 63 ppb. As a result, it has been determined that the Agassiz site would have achieved the ozone CAAQS for 2013-2015 if not for the influence of wildfire smoke.

[10] Teakles, A.D., So, R., Ainslie, B. et al. (2017) Impacts of the July 2012 Siberian fire plume on air quality in the Pacific Northwest. *Atmos. Chem. Phys*. 17, pp. 2593-2611.
[11] G. Doerksen, personal communication.

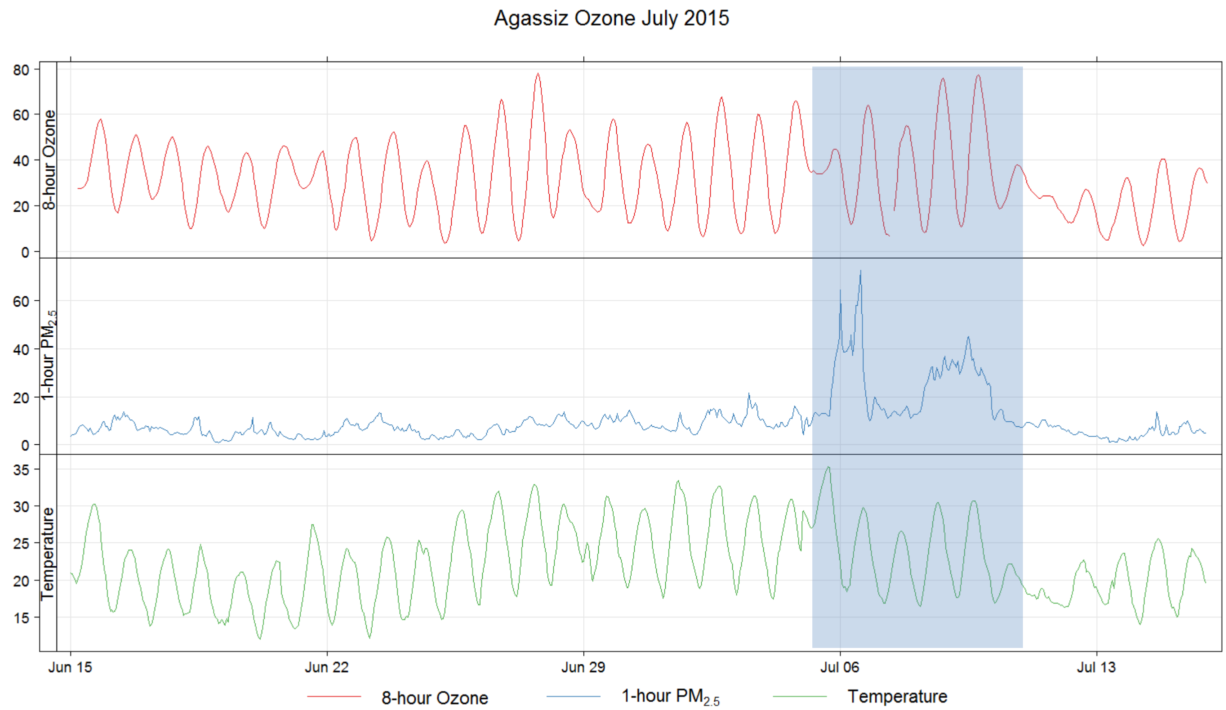

Figure II-1. Eight-hour rolling average ozone concentrations (ppb), 1-hour $PM_{2.5}$ concentrations ($\mu g/m^3$) and 1-hour temperature measurements (^oC) at Agassiz between June 15 and July 15, 2015. Shaded area from July 5-10, 2015 highlights approximate period during which wildfire smoke advisory was issued by Metro Vancouver.

Table II-1. Days when the daily 8-hour maximum ozone concentrations exceeded 63 ppb at Agassiz (in order of decreasing ozone concentrations).

Julian Date	Date	No. Valid Hrs	Daily 8-hr O_3 Max (ppb)	Daily $PM_{2.5}$ ($\mu g/m^3$)	Wildfire Smoke-related Air Quality Advisory?	Daily Max. Temperature (^oC)
178	6/27/2015	24	78	8.6	N	32.9
190	7/9/2015	24	77.5	17.1	Y	30.7
189	7/8/2015	24	76	25.4	Y	30.4
183	7/2/2015	24	67.6	10.7	N	32.6
177	6/26/2015	24	66.7	5.3	N	32
185	7/4/2015	24	65.9	9.6	N	30.9
187	7/6/2015	24	64	37.4	Y	29.8

Table II-2. Summary of notable wildfires in southwestern B.C. during the summer of 2015.[12]

Fire #	Latitude	Longitude	Discovered	Size (ha)	Geographic
V30160 (2015)	50 22.651	123 33.343	14-Jun-15	12495	Elaho 67km
V30241 (2015)	50 40.719	123 22.056	30-Jun-15	6735	Boulder Creek
V10247 (2015)	49 54.927	121 53.365	01-Jul-15	2985	Cougar Creek
V50256 (2015)	49 31.267	123 48.901	02-Jul-15	423	Old Sechelt Mine

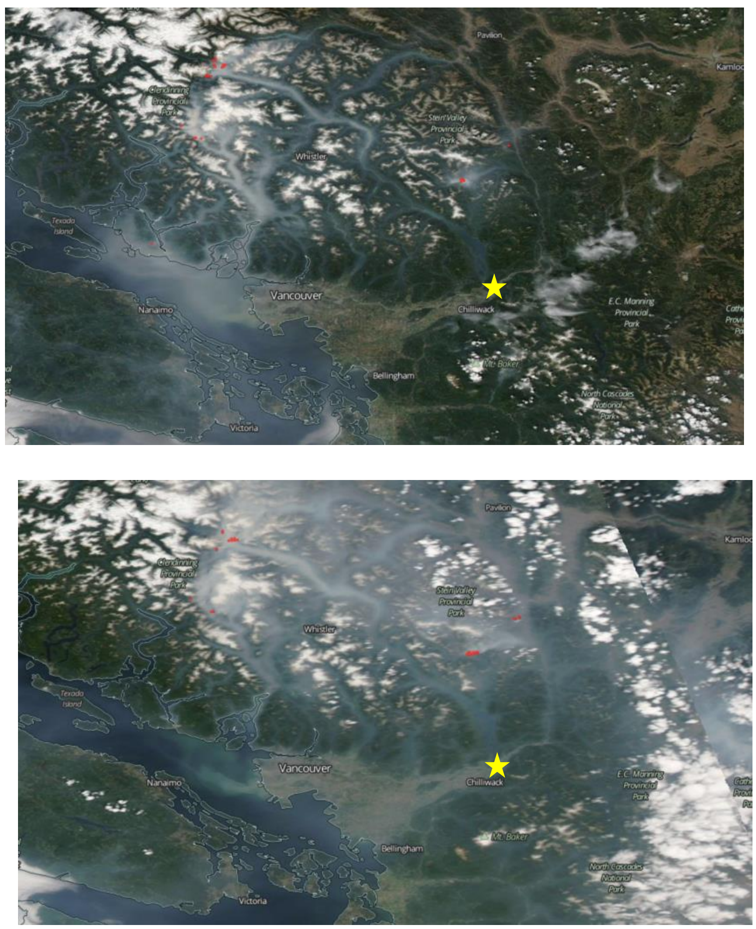

Figure II-2. NASA Worldview satellite images from July 8, 2015 (upper) and July 9, 2015 (lower). Red squares identify fires/thermal anomalies. Agassiz monitoring site approximated by yellow star.

[12] Source: B.C. Wildfire Management Branch (http://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-statistics).

$PM_{2.5}$

Wildfire-influenced $PM_{2.5}$ data are summarized in Table II-3. The flagged periods overlap with Air Quality Advisories issued by Metro Vancouver in response to elevated $PM_{2.5}$ concentrations due to wildfire smoke. The data were excluded from the determination of management levels, but ultimately did not affect the overall management level for the air zone.

Table II.3 – TF/EE-influenced $PM_{2.5}$ data.

Location	Date	Daily Mean (μg/m^3)	Wildfire Smoke-related Air Quality Advisory?
Abbotsford-Airport	2015-07-05	35	Y
Burnaby South	2015-07-05	55.6	Y
Burnaby-Kensington Park	2015-07-05	78.3	Y
Chilliwack	2015-07-05	30.4	Y
Horseshoe Bay	2015-07-05	65.9	Y
Langley	2015-07-05	45.7	Y
Mission	2015-07-05	29.8	Y
North Delta	2015-07-05	57.3	Y
North Vancouver-2nd Narrows	2015-07-05	46.0	Y
North Vancouver-Mahon Park	2015-07-05	59.9	Y
Pitt Meadows	2015-07-05	50.8	Y
Port Moody	2015-07-05	56	Y
Richmond South	2015-07-05	49.3	Y
Richmond-Airport	2015-07-05	54.2	Y
Surrey	2015-07-05	58.3	Y
Tsawwassen	2015-07-05	56.8	Y
Abbotsford-Airport	2015-07-06	44.9	Y
Abbotsford-Mill Lake	2015-07-06	82.5	Y
Agassiz	2015-07-06	37.4	Y
Burnaby South	2015-07-06	48.3	Y
Burnaby-Kensington Park	2015-07-06	49.8	Y
Chilliwack	2015-07-06	36.6	Y
Hope	2015-07-06	28.4	Y
Horseshoe Bay	2015-07-06	59.6	Y
Langley	2015-07-06	35.9	Y
Mission	2015-07-06	62.1	Y
North Delta	2015-07-06	34.6	Y
North Vancouver-2nd Narrows	2015-07-06	35.2	Y
North Vancouver-Mahon Park	2015-07-06	53.3	Y

Table II-3 (continued).

Location	Date	Daily Mean (mg/m^3)	Wildfire Smoke-related Air Quality Advisory?
Pitt Meadows	2015-07-06	41.5	Y
Port Moody	2015-07-06	56.4	Y
Surrey	2015-07-06	33.2	Y
Burnaby-Kensington Park	2015-07-08	28.7	Y
Hope	2015-07-08	31	Y
Horseshoe Bay	2015-07-08	33	Y
North Vancouver-2nd Narrows	2015-07-08	28.9	Y
North Vancouver-Mahon Park	2015-07-08	34.5	Y
Port Moody	2015-07-08	29.4	Y
Agassiz	2015-07-09	34	Y
Burnaby-Kensington Park	2015-07-09	28.7	Y
Hope	2015-07-09	35.8	Y
Horseshoe Bay	2015-07-09	32.7	Y
North Vancouver-Mahon Park	2015-07-09	31.7	Y
Abbotsford-Airport	2015-08-23	30.1	Y
Agassiz	2015-08-23	43.7	Y
Chilliwack	2015-08-23	39.9	Y
Hope	2015-08-23	42.5	Y