Air quality management in Nelson – the potential impact of an annual average PM$_{2.5}$ NES
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EXECUTIVE SUMMARY

The Ministry for the Environment is in carrying out a review how particulate matter is managed with particular focus being given to whether PM$_{2.5}$ should be monitored across the country and the value of setting rules for PM$_{2.5}$ and long term exposure. The review arises as a result of a Parliamentary Commission for the Environment Report (2015) report on the state of air quality in New Zealand.

Nelson City Council is in the process of an Air Plan review with priority being given to assessing rule options for wood burners. The objective of this report is to evaluate the possible implications of the introduction of a National Environmental Standard (NES) for annual average PM$_{2.5}$. Compliance with the WHO 24-hour average PM$_{2.5}$ guideline is also considered.

Current World Health Organisation guidelines for PM$_{2.5}$ are 10 µg/m$^3$ (annual average) and 25 µg/m$^3$ (24-hour average, three allowable exceedences). A recent report by WHO recommends a review of the PM$_{2.5}$ guidelines as a result of health impacts literature which suggest a lower long term (annual) guideline may be required.

Monitoring of PM$_{2.5}$ in Nelson is limited to Airshed A. Annual average PM$_{2.5}$ concentrations for each Airshed have been estimated based on PM$_{2.5}$ monitoring data for Airshed A, ratios of PM$_{2.5}$ to PM$_{10}$ and integrating source apportionment data where required. Monitoring of PM$_{2.5}$ for Airsheds B1, B2 and C is required to confirm the estimates. Ongoing monitoring of PM$_{2.5}$ in Airshed A is also recommended to increase certainty around current concentrations.

The assessment does not include an evaluation for worst case year in terms of meteorology.

Annual average PM$_{2.5}$

Results suggest Airshed A and Airshed B1 are unlikely to comply with the existing WHO guideline for annual average PM$_{2.5}$ (10 µg/m$^3$). Airsheds B2 and C are likely to comply with the existing WHO annual average guideline for PM$_{2.5}$. If the guideline were reduced to 8 µg/m$^3$ Airsheds A, B1 and B2 are all likely to be non-compliant. Airshed C may be compliant.

In Airshed A, domestic heating within the Airshed is likely to contribute around 42% of the annual average PM$_{10}$ concentrations and around 65% of the annual average PM$_{2.5}$ concentrations. A further 8% of the PM$_{2.5}$ concentrations are likely to arise from domestic heating emissions in other Airsheds. The next largest contributor to annual average PM$_{2.5}$ concentrations is estimated to be natural sources at 15%. Domestic heating would therefore need to be the focus of any reduction in PM$_{2.5}$ concentrations to meet an annual average concentration of 10 µg/m$^3$.

In Airshed B1 domestic heating is estimated to contribute around 22% (including other Airshed contributions) of the annual average PM$_{10}$ and 38% of the annual average PM$_{2.5}$ concentrations. In this Airshed industry is estimated to be the main contributor to annual average concentrations for both PM$_{10}$ and PM$_{2.5}$ based on a mass emissions approach. However, this does not account for the increased dispersion associated with some industrial sources and it is there likely that the industry contribution is overestimated. Monitoring is recommended to confirm PM$_{2.5}$ concentrations as there is more uncertainty with the method of estimation in this Airshed.

In Airshed A, a reduction in PM$_{10}$ concentrations is required to meet the current NES for PM$_{10}$ (24-hour average, one allowable exceedance). If PM$_{10}$ concentrations are reduced by 14% it is likely that the annual average PM$_{2.5}$ concentrations would reduce to below 10 µg/m$^3$. However, more monitoring is recommended to increase certainty around current annual average PM$_{2.5}$ concentrations.

