Air Quality in Quesnel

A Summary of Recent Trends in Levels of Particulate Matter

June 2016

Prepared for

QUESNEL 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 Quesnel, BC. As part of the Quesnel Air Quality Roundtable, the MoE supports stakeholders to achieve the goals of the Quesnel 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 particularly irritating to those with pre-existing conditions[4]. The main sources of coarse particulates include winter traction material, dust from unpaved roads, parking lots, unvegetated 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

Air quality monitoring in Quesnel, including continuous monitoring of $PM_{2.5}$ and PM_{10}, is conducted at the Quesnel Junior Secondary School (referred to as QSS in this report). Monitoring at Maple Drive Junior Secondary School (MDR) and West Correlieu Secondary School (COR) was ceased in August 2015 and July 2014 respectively, as these two buildings were abandoned. There are two meteorological stations in Quesnel, located at the QSS site and Cariboo Pulp & Paper Co. (CPP). Real time air quality data are available at www.bcairquality.ca. The Quesnel 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] WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Global update 2005. Summary of risk assessment. WHO/SDE/PHE/OEH/06.02
[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

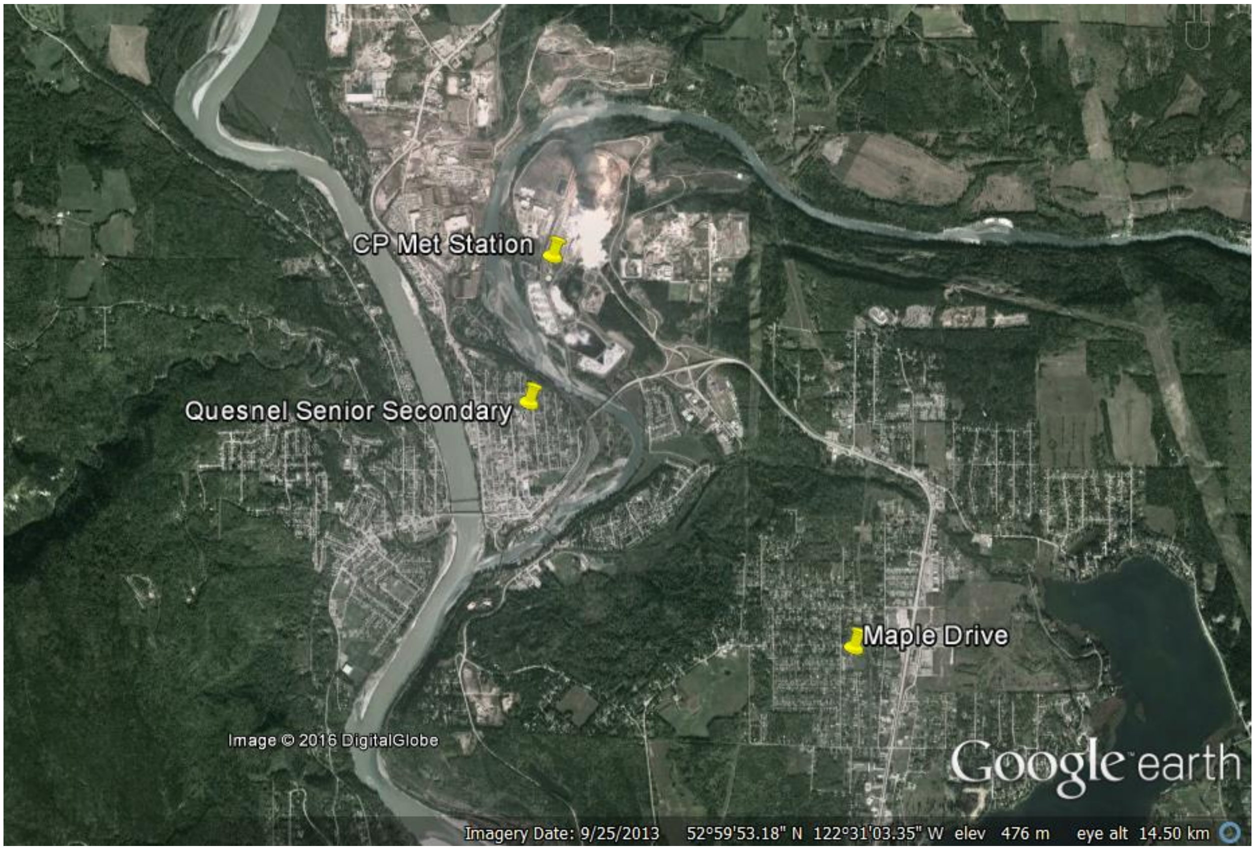

Figure 1: Air quality and meteorological monitoring stations in Quesnel.

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 Quesnel 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 provincial 24-hour objective (midnight to midnight) for $PM_{2.5}$ is based on the 98th 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]
$PM_{2.5}$	24-hour[2]	25 µg/m^3	18 µg/m^3
	Annual	8 µg/m^3	

[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/m³	40 µg/m³

[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 several 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[5] than TEOM Series 1400a instruments (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.

To date, one SHARP monitor has been installed in Quesnel at the QSS station. 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 instruments in late January/early February of 2014 at the QSS station have been provided in Figure 2 to demonstrate differences in values reported between the two instruments in the winter.

