Air Quality in Williams Lake

A Summary of Recent Trends in Levels of Particulate Matter

June 2016

Prepared for

WILLIAMS LAKE AIR QUALITY ROUNDTABLE

BRITISH COLUMBIA MINISTRY OF ENVIRONMENT

ENVIRONMENTAL PROTECTION DIVISION

MONITORING, ASSESSMENT AND STEWARDSHIP

1 Introduction

The Ministry of Environment (MoE), in collaboration with stakeholders, maintains and operates the air quality and meteorological monitoring network in Williams Lake, BC. As part of the Williams Lake Air Quality Roundtable, the MoE supports stakeholders to achieve the goals of the Williams Lake Airshed Management Plan (AMP). The MoE provides regular updates to the roundtable on air quality trends and issues. This report evaluates recent trends in $PM_{2.5}$[1] and PM_{10}[2] relative to AMP goals and provincial objectives. Other pollutants have been consistently below these targets and are therefore not discussed.

Fine particulate matter ($PM_{2.5}$) is of particular concern due to its adverse health effects, predominantly to the respiratory and cardiovascular systems. Both short-term and long-term exposures are associated with adverse health effects[3]. Sources of $PM_{2.5}$ include but are not limited to industrial processes, space heating, wood burning home heating devices, motorized transport and forest fires. Local topography facilitates stagnant air conditions through the formation of inversions, preventing the dispersion of pollutants and allowing high levels of $PM_{2.5}$ and PM_{10} to build up in the air.

PM_{10} includes $PM_{2.5}$, as well as larger particles (coarse particulate matter) that are considered to be less of a human health concern than $PM_{2.5}$, but can still be irritating to those with pre-existing conditions[4]. The main sources of coarse particulates include winter traction material, dust from unpaved roads, parking lots, un-vegetated surfaces, construction and emissions from wood processing industries. Higher PM_{10} concentrations tend to occur in the late winter and early spring when loose winter traction material becomes exposed on road surfaces.

2 Air Quality Monitoring

In Williams Lake, $PM_{2.5}$ and PM_{10} are both currently monitored at Columneetza Secondary School. A second monitoring station at CRD Library was discontinued in 2014 because it was determined that the CRD station was not providing any additional information than what was already been provided by the Columneetza station. Two non-continuous Partisol instruments are located at the Fire Hall and Williams Lake Golf and Tennis Club. Data collection at these stations occurs on the NAPS (National Air Pollution Surveillance Program) schedule – for 24 hours every six days. Monitoring at the Glendale School was discontinued as the building was abandoned. There is one meteorological station in Williams Lake, located at Canadian Tire. Real time air quality data are available at www.bcairquality.ca. The local monitoring network is shown in Figure 1 below.

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[1] $PM_{2.5}$: particulate matter with aerodynamic diameters less than or equal to 2.5 micrometers.
[2] PM_{10}: particulate matter with aerodynamic diameters less than or equal to 10 micrometers.
[3] World Health Organization, 2005. Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Retrieved from http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf
[4] World Health Organization, 2013. Health effects of particulate matter. Policy implications for countries in eastern Europe, Caucasus and central Asia. Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf

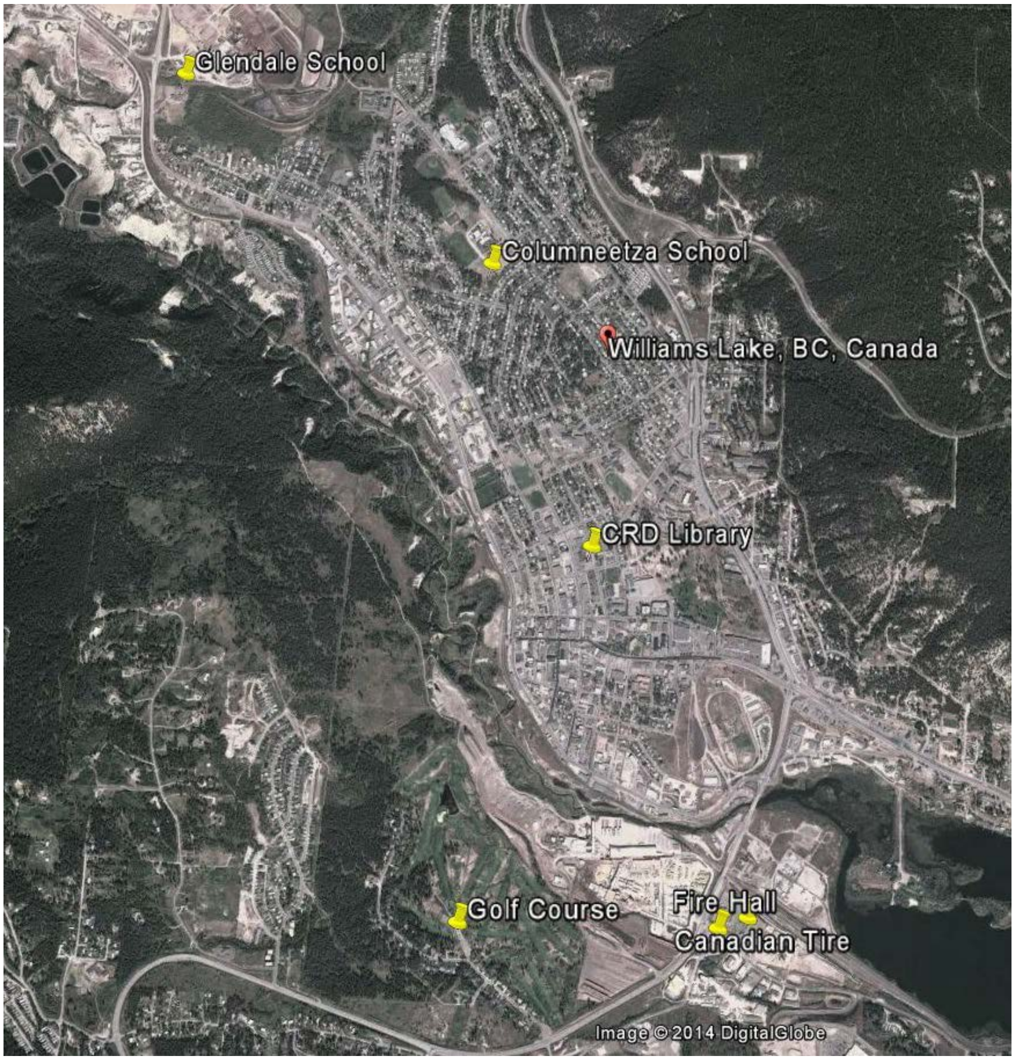

Figure 1: Air quality and meteorological monitoring stations in Williams Lake.