In Airshed B1 it is likely that the 24-hour average PM$_{10}$ concentrations already meet the NES for PM$_{10}$. The estimate of annual average PM$_{2.5}$ concentration for this Airshed is 12 µg/m$^3$ and was estimated based on subtracting coarse fraction sources from PM$_{10}$ concentrations. Reductions in PM$_{10}$ concentrations associated with the natural attrition replacement of older burners is unlikely to reduce annual PM$_{2.5}$ concentrations by sufficient amounts to achieve an annual standard of 10 µg/m$^3$ for PM$_{2.5}$.
24-hour average PM$_{2.5}$

Airsheds A and B1 are unlikely to comply with a 24-hour average PM$_{2.5}$ standard with reductions of around 20-30% in Airshed A and possibly up to around 15% in Airshed B1 to achieve compliance. Airshed B2 may be compliant although monitoring is required to confirm this. It is likely that Airshed C would comply with a 24-hour average PM$_{2.5}$ standard of 25 µg/m$^3$.

Recommendations

1. It is recommended that priority be given to monitoring of PM$_{2.5}$ in Airshed B1 and that the monitoring period include both seasons to enable calculation of annual average concentrations. A one it two day sampling regime should suffice while monitoring is investigative.

2. Investigative monitoring of PM$_{2.5}$ in Airshed A should continue to confirm existing annual average concentrations. A one day in two sampling regime should suffice. Continuous monitoring (every day) may be required in the future if a PM$_{2.5}$ NES is introduced and the Airshed is found to be non-compliant.

3. Investigative monitoring of PM$_{2.5}$ would also be required in Airsheds B2 and C (e.g., for two years in each location depending on results) if an NES for PM$_{2.5}$ was established.
TABLE OF CONTENTS

1 Introduction .......................................................................................................................................................... 7
  1.1 WHO guidelines and recommendations for PM10 and PM2.5 ................................................................. 8

2 PM10 and PM2.5 monitoring ............................................................................................................................. 9

3 Airshed A .......................................................................................................................................................... 10
  3.1 Annual average PM2.5 concentrations ........................................................................................................ 10
  3.2 Comparison of annual average concentrations to WHO guidelines ......................................................... 11
  3.3 24-hour average PM2.5 concentrations ....................................................................................................... 11
  3.4 Comparison of 24-hour average PM2.5 concentrations to WHO guidelines .............................................. 12

4 Airshed B1 ...................................................................................................................................................... 13
  4.1 Annual average PM2.5 concentrations ........................................................................................................ 13
  4.2 Comparison of annual average concentrations to WHO guidelines ......................................................... 13
  4.3 24-hour average PM2.5 concentrations ....................................................................................................... 14
  4.4 Comparison of 24-hour average PM2.5 concentrations to WHO guidelines .............................................. 14

5 Airshed B2 ...................................................................................................................................................... 15
  5.1 Annual average PM2.5 concentrations ........................................................................................................ 15
  5.2 Comparison of annual average concentrations to WHO guidelines ......................................................... 15
  5.3 24-hour average PM2.5 concentrations ....................................................................................................... 15
  5.4 Comparison of 24-hour average PM2.5 concentrations to WHO guidelines .............................................. 16

6 Airshed C ....................................................................................................................................................... 17
  6.1 Annual average PM2.5 concentrations ........................................................................................................ 17
  6.2 Comparison of annual average concentrations to WHO guidelines ......................................................... 17
  6.3 24-hour average PM2.5 concentrations ....................................................................................................... 17
  6.4 Comparison of 24-hour average PM2.5 concentrations to WHO guidelines .............................................. 18

7 Domestic heating contribution .......................................................................................................................... 19
  7.1 Airshed A ..................................................................................................................................................... 19
  7.2 Airshed B1 .................................................................................................................................................. 19

8 Impact of management options on annual average PM2.5 ............................................................................ 21
  8.1 Impact of reductions in 24-hour average PM10 on annual average PM2.5 concentrations ...................... 21
  8.2 Impact of allowing new installations of burners in Airshed B2 and C on annual average PM2.5 concentrations .......................................................................................................................... 21

9 Summary ......................................................................................................................................................... 22

10 References ....................................................................................................................................................... 23