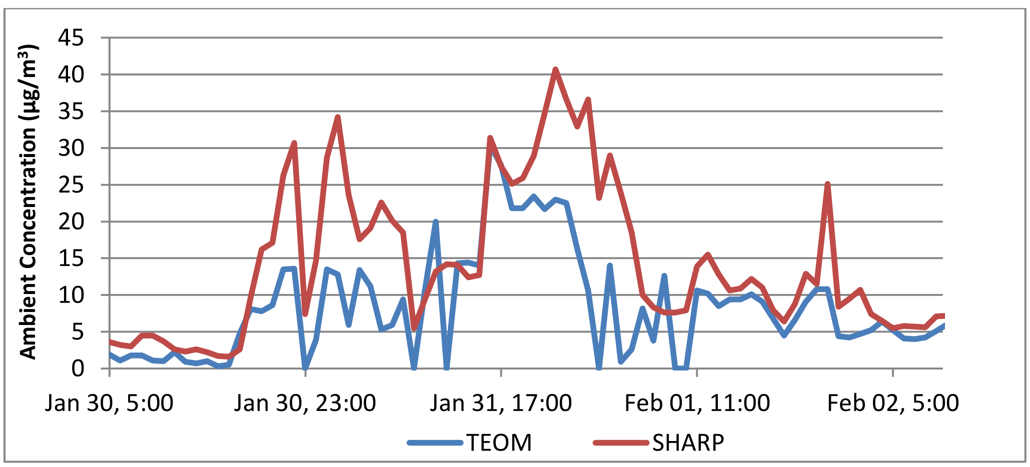

Figure 2: $PM_{2.5}$ concentrations measured by TEOM and SHARP monitors at the QSS station as an inversion formed in January/February of 2014.

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.

[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.

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 Quesnel in 2015, two were issued in 2014 (on July 15th and August 4th). Because forest fire smoke had minimal impacts on air quality in Quesnel 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 $PM_{2.5}$ concentrations in Quesnel is shown in Figure 3 (a wildfire smoke advisory for Quesnel was issued on July 15th at 18:00).

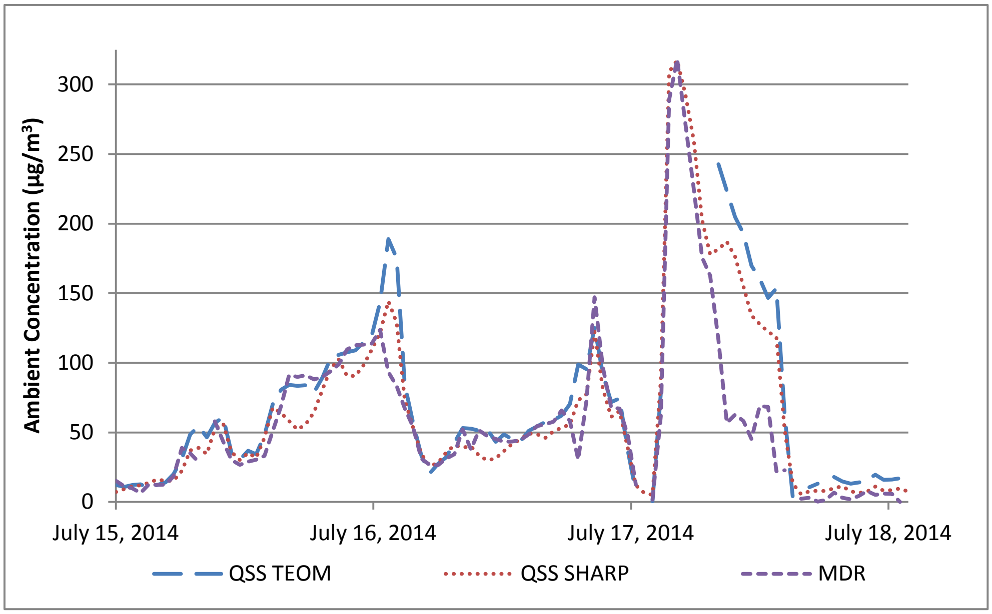

Figure 3: Elevated $PM_{2.5}$ concentrations at different monitoring stations in Quesnel during a forest fire smoke event in the summer of 2014.

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 concentrations at QSS and MDR in 2014 can be seen in Figure 4. These estimates suggest that forest fires accounted for 10-20% of PM concentrations in 2014 (but this is highly variable depending on the year). In 2014, both $PM_{2.5}$ TEOMs reported concentrations meeting the provincial $PM_{2.5}$ objective of 8 µg/m^3 before forest fire impacts were removed. The $PM_{2.5}$ SHARP monitor located at QSS, however, was still above 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.