2.1 Data Completeness Criteria

Mean daily (midnight to midnight) $PM_{2.5}$ and PM_{10} values require at least 18 hourly measurements to be considered valid by the MoE. Annual data sets require at least 75% of calendar days for each quarter of the year to be valid in order for the year to be considered valid. Missing data, which is generally due to instrument failure, can bias annual statistics if a significant fraction of data is missing. Data sets that did not meet data completeness requirements have been flagged in this report. Please note that data from 2015 is subject to validation and may change, but large charges are not anticipated.

2.2 Provincial Objectives and Airshed Goals

The Province and the Williams Lake Air Quality Roundtable have both set 24-hour objectives for $PM_{2.5}$. The Province also has an annual objective (Table 1). Attainment of the 24-hour objective (midnight to midnight) for $PM_{2.5}$ is based on the 98^{th} percentile rather than the maximum value in order to limit the influence of extreme events. The airshed goal is calculated based on a 3 year rolling mean, while provincial objectives are based on 1 year averages. Mean annual concentrations are calculated by averaging daily values for the year.

Table 1: Summary of provincial and AMP air quality objectives for $PM_{2.5}$

Pollutant	Averaging period	Provincial Objective	AMP Objective[1]
$PM_{2.5}$ (µg/m^3)	24-hour[2]	25	18
	Annual	8	

[1] Based on 3-year moving average of 98th percentile
[2] Based on 98th percentile

The Province and the AMP have also set 24-hour objectives for PM_{10}, with the Province using the maximum daily average for the year, and the AMP using a 3 year rolling average of the 98th percentile of daily averages (Table 2).

Table 2: Summary of provincial and AMP air quality objectives for PM_{10}

Pollutant	Averaging period	Provincial Objective	AMP Objective[1]
PM_{10}	24-hour	50 µg/m^3	40 µg/m^3

[1] Based on 3-year moving average of 98th percentile

2.3 Monitoring Upgrades

The MoE is upgrading the $PM_{2.5}$ monitoring network across the Province with newer technology. Older instruments have been kept in use for some years in order to understand how the change in equipment influences annual statistics. The newer SHARP Model 5030 instruments (Thermo, MA, USA) are anticipated to report ~20% higher $PM_{2.5}$ values than TEOM Series 1400a instruments[5] (Rupprecht and Patashnick Co. Inc., NY, USA). This discrepancy is due to the older TEOM models not fully capturing the volatile component of $PM_{2.5}$, and therefore underreporting ambient $PM_{2.5}$ concentrations, particularly in the winter when temperatures are cold and wood smoke is prevalent.

A SHARP monitoring instrument was installed at the Columneetza station in 2009, but due to instrumentation issues and delays with replacement equipment, 2014 was the first year that met data completeness criteria. For comparative purposes with the other stations and with previous results, data from both the TEOM and SHARP instruments have been included in this report. Results from the TEOM and SHARP $PM_{2.5}$ instruments in February of 2014 at the Columneetza station have been provided in Figure 2 to demonstrate differences in values reported between the two instruments in the winter, with PM_{10} results also provided for comparison.

[5] Environment Canada, 2004. Performance of Continuous $PM_{2.5}$ Monitors at Canadian Monitoring Locations. NAPS Managers Technical Working Group on PM Measurement Technology, November 2004.

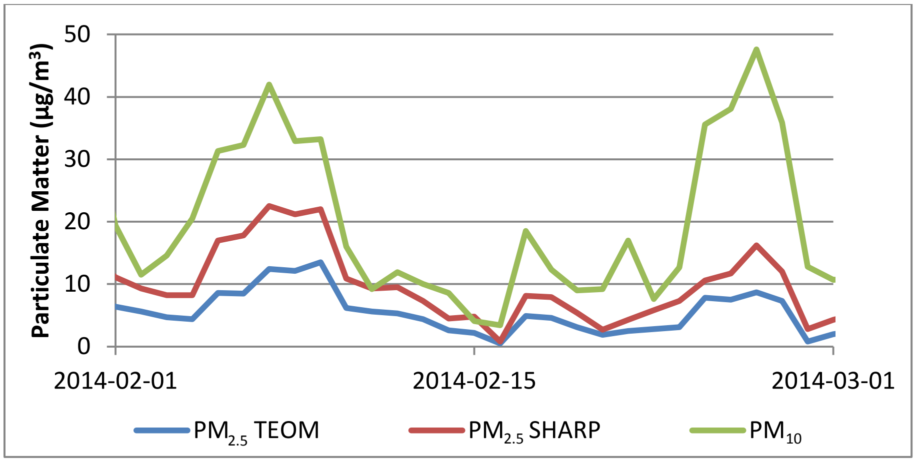

Figure 2: SHARP and TEOM $PM_{2.5}$ instrument readings for the month of February at Columneetza station, with PM_{10} data for comparison.

The use of SHARP $PM_{2.5}$ instruments for measurement and reporting means that air quality targets will likely be more difficult to meet. However, this is due to an improvement in monitoring accuracy and does not necessarily reflect a change in air quality. Please note that PM_{10} continues to be monitored using TEOMs.

2.4 Forest Fire Smoke

Smoke from forest fires can result in a significant deterioration in air quality, sometimes for extended periods of time, and is often the primary cause of $PM_{2.5}$ and PM_{10} exceedances over the summer. While no wildfire smoke advisories were issued in Williams Lake in 2015, three were issued in 2014 (from July 15th – 19th, August 6th – 10th and 18th – 19th). Because forest fire smoke had minimal impacts on air quality in Williams Lake in 2015, the following discussion of forest fire impacts will focus on data from 2014. An example of the impact of forest fire smoke on $PM_{2.5}$ and PM_{10} levels at the Columneetza station in July of 2014 can be seen in Figure 3.