Appendix A: Distribution in PM10 emissions across Airsheds ............................................................................ 24
1 INTRODUCTION

A 2015 review of the state of air quality in New Zealand by the Parliamentary Commissioner for the Environment recommended that the Minister for the Environment review how particulate matter is managed with particular focus being given to whether PM$_{2.5}$ should be monitored across the country and the value of setting rules for PM$_{2.5}$ and long term exposure. The focus on PM$_{2.5}$ and annual average exposure is consistent with a recent WHO report (World Health Organization, 2013) which places priority on annual average exposure and indicates that it is likely that WHO would review both short and long term guidelines for PM$_{2.5}$ and potentially for PM$_{10}$.

A PM$_{2.5}$ standard or guideline was not included for New Zealand in the National Environmental Standard because it was proposed that management of PM$_{10}$ to meet the NESAQ would result in reductions in concentrations of PM$_{2.5}$ and because it was argued that the coarse fraction did result in health impacts. This management by proxy position is unlikely to be considered robust in terms of future reviews of New Zealand guidelines and standards given the increased evidence with respect to long term exposures and impacts of PM$_{2.5}$.

The Nelson City Council’s Air Plan became operative in 2008. The Plan included management measures targeting domestic home heating as the main source of winter time breaches of the National Environmental Standard (NES) for PM$_{10}$. The plan aimed to reduce PM$_{10}$ concentrations in Nelson’s Airshed A by 70% and in other Airsheds by lesser amounts. The measures included in the Air Plan were:

i. A ban on outdoor rubbish burning from 2004

ii. Emission limits for new installations of solid fuel burners of 1.5 g/kg and an energy efficiency of 65% (when tested to NZS 4013).

iii. A ban on the use of open fires from January 2008.

iv. A ban on the installation of solid fuel burners in new dwellings or existing dwellings using other heating methods from November 2008.

v. Airshed A and B1 - staged phase out of older burners from 2010, 2011 and 2013. The latter phase out date of wood burners installed between 2000 and 2003 was withdrawn following 2011 revisions to the NES. This resulted in approximately 120 burners in Airshed A which did not get phased out and for which no legislative replacement date currently exists.


An evaluation of the effectiveness of the Air Plan in reducing PM$_{10}$ concentrations in Nelson to meet the NES was carried out in 2014 (Wilton, 2014). Results suggested significant reductions in concentrations in Airshed A and B1 where concentrations in breach of the NES historically occurred. Additional reductions in 2014 levels of around 14% are likely to be required for ongoing compliance with the NES in Airshed A (Wilton & Zawar Reza, 2014).

Nelson City Council are in the process of an Air Plan review. Understanding the relationship between sources of 24-hour average PM$_{10}$ concentrations and annual average PM$_{2.5}$ concentrations will enable the Council to more effectively manage air quality.

Depending on the contributions of natural sources to PM$_{10}$ events, it is likely that many urban areas would require more stringent management to reach a guideline of 25 µg/m$^3$ for PM$_{2.5}$ (as recommended in WHO (2006) than to reach a target of 50 µg/m$^3$ for PM$_{10}$. However, if an annual average PM$_{2.5}$ standard alone is adopted it may influence the extent of focus on required on solid fuel burning for domestic home heating. An understanding of the relationship between the contribution of domestic heating to a 24-hour average PM$_{10}$ standard relative to an annual average PM$_{2.5}$ standard is necessary to future proof the outcomes of the Air Plan Review.

The objectives of this study are to advise NCC on:

- The likely annual average PM$_{2.5}$ concentrations in Nelson relative to existing and possible future WHO annual average PM$_{2.5}$ guidelines.
- The likely relative contribution of domestic heating to annual average PM$_{2.5}$ concentrations in Nelson.
The likely implications of a 24-hour average NES for PM$_{2.5}$ (relative to the existing PM$_{10}$ NES) in Nelson based on the current WHO value of 25 µg/m$^3$.