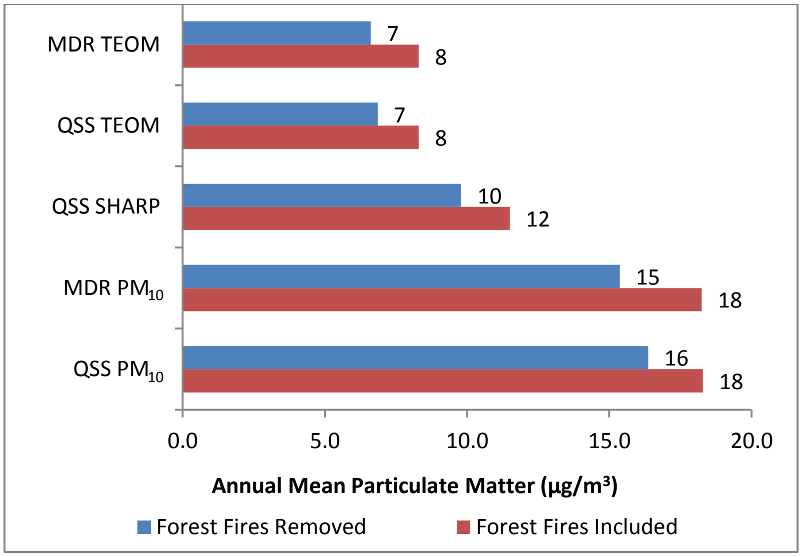

Figure 4: Annual mean concentrations of $PM_{2.5}$ and PM_{10} at the MDR and QSS stations in 2014.

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 influence of forest fires on 98th percentile daily mean $PM_{2.5}$ values and maximum daily PM_{10} values can be seen in Figures 5 and 6, respectively. Only the QSS TEOM was below the provincial objective after the estimated effects of forest fire smoke were removed. The other $PM_{2.5}$ monitors – MDR TEOM and QSS SHARP, and the PM_{10} monitors at QSS and MDR, still reported concentrations above provincial objectives after forest fire impacts were removed from the data, suggesting that other factors are also responsible for exceedances of the provincial $PM_{2.5}$ and PM_{10} objectives.

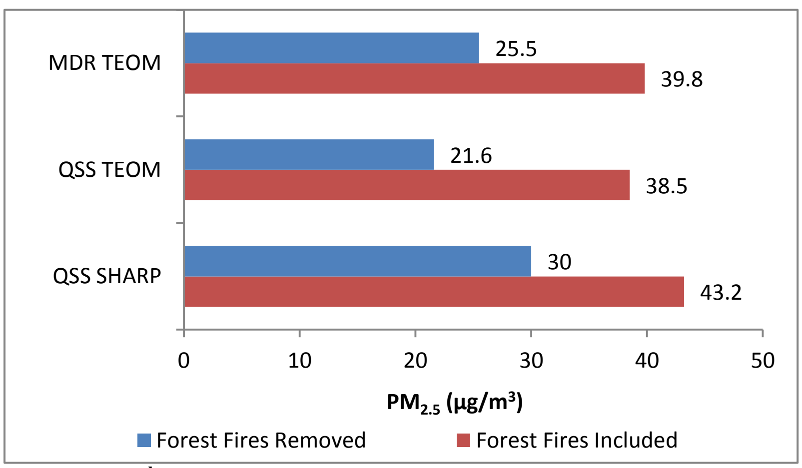

Figure 5: 98th Percentile of daily $PM_{2.5}$ concentrations at the MDR and QSS stations in 2014.

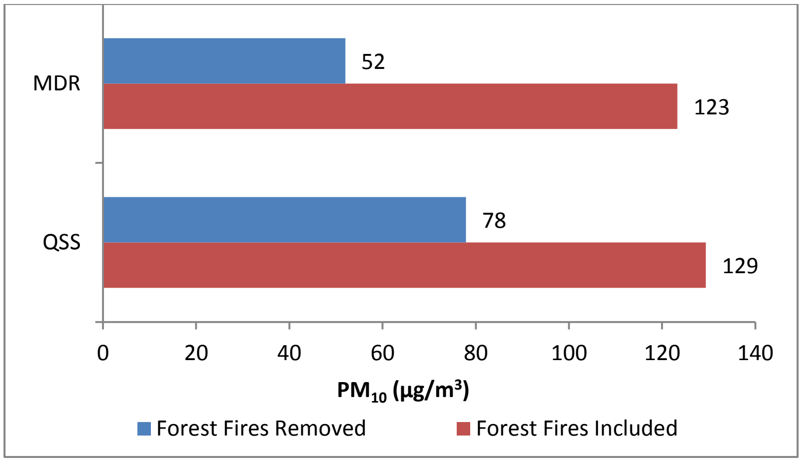

Figure 6: Maximum daily PM_{10} concentrations at the MDR and QSS stations in 2014.

The portion of annual exceedances attributable to forest fires in 2014 is provided in Table 3. Forest fires accounted for the majority of exceedances, particularly among the $PM_{2.5}$ TEOM monitors, which are known to underestimate $PM_{2.5}$ concentrations during cold weather when inversions tend to occur. Table 3 also indicates that PM_{10} is an issue at QSS based on the number of 'other' exceedances recorded by the PM_{10} monitors. This can also be seen in the particularly high PM_{10} value at QSS in Figure 6 even after removing the effects of forest fire smoke.

Table 3: The number of $PM_{2.5}$ and PM_{10} exceedances of the 24-hour provincial objective in 2014.

	QSS TEOM	QSS SHARP	QSS PM_{10}	MDR TEOM	MDR PM_{10}
Forest Fire Related	11	14	7	13	7
Other Exceedances	2	12	10	6	1
Total	13	26	17	19	8

Figure 7 shows the annual pattern of $PM_{2.5}$ and PM_{10} variation at the QSS station in 2014. PM_{10} exceedances during the wildfire season (July - September) were primarily driven by $PM_{2.5}$ levels, and were therefore most likely caused by forest fire smoke. PM_{10} exceedances in the spring are primarily driven by the coarse fraction (size between 2.5 and 10 microns) of PM_{10}, likely emanating from unpaved roads and winter traction material.