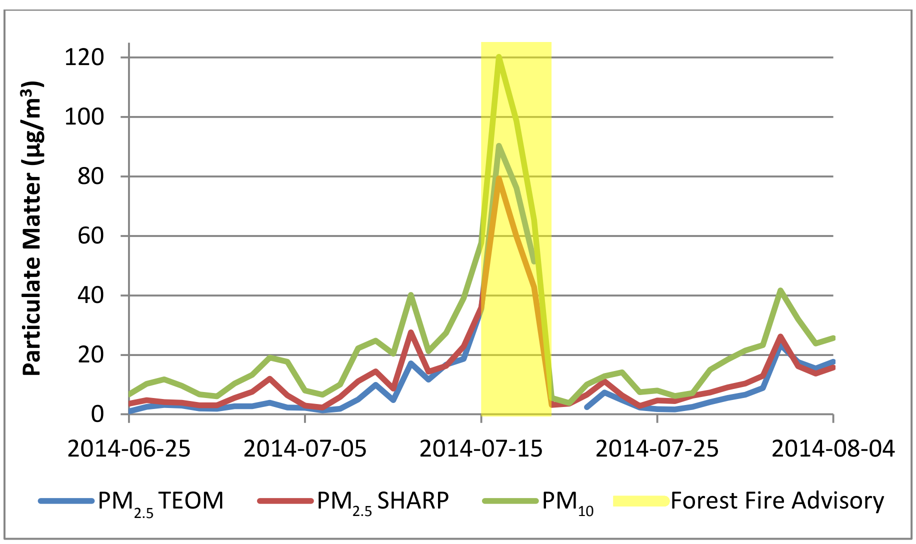

Figure 3: Effect of forest fire smoke on mean daily $PM_{2.5}$ and PM_{10} levels at Columneetza station in Williams Lake in July of 2014 (July smoke advisory was 15th – 19th).

Due to the unpredictable nature of wildfire events, wildfire smoke cannot be effectively managed at the community level. $PM_{2.5}$ and PM_{10} concentrations excluding forest fire smoke were estimated in order to determine how effective local efforts have been in reducing local emissions, as forest fire events can otherwise confound trends and prevent an accurate evaluation of progress made as a result of the airshed planning process. This was done by not including data from days in July, August and September with $PM_{2.5}$ values greater than 20 µg/m^3. There is no standard method for removing the effect of wildfires from datasets, but this simple method has been found to work well for interior communities in this province.

The estimated influence of forest fires on annual mean $PM_{2.5}$ and PM_{10} concentrations in 2014, as measured by two $PM_{2.5}$ instruments and a PM_{10} instrument, can be seen in Figure 4. These estimates suggest that forest fires accounted for 9-18% of annual PM concentrations in 2014 (but this is highly variable depending on the year). The $PM_{2.5}$ TEOM reported a concentration below the provincial $PM_{2.5}$ objective of 8 µg/m^3 before forest fire impacts were removed. The $PM_{2.5}$ SHARP monitor, however, only met the provincial objective after removing forest fire impacts. While there is no annual average objective for PM_{10}, forest fire smoke contributed to annual mean PM_{10} as well.

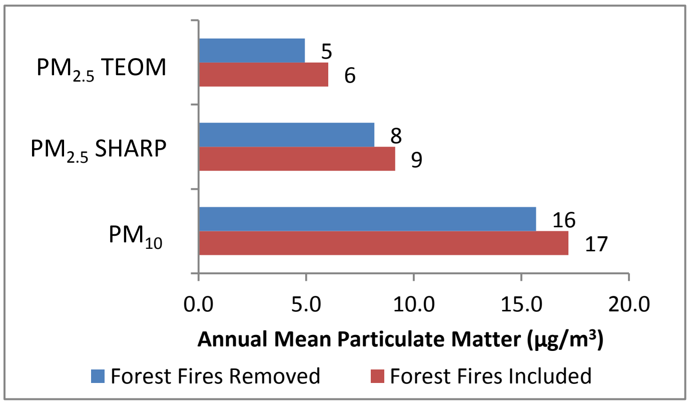

Figure 4: Annual mean particulate matter concentrations at Columneetza station in 2014.

Though relatively rare and often short term, wildfires can have extreme impacts on air quality. As such, they tend to have a greater impact on maximum values and exceedances than they do on annual means. The estimated influence of forest fires on 98th percentile daily mean $PM_{2.5}$ and maximum daily PM_{10} values at the Columneetza station can be seen in Figures 5 and 6, respectively. While the TEOM $PM_{2.5}$ monitor was already below the 25 µg/m^3 provincial objective, removing the effects of forest fires resulted in the SHARP monitor meeting this objective as well. In contrast, the PM_{10} monitor was still well above the 50 µg/m^3 objective after removing the effects of forest fires, suggesting that other factors are also responsible for exceedances of the provincial PM_{10} objective.

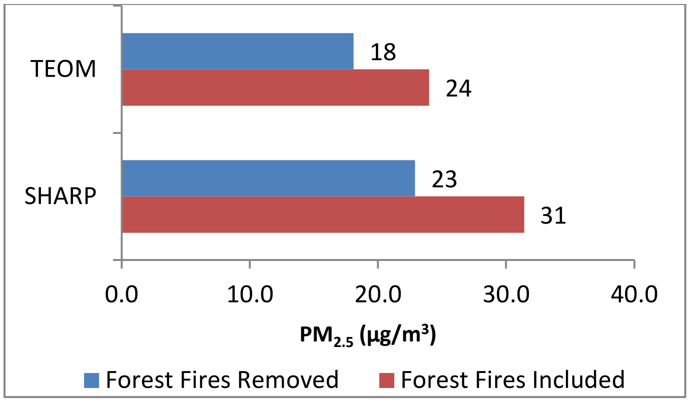

Figure 5: 98th Percentile of daily $PM_{2.5}$ concentrations at Columneetza station in 2014.

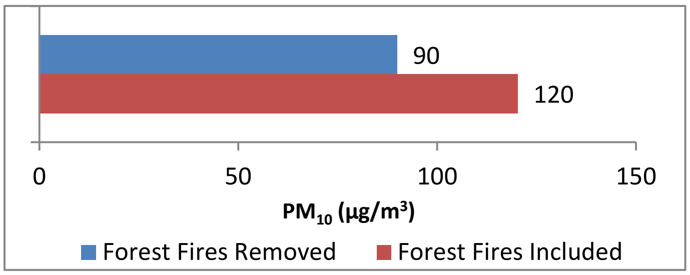

Figure 6: Maximum daily PM_{10} concentrations at Columneetza station in 2014.

The portion of annual exceedances (24-hour average >25 µg/m^3) recorded at the Columneetza station in 2014 is provided in Table 3. The TEOM and SHARP $PM_{2.5}$ monitors recorded a similar number of exceedances during the forest fire season, but the SHARP recorded a much higher number of exceedances over the remainder of the year, which would have primarily occurred during winter stagnation conditions. This discrepancy is likely in part because TEOM monitors underestimate the volatile component of PM, particularly during cold conditions. This can be seen in Figure 2, where at times the TEOM appears to be only reporting approximately half the $PM_{2.5}$ concentration of the SHARP, whereas there is much less of a difference between the two sensors in the summer (Figure 3).

