Report on the 2015 Air Quality as Measured at the Federal Building Monitoring Station in Downtown Kamloops, BC

prepared by

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ABSTRACT

This report examines the air quality measurements made at the Federal Building monitoring station in downtown Kamloops for the year 2015. The measurements were made, quality controlled, and archived by the British Columbia Ministry of the Environment (BC MOE). The report compares the data to those collected since data records began in 1998. The focus is on measurements of concentrations of fine particulates in the air, $PM_{2.5}$ (in micrograms per cubic meter, $\mu g/m^3$), but data on concentrations of gaseous pollutants are also given.

The mean annual value of $PM_{2.5}$ for 2015 was 8.5 $\mu g/m^3$. This is slightly below the long-term average for downtown Kamloops of 8.7 $\mu g/m^3$. For comparison, the mean annual value of $PM_{2.5}$ for 2014 was 9.1 $\mu g/m^3$. Fourteen of the 18 years of record have had $PM_{2.5}$ values above the British Columbia Air Quality Objective (AQO) of 8 $\mu g/m^3$. All 18 years of record have had $PM_{2.5}$ values above the British Columbia Goal of 6 $\mu g/m^3$. There were several pollution episodes during the summer when 24-hour average concentrations of $PM_{2.5}$ exceeded the provincial AQO value of 25 $\mu g/m^3$.

Concentrations of the four pollutant gases measured at the Federal Building monitoring station, ozone (O_3), sulphur dioxide (SO_2), nitrogen oxide (NO) and nitrogen dioxide (NO_2), showed significant seasonal patterns and concentrations that were within provincial AQOs where such guidelines exist.

This report also compares PM2.5 values for 2015 in four cities in the interior of British Columbia: Kamloops, Kelowna, Vernon and Prince George. The discussion is used to highlight

both the influence of forest fire events on monthly and annual averages and on the need for caution when comparing average or median values for the different cities. For example, the annual average value for Kelowna was the highest of the four cities but the annual median value was the lowest. This was because of the impact of high concentrations of particulates from forest fires over a short period in August on the annual air quality parameters for Kelowna.

1. Introduction and Overview of the Data

This is the fifth in a series of reports (previously, Tsigaris and Schemenauer, 2014a, 2014b, 2015, 2016a) that have been written to inform the public, politicians and government decision makers on the quality of the air in Kamloops.

The air quality measurements made at the Federal Building monitoring station in downtown Kamloops in 2015 were $PM_{2.5}$ ($\mu g/m^3$), ozone (O_3) (in parts per billion, ppb), sulphur dioxide (SO_2) (in ppb), nitrogen oxide (NO) (in ppb) and nitrogen dioxide (NO_2) (in ppb). These measurements are discussed below. Hourly meteorological data were not collected and are not available for comparison to the air quality data.

A brief discussion is given for the pollutant gases but they are not discussed in detail, since the main focus is on the fine particulate matter in the air. The focus of the previous reports has also been on $PM_{2.5}$, particulate matter with aerodynamic diameters less than 2.5 μm (micrometers). These data have been available from the downtown monitoring station since 1998. $PM_{2.5}$ concentrations have important implications for public health and are typically produced in large amounts by open-pit mining operations (Environment Canada, National Pollutant Release Inventory database). Scientific publications discussing epidemiological and other medical studies linking airborne particulate concentrations to human health concerns can be found on the website of the Kamloops Physicians for a Healthy Environment Society (www.KPHES.ca).

All of the data are from the British Columbia Ministry of the Environment (BC MOE) monitoring site and BC MOE maintains the instrumentation, does the quality control of the data, and archives the data. This report presents an analysis of the archived data (as downloaded on January 1st 2016).

2. How 2015 $PM_{2.5}$ Values Compare to Previous Years in Kamloops

a) Monthly and Annual Averages

Table 1 shows this year's monthly averages of $PM_{2.5}$ and compares them to those for last year as well as the historical averages. In 2015 monthly averages followed the pattern of the historical averages as presented in the last two columns. April, May and June have the lowest concentrations of $PM_{2.5}$ in Kamloops. August with forest fires and November with slash burning have $PM_{2.5}$ values that are highly elevated. This year August was slightly worse than November while last year the opposite was found. Winter months have higher average $PM_{2.5}$ relative to spring and early summer due to the inversions that Kamloops experiences and changes in emission sources. Relative to last year, the annual average is lower and this is due to the month of November not being as bad as last year, July forest fires being less impactful, and the three winter months having significantly lower $PM_{2.5}$ concentrations.

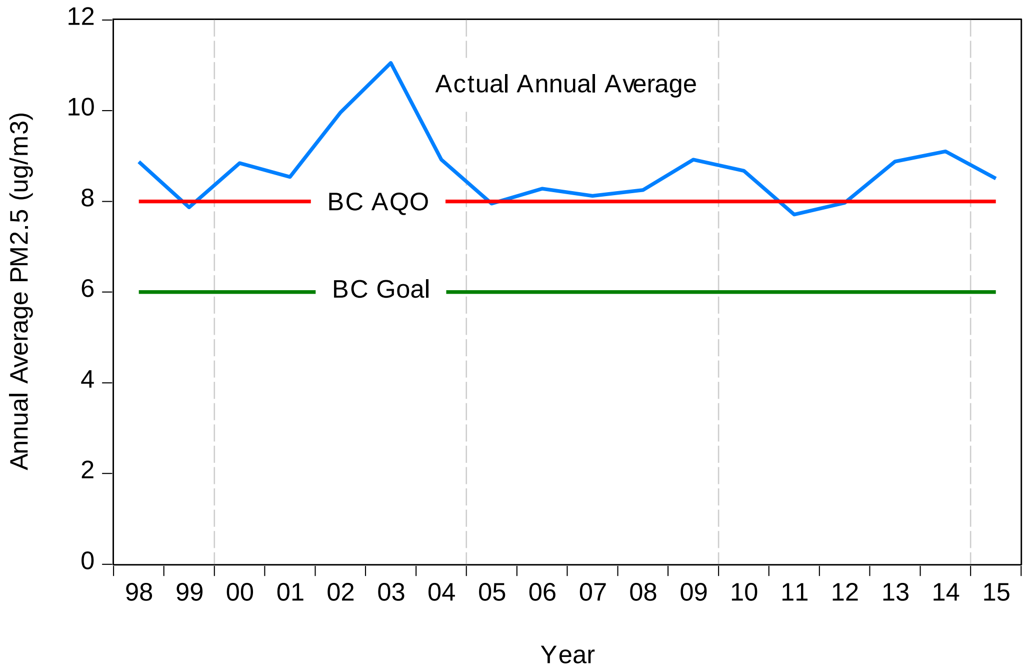
Table 1: Comparisons of monthly and annual average concentrations of $PM_{2.5}$ ($\mu g/m^3$) for 2015, to those for 2014 and to those for the historical averages.