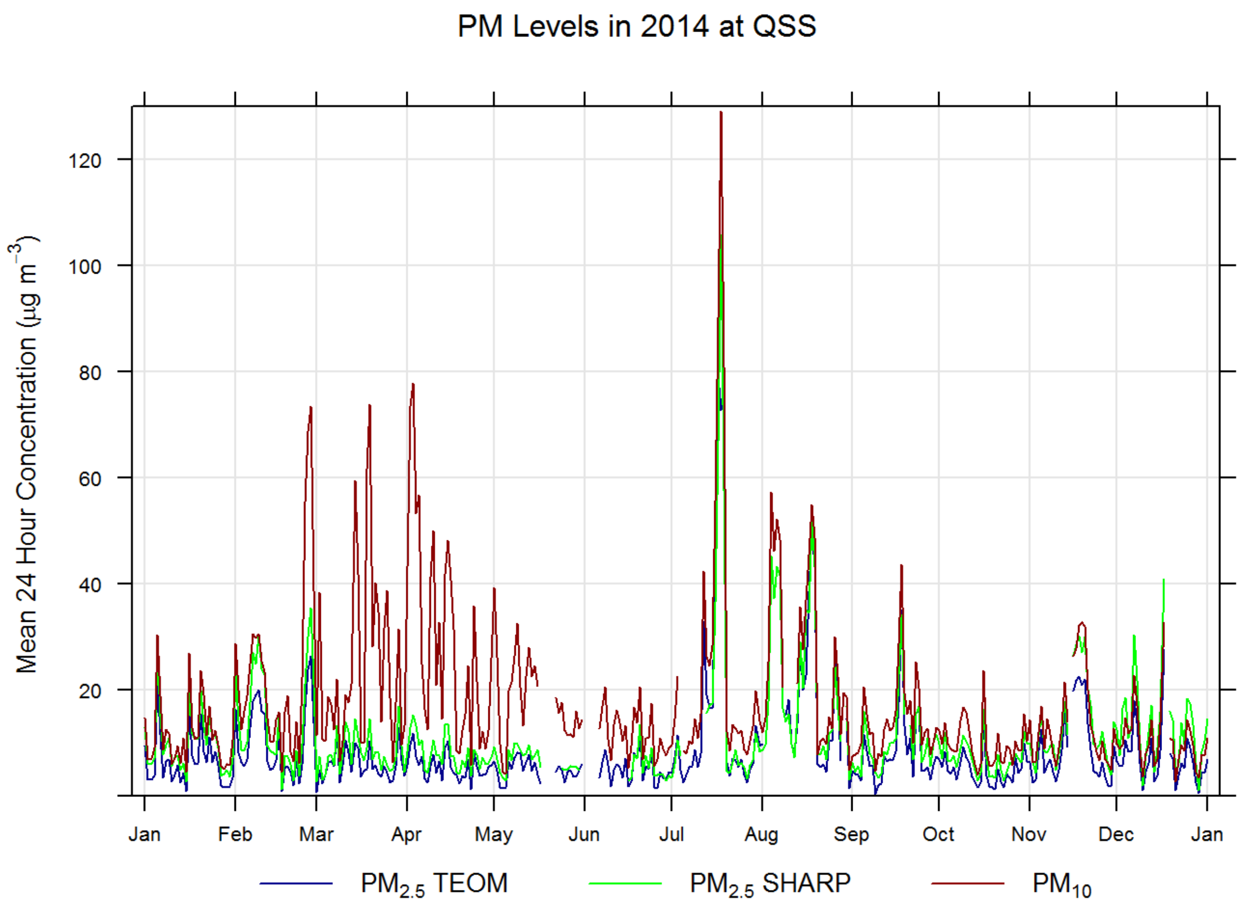

Figure 7: PM 24-hour mean concentrations at the QSS station in 2014. Note how there tends to be a greater disparity between PM_{10} and $PM_{2.5}$ concentrations later in the winter, suggesting a higher proportion of PM_{10} is composed of coarse particles like dust and traction material.

Figure 8 shows the annual pattern of $PM_{2.5}$ and PM_{10} variation at the QSS 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 was little to no impact from wild fire smoke.