The likely implications of an annual average NES for PM$_{2.5}$ (relative to the existing 24-hour average PM$_{10}$ NES) in Nelson based on the current WHO value of 10 µg/m$^3$.

The likely impact of management measures to reduce 24-hour average PM$_{10}$ concentrations to meet the NES in Airshed A and B1 on annual average PM$_{2.5}$ concentrations.

The likely impact of allowing installations of solid fuel burners in new houses and existing dwellings currently using other heating methods in Airshed B2 and C on annual average PM$_{2.5}$ concentrations.

1.1 WHO guidelines and recommendations for PM$_{10}$ and PM$_{2.5}$

The World Health Organisation (WHO) is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends ("World Health Organisation," 2014).

The current WHO guidelines are:

- PM$_{10}$ - 50 µg m$^{-3}$ (24-hour average, three allowable exceedences) and 20 µg m$^{-3}$ annual average.
- PM$_{2.5}$ - 25 µg m$^{-3}$ (24-hour average, three allowable exceedences) and 10 µg m$^{-3}$ (annual average) (World Health Organization, 2006).

Technical supporting documentation indicates that particulate is considered a no threshold contaminant (there is no safe threshold) and that there is insufficient evidence for policy differentiation based on composition.

In 2013 the WHO conducted a review of evidence for air quality guidelines. The review identified new health outcomes associated with exposure to particulate concentrations, additional support for other health outcomes and makes recommendations that WHO review both short and long term guidelines for PM$_{2.5}$ and potentially for PM$_{10}$. 


2 PM\textsubscript{10} AND PM\textsubscript{2.5} MONITORING

Air quality in Nelson is managed based on four areas referred to as Airsheds. Figure 2.1 shows the boundaries of the existing Airsheds within Nelson. The distribution of emissions within these Airsheds is shown in Appendix A. Air quality monitoring for PM\textsubscript{10} has been carried out in Airshed A using continuous monitoring since 2001 and in Airshed B1 since 2005. Air quality monitoring of PM\textsubscript{2.5} using gravimetric sampling based on a one day in six sampling regime has been carried out in Airshed A since 2008.

![Air Sheds](image)

**Figure 2-1: Nelson Airshed Areas**

Monitoring of PM\textsubscript{10} in Airsheds B2 and C has been intermittent with monitoring conducted in 2010 and 2015 in Airshed B2 and 2008, 2009, 2014 and 2015 in Airshed C. Monitoring was also carried out at a range of locations in Airshed B2 and C in the early 2000s.

An additional study of value when considering the contribution of PM\textsubscript{10} and PM\textsubscript{2.5} and sources was a receptor modelling apportionment study carried out in Airshed A (Ancelet, Davy, & Trompetter, 2013) from 2008 to 2012 and in Airshed B1 (Ancelet, Davy, Trompetter, & Markwitz, 2010) in 2008 and 2009. The study in Airshed A included by the PM\textsubscript{10} and PM\textsubscript{2.5} size fraction and is of value in illustrating the impact of natural sources within both size fractions. For PM\textsubscript{10} a greater contribution from natural sources is expected because of the nature of the mechanism of formation. In Airshed A the average contribution of marine aerosol and soil/ dust to PM\textsubscript{10} was found to be around 6.6 µg/m\textsuperscript{3} for a sampling period from May to September. In comparison the contribution of the same sources to PM\textsubscript{2.5} concentrations was found to be 1.2 µg/m\textsuperscript{3} on average. Because the majority of other sources of PM\textsubscript{10} lie within the PM\textsubscript{2.5} size fraction, the relative contribution of natural source contributions to PM\textsubscript{2.5} concentrations is lower than for PM\textsubscript{10} concentrations. It would therefore be expected that anthropogenic sources of particulate such as domestic heating and motor vehicles would have a greater proportional contribution to annual average PM\textsubscript{2.5} than annual average PM\textsubscript{10}.