	This year 2015	Last year 2014	2011-2015 BAM	All years 1998-2015
January	9.8	11.1	10.5	10.6
February	7.5	8.4	8.8	10.3
March	7.7	7.9	7.4	7.2
April	5.9	5.0	5.8	6.8
May	6.6	6.6	6.6	6.9
June	6.0	5.5	6.0	6.7
July	8.7	12.4	9.1	8.2
August	13.2	13.1	9.5	11.4
Sept	7.0	7.2	7.3	7.6
October	8.8	7.8	8.8	8.6
November	12.6	15.8	12.3	12.2
December	7.9	10.3	9.9	9.9
Annual Ave.	8.5	9.1		8.7

Note: BAM refers to the more recent years when the new instrument to measure $PM_{2.5}$ was in place at the Federal Building monitoring site.

Figure 1 shows a plot of the historical annual averages in Kamloops for the period 1998 to 2015. It makes use of the simple adjustment developed to bring the measurements made with the TEOM instrument prior to 2011 in line with the modern BAM monitor. This protocol has been discussed extensively in a previous report (Tsigaris and Schemenauer, 2014b). The norm has been for downtown Kamloops to exceed the B.C. AQO (8 $\mu g/m^3$) and this year is no exception. The historical average over the entire period 1998-2015 remains at 8.7 $\mu g/m^3$, which was found in the earlier report (Tsigaris and Schemenauer, 2014b) for the period 1998-2013.

Figure 1: Historical Annual Average $PM_{2.5}$ in Downtown Kamloops, 1998-2015. See Tsigaris and Schemenauer (2014b) for a discussion of the data analysis.



Note: The vertical lines are at the start of the bins for years 2000, 2005, 2010, and 2015

b) Hourly and Daily $PM_{2.5}$ Values

Presently, $PM_{2.5}$ is the measured pollutant that has the most impact on the health of people in the city of Kamloops. It will be examined in more detail in this section. Figure 2 shows the distribution of daily values of $PM_{2.5}$. Most of the values are below the B.C. AQOs. However, there were three days where the 24-hour daily average exceeded the Air Quality Objective. This happened on 10 July and again on 23 and 24 August. These high values were due to forest fires in the interior of British Columbia.

Figure 3 shows the frequency of hourly observations. The distribution is skewed towards lower values and the forest fires do influence the annual average. On eleven of the 365 days of the year the 24-hour daily average exceeded 20 $\mu g/m^3$. All of these elevated daily measurements were during the summer forest fire season except one which occurred in November. On thirty days of the year the daily average exceeded 15 $\mu g/m^3$ and many of these observations fell in the month of November and other winter months. Finally, out of 365 days, $PM_{2.5}$ exceeded the value assigned to the annual AQO average (8 $\mu g/m^3$) on 151 days. This was 41 percent of the time. The $PM_{2.5}$ maximum hourly value, which was 188 $\mu g/m^3$, occurred on August 23rd at 6:00 pm. As seen from Table 1, the best air quality in Kamloops, in terms of $PM_{2.5}$, was in the spring and early summer. This is consistent with the historical trends

Figure 2: Daily average $PM_{2.5}$ in Downtown Kamloops, for the 12 months of 2015.