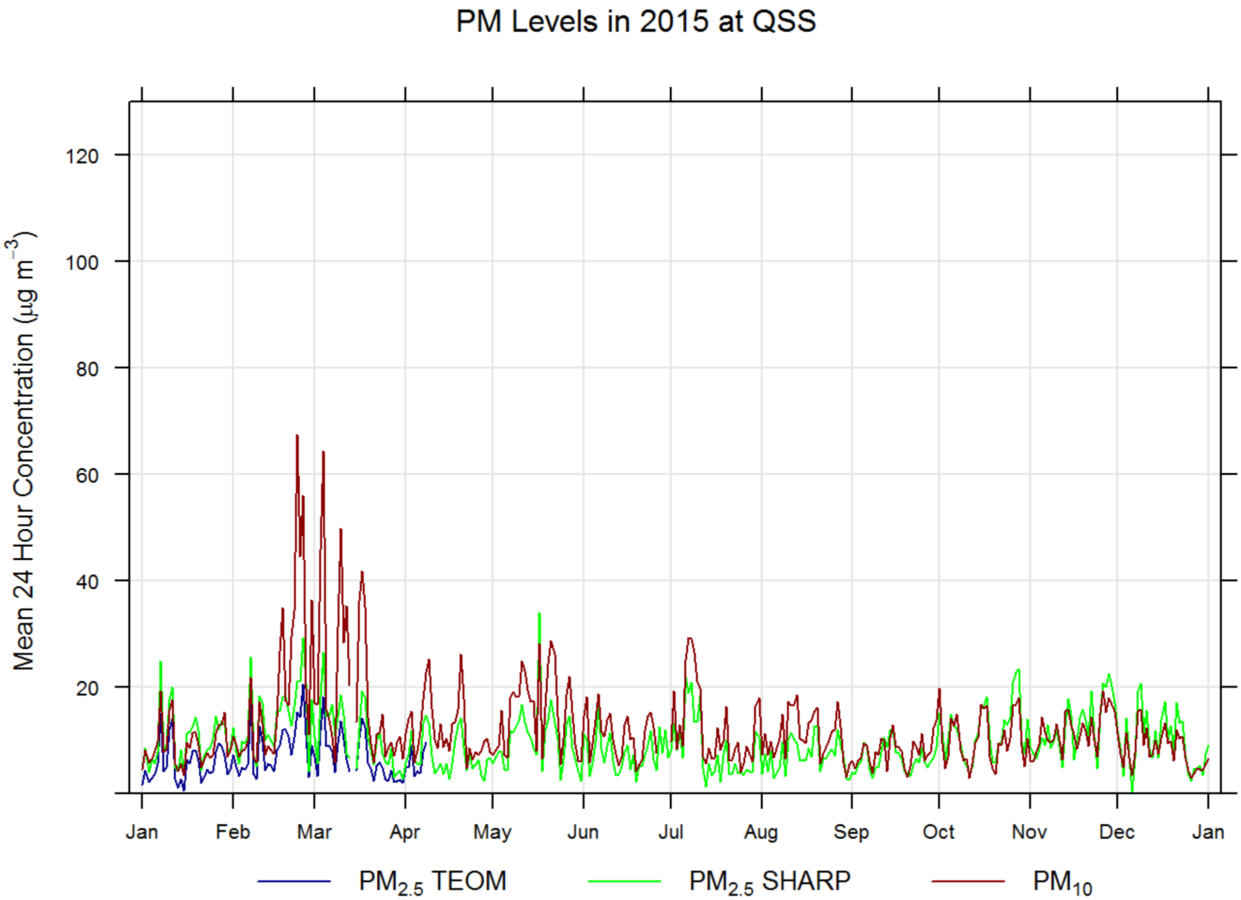

Figure 8: PM 24-hour mean concentrations at the QSS station in 2015. Note the disparity between PM_{10} and $PM_{2.5}$ concentrations in late winter/early spring, suggesting a high proportion of PM_{10} is composed of coarse particles like dust and traction material. Data from 2015 is subject to validation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

3 Recent Trends in $PM_{2.5}$

Mean $PM_{2.5}$ values in Quesnel have been fairly stable since 2004, with the exception of those years impacted by forest fire smoke (2010, 2012 and 2014). Forest fires had a particularly strong influence on air quality in Quesnel in 2010, resulting in a sharp increase in the record. Values increased again in part due to the influence of forest fires in 2014, resulting in the annual provincial objective not being met by TEOM or SHARP instruments at either of the two sampling stations that met data completeness criteria – QSS and MDR (Figure 9). QSS SHARP concentrations decreased from 2014 to 2015, but still exceeded the objective in 2015 despite no apparent forest fire smoke impacts occurring over the summer (Figure 8).

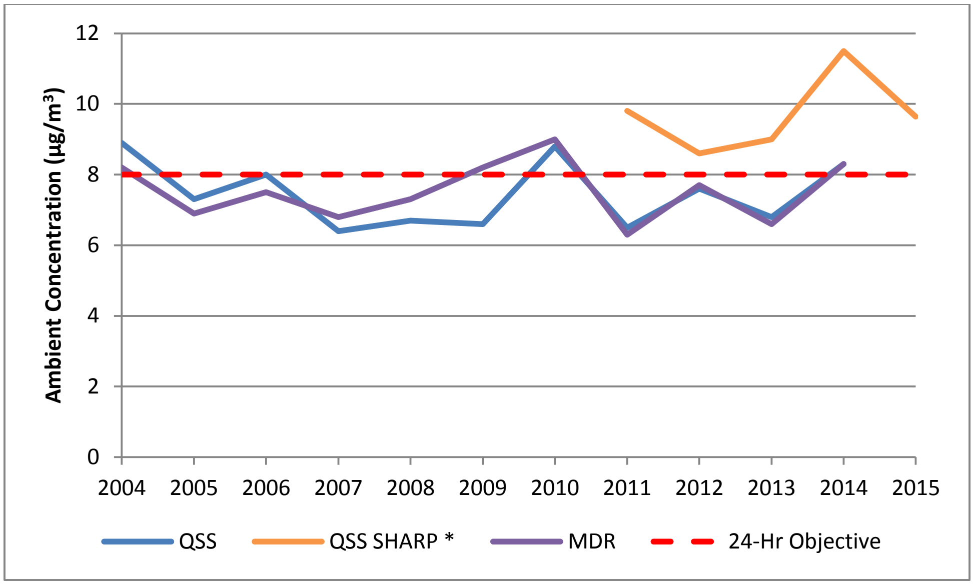

Figure 9: $PM_{2.5}$ Annual Mean Concentrations for the 2004-2014 period.
*** Data completeness criteria were not met by QSS SHARP in 2011 and 2012. QSS SHARP data was only available after 2010. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