In Airshed B2 the receptor modelling study focused only on the PM\textsubscript{10} size fraction. Two additional industry related sources (fertiliser and surface coating) were identified in this Airshed and were found to contribute 13% of the PM\textsubscript{10} (Ancelet et al., 2010). These contributions are most likely to be in the coarse mode (PM\textsubscript{10\\textsubscript{2.5}}) owing to the mechanisms of formation. Marine aerosol was found to contribute 18% and soil 16% of the PM\textsubscript{10} over the duration of the sampling.
3 AIRSHED A

3.1 Annual average PM$_{2.5}$ concentrations

Monitoring of PM$_{2.5}$ has been carried out in Airshed A using a gravimetric one day in six sampling regime since 2008 at the St Vincent Street air quality monitoring site. An estimate of the likely annual average PM$_{2.5}$ concentration per year from 2008 to 2014 has been made for Airshed A using the following methodology. No PM$_{2.5}$ data were available for 2015 at the time this report was prepared.

For all years except 2013

Annual average PM$_{2.5}$ and PM$_{10}$ concentrations were estimated based on seasonally adjusted concentrations for PM$_{2.5}$ sample days. A ratio of PM$_{2.5}$ to PM$_{10}$ was established based on these data. The annual average PM$_{10}$ (all sample days) was multiplied by the PM$_{2.5}$ to PM$_{10}$ ratio for that year to give an annual average PM$_{2.5}$ concentration.

For 2013

Sample days for PM$_{2.5}$ during 2013 were limited to only eight samples for the whole of winter and 22 samples for non-winter months. Estimates of annual average concentrations of PM$_{2.5}$ were made for 2013 based on PM$_{10}$ data using the following ratios:

- May – August – 86% (based on median annual ratio)
- Other months – 54% (based on median annual ratio)

Table 3.1 compares the annual average PM$_{2.5}$ and PM$_{10}$ concentrations as well as the seasonal relationships and differences between data and existing WHO guidelines or NES for Airshed A. This shows the winter concentrations of PM$_{2.5}$ are much higher (22–40 µg/m$^3$) than the concentrations during the non-winter months (5-7 µg/m$^3$). Winter concentrations of PM$_{2.5}$ are likely to have reduced from 36-40 µg/m$^3$ around 2008 and 2009 to around 22-23 µg/m$^3$ during 2013-2014. Based on the ratio of PM$_{2.5}$ to PM$_{10}$ for 2008 (75%) the annual average PM$_{2.5}$ concentration for 2001 is likely to have been around 26 µg/m$^3$. Estimated annual average PM$_{2.5}$ concentrations for 2014 exceed the annual WHO guideline for PM$_{2.5}$ of 10 µg/m$^3$. Data for PM$_{10}$ for 2015 suggest an annual average PM$_{2.5}$ concentration is likely to be more similar to 2013 than 2014. The assessment does not include an evaluation for worst case year in terms of meteorology.

Table 3.1: Summary PM$_{10}$ and estimated PM$_{2.5}$ data for Airshed A

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</thead>
<tbody>
<tr>
<td>Annual average PM$_{2.5}$ (estimated)</td>
<td>16</td>
<td>17</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>12.5</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Annual average PM$_{10}$</td>
<td>21</td>
<td>22</td>
<td>18</td>
<td>18</td>
<td>17</td>
<td>18</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Average winter PM$_{2.5}$ (µg/m$^3$)</td>
<td>36</td>
<td>40</td>
<td>28</td>
<td>27</td>
<td>26</td>
<td>24</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Average (non-winter) PM$_{2.5}$ (µg/m$^3$)</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Reduction to meet annual average PM$_{2.5}$ of 10 µg/m$^3$</td>
<td>37%</td>
<td>40%</td>
<td>23%</td>
<td>21%</td>
<td>22%</td>
<td>20%</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Second highest PM$_{10}$ (24-hour average)</td>
<td>69</td>
<td>77</td>
<td>58</td>
<td>64</td>
<td>53</td>
<td>58</td>
<td>52</td>
<td>49</td>
</tr>
<tr>
<td>Reduction to meet 24-hour average PM$_{10}$ of 50 µg/m$^3$</td>
<td>28%</td>
<td>35%</td>
<td>14%</td>
<td>22%</td>
<td>6%</td>
<td>14%*</td>
<td>4%*</td>
<td>0%*</td>
</tr>
</tbody>
</table>