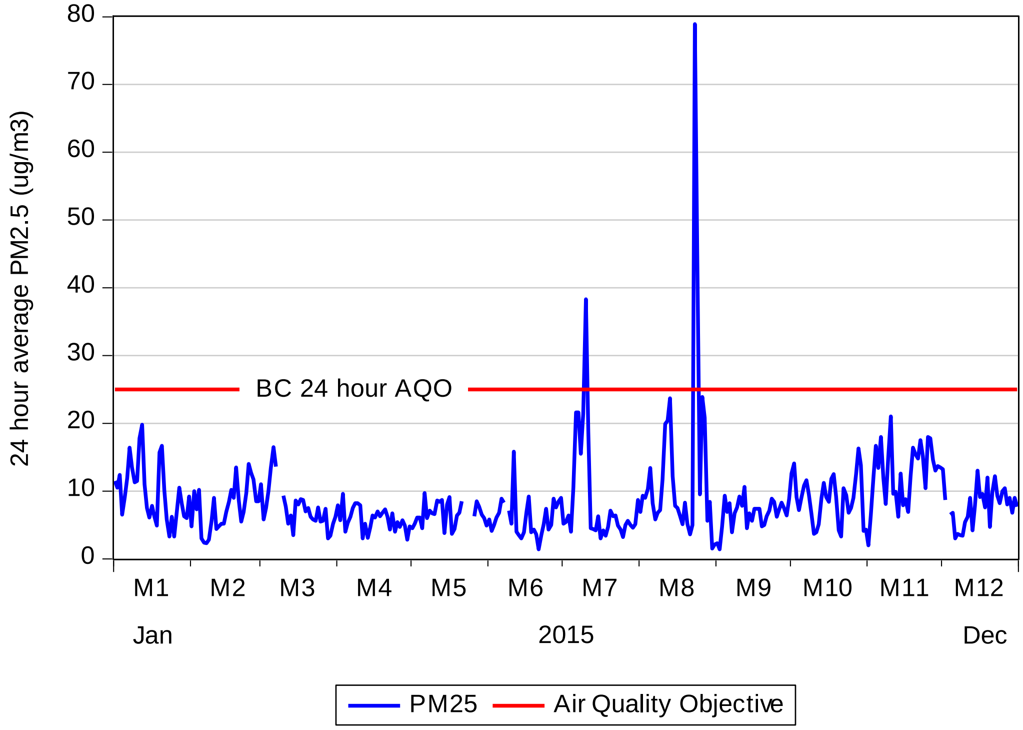
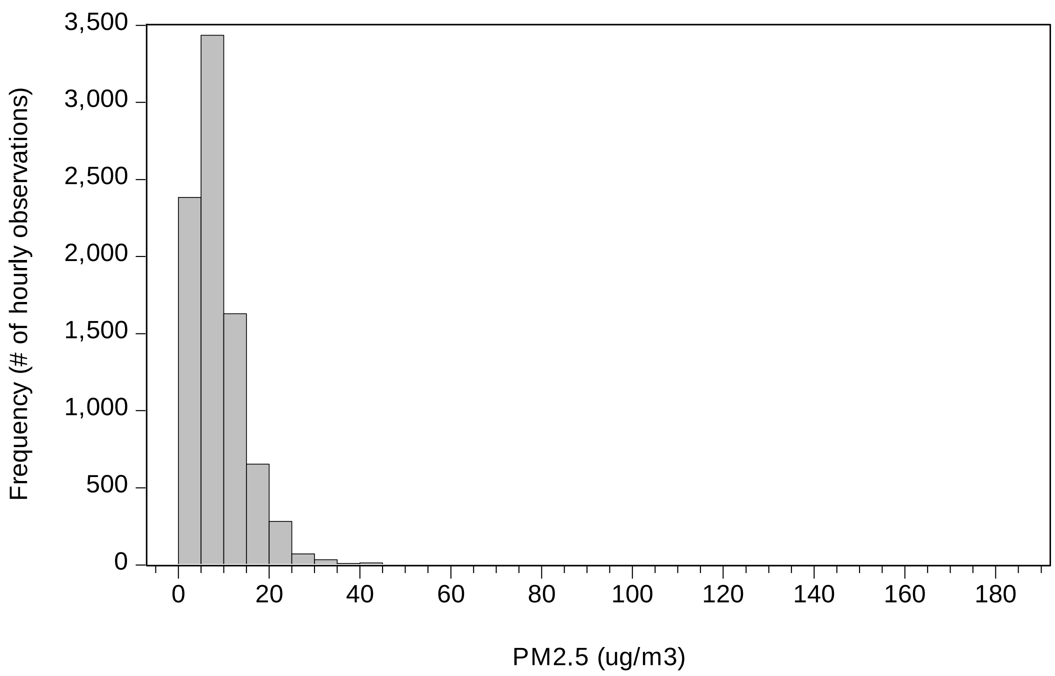


Figure 3: Hourly $PM_{2.5}$ frequency distribution, for downtown Kamloops in 2015



3. Comparison of Annual $PM_{2.5}$ Values to Those Used in the KGHM Ajax Application

The measurements of fine particulate concentrations in downtown Kamloops from 1997 to 2015 were obtained from two instruments. The TEOM was used up to the middle of 2010 and a more accurate BAM instrument has been used since. This is discussed extensively by Tsigaris and Schemenauer (2014b) who calculated the adjustment necessary to the TEOM data in order to have a compatible data set for the entire period of record. It is universally accepted by agencies such as the World Health Organization, Environment Canada, the British Columbia Ministry of the environment, the BC lung Association, and others that the TEOM data are low compared to those obtained from the BAM instrument. They cannot be presented in the same graph without a correction to the TEOM data or with a break in the graph and a clear statement to the reader that the two sets of data are incompatible. If data from both instruments are shown without correction, then conclusions should only be based on the more recent BAM data.

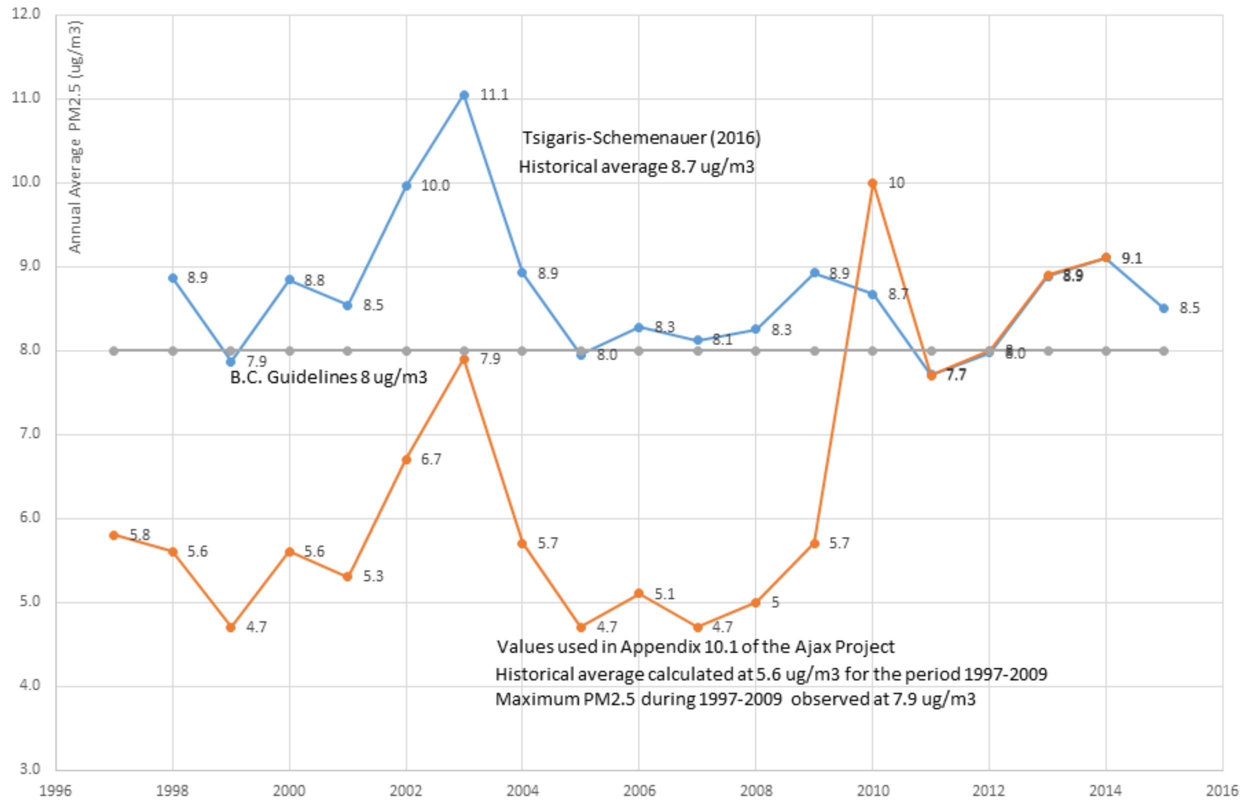
In Figure 4, the long term data for $PM_{2.5,}$ as measured at the Federal Building in downtown Kamloops, are presented. This is an updated presentation as in Figure 1, with more recent years added, from that shown in Tsigaris and Schemenauer (2014b). Also shown in Figure 4 are the annual values as used by KGHM Ajax in their application for the proposed mine on the edge of Kamloops (KGHM Ajax Application: Appendix 10.1 Table 2.8).