Table 3: Number of days with 24-h concentration greater than 25 µg/m^3 in 2014, and the number of exceedances attributable to forest fires at Columneetza station.

Pollutant	$PM_{2.5}$		PM_{10}
Provincial Objective	25 µg/m^3		50 µg/m^3
Instrument	TEOM	SHARP	TEOM
# of Exceedances	7	15	9
Forest Fire Related	6 (86%)	9 (60%)	6 (67%)
Other Exceedances	1 (14%)	6 (40%)	3 (33%)

Figure 7 shows the annual pattern of $PM_{2.5}$ and PM_{10} variation at the Columneetza station in 2014. PM_{10} exceedances during the wildfire season (July - September) are primarily composed of $PM_{2.5}$, and were therefore most likely caused by forest fire smoke. The PM_{10} exceedance in late September has a lower proportion of $PM_{2.5}$, and may have been caused by dust rather than smoke. Exceedances in the winter and spring are primarily composed of the coarse (between 2.5 and 10 microns) fraction of PM_{10}, likely emanating from unpaved roads and winter traction material.

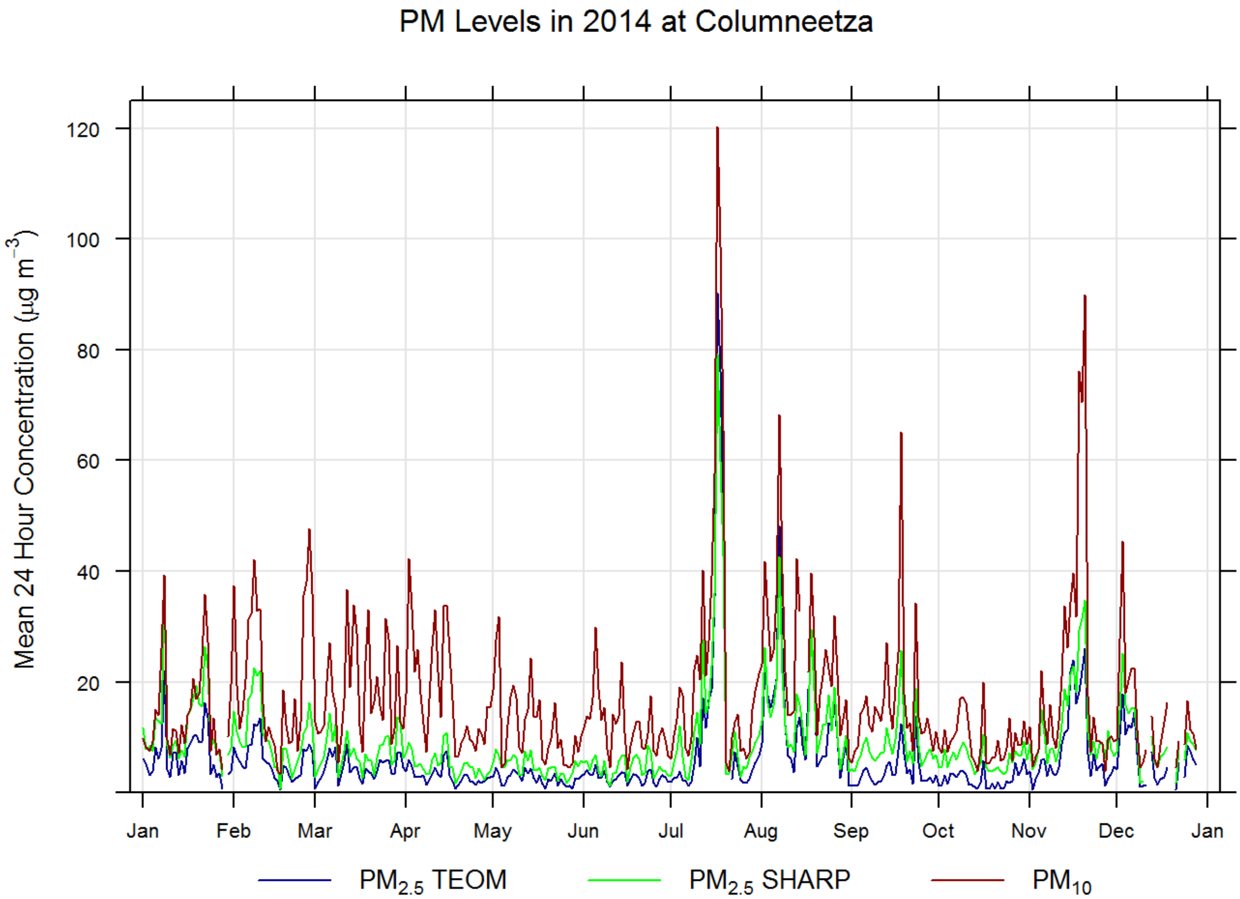

Figure 7: PM 24-hour mean concentrations at the Columneetza station in 2014. Note how there tends to be a greater disparity between PM_{10} and $PM_{2.5}$ concentrations later in the winter, suggesting a higher proportion of PM_{10} is composed of coarse particles like dust and traction material.

Figure 8 shows the annual pattern of $PM_{2.5}$ and PM_{10} variation at the Columneetza station in 2015. Similar patterns can be seen in both 2014 and 2015, including elevated PM_{10} concentrations in late winter/early spring. However, peak concentrations for $PM_{2.5}$ and PM_{10} were much lower in 2015, particularly in the summer as there were much more limited impacts from wild fire smoke.