Winter = May to August

*note that the reduction required in 2014 PM$_{10}$ concentrations to meet this limit has been estimated at 14% based on worst case meteorology to date.
** data from January to April only

The percentage reduction in concentrations required for the annual average PM$_{2.5}$ concentration to meet a limit of 10 µg/m$^3$ (WHO current annual average guideline) and the second highest daily PM$_{10}$ concentration to meet the existing NES limit for New Zealand (50 µg/m$^3$ 24-hour average) is also shown in Table 3.1.

It is also worth noting that there is a difference in the way year to year variability in meteorological conditions impacts on these two different exposure periods. For the 24-hour average the influencing factor is the extent of impact of meteorology on a given day. That is, how low the wind speeds are and how stable the lower atmosphere whereas for the annual average the frequency of calm stable conditions is a key variable.

### 3.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM$_{10}$ is 20 µg/m$^3$. Monitoring data from St Vincent Street shows Airshed A has been compliant with this guideline since 2010.

The WHO annual average guideline for PM$_{2.5}$ is 10 µg/m$^3$. Recent annual average PM$_{2.5}$ concentrations have been estimated at around 11-13 µg/m$^3$.

Airshed A is unlikely to comply with the current WHO annual average PM$_{2.5}$ guideline and potential future reductions in this guideline would further limit compliance.

Data suggests the reduction required to meet an annual average PM$_{2.5}$ guideline (9-20%) in Airshed A is greater than required to meet the current NES for PM$_{10}$ (24-hour average of 50 µg/m$^3$) which has been estimated at around 14% (Wilton & Zawar Reza, 2014).

### 3.3 24-hour average PM$_{2.5}$ concentrations

Table 3.2 compares the measured daily maximum, second and third highest PM$_{2.5}$ concentrations to the WHO guidelines for 24-hour average PM$_{2.5}$. Note that PM$_{2.5}$ monitoring is carried out on a limited sampling frequency. The current WHO guideline for 24-hour PM$_{2.5}$ allows three exceedences per year. Because of missing data owing to the sampling regime the fourth highest measured concentration per year (which would be indicative of the reduction required for compliance) is unlikely to be represent the appropriate value for determining compliance. The second highest concentrations would provide a better indication of the likely values from which concentrations would have to be reduced.

<table>
<thead>
<tr>
<th>Table 3.2: Summary PM$_{2.5}$ daily concentrations for Airshed A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum measured PM$_{2.5}$ (24-hour average)</strong></td>
</tr>
<tr>
<td>Difference compared to 24-hour average PM$_{2.5}$ of 25 µg/m$^3$</td>
</tr>
<tr>
<td><strong>Second highest PM$_{2.5}$ (24-hour average)</strong></td>
</tr>
<tr>
<td>Difference compared to 24-hour average 25 µg/m$^3$</td>
</tr>
<tr>
<td><strong>Third highest PM$_{2.5}$ (24-hour average)</strong></td>
</tr>
<tr>
<td>Difference compared to 24-hour average 25 µg/m$^3$</td>
</tr>
<tr>
<td>Reduction to meet current PM$_{10}$</td>
</tr>
</tbody>
</table>
3.4 Comparison of 24-hour average PM$_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for PM$_{2.5}$ is 25 µg/m$^3$. Recent 24-hour average PM$_{2.5}$ concentrations likely to represent the fourth highest concentrations$^1$ per year are around 30-40 µg/m$^3$.

Airshed A doesn’t comply with the current WHO 24-hour average PM$_{2.5}$ WHO guideline and potential future reductions in this guideline would further limit compliance.