Figure 4 illustrates quite clearly that the TEOM values used by KGHM Ajax for the period 1997 to 2009 are uncorrected. There is a tremendous jump in values in 2010 that is unexplained in the KGHM Ajax Application. In fact, the reason for the jump in values is not some huge change in the air quality in Kamloops but rather a change to the modern BAM instrument. In order to look at and use the entire period of record there must be a scientifically valid and properly applied correction to the data in the period when the TEOM instrument was used.

As seen from the figure the values obtained from the TEOM instrument for the period 1997 up to 2009 are lower by an amount of about 3.2 µg /m³. This creates a misleading impression that the air quality in the city of Kamloops was better during that period than it really was. For the years from 2011 up to 2014 the values shown by KGHM Ajax in their application are the same as those in this report because they are using the data set from the modern BAM instrument as archived by the BC MOE as is done in this report. KGHM Ajax also reports a long-term average value for fine particulates in Kamloops of 5.6 µg /m³, which they take only for the period 1997 to 2009 and which uses the TEOM data that is biased low as is readily seen in Figure 4.

This leaves 2010 where this study reports an annual average value of 8.7 µg /m³ while KGHM Ajax reports a value of 10.0 µg /m³. This happens because in 2010 this report adjusts the TEOM Brocklehurst data for the full 2010 year by the 3.2 ug/m3 offset. In contrast, KGHM Ajax show an average calculated from around May 20th 2010 until the end of the year exclusively from BAM data at the Federal Building. So the KGHM Ajax value is high because it is only for a partial year, i.e. the latter portion of the year when forest fires and slash burning typically produce higher monthly values in the city of Kamloops (Tsigaris and Schemenauer, 2015).

Figure 4: annual average values of $PM_{2.5}$ for downtown Kamloops for the period from 1997 to 2015. The upper line (in blue) shows values calculated according to the method of Tsigaris and Schemenauer (2014b). The lower line (in red) shows values as used by KGHM Ajax in their application for the proposed mine on the edge of the city of Kamloops



4. Comparison of $PM_{2.5}$ Values in Aberdeen and Downtown Kamloops

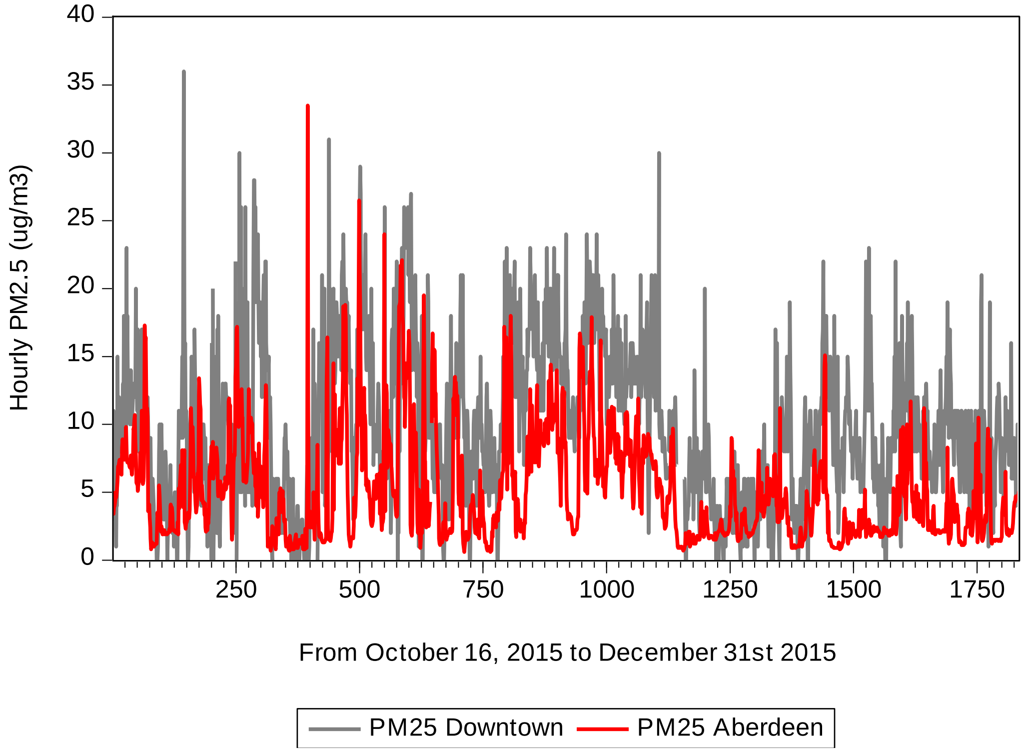
As of 16 October 2015 there are two air quality monitoring stations in Kamloops operated by the BC MOE. The Aberdeen station records meteorological data as well as air quality parameters and is located at an elevation about 300 m above the downtown Federal Building station. A detailed analysis of the available data in 2015 from the Aberdeen station can be found in the report by Tsigaris and Schemenauer (2016a).