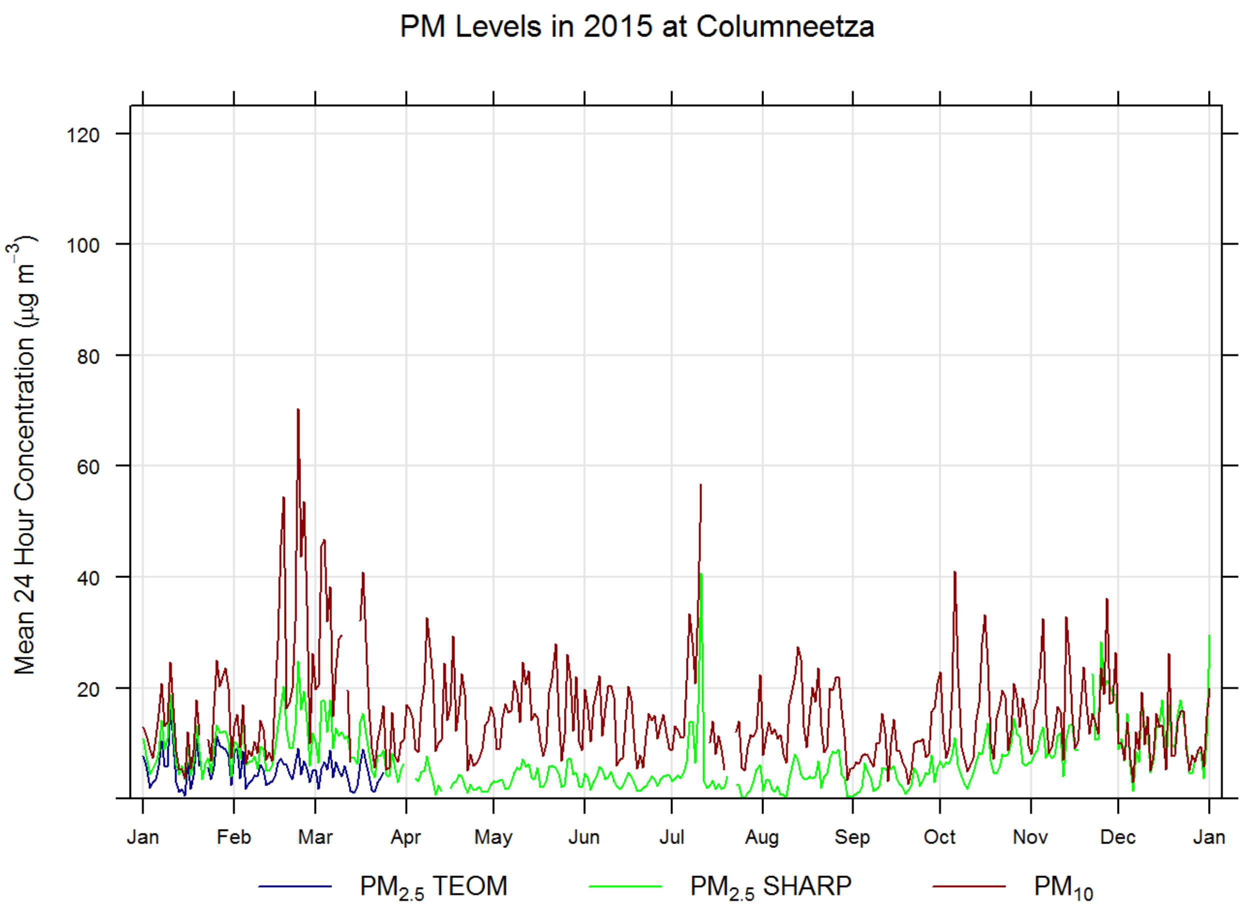

Figure 8: PM 24-hour mean concentrations at the Columneetza station in 2015. Note the disparity between PM_{10} and $PM_{2.5}$ concentrations in late winter/early spring, suggesting a high proportion of PM_{10} is composed of coarse particles like dust and traction material. Data from 2015 is subject to validation and may change, though no large changes are anticipated.

3 Recent Trends in $PM_{2.5}$

The annual provincial objective for $PM_{2.5}$ was met almost every year since 2004, with the exception of 2010 due to forest fires and 2014 with the switch to the new SHARP monitor. Between 2004 and 2007, $PM_{2.5}$ values at both stations showed a consistent decreasing trend. Forest fires had a particularly strong influence on air quality in Williams Lake in 2010, which resulted in a sharp increase in $PM_{2.5}$ concentrations. Values increased again in 2014 due to the influence of forest fires. Data collected at Columneetza by a TEOM $PM_{2.5}$ instrument found that the annual provincial objective was still met that year. However, the more accurate SHARP found that Columneetza did not meet the provincial objective in 2014 for annual mean (Figure 9), even when forest fires were removed from the data (Figure 4). The mean $PM_{2.5}$ concentration measured in 2015 by the SHARP was much lower.

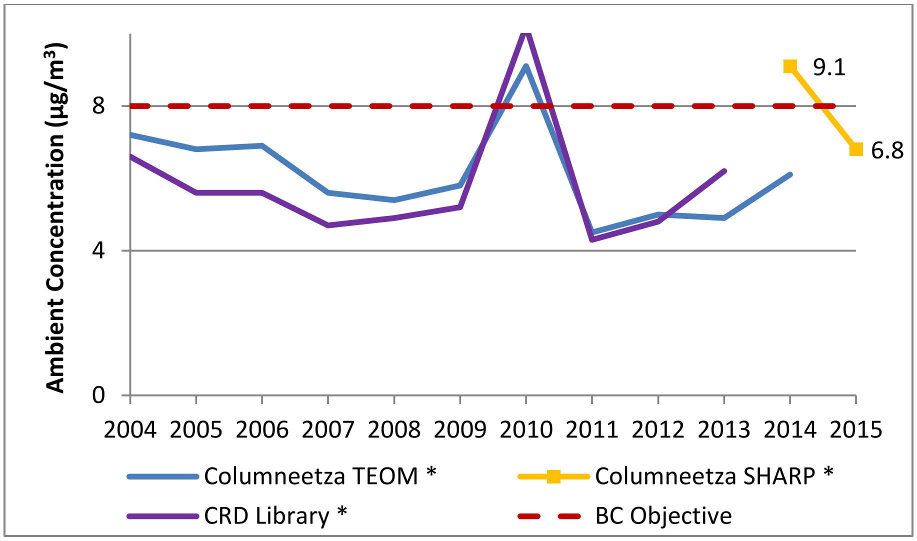

Figure 9: $PM_{2.5}$ Annual Hourly Mean for the 2004-2014 period.
*** Data completeness criteria not satisfied at Columneetza in 2007 and 2009 and CRD in 2010 and 2013. Data was not available at CRD in 2014. Valid Columneetza SHARP data was only available in 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

The 24-hour (midnight to midnight) $PM_{2.5}$ AMP goal (rolling 3-year average of the 98th percentile of daily means) was met in 2014 for at the Columneetza station (Figure 10). This graph does not include data from the $PM_{2.5}$ SHARP instrument because insufficient data is available to produce a three year average. Data completeness criteria were not met at Columneetza in 2007 and 2009 and at CRD Library in 2010, but the missing data is not expected to significantly bias annual statistics. In 2013 however, data wasn't collected at the CRD Library station for the last three quarters of the year as the station was in the process of being closed, so data from 2013 is not likely to be representative of air quality trends over the year. The influence of forest fires on $PM_{2.5}$ levels, particularly in 2010, can be clearly seen on both stations in Figures 10 and 11.