Data suggests the reduction required to meet a 24-hour average PM$_{2.5}$ guideline in Airshed A is greater than required to meet the current NES for PM$_{10}$ (24-hour average of 50 µg/m$^3$) which has been estimated at around 14% (Wilton & Zawar Reza, 2014).

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$^1$ The fourth highest concentration represents compliance or otherwise with a guideline in an instance where there are three permitted exceedences.
4 AIRSHED B1

4.1 Annual average PM$_{2.5}$ concentrations

No monitoring for PM$_{2.5}$ has been carried out in Airshed B1. Using the ratio of PM$_{2.5}$ to PM$_{10}$ from Airshed A is unlikely to give a good representation for Airshed B1 owing to the differences in sources and the higher contribution of soil and marine aerosol in Airshed B1.

Estimates of annual average concentrations of PM$_{2.5}$ were therefore made for 2008 to 2014 by subtracting from the PM$_{10}$ the monthly average source apportionment concentrations for dusts and marine aerosol from the 2008/2009 study period (excluding the small contribution in the finer PM$_{2.5}$ size fraction) and by subtracting the proportional contribution of industrial sources (fertiliser and surface coatings) identified in the source apportionment study for Tahunanui (Ancelet et al., 2010). Note that the method is indicative only and that actual monitoring of PM$_{2.5}$ should be carried out to determine compliance or otherwise with any PM$_{2.5}$ guidelines or standards.

Table 4.1 shows the estimated annual average PM$_{2.5}$ as well as the differences between these data and existing WHO guidelines or NES for Airshed B1. The percentage reduction in concentrations required for the annual average PM$_{2.5}$ concentration to meet a limit of 10 µg/m$^3$ (WHO current annual average guideline) and for the second highest daily PM$_{10}$ concentration to meet the existing NES limit for New Zealand (50 µg/m$^3$ 24-hour average) is also shown in Table 4.1.

Table 4.1: Summary PM$_{10}$ and estimated PM$_{2.5}$ data for Airshed B1

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<td>Annual average PM$_{2.5}$ (estimated)</td>
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<td>Annual average PM$_{10}$</td>
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<td>17</td>
<td>20</td>
<td>21</td>
<td>20</td>
<td>19*</td>
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<tr>
<td>Reduction to meet annual average PM$_{2.5}$ of 10 µg/m$^3$</td>
<td>26%</td>
<td>24%</td>
<td>4%</td>
<td>8%</td>
<td>15%</td>
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<td>1%</td>
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<tr>
<td>Second highest PM$_{10}$ (24-hour average)</td>
<td>57</td>
<td>60</td>
<td>48</td>
<td>48</td>
<td>52</td>
<td>43</td>
<td>50</td>
<td>42</td>
</tr>
<tr>
<td>Reduction to meet 24-hour average PM$_{10}$ NES of 50 µg/m$^3$</td>
<td>12%</td>
<td>17%</td>
<td>4%</td>
<td>0%</td>
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*incomplete data – indicative only

4.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM$_{10}$ is 20 µg/m$^3$. Data suggests Airshed B1 is probably non-compliant with this guideline although further monitoring it recommended.

The WHO annual average guideline for PM$_{2.5}$ is 10 µg/m$^3$. Recent annual average PM$_{2.5}$ concentrations have been estimated at around 10-12 µg/m$^3$ although the data are indicative only and it is possible that Airshed B1 is compliant with the current WHO guideline for PM$_{2.5}$.