In this report, a brief comparison is presented of the fine particulate matter at the two stations. The average $PM_{2.5}$ in Aberdeen was found to be 5.1 $\mu g/m^3$ for the period from 16 October 2015 at 4:00 pm until 31 December 2015 at 11:00 pm (these are archived times). During this same time period, downtown Kamloops averaged 10.0 $\mu g/m^3$. The value at the Aberdeen station is almost 50 percent lower; however, just because one is averaging below the other does not mean that they are not correlated. Industrial and other human activities, common weather patterns like inversions, forest fires in the surrounding area or at a distance, as well as slash burning, do not affect only downtown Kamloops, these common elements affect Aberdeen also. On average, when PM 2.5 values increase or decrease at one station they also do so at the other.

Figure 5 clearly shows a strong positive association (swings are often in the same direction) between the sets of values recorded at the two stations. The red pattern is from Aberdeen and the gray from downtown Kamloops. The gray line is most of the time above the red line and as a result the average value is higher. The Pearson correlation coefficient between the two is positive at 0.46 (p-value 0.000). A value of 0.46 is considered relatively high given that a value of one implies a perfect relationship, while a value of zero implies no correlation. Note that we are not implying causation but correlation. When a p-value is extremely low, as is the case here, there is very little probability that the correlation is caused by chance alone.

It is worth noting that, for the time period with data at the Aberdeen monitoring station in the upper south part of the city of Kamloops, the value of 5.1 $\mu g/m^3$ is well above the background concentrations that one would expect in areas free of urban or industrial pollution.

Figure 5: Hourly pattern of $PM_{2.5}$ concentrations at the Aberdeen and Federal Building (downtown) monitoring stations for the period noted.



5. Comparison of PM 2.5 Values in Kamloops, Kelowna, Vernon and Prince George: Influence of Forest Fire Events on Monthly and Annual Averages

Table 2 presents data that allows for a comparison of the $PM_{2.5}$ concentrations in four cities in the interior of British Columbia in 2015. Using the annual average, Kamloops has the lowest $PM_{2.5}$ concentration followed by Kelowna, Prince George, and Vernon in that order. However, these averages are misleading as they are strongly affected by summer forest fires in 2015 as seen from the August averages presented in Table 2. In 2015 Kelowna and Vernon were affected a lot more than Kamloops by forest fires in July and especially by the August forest fires. This does not mean that forest fires should be discounted but that they can skew the results and hide other important information. The least affected by forest fires was Prince George and it had an annual average $PM_{2.5}$ concentration for 2015 very similar to Kelowna. An analysis using paired difference t-tests between Kamloops-Kelowna, Kamloops-Vernon and Kamloops-Prince George found no statistical significance difference between the three comparisons (p-values of 0.724, 0.079 and 0.661 respectively). Hence, when forest fire days are kept in the data sets for the four cities we cannot conclude that Kamloops had better air quality in 2015 than the other three cities.

Forest fires caused elevated $PM_{2.5}$ levels in July (from the 7^{th} to 10^{th}) and much more impactful levels from 23-27 August for Kamloops and from 23-29 August for Vernon and Kelowna. Kamloops, Kelowna and Vernon advisory notices are for those time periods. In addition, November is the start of the slash burning period and for that month Kelowna was affected the least, followed by Vernon, Kamloops and Prince George. Prince George was affected the most with many of its advisories issued in November. The maximum hourly value for the year was in November for Prince George.

In order to gain more insight into influences on the air quality in the four cities, the averages for the April to June period, the months considered to have the best air quality, are also reported in Table 2. One would expect minimal differences between the cities but one finds Kelowna had the cleanest air in the spring time, followed by Vernon, Kamloops and then Prince George. A paired difference t-test between Kamloops and Kelowna for the spring/early summer period confirms that Kamloops has a statistically significantly worse air quality than Kelowna (p-value 0.000) and worse with respect to Vernon (p-value: 0.029) but no statistical significant difference with Prince George (p-value 0.075).

The annual averages without the forest fire advisory days are also presented in Table 2, to see what the overall average would be without days with advisories issued for forest fires. This clearly shows that Kelowna (1.9 $\mu g/m^3$) and Vernon (1.4 $\mu g/m^3$) had significant impacts from forest fires, while Kamloops had the least impact 0.4 $\mu g/m^3$. Here the ranking changes and conforms with the spring results, having Kelowna with the best air quality, followed by Vernon, Kamloops and finally Prince George. A paired difference t-test confirms that Kamloops has worse air quality than Kelowna but not significantly different from Vernon and Prince George (p-values of 0.000, 0.338 and 0.158 respectively). The annual median values for the four cities, which do not place more weight on extreme values such as forest fires or slash burning than any other values in the sample, show Kelowna with the lowest $PM_{2.5}$ value (6.4 $\mu g/m^3$) and the remaining three cities tied at 7.4 $\mu g/m^3$. A Mann-Whitney nonparametric test confirms that Kamloops has worse air quality than Kelowna (p-value 0.002) and we cannot conclude that Kamloops is statistically significant different from Vernon or from Prince George (p-values of 0.7938 and 0.6276). We can conclude that Kamloops is at a fork in the road and making a choice to add a significant source of anthropogenic emissions to our airshed will move Kamloops further away from Kelowna. Kamloops could end up with the worst air quality of the four cities.

Table 2: Comparison of various statistical parameters describing the $PM_{2.5}$ concentrations for four cities in the interior of British Columbia in 2015.

	Kamloops	Kelowna	Vernon	Prince George
2015 average (μg/m^3)	8.5	8.8	9.3	8.9
August average (μg/m^3)	13.2	29.3	22.4	6.2
November average (μg/m^3)	12.6	9.0	11.6	13.8
Spring Average (μg/m^3)	6.2	5.2	5.7	8.3
Maximum daily ave. (μg/m^3)	78.9	294.5	142.7	43.9
# of days PM2.5 > 25 μg/m^3	3	8	9	6
Overall median (μg/m^3)	7.4	6.4	7.4	7.4
Ave. no forest fires* (μg/m^3)	8.1	6.9	8.0	8.9

*The 24-hour daily average was used to compute the overall averages. The average no forest fires was computed by removing days on which forest fire advisories were issued. These were days when the $PM_{2.5}$ exceeded 25 μg/m^3.

What this section illustrates is that sometimes presenting only the average values for the four cities does not provide sufficient information to properly understand how the air quality compares between the different cities. Major sources of $PM_{2.5}$ such as forest fires may impact a number of cities but can have a substantially greater impact on the air quality in one specific city. Seeing a maximum 24-hour average value in Kelowna in 2015 of 294.5 μg/m^3 while Prince George only had a maximum 24-hour average value of 43.9 μg/m^3 is a clear illustration of the type of somewhat random event that can occur during the course of the year.

6. Concentrations of Other Air Contaminants in Downtown Kamloops

a) Overview

In this section air quality information for the gaseous pollutants will be examined. They will be compared to concentrations of $PM_{2.5}$ where appropriate. Table 3 shows the monthly average values of five air contaminants in downtown Kamloops.

Table 3: Monthly Average Values of Air Contaminants in Downtown Kamloops in 2015

	SO_2	NO_2	NO	$PM_{2.5}$	O3
	(ppb)	(ppb)	(ppb)	(μg/m^3)	(ppb)
January	0.6	16.5	18.3	9.8	8.5
February	0.4	15.4	13.9	7.5	10.1
March	0.5	12.7	7.4	7.7	22.8
April	0.3	10.4	4.6	5.9	31.3
May	0.5	9.0	3.5	6.6	34.4
June	0.6	7.5	3.7	6.0	30.0
July	0.3	7.8	3.1	8.7	26.7
August	0.8	8.0	3.0	13.2	27.2
Sept	0.6	9.1	5.2	7.0	17.2
October	0.4	11.7	12.5	8.8	9.4
November	0.7	14.1	9.6	12.6	12.5
December	0.6	14.2	7.2	7.9	11.8
Annual	0.5	11.4	7.6	8.5	20.3
Total hours	8328	8300	8327	8556	8308

A clear seasonality is evident in some of the measurements. In 2015, August had the highest particulate concentrations, with the main cause being forest fires, followed by November where the cause has been argued to be slash burning (Tsigaris and Schemenauer, 2015). Ozone builds up in the spring and early summer in response to increased sunshine and then falls in the winter season. $S0_2$ is consistently very low but the highest months are again August followed by November. Nitrogen gases are quite highly correlated, with higher values in the winter and lower levels in the summer.

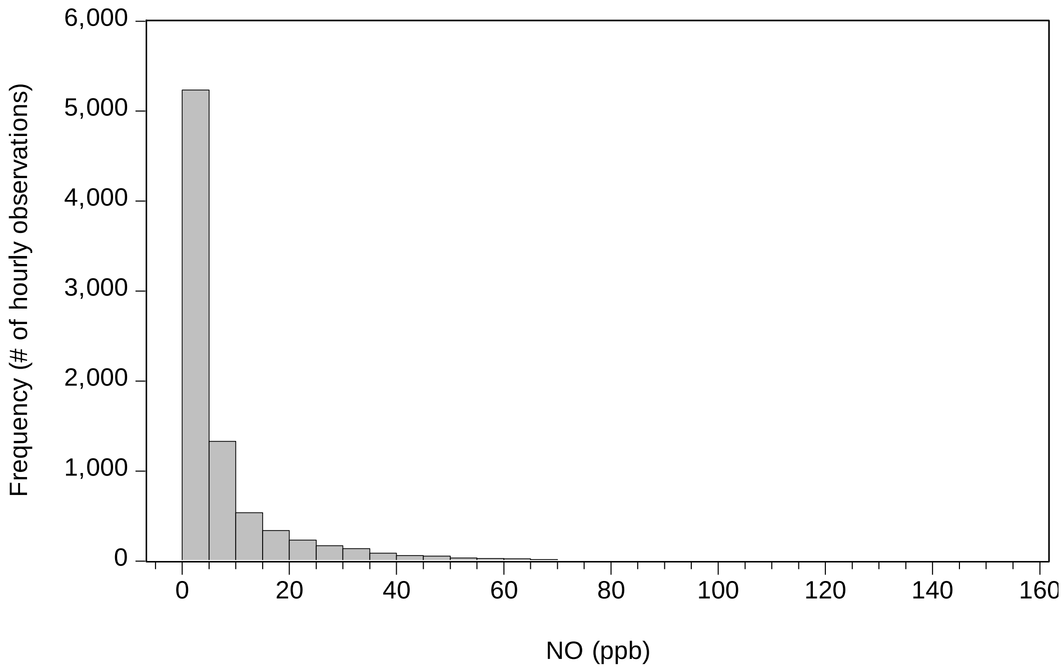
Averages over months however hide interesting hourly or daily fluctuations and a more detailed look at the data is undertaken below.

b) Discussion of Individual Gaseous Pollutants

i) Nitrogen Oxide (NO)

NO is called nitrogen oxide in the summary information provided on the B.C. Air Quality Site. It is also referred to as nitric oxide. The NO maximum hourly value occurred on 20 January at 0900 PST. It was 156.7 ppb. The distribution shown in Figure 6 is clearly skewed towards lower values. The gas-phase chemistry will not be discussed here. It is very complicated and the presentation for all of the gases will be limited to showing the archived data. NO and N02 are products of high temperature combustion and may be emitted by vehicles, power plants, forest fires, slash burning and so on.

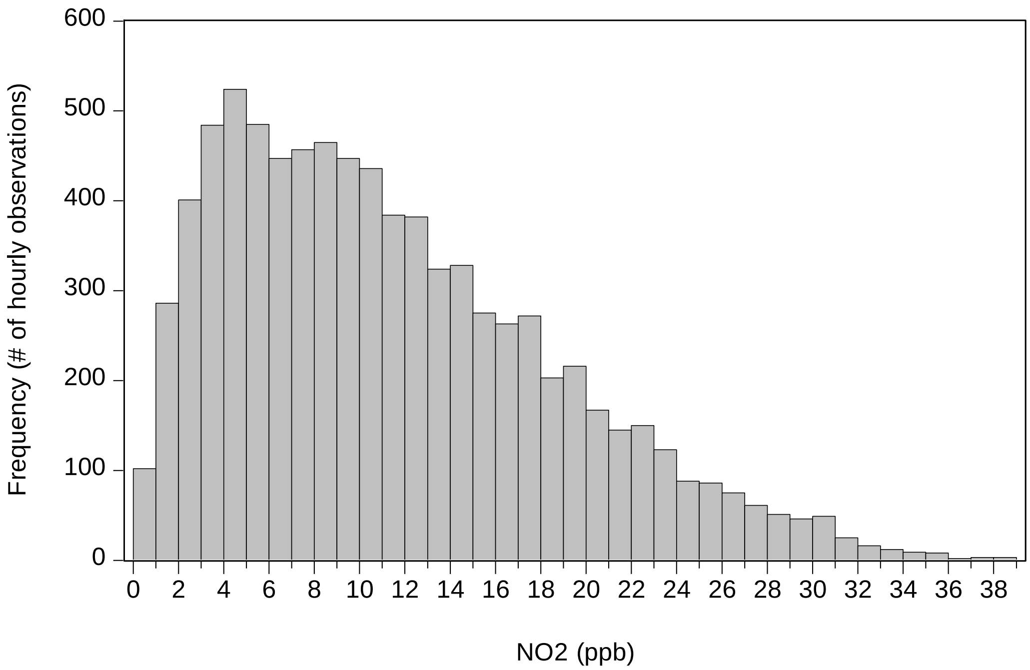
Figure 6: Distribution of hourly nitrogen oxide values for the downtown Kamloops monitoring station in 2015



ii) Nitrogen Dioxide ($N0_2$)

Figure 7 shows the distribution of hourly values of $N0_2$. The B.C. Air Quality Objective for nitrogen dioxide (1 hour average) is 210 ppb. There were no hours exceeding the objective during the measurement period. The NO_2 maximum hourly value occurred on 20 January at 0900 PST. It was 38.9 ppb. The distribution is not as skewed as for NO but values are in general low relative to the environmental objective. Both NO and N02 hourly maxima for the year occurred on the same hour and on the same day.

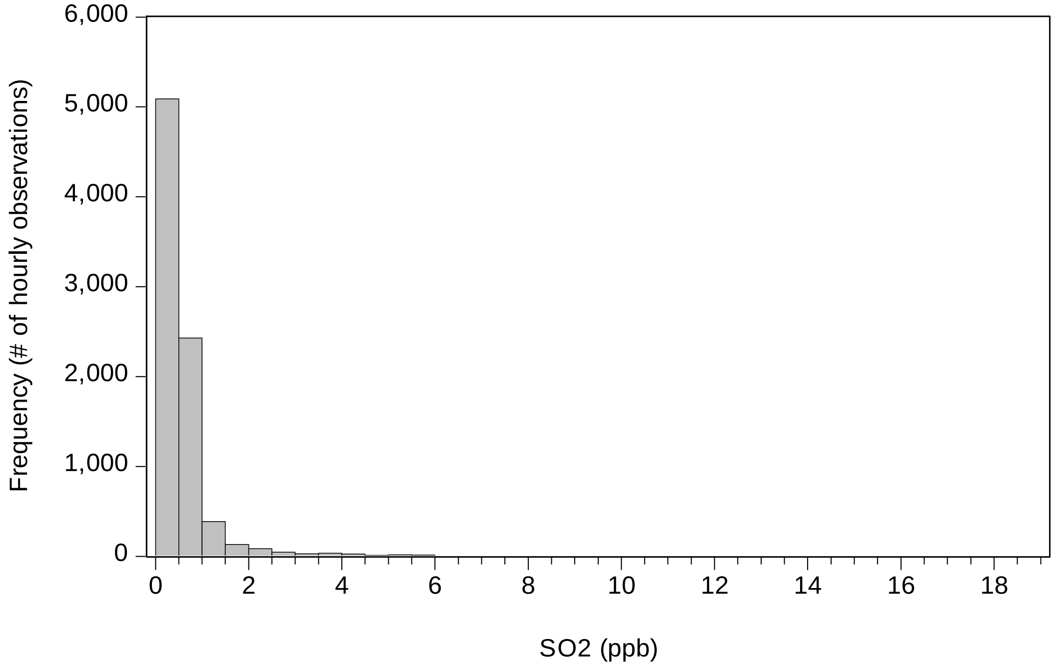
Figure 7: Distribution of hourly nitrogen dioxide values for the downtown Kamloops monitoring station in 2015



iii) Sulphur Dioxide (SO_2)

Sulphur is present in fossil fuels and is converted to sulphur dioxide when the fuel is burnt. The hourly averaged SO_2 values at the downtown monitoring site are consistently very low. Most of the hourly values are below 2 ppb whereas the B.C. Air Quality Objective for sulphur dioxide (1 hour average) is 75 ppb. There were no hours exceeding the objective during the measurement period. The SO_2 maximum hourly average occurred on 27 August at 1000 PST and was 18.6 ppb. Figure 8 shows the distribution of hourly values of $S0_2$.

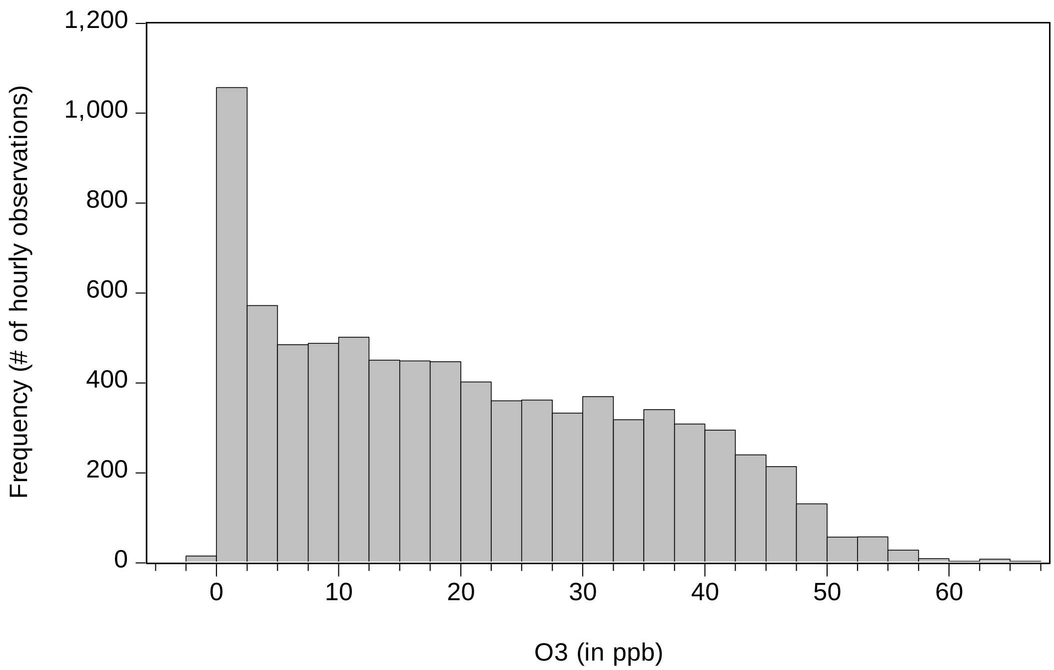
Figure 8: Distribution of hourly sulphur dioxide values for the downtown Kamloops monitoring station in 2015



iv) Ozone (O3)

Ozone is generally formed downwind from sources of precursor gases from which the ozone forms in the presence of sunlight. The B.C. Air Quality Objective for Ozone (1 hour average) is 82 ppb. There were no hours exceeding the objective during the measurement period. The Ozone maximum level occurred on 6 June at 0600 PST and was 67.2 ppb. Figure 9 shows the distribution of hourly values of O_3.

Figure 9: Distribution of hourly ozone values for the downtown Kamloops monitoring station in 2015



7. Discussion

The major problem with Kamloops air quality remains the airborne fine particulate concentrations. Because this pollutant makes up only one component of the publicly reported Air Quality Health Index (AQHI), the AQHI is almost always low in Kamloops and provides the public with no useful information on the health risks associated with particulates in the air. Attention needs to be paid to lowering present particulate concentrations in our air and on being aware of the impacts new industry will have on making those values even higher.

The mean annual value of $PM_{2.5}$ for 2015 was 8.5 $\mu g/m^3$. This is slightly below the long-term average for downtown Kamloops of 8.7 $\mu g/m^3$. Nevertheless, it remains above the British Columbia Air Quality Objective (AQO) of 8 $\mu g/m^3$ and is well above the provincial goal of an annual average of 6 $\mu g/m^3$. In 2015 there were only three days when the 24-hour average concentrations of $PM_{2.5}$ exceeded the provincial AQO value of 25 $\mu g/m^3$.

Fourteen of the 18 years of record have had $PM_{2.5}$ values above the British Columbia Air Quality Objective (AQO) of 8 $\mu g/m^3$. All 18 years of record have had $PM_{2.5}$ values above the British Columbia Goal of 6 $\mu g/m^3$.

Concentrations of the four pollutant gases measured at the Federal Building monitoring station, ozone (O_3), sulphur dioxide (SO_2), nitrogen oxide (NO) and nitrogen dioxide (NO_2), showed significant seasonal patterns. The measured concentrations were within provincial AQOs where such guidelines exist. SO_2 values were very low in all months. O_3 values peaked in late spring and early summer and were almost 3 times as high then as in the winter. This is largely a response to changes in solar radiation.

NO and NO_2 were about twice as high in the winter as in the summer. NO increased by about 15 ppb from summer to winter and NO_2 values increased by about 8 ppb from summer to winter. This will be in part a signature of increased emissions from transportation, industry, and residential heating in downtown Kamloops in the colder months. This is supported by the fact that the monthly average values for NO_2 were about 12 ppb higher downtown, where there is a higher density of industry, transportation and homes, than at the Aberdeen monitoring station (data not shown here) in November and December. NO is oxidized in the atmosphere to form NO_2. The sum of the two is often referred to as NOx. As well as vehicles, building heating systems and boilers are sources of NOx. Along with increased emissions in the winter there is less mixing in the lower atmosphere and this coupled with the valley inversions that are often seen in Kamloops can also contribute to higher concentrations of NOx in the winter. It should be kept in mind, however, that the values are considerably lower than one might see in a large city.

This report looked at the impact that forest fire events lasting from a few days to a week can have on the annual averages of $PM_{2.5}$ for a city. When plumes of smoke produce very high hourly values in Kelowna, as it did in August 2015, it can result in the annual average for the city rising significantly. The annual average value for Kelowna exceeded that for Kamloops, Vernon, and Prince George in 2015; however, if one looks at the annual median values for the cities, then Kelowna would be considered to have the lowest value of $PM_{2.5}$ and the cleanest air. It is important to choose an appropriate statistical parameter and also to examine the significance or lack thereof in differences between cities.

The brief discussion in this report comparing $PM_{2.5}$ for cities in the Interior of British Columbia has some lessons for Kamloops. Should a major source of fine particulate emissions be added on the upwind edge of Kamloops, the resulting increase in $PM_{2.5}$ concentrations will probably result in Kamloops moving further away from Kelowna’s cleaner air and a higher annual average $PM_{2.5}$ value than Vernon or Prince George. Kamloops is at a fork in the road and needs to decide if this is an acceptable direction for the future of the city.

Source for the Data

The hourly measurements were made and archived by the British Columbia Ministry of the Environment who also did the quality assurance and quality control of the measurements. As these data were downloaded from the archive immediately after the year end, it is possible that some small changes may be made in the final archived data set. With respect to the data, BC MOE says "Data found on this web site is accessible in raw form before all quality assurance reviews are complete. This data is preliminary and is subject to change during the review process. Final data reviews for a given calendar year are usually completed by June 1st of the following year."

Authorship

The authors of this report, Prof. Peter Tsigaris and Dr. Robert Schemenauer, have prepared this and previous reports on a volunteer basis with no direction from any organization and no remuneration in terms of salary or any other form. The work is a contribution to the community, with the hope that it leads to a better understanding of the environment in which we live.

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