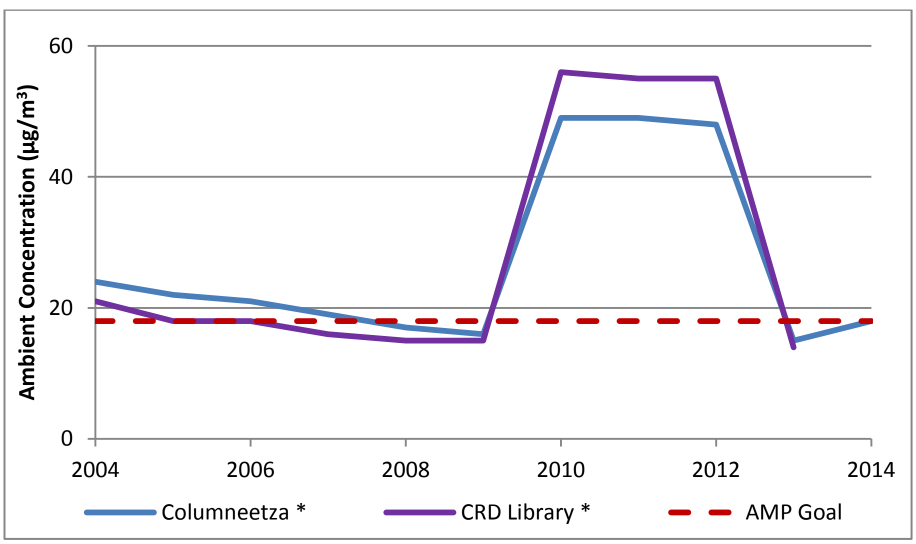

Figure 10: $PM_{2.5}$ Rolling 3-Year Mean of the 98th Percentile for the 2004-2014 period.
*** Data completeness criteria not satisfied at Columneetza in 2007 and 2009 and CRD in 2010 and 2013. Data was not available at CRD in 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

As with the annual objective, the daily 98th percentile objective was not met by the SHARP in 2014, but was met by the TEOM in 2014 and the SHARP in 2015 at the Columneetza station (Figure 11). When forest fire data is removed, the SHARP also meets this objective in 2014 (Figure 5). Other than in 2010, the TEOMs at both the Columneetza and CRD Library stations consistently met the provincial objective, but this trend is unlikely to continue as $PM_{2.5}$ monitoring is now conducted using the SHARP instruments, which are more accurate particularly in cold conditions when local sources of $PM_{2.5}$ are elevated. This is expected to result in more exceedances of provincial objectives and AMP goals due to the changes in monitoring equipment accuracy, rather than being caused by an actual increase in $PM_{2.5}$ emissions.

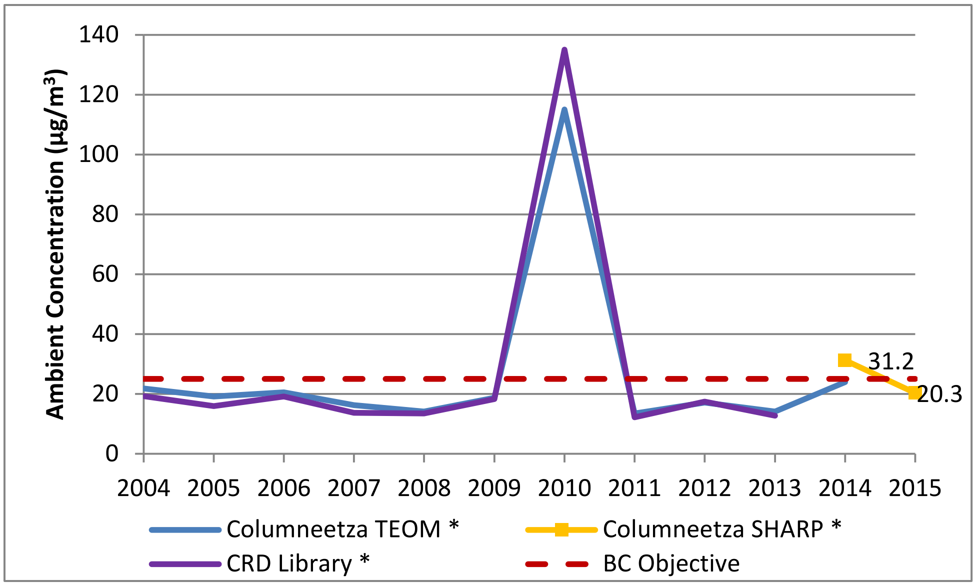

Figure 11: $PM_{2.5}$ 98th Percentile for the years 2004-2014.
*** Data completeness criteria not satisfied at Columneetza in 2007 and 2009 and CRD in 2010 and 2013. Data was not available at CRD in 2014. Valid Columneetza SHARP data was only available in 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

4 Recent Trends in PM_{10}

At the Columneetza station, the AMP goal for PM_{10} (rolling 3-year average of the daily 98th percentile) was not met in 2015, and was only met twice from 2004 to 2015 (Figure 12). No data on PM_{10} was collected at the CRD Library station for the last two quarters of 2012 and 2014, so data completeness criteria was not met and data for those years was not likely to have been representative of air quality trends for those years. PM_{10} data also did not meet completeness criteria at Columneetza in 2007 and 2010 and at CRD Library in 2012, but the missing data in those years is not believed to have significantly biased annual statistics.

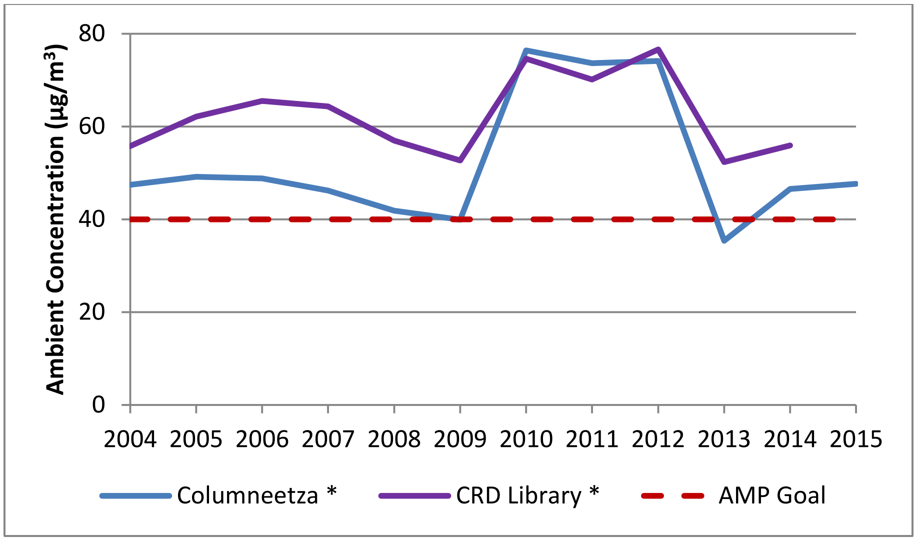

Figure 12: PM_{10} Rolling 3-Year Mean of the 98th Percentile for the 2004-2014 period.
*** Data completeness criteria not satisfied at Columneetza in 2007 and 2010 and CRD in 2012, 2013 and 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

Between 2004 and 2009, average annual PM_{10} values declined at both stations. Smoke from forest fires resulted in increased PM_{10} levels, particularly in 2010, and to a lesser degree in 2014. The increase at CRD Library in 2012 may have been due to unrepresentative data, as well as increased dust/emissions from sources located closer to the CRD Library station than to Columneetza (Figure 13). Forest fire smoke is unlikely to have influenced the CRD annual mean in 2012, as data was only available for the first 5 months of the year – well before the forest fire season begins.

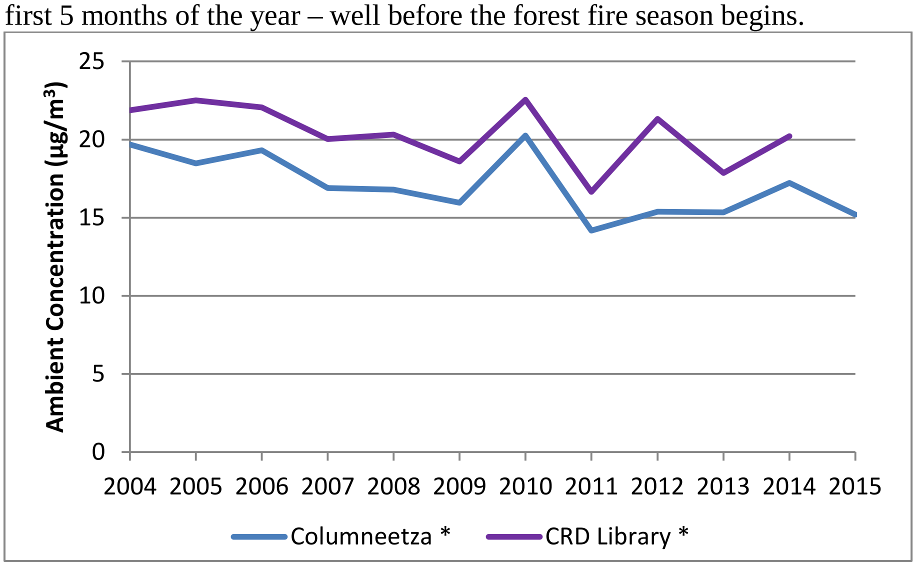

Figure 133: PM_{10} Annual Mean for the 2004-2014 period.
*** Data completeness criteria not satisfied at Columneetza in 2007 and 2010 and CRD in 2012, 2013 and 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

4.1 PM_{10} Exceedances

The 24-hour provincial objective for PM_{10} is 50 µg/m^3. A general decrease in exceedances at the CRD Library station since 2005 suggests that local efforts to reduce emissions are having some success in improving air quality (Figure 14). The number of exceedances was consistently higher at the CRD Library station, likely because it is closer to traffic sources.

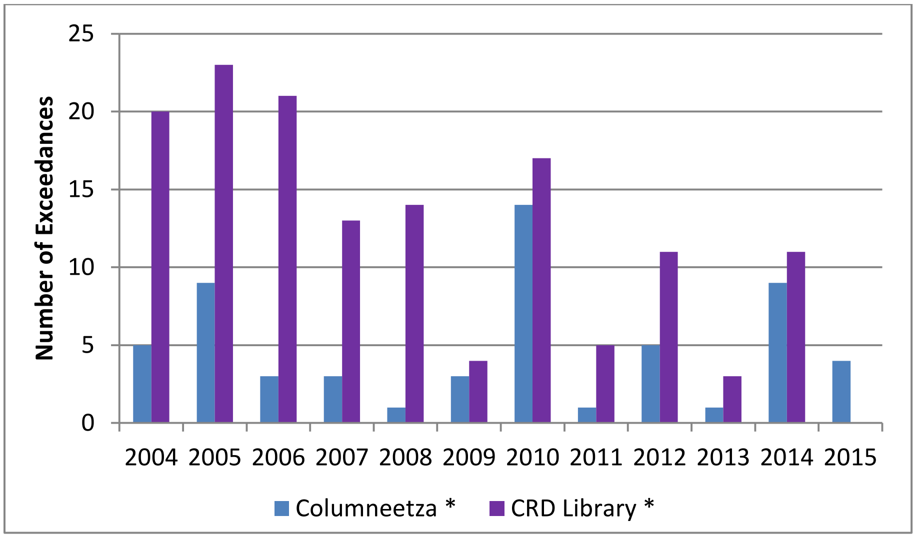

Figure 144: Number of daily (midnight to midnight) PM_{10} exceedances (>50 μg/m^3) in Williams Lake. Exceedances at CRD in 2014 were particularly high given that PM_{10} data was only available for 167 days of the year.

*** Data completeness criteria not satisfied at Columneetza in 2007 and 2010 and at CRD in 2012, 2013 and 2014. Data from 2015 is subject to validation and may change, though no large changes are anticipated. Monitoring at CRD Library ended in 2014.**

Exceedances increased in 2010 largely due to forest fire smoke (Figure 14). In 2014, all 11 PM_{10} exceedances that occurred at CRD were in January, February, March and April, which are months not typically associated with wildfire activity. No data was available at the CRD station from mid-June through the end of the year, so the total number of exceedances is likely higher. In comparison, 6 of the 9 PM_{10} exceedances at Columneetza occurred during months that are typically active wildfire periods (July – September), suggesting that PM_{10} exceedances at the Columneetza station are often caused by wildfire smoke, while CRD Library station likely has a consistently higher annual mean and number of exceedances due to local sources.

In 2015, there were only 4 exceedances at Columneetza, three of which occurred on February 18th, 23rd and 25th. There was no precipitation in Williams Lake reported by Environment Canada[6] from February 15-18 and February 20-25. Wind speeds were low and $PM_{2.5}$ made up only a small proportion PM_{10}, suggesting that wood smoke played a limited role. Instead, the main cause of these PM_{10} exceedances was likely due to dust from various sources (including traction material) drying out due to the lack of precipitation and eventually being mobilized by road traffic. The other exceedance occurred in July during high $PM_{2.5}$ concentrations and was likely due to forest fire smoke.

5 Partisol Measurements

Partisol instruments provide non-continuous measurements (daily averages sampled once every six days), so they cannot be directly compared against AMP goals and provincial objectives. They are nonetheless useful in increasing the number of monitoring locations to help determine spatial variability in air quality within the city and to provide information on particulate composition.

$PM_{2.5}$ levels at the Fire Hall are quite similar to those measured at the Columneetza station, and are generally quite low. TSP or Total Suspended Particulate, is also measured at the Fire Hall, but was only

[6] Environment and Climate Change Canada website: http://climate.weather.gc.ca/index_e.html

available in 2014 beginning on March 3rd. TSP is a measure of all particulate matter in ambient air. It therefore includes particulate matter larger than PM_{10} which is of lower significance regarding health impacts than $PM_{2.5}$ and PM_{10}. Nonetheless, high TSP values at the Fire Hall suggest influence of local sources, particularly in the colder months (Figure 15).

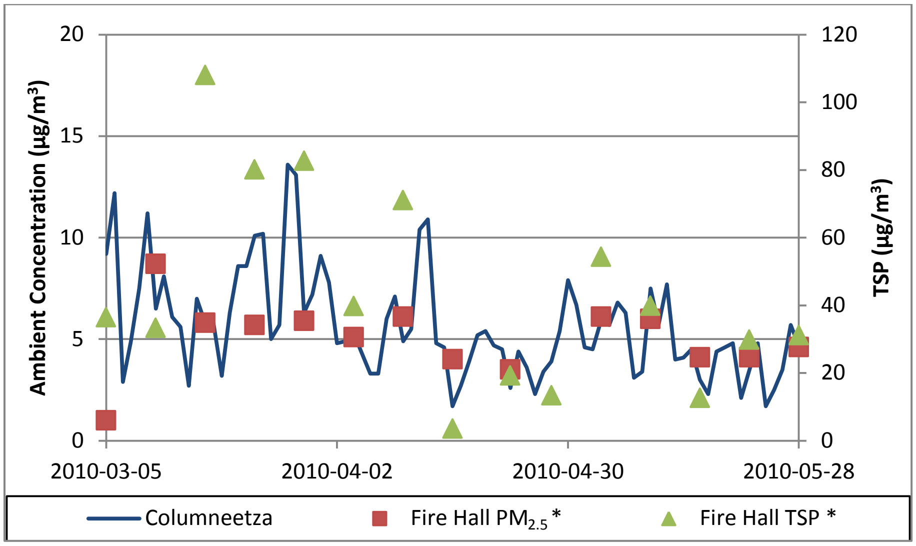

Figure 155: Non-continuous TSP and $PM_{2.5}$ data from the Fire Hall, with continuous Columneetza $PM_{2.5}$ (SHARP) data for comparison. TSP data is plotted against the secondary Y axis on the right.

PM_{10} levels at the Williams Lake Golf Course, Glendale School and Columneetza stations showed high variability (Figure 16). The lack of a consistent relationship between measurements at the Glendale and Golf Course locations suggests influence of local sources. At the Glendale station in 2014, of 75 days monitored, 12 days (16%) were above 40 µg/m³, while at the Golf Course station, only 3 out of 85 (3.5%) days monitored were above 40 µg/m³, suggesting that the industrial sources in the north of the city may be influencing air quality at the Glendale School.

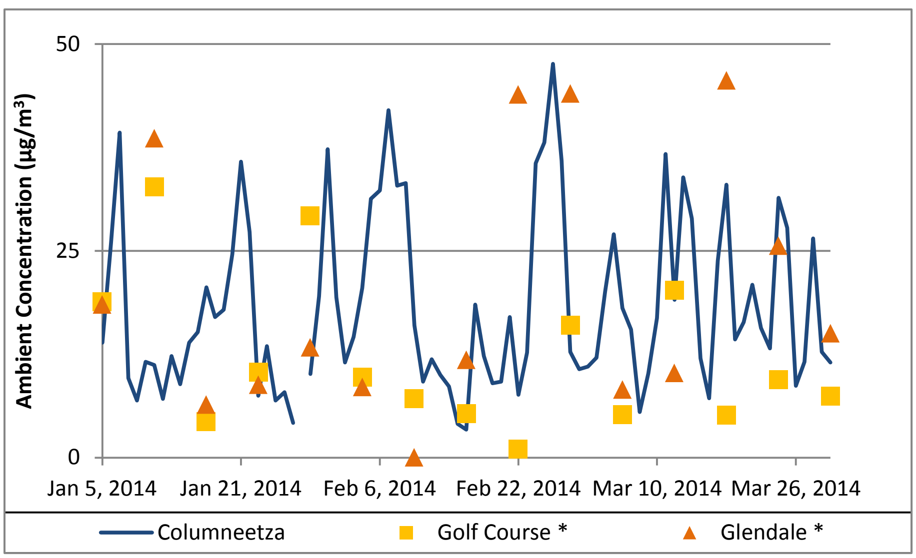

Figure 166: Non-continuous Partisol PM_{10} data from the Williams Lake Golf Course and Glendale School, with continuous PM_{10} (Columneetza) data for comparison.

6 Recommendations/Conclusions

Most non-forest fire related $PM_{2.5}$ exceedances occurred during winter inversion conditions when cold temperatures and low wind speeds create stagnant air conditions and support the buildup of pollution in ambient air. The MoE will continue to provide advanced warning to stakeholders in Williams Lake before winter inversions occur, in order to allow stakeholders to reduce $PM_{2.5}$ emissions by taking actions like switching to cleaner fuels for space heating during inversions.

PM_{10} exceedances also continue to be an issue over the winter. This problem could be reduced by improving dust control methods including the removal of winter traction material, improved application methods and management of unpaved surfaces.