The AMP objective for $PM_{2.5}$ (the rolling 3-year average of annual 98th percentiles of daily means) has not been met at the QSS or MDR stations in recent years (Figures 10). The $PM_{2.5}$ 24-hour provincial objective (the 98th percentile of daily means) was met in 2015 by the QSS SHARP, but was not met in 2014 at either station, most likely due to the impact of forest fire smoke (Figure 11). The impact of forest fire smoke in 2010, 2012 and 2014 can be seen more clearly in Figure 11.

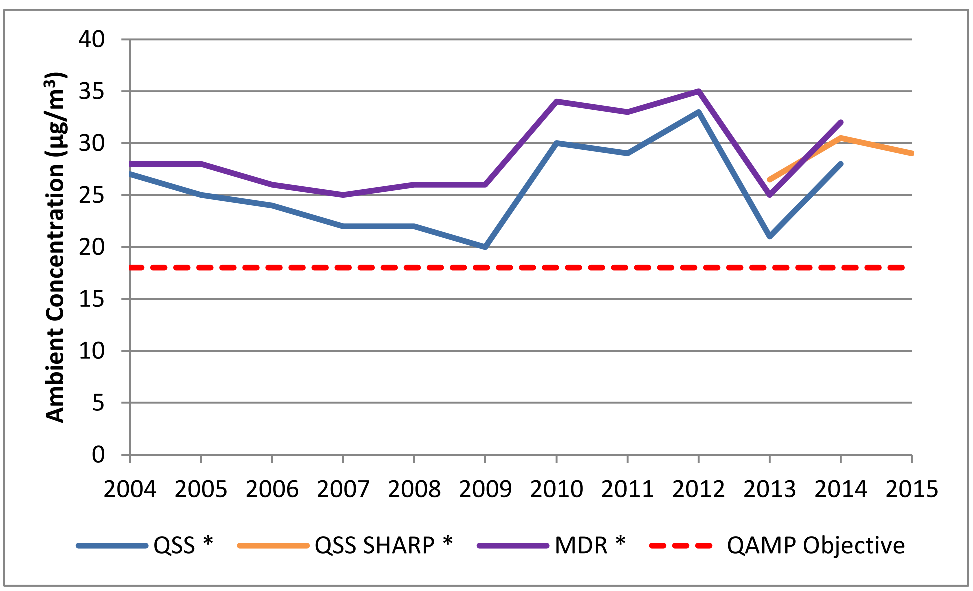

Figure 10: $PM_{2.5}$ Rolling 3-Year Mean of the 98th Percentile for the 2004-2014 period.
*** Data completeness criteria were not met by QSS SHARP in 2011 and 2012. QSS SHARP data was only available after 2010. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

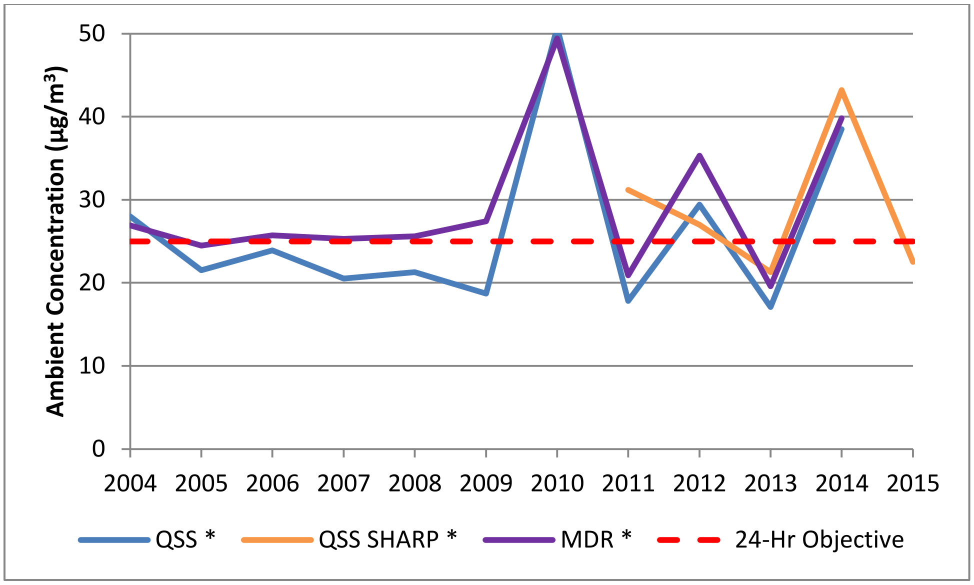

Figure 11: PM$_{2.5}$ 98th Percentile for the years 2004-2014.
*** Data completeness criteria were not met by QSS SHARP in 2011 and 2012. QSS SHARP data was only available after 2010. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

3.1 PM$_{2.5}$ Exceedances

The number of days when the 24-hour average PM$_{2.5}$ concentrations exceeded 25 µg/m^3 can be seen in Figure 12. There was an increase in the number of PM$_{2.5}$ exceedances at all stations in years with heightened forest fire activity in the area (2010, 2012 and 2014). Fewer exceedances occurred in 2011 and 2013 when forest fires had a limited influence on air quality. The Ministry of Environment issues air quality advisories if 24-hour average PM$_{2.5}$ concentrations are expected to exceed 25 µg/m^3.