Data suggests the 24-hour average PM$_{10}$ concentrations in Airshed B1 are probably compliant with the NES for PM$_{10}$. 
4.3 24-hour average PM\textsubscript{2.5} concentrations

The highest daily 24-hour average PM\textsubscript{2.5} concentrations were estimated using PM\textsubscript{10} data for Airshed B1 and assuming a winter ratio of PM\textsubscript{2.5} to PM\textsubscript{10} of 0.8. The ratio was determined using the PM\textsubscript{10} source apportionment data for the highest concentrations days. On these days marine aerosol and soil contributed 12% and fertiliser and surface coatings 8% of the daily PM\textsubscript{10}. All other sources of PM\textsubscript{10} were assumed to be within the fine (PM\textsubscript{2.5} size fraction). Table 4.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) PM\textsubscript{2.5} concentration per year for Airshed B1 based on the PM\textsubscript{10} data. This suggests the Airshed would be in breach of a daily guideline for PM\textsubscript{2.5} of 25 µg/m\textsuperscript{3}.

Table 4.2: Estimated/ indicative PM\textsubscript{2.5} daily concentrations for Airshed B1

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth highest PM\textsubscript{10} µg/m3</td>
<td>56</td>
<td>57</td>
<td>41</td>
<td>44</td>
<td>48</td>
<td>42</td>
<td>48</td>
</tr>
<tr>
<td>Estimated fourth highest PM\textsubscript{2.5} (24-hour average)</td>
<td>45</td>
<td>46</td>
<td>33</td>
<td>35</td>
<td>38</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Difference compared to 24-hour average PM\textsubscript{2.5} of 25 µg/m3</td>
<td>48%</td>
<td>49%</td>
<td>24%</td>
<td>31%</td>
<td>38%</td>
<td>26%</td>
<td>38%</td>
</tr>
<tr>
<td>Reduction to meet current PM\textsubscript{10} NES</td>
<td>21%</td>
<td>12%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
</tr>
</tbody>
</table>

4.4 Comparison of 24-hour average PM\textsubscript{2.5} concentrations to WHO guidelines

The WHO 24-hour average guideline for PM\textsubscript{2.5} is 25 µg/m\textsuperscript{3}. It is likely that PM\textsubscript{2.5} concentrations in Airshed B1 are around 30- 40 µg/m\textsuperscript{3} for the fourth highest concentrations (with the first three highest concentrations being allowed).

It is likely that Airshed B1 doesn’t comply with the current WHO 24-hour average PM\textsubscript{2.5} WHO guideline and potential future reductions in this guideline would further limit compliance.

Data suggests a reduction of around 26-38% would be required to meet a 24-hour average PM\textsubscript{2.5} guideline of 25 µg/m\textsuperscript{3} in Airshed B1.
5 AIRSHED B2

5.1 Annual average PM$_{2.5}$ concentrations

No monitoring for PM$_{2.5}$ has been carried out in Airshed B2 and PM$_{10}$ monitoring has been limited to the winter months only. Thus estimation of an annual average PM$_{2.5}$ concentration would be indicative only.

Estimates of annual average concentrations of PM$_{2.5}$ were made for 2010 and 2015 by multiplying winter concentrations of PM$_{10}$ by a ratio of 86% (median ratios for Airshed A) and using an average summertime PM$_{10}$ concentration of 5.5 µg/m$^3$ (Airshed A PM$_{10}$ monitoring data for 2015 adjusted for PM$_{2.5}$ ratio). Airshed A ratios were used because the relative contributions of sources are similar in Airshed B2 to Airshed A. Summer PM$_{2.5}$ concentrations from Airshed A were used in the absence of any other Airshed data on summer concentrations of PM$_{2.5}$.

Table 5.1 shows the estimated annual average PM$_{2.5}$ for Airshed B2. This suggests PM$_{2.5}$ may be compliant with the WHO annual average guideline for PM$_{2.5}$ in Airshed B2. Monitoring of PM$_{2.5}$ in this Airshed would be required to confirm this as there are a number of assumptions used.

Table 5.1: Summary PM$_{10}$ and estimated PM$_{2.5}$ data for Airshed B2

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average PM$_{2.5}$ (estimated)</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Annual average PM$_{10}$</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Reduction to meet annual average PM$_{2.5}$ of 10 µg/m$^3$</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>Second highest PM$_{10}$ (24-hour average)</td>
<td>40</td>
<td>29</td>
</tr>
<tