The Influence of Prescribed Burning of Wood in the Kamloops Fire Centre on the PM2.5 Values in Kamloops in the Month of November

prepared by

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ABSTRACT

Kamloops experienced very high hourly values and daily averages of $PM_{2.5}$ (fine particulates in the air less than 2.5 micrometers in aerodynamic diameter) for an extended period in November, 2014. The episode corresponded to a time when a high pressure system dominated the weather over Western Canada. The episode described in this report covered a large area, which included Kamloops, and is shown to have been present in both Vernon and Kelowna as well. The cause of the high concentrations of $PM_{2.5}$ was not residential emissions. It was very likely related to the permitted prescribed burning of wood (slash) in forests in and around Kamloops. November 2014 had the highest single day average $PM_{2.5}$ (37 $\mu g/m^3$) of any November in the last five years, a period during which the same instrument was used consistently to measure $PM_{2.5}$. This report demonstrates for the first time that $PM_{2.5}$ values in a number of cities in the Interior of British Columbia were highly correlated during a period of prescribed burns, with inter-city correlation coefficients exceeding 0.9 over a twenty day period. The report also presents, for the first time, the monthly average values of $PM_{2.5}$ in Kamloops for the period 1998 to 2014. This highlights the fact that, of the 12 months, November and August have the highest $PM_{2.5}$ averages.

This examination of the $PM_{2.5}$ database going back to 1998 showed consistently high $PM_{2.5}$ values in November, a period that occurs after the forest fire season and before the main winter heating season. In fact, it is shown that the month with the worst average (or median) $PM_{2.5}$ in Kamloops is November. This is the period when permits are issued to allow burning of large amounts of wood in the forests and on rural properties. The effect of this on the air quality in Kamloops is discussed. It is important to consider changes to the management of prescribed burns when discussing ways to improve our air quality. This is relevant not just near cities in British Columbia, but throughout the province, as the smoke generated by the burning of slash travels great distances and can cover areas in excess of 10,000 km^2.

Introduction and Overview of the Data

This is the third in a series of reports that have been written to inform the public, politicians and government decision makers on the quality of the air in Kamloops. As the title indicates, the focus is on the airborne fine particulate concentrations ($PM_{2.5}$) in the month of November. Both public comments and the data from the British Columbia Ministry of the Environment indicated that there were airborne particulate problems in Kamloops in November 2014. One of the authors flew across the southern part of the province to Vancouver on 16 November and then up to Kamloops. His comments were:

> "This morning I flew across B.C. from east to west passing south of Merritt about 0800. After landing in Vancouver I flew up to Kamloops landing here about 1115. This gave me a good perspective on the southern part of the province and I took a lot of pictures on the first trip. What I saw was interesting.
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> The air was very clear passing from the Alberta border to somewhere west of Revelstoke. Once I was south of the South Thompson and Thompson River valleys, the air was noticeably murkier at low levels and the three valley junction area in Kamloops was obscured. Once I was west of the Fraser River the air cleared again and the valleys had good visibility as I approached Vancouver. Flying out of Vancouver towards Kamloops the visibility was again very good until around Ashcroft and then once over Kamloops Lake it was very poor. Around the Domtar mill the visibility was close to nil in large part due to all the water vapour being emitted along with the usual PM into the background mix. Of interest was that there appeared to be a widespread subsidence inversion over southern B.C. around 1000 m elevation, more or less. This is a natural consequence of the high pressure area that has been over the province. When I was over Kamloops Lake looking north there was a very distinct reddish brown layer in the distance, not sure how far away but it would have to be within 30 km or so I would guess. This coloured layer was just below the inversion base and very pronounced. It would be consistent with comments that there is slash burning in the area and the particulates are then being carried by a north wind into our valleys."
>
> Dr. Robert S. Schemenauer, Ph.D.
> November, 16, 2014

A quick look at the $PM_{2.5}$ data showed a rapid rise in values in Kamloops on 14 November, from already elevated values. The values stayed very high until 21 November. Unfortunately, the BC MOE data are missing from 18 to 21 November (a similar situation occurred in Prince George from 10 to 17 November). This report examines this episode in detail and the November monthly data are looked at with respect to the full year of measurements in Kamloops.

The B.C. Wildfire Management Branch has stated (British Columbia, 2010) that they encourage prescribed burns of slash in the forests to reduce the probability of wildfires and that this will reduce airborne particulates. In turn, industry (Pinnacle, 2014) stated that if the slash went to their pellet plants instead of being burnt in the forests, it would reduce airborne particulates. Clearly the issue of how slash burning impacts $PM_{2.5}$ levels in the province is complicated but it cannot be discussed and dealt with until the data are analyzed and shared with the public. This report does that.

November Values in Comparison to Other Months of the Year

Citizens of Kamloops receive frequent admonitions, from their politicians and provincial government bureaucrats, to stop using wood stoves and drive less when airborne particulate levels rise. It is important that we properly diagnose the cause of the problem so that we can appropriately target our interventions. Are residential vehicle and wood stove emissions the real causes of the high November values measured in Kamloops? To answer this, one needs to begin by looking at the full history of $PM_{2.5}$ values since 1998. In more recent years the data were obtained from a BAM instrument (Tsigaris and Schemenauer, 2014a); however, prior to 2010 a different instrument, the TEOM, was used and it is known to have measured values that were far too low. Corrections to these values are being made in Canada, the USA and Europe. Tsigaris and Schemenauer (2014b) calculated the needed correction factors for measurements made with the TEOM in Kamloops and created a consistent long-term data base. These data are used in the discussion below.

The descriptive statistics of monthly average $PM_{2.5}$ values (1998 to 2014) for Kamloops are shown in Table 1. Figure 1 shows the average monthly average for each month of the year as well as bars one standard error from either side of the average. Also shown in Figure 1, for reference, are the B.C. guideline value of 8 $\mu g/m^3$ (for an annual average) as well as the B.C. planning goal of 6 $\mu g/m^3$.

This is the first time that a homogenized (TEOM and BAM measurements) data set of monthly values has been calculated and made available to the public in Kamloops. The reconstructed data used were from the regression adjustments taking into account cold and warm periods of the year (see Tsigaris and Schemenauer, 2014b).The evidence shows a regular pattern of values well over the B.C. guideline value and the planning goal in the colder months (November to February). In the months of July and September the values are statistically indistinguishable from the B.C. guideline (maximum), within a 5% margin of error. For the month of October, $PM_{2.5}$ increases to above 8 ug/m^3. Air quality is better in spring and early summer. Between March and June Kamloops has the best air quality of the year. In August the average value rises to 11.3 $\mu g/m^3$ mainly due to forest fires. August also has the highest standard error. November is the worst month of the year for $PM_{2.5}$, with the highest average value, 12.1 $\mu g/m^3$. The high averages for November and August rise above the cyclical pattern for the other months. The working hypothesis presented here is that the August value is driven up by forest fires and that the November value is driven up by prescribed burning. Table 1 provides further descriptive statistics on the distribution of the monthly average $PM_{2.5}$ over the years 1998-2014.

Table 1: Descriptive statistics for the Average PM2.5 (μg/m^3) for each month, for the years 1998-2014.

Month	Average	Standard Error	Minimum	Maximum	Q1	Median	Q3
January	10.7	0.55	6.4	15.8	9.4	10.5	11.4
February	10.4	0.53	6.6	14.5	8.5	10.6	12.0
March	7.1	0.23	5.5	9.8	6.5	7.0	7.7
April	6.8	0.23	5.0	8.9	6.2	6.7	7.5
May	6.9	0.17	5.7	9.0	6.6	6.8	7.2
June	6.7	0.24	5.5	8.4	5.9	6.5	7.6
July	8.2	0.38	6.1	12.4	7.3	7.8	8.8
August	11.3	1.42	5.6	25.8	7.5	8.5	15.1
September	7.6	0.40	4.7	10.4	6.6	7.3	9.0
October	8.6	0.32	6.0	10.9	7.9	8.5	9.7
November	12.1	0.78	7.7	19.9	10.0	11.1	14.1
December	10.0	0.31	8.0	12.5	9.1	9.7	10.7

Note: Standard error is the standard deviation of the average of the average monthly values. Q1 is the first quartile: 25 percent of the data are less than or equal to this value. Q3 is the third quartile: 25 percent of the data are greater than this value.

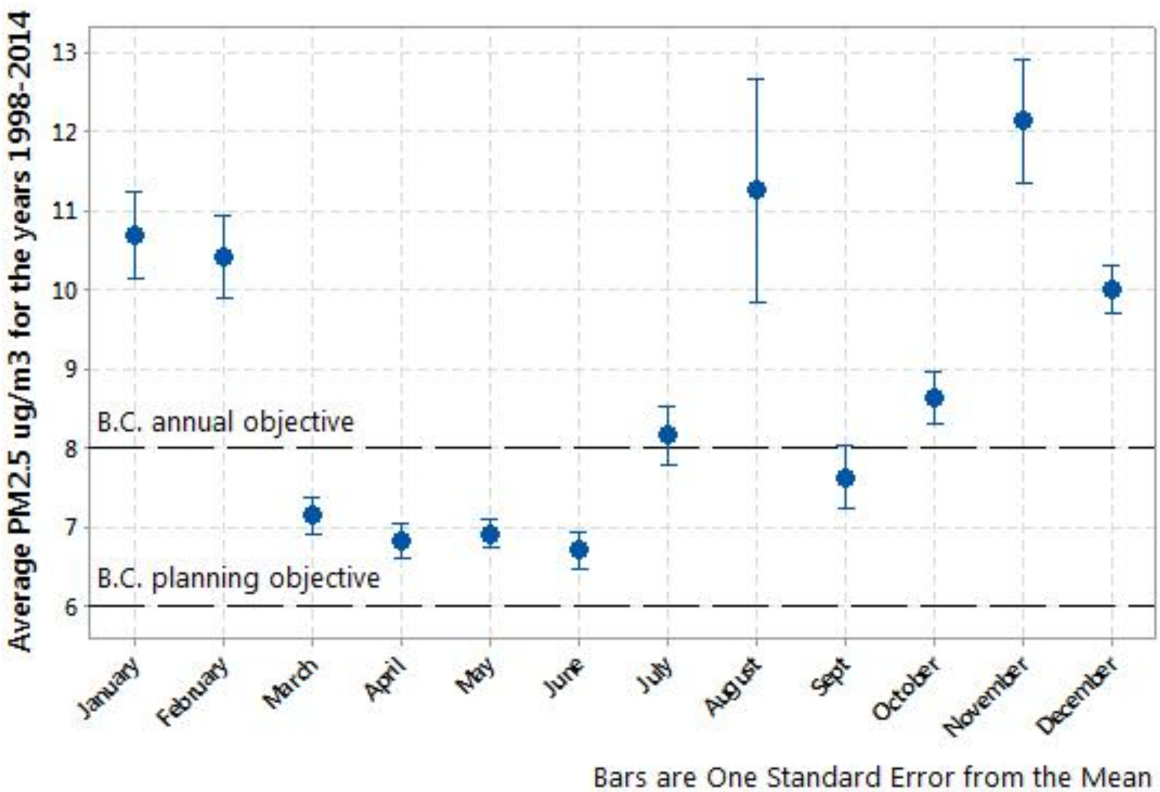

Figure 1. The average of the monthly average $PM_{2.5}$ values for Kamloops, British Columbia, for the period 1998 to 2014. Calculations are made from the reconstructed data set as per Tsigaris and Schemenauer (2014b). The circles show the mean values for each month and the bars show one standard error above and below the means. The original measurements were made, quality controlled and archived by the British Columbia Ministry of the Environment.

Figure 2 presents a closer look at the November monthly averages by plotting the observations on a histogram. The distribution is skewed slightly and this can be seen from Table 1 where the median value is less than the mean by 1.1 μg/m^3. The mode (most frequent outcome) of the distribution is even lower at 10 ug/m3. The lowest November monthly average occurred in 2009. November 2014 was not the worst November month over the entire period. November 2002 and 2003 had higher monthly averages as calculated from the re-constructed data. This will be examined in more detail in a future report.

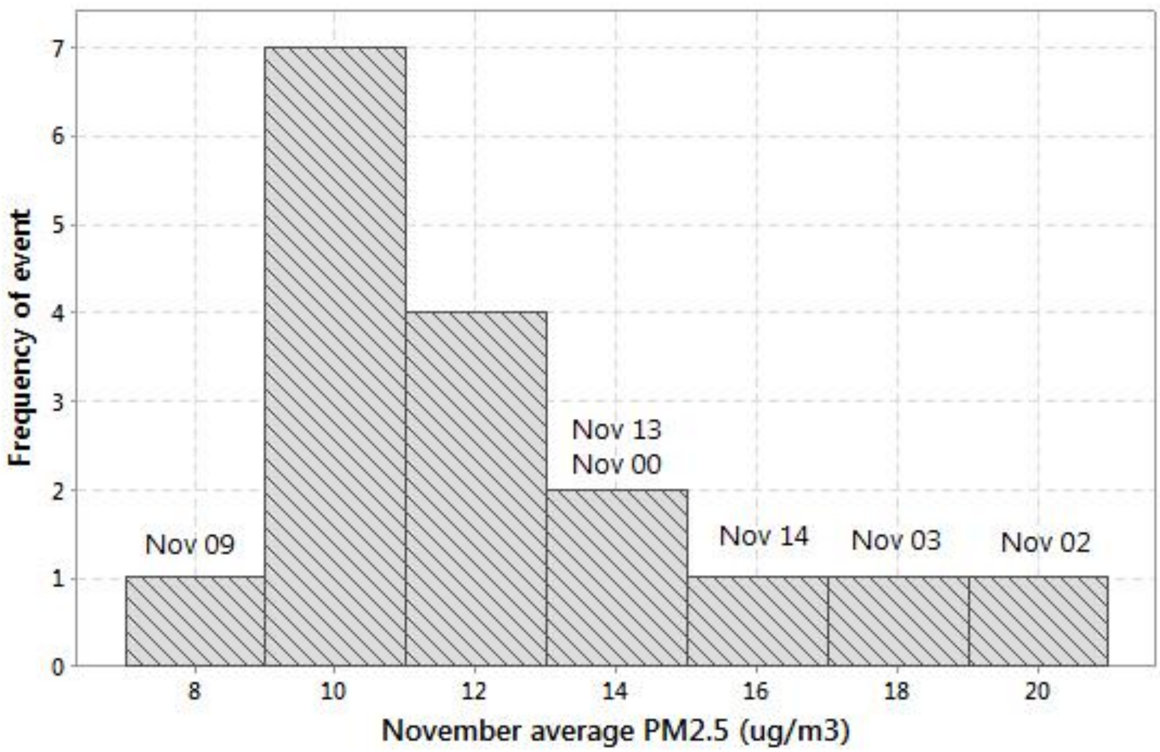

Figure 2: Histogram of November monthly averages 1998-2014

The difference in average $PM_{2.5}$ values between November and the other months varies widely (Table 2). The largest difference was with the spring months (November is over 5 μg/m^3 higher). November is also higher relative to the other winter months by about 1.7 μg/m^3. The difference in averages is statistically significant at the 95% confidence level. November average $PM_{2.5}$ was slightly higher than that of August but not statistically significantly different. An interesting comparison is with the month of October as they are both fall months. The average difference between November and October is 3.5 μg/m^3. Even with November (daily average temperature +2.1 C) being colder than October (+8.5 C), residential wood stove burning cannot explain this difference, as December (- 2.7 C) and January (-2.8 C) are much colder months than November, requiring more residential heating, and they have a significantly lower average $PM_{2.5}$. Table 3 shows the differences in median values between November and the other months. Averages could be affected by some extreme event during the month and this has an impact on the test results. Examining median differences using non-parametric statistics puts less weight on extreme events such as open burning and forest fires impacts and thus provides additional information on the seasonal air quality in Kamloops. Table 3 confirms that November is still the worst month, when differences in median values are examined, as is seen from the second column of Table 3. Note that median differences are smaller than mean differences for each of the months. A two tailed test for differences in the median is rejected for all months except for the winter months of January and February (p-values of 0.18 and 0.20 respectively). Clearly this table is an indication that November is affected by some significant event which deteriorates the air quality relative to the months of January and February. It is significantly different from the adjacent months and marginally significant (p-value of 0.07) in a two-tailed test with respect to the month of August. In this test August forest fires receive less weight and so does open burning which happens in November.

Table 2: Difference ($\mu g/m^3$) between the average of the monthly average $PM_{2.5}$ values for November and the averages for other months: for the period 1998-2014.

Month	Average Difference	t-stats for zero difference	p-value	Lower bound 95% confidence	Upper bound 95% confidence
January	1.4	2.6	0.02	0.3	2.6
February	1.7	2.4	0.03	0.2	3.2
March	5.0	7.7	0.00	3.6	6.4
April	5.3	6.6	0.00	3.6	7.0
May	5.2	6.3	0.00	3.5	7.0
June	5.4	7.1	0.00	3.8	7.1
July	4.0	4.7	0.00	2.2	5.8
August	0.9	0.6	0.57	-2.4	4.1
September	4.5	5.3	0.00	2.7	6.3
October	3.5	4.8	0.00	2.0	5.1
December	2.1	3.1	0.00	0.7	3.6

Note: A paired difference t-test was conducted to determine if the differences were statistically significant. The p-value shows significance. A p-value less than 5 percent (0.05) indicates a statistically significant average difference between November and the other month being tested.

Table 3: Difference ($\mu g/m^3$) between the median of the monthly average $PM_{2.5}$ values for November and the medians for other months: for the period 1998-2014.

Month	Median Difference	W for zero difference	p-value	Lower bound 95% confidence	Upper bound 95% confidence
January	0.9	336	0.19	-0.3	2.9
February	1.2	337	0.18	-0.5	2.9
March	4.1	435	0.00	3.2	6.1
April	4.4	440	0.00	3.4	6.4
May	4.2	441	0.00	3.6	6.2
June	4.7	438	0.00	3.5	6.4
July	3.3	415	0.00	2.1	5.0
August	2.3	351	0.07	-0.2	3.7
September	3.9	424	0.00	2.6	5.9
October	2.8	409	0.00	1.4	4.7
December	1.4	366	0.02	0.3	3.2

Note: A Mann-Whitney nonparametric difference in median test was conducted to determine if the median differences were statistically significant. The p-value shows significance. A p-value less than 5 percent (0.05) indicates a statistically significant median difference between November and the other month being tested.

The pattern of the monthly means over the 12 months of the year will not be investigated here but will be examined in a future report. The higher cold season and lower warm season $PM_{2.5}$ values could be due to changes in industrial, residential and natural emissions of $PM_{2.5}$; however, it also might be that total emissions are relatively constant and the cold season rises are influenced by changes in the weather in Kamloops, e.g. emissions might be relatively constant but inversions and stagnant air might result in higher winter $PM_{2.5}$ values. This is a separate issue than the high values seen for August and November, which rise well above the annual trend line.

Very High PM2.5 Values in November 2014

The daily average $PM_{2.5}$ values for November 2014 are shown in Figure 3. The B.C. guideline value of 25 $\mu g/m^3$ for a 24-hour average was exceeded for a number of days in the middle of the month.

As is evident from Figure 3, there are four missing days from the middle of the event, days 18 to 21 November inclusive. These are important values to know both from a health perspective and to properly define the monthly average.

If the November airborne fine particulate concentrations have an origin that is regional in scope, as opposed to being generated from local sources, then the $PM_{2.5}$ measurements in cities in the B.C. Interior should show a similar pattern. This is examined in Figure 4. Data from Kamloops are plotted along with data from Kelowna and Vernon. The Vernon and Kelowna data were obtained from modern Sharpe instruments, which meet USA Federal Equivalent Method standards as does the BAM instrument used in Kamloops. To the eye there is a good correlation and the statistical analysis in Table 4 shows that the correlation between the three cities for the period from 7 November to 30 November ranged from 0.89 to 0.96.

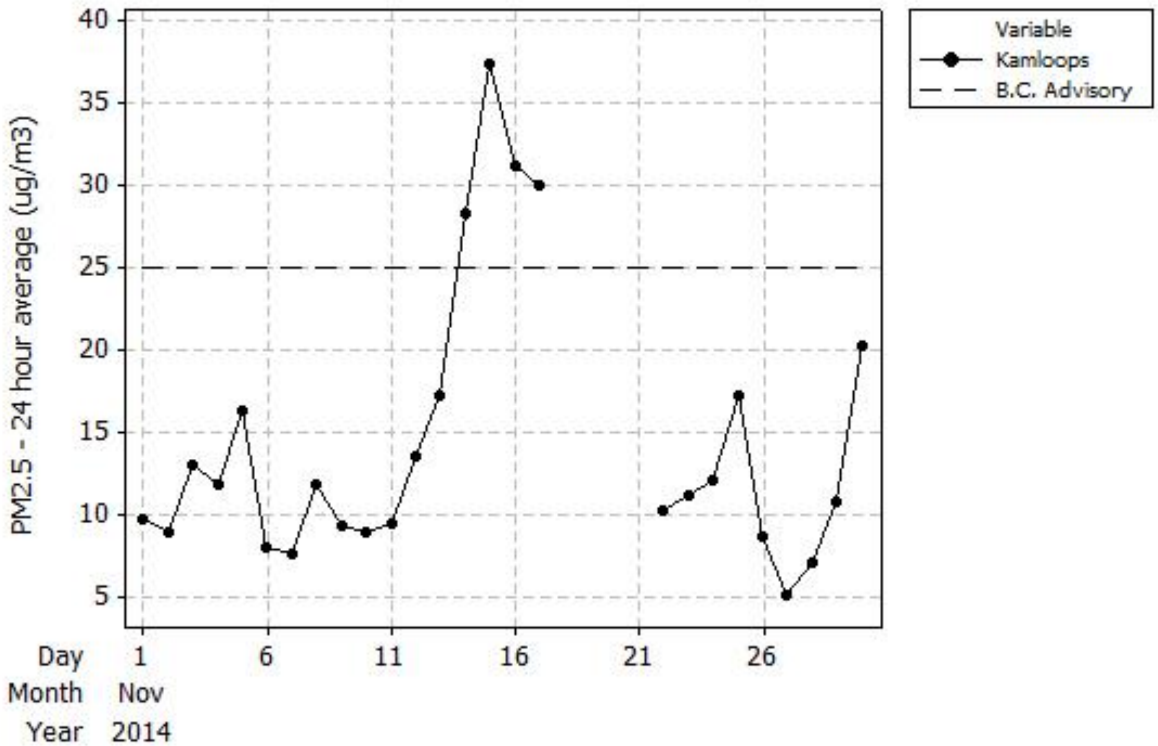

Figure 3: Kamloops daily average values of $PM_{2.5}$ for November, 2014. The original measurements were made, quality controlled and archived by the British Columbia Ministry of the Environment.

Table 4: Pearson correlation matrix of daily $PM_{2.5}$ values from 7 to 30 November

	Kamloops	Kelowna	Vernon
Kamloops	1	-	-
Kelowna	0.89 (0.000)	1	-
Vernon	0.96 (0.000)	0.94 (0.000)	1

Note: p-values in parenthesis

This strong correlation (Table 4) then allowed the missing four days of Kamloops data to be predicted from the Vernon measurements with a high degree of confidence. The regression results that were used to predict the missing values are shown in the appendix. The data are missing in Kamloops from 18 November at 10:00 a.m. to 21 November at 10:00 a.m.

These four calculated daily average values for Kamloops are shown on Figure 4 in brown. The monthly average for November 2014 in Kamloops is then calculated from the 26 days with measurements and the four days with values calculated from the Vernon measurements.

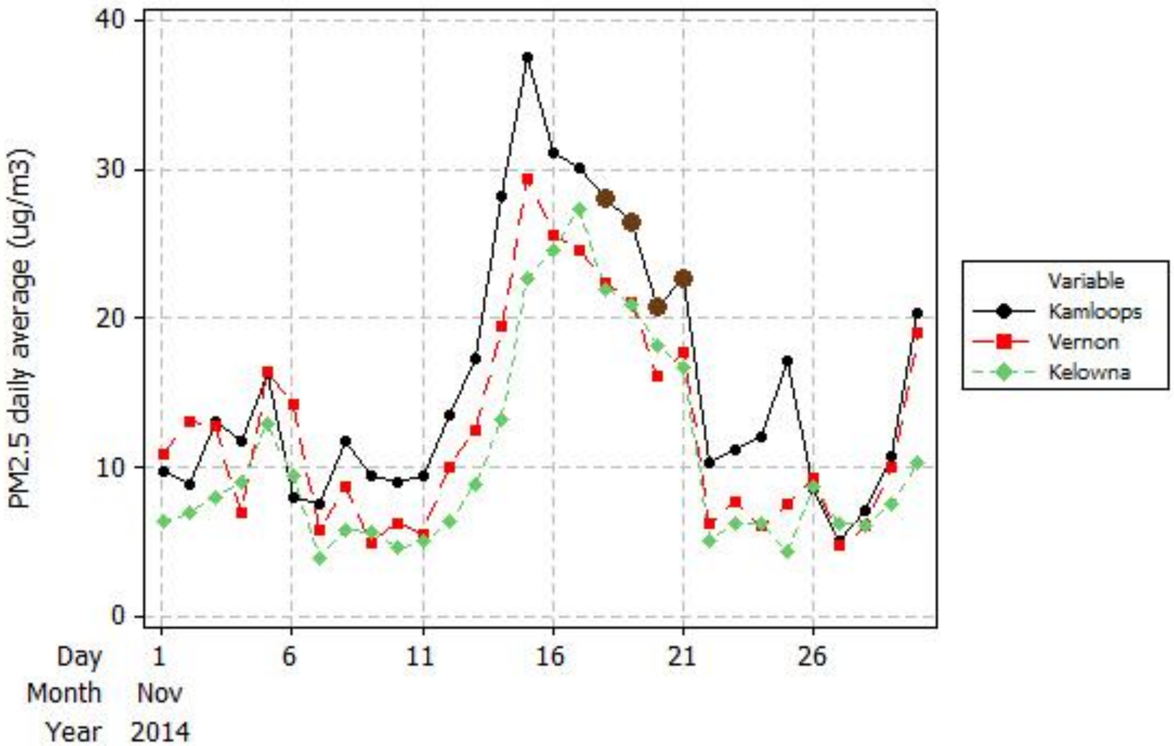

Figure 4: Vernon, Kamloops and Kelowna daily $PM_{2.5}$ averages during November 2014. Four values for Kamloops (in brown) were calculated from the Vernon measurements. The original measurements were made, quality controlled and archived by the British Columbia Ministry of the Environment.

Figure 4 shows a very important result from this study. It clearly demonstrates that the November 2014 airborne fine particulates in the Interior of B.C. are distributed regionally. The correlations between the measurements in the different cities are high. During the period of highest values the weather in the province was dominated by a high pressure area (Environment Canada) but even in other parts of the month the values in the different cities are correlated. The Kamloops values are typically the highest, with Vernon data in the middle and Kelowna with the lowest values. Vernon is 90 km ESE of Kamloops. Kelowna is 110 km SSE of Kamloops. Vernon is 45 km N of Kelowna. For a similar pattern and similar values to be seen in all these locations requires a regional source. This would have to be either prescribed burns of slash on a large scale or long range transport of particulates from some other part of North America. The latter possibility is unlikely due to the stagnant surface conditions resulting from the large high pressure ridge over Western Canada during the month.

An examination of the Ventilation Index (VI) calculations for November 2014 (B.C. Government) shows that the values were generally poor for most of the month and as such prescribed burns should not have taken place. One exception was for a few days with afternoon values in the good range just prior to 11 November, which was followed by the subsequent spike in $PM_{2.5}$ values beginning on 12 November, and values in the good range on 28 and 29 November followed by the spike in $PM_{2.5}$ at the end of the month.

In the previous section (Figure 2) it was shown that November 2014 was the third worst November since 1998 and November 2013 was the fourth worst November. Table 5 shows the highest daily average within the month of November, for the period since 2010 with the new modern instrument installed. November 2014 has the highest daily average value for all November days since 2010. It reached 37 μg/m^3 on 15 November 2014.

Table 5: Highest 24 hour average PM2.5 during the month of November since 2010.

Federal Building, BAM	Highest 24 hour average PM2.5 during the month of November, 2010-2014				
Event Date	11/28/2010	11/7/2011	11/14/2012	11/22/2013	11/15/2014
24 hour avg PM2.5 value	18	23	18	25	37

Note: The $PM_{2.5}$ values are in μg/m^3.

Conclusions

The first report in this series (Tsigaris and Schemenauer, 2014a) looked at the hourly Kamloops $PM_{2.5}$ data from the last three years, all from the same type of instrument. The second report (Tsigaris and Schemenauer, 2014b) looked at the hourly Kamloops $PM_{2.5}$ data from the last 16 years and reconstructed a coherent database by calculating adjustments for the data from the previous instrument used in the city. This third report makes use of the full hourly database, from 1998 to 2014, to examine how November 2014 ranks in terms of $PM_{2.5}$ during that period and how it relates to averages for other months of the year. This work adds to the current information available regarding $PM_{2.5}$ pollution in Kamloops and, to our knowledge, has not previously been examined or reported.

The major conclusions are:

1. The month of the year with the worst average $PM_{2.5}$ in Kamloops is November. August has the second highest monthly average $PM_{2.5}$ in Kamloops. These statements hold true whether average or median values are examined.

2. November 2014 had the third highest average PM2.5 value of all the Novembers since records began in 1998.

3. $PM_{2.5}$ values in a number of cities in the Interior of British Columbia were highly correlated during a period of prescribed burns, with inter-city correlation coefficients exceeding 0.9 over a twenty day period.

4. When daily average values of $PM_{2.5}$ in Kamloops are missing, it has been shown that under certain weather conditions they can be reliably calculated from those of Vernon or Kelowna.

5. Monthly average values of $PM_{2.5}$ for the period 1998 to 2014 show lower values in the summer and higher values in the winter, with November and August having values that are well above the trend for the other months.

6. The highest (37 $\mu g/m^3$) one-day average $PM_{2.5}$ of any November day in five years of measurements in Kamloops with the same instrument (BAM) occurred on 15 November 2014.

7. For six days in November 2014, Kamloops exceeded the B.C. guideline value of 25 $\mu g/m^3$ for a 24 hour period.

8. Because of the demonstrated regional nature of the high $PM_{2.5}$ values, the cause cannot be residential wood burning or private vehicle use in the cities.

9. The most likely regional-scale source of elevated levels of $PM_{2.5}$ during a stagnant air situation in November is prescribed burning of wood (slash) in forests and rural areas.

10. High November and August levels of PM2.5 are directly related to the type of protocols put in place provincially to manage prescribed burns and fight forest fires. These protocols need to be examined carefully to see how the human health impacts of high PM2.5 values can be reduced.

11. The impact of prescribed burning on the $PM_{2.5}$ levels in other months of the cold season should also be investigated and quantified.

12. Pollution episodes are associated with negative health impacts. It is recommended that there be a study of the health impacts of these air pollution episodes to estimate the costs in mortality and morbidity (both acute and chronic) to the people of the City of Kamloops.

Slash burning is not limited to just November, it can occur anytime after the forest fire season and typically might go from October into April. Local permits are required from the Kamloops Fire Centre and the permit holders are asked to burn when the ventilation index is good. How well this works in practice is not known but, clearly, it did not achieve its goal in 2014 as is evidenced by the high levels of $PM_{2.5}$ measured throughout the Southern Interior during November.

New priorities need to be introduced into decisions on how to manage forest fires and prescribed burns in order to reduce the impacts of the particulate matter produced on human health. These might involve: not allowing surges in burning when there are a few days of good ventilation index values in a long period of poor values; chipping and distribution of waste wood in the forest or on rural land; burying slash for decomposition; compressing waste wood for appropriate industrial use that lessens emissions of $PM_{2.5}$; or other ideas that experts in the field feel merit investigation.

Air quality is already compromised in Kamloops. City and provincial politicians and bureaucrats need to address how to reduce the negative impact of the large sources of emissions of $PM_{2.5}$ that are affecting the city, namely: prescribed burning of wood; forest fires, mines; and mills.

Source for the Data

The hourly measurements were made by the British Columbia Ministry of the Environment, who also did the quality assurance and quality control of the measurements.

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Appendices on the Following Pages

Appendix 1: Estimating Missing $PM_{2.5}$ Values

Appendix 2: November 2014 Ventilation Index Values for Kamloops

Appendix 1: Estimating Missing $PM_{2.5}$ Values

As described above, there are some days during the high November $PM_{2.5}$ event in Kamloops where data are missing from the B.C. MOE database. In this appendix we estimate the missing values for Kamloops based on what was observed for those days in Vernon and then adjusted with the estimated regression coefficients. Figure A1 confirms the strong positive association between Kamloops and Vernon daily average $PM_{2.5}$ values. The regression fit is very good as indicated by the significance coefficients and very high adjusted R square value.

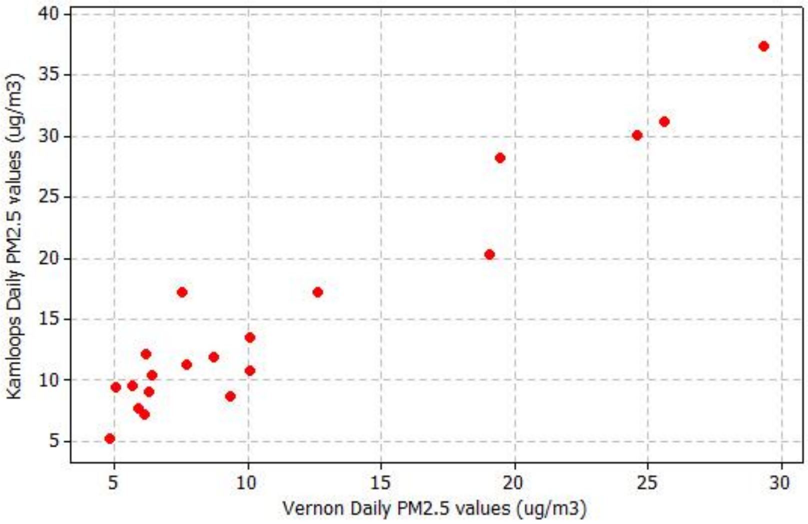

Figure A1: Scatter plot of Vernon Daily average PM2.5 values and Kamloops Daily average values excluding the four missing days.

The regression results are presented below:

Table A1: Regression results

Predictor	Coefficient	SE Coef	t-stats	p-value
Constant term	2.08	1.07	1.93	0.069
Vernon value	1.16	0.08	14.80	0.000
Standard error of regression			2.62	
Adjusted R-Square			92%	

Figure A2 shows the fitted regression line and the confidence interval for the line (red dotted line) as well as for the predicted values (green dotted lines). There were two unusual observations. The first unusual observation was the 15th of November value of 37 $\mu g/m^3$ but the fitted value was 36 $\mu g/m^3$ when Vernon daily average that day was 29.3 $\mu g/m^3$. The other unusual observation was on November 25th when Kamloops recorded a 24 hour average of 17.2 $\mu g/m^3$ while in Vernon the 24 hour average was 7.5 $\mu g/m^3$.

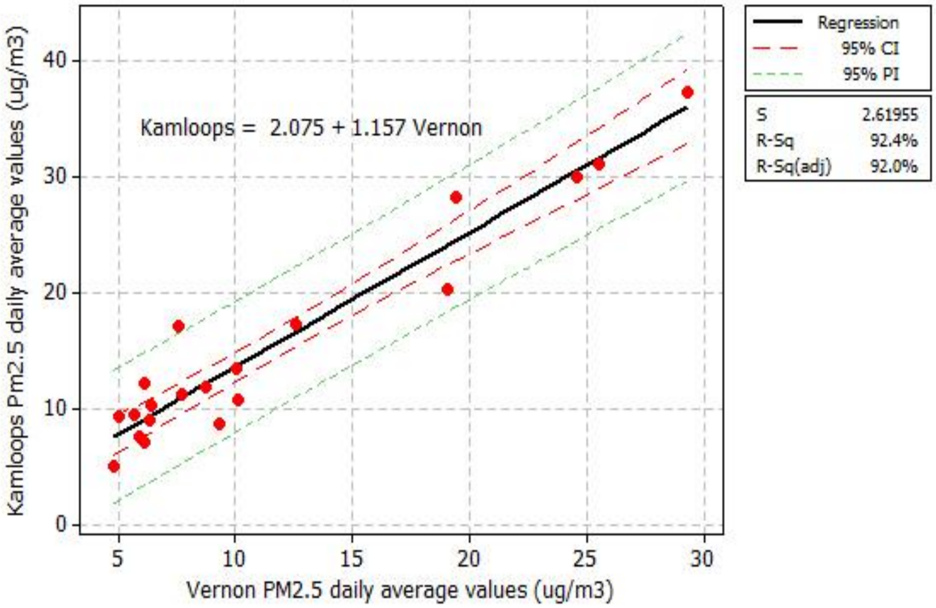

Figure A2: Fitted regression with confidence intervals.

Figure A3 shows the actual and fitted values. Although the actual values are missing for the period November 18th to 21st the predicted values are shown to decline but are still high with the 18th and 19th exceeding the B.C. advisory of 25 ug/m3.

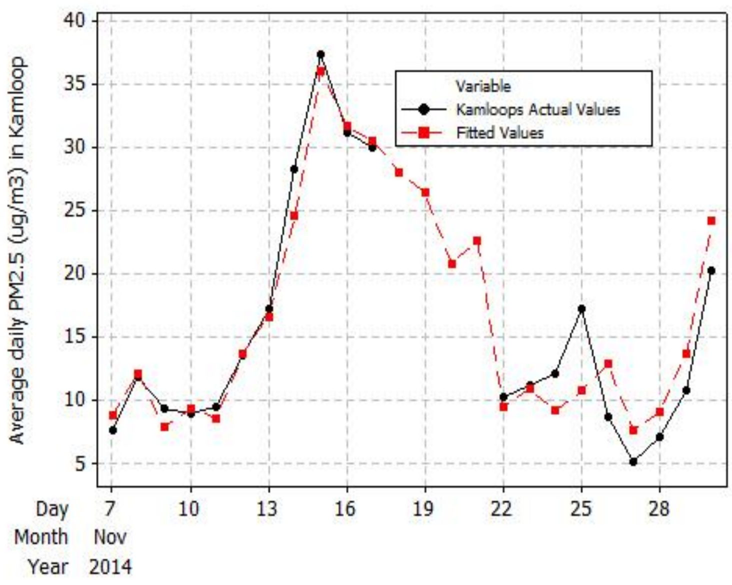

Figure A3: Actual and fitted values for Kamloops. Fitted values based on Vernon values. Values on the vertical axis are in μg/m^3.

Table A2 below shows the actual and the predicted four values (bolded) for Kamloops from 12 to 25 November. Vernon exceeded the 24 hour B.C. guideline for two days, Kelowna for one day and Kamloops for six consecutive days of the month. The average of the month with the missing values was 14.5 μg/m^3 and with the missing values estimated the average for the month increases to 15.8 μg/m^3 a difference of 1.3 μg/m^3.

Table A2: Actual values in the three cities

	Vernon	Kelowna	Kamloops
11/12/2014	10.0	6.5	13.5
11/13/2014	12.6	8.9	17.3
11/14/2014	19.4	13.3	28.3
11/15/2014	29.3	22.7	37.4
11/16/2014	25.6	24.6	31.2
11/17/2014	24.6	27.3	30.0
11/18/2014	22.4	22.0	**28.0**
11/19/2014	21.0	21.0	**26.4**
11/20/2014	16.2	18.2	**20.8**
11/21/2014	17.8	16.7	**22.6**
11/22/2014	6.4	5.2	10.3
11/23/2014	7.7	6.3	11.2
11/24/2014	6.1	6.2	12.2
11/25/2014	7.5	4.4	17.2

Note: Bolded red values are the predicted values from this report.

Appendix 2: November 2014 Ventilation Index Values for Kamloops

Year	Month	Day	VI 0700	Category	VI 1600	Category
2014	11	1	12	Poor	21	Poor
2014	11	2	10	Poor	18	Poor
2014	11	3	10	Poor	24	Poor
2014	11	4	14	Poor	84	Good
2014	11	5	10	Poor	20	Poor
2014	11	6	22	Poor	11	Poor
2014	11	7	13	Poor	72	Good
2014	11	8	9	Poor	28	Poor
2014	11	9	11	Poor	99	Good
2014	11	10	18	Poor	99	Good
2014	11	11				
2014	11	12	10	Poor	15	Poor
2014	11	13	10	Poor	13	Poor
2014	11	14	14	Poor	15	Poor
2014	11	15	10	Poor	13	Poor
2014	11	16	9	Poor	10	Poor
2014	11	17	9	Poor	10	Poor
2014	11	18	9	Poor	32	Poor
2014	11	19				
2014	11	20	10	Poor	21	Poor
2014	11	21	9	Poor	17	Poor
2014	11	22	16	Poor	53	Fair
2014	11	23	10	Poor	38	Poor
2014	11	24	9	Poor	10	Poor
2014	11	25	10	Poor	11	Poor
2014	11	26	10	Poor	25	Poor
2014	11	27	13	Poor	12	Poor
2014	11	28	73	Good	58	Good
2014	11	29	88	Good	65	Good
2014	11	30	10	Poor	15	Poor

Note: VI 0700 is the ventilation index calculated for 7 a.m. and VI 1600 is the ventilation index calculated for 4 p.m. Data are missing for 11 and 19 November. Data are from the B.C. Government website.

VENTILATION GUIDELINES:
POOR: 0-33
FAIR: 34-54
GOOD: 55-100