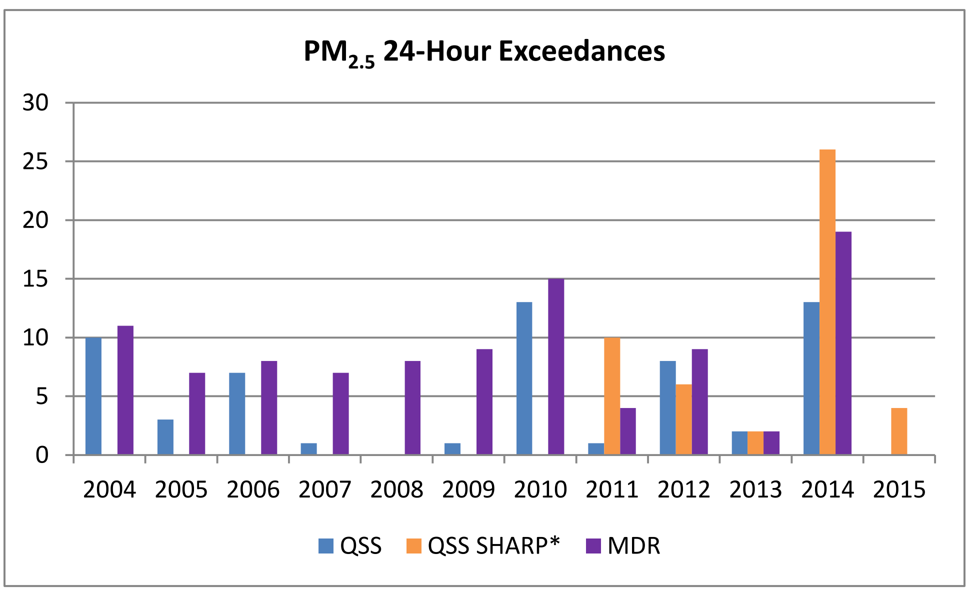

Figure 12: Number of PM$_{2.5}$ exceedances in Quesnel.
*** Data completeness criteria were not met by QSS SHARP in 2011 and 2012. QSS SHARP data was only available after 2010. Data from 2015 is only available for the QSS SHARP, and is subject to validation and may change, though no large changes are anticipated.**

4 Recent Trends in PM_{10}

The AMP goal for PM_{10} was not met at either station in recent years (Figure 13).

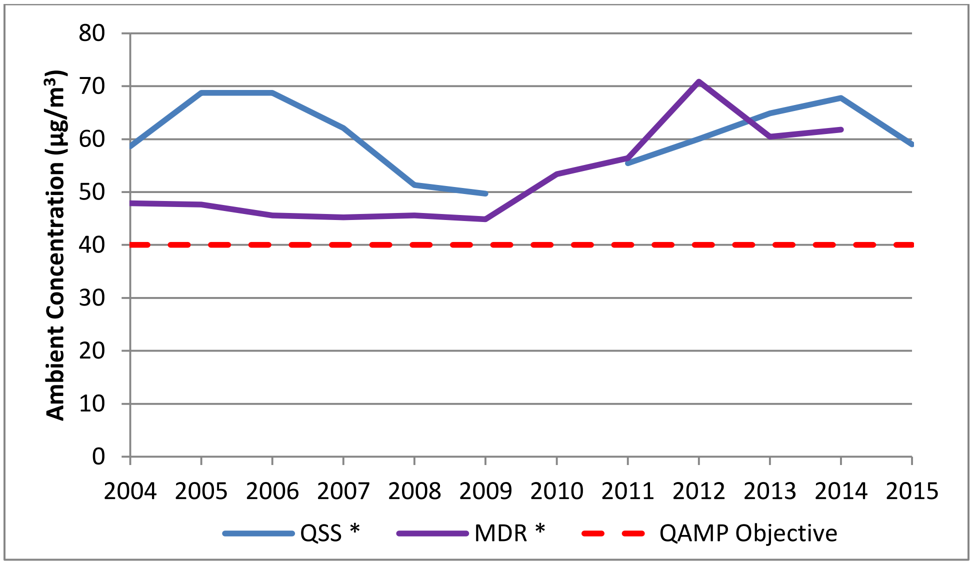

Figure 13: PM_{10} Rolling 3-Year Mean of the 98th Percentile for the 2004-2014 period.
*** Data completeness criteria were not met by QSS in 2009, 2011 and 2012 and MDR in 2014. Data was not available at QSS in 2010. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

Mean PM_{10} values were fairly stable at all stations over the 2004 to 2014 period (Figure 14). Smoke from forest fires likely caused higher PM_{10} levels in 2010, 2012 and 2014, but the impact isn't as clear as with $PM_{2.5}$.

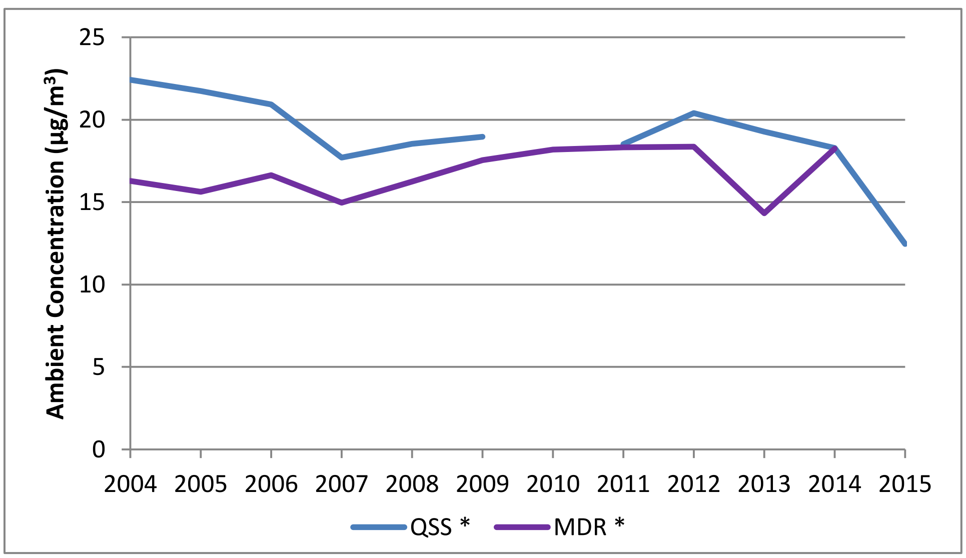

Figure 144: PM_{10} Annual Mean for the 2004-2014 period.
*** Data completeness criteria were not met by QSS in 2009, 2011 and 2012 and MDR in 2014. Data was not available at QSS in 2010 and MDR in 2015. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

4.1 PM_{10} Exceedances

The number of exceedances of the 24-hour provincial PM_{10} objective of 50 µg/m^3 can be seen in Figure 15. There didn't appear to be a clear trend between the QSS and MDR stations. PM_{10} tends to be more heavily influenced by local factors than $PM_{2.5}$, so changes to local conditions, including a decrease in unpaved areas, increased road dust due to low precipitation and nearby construction, can have a significant impact on local PM_{10} levels but little to no impact on a more distant air quality station.

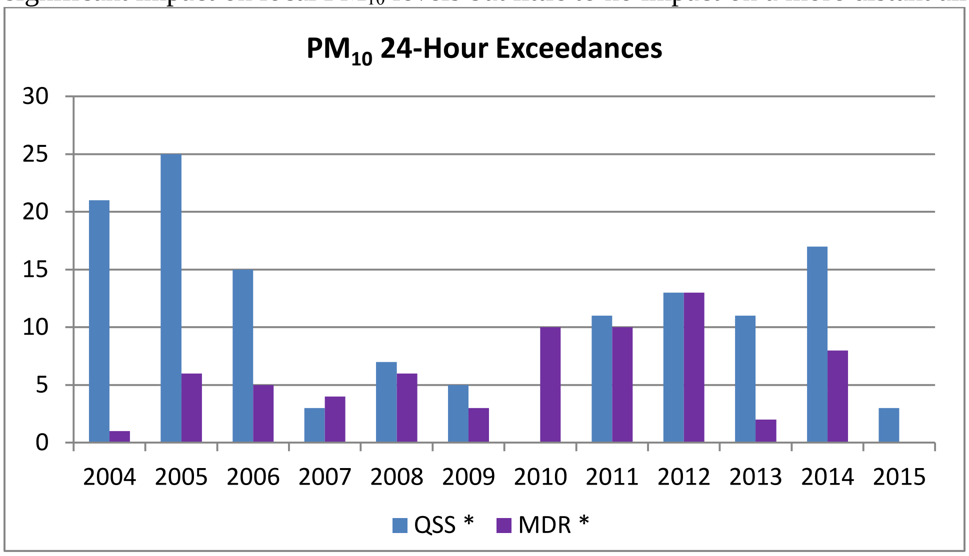

Figure 5: Number of $PM_{2.5}$ exceedances in Quesnel.
*** Data completeness criteria were not satisfied by QSS in 2009, 2011 and 2012 and MDR in 2014. Data was not available at QSS in 2010. Data from 2015 is subject to validation and may change, though no large changes are anticipated.**

In 2015, only three exceedances occurred in late February and early March. Two of the exceedances occurred on February 23rd and 25th following no precipitation reported (by the Environment Canada Quesnel weather station[6]) since February 20th. The other exceedance occurred on March 4th following no precipitation since February 29th. Wind speeds were low and $PM_{2.5}$ made up only a small proportion of total 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.

5 Recommendations/Conclusions

Most non-forest fire related $PM_{2.5}$ exceedances occurred during winter inversion conditions, during which cold temperatures and low wind speeds create stagnant conditions which facilitate the buildup of pollution in ambient air. The MoE will continue to provide advanced notice to stakeholders in Quesnel 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 road surfaces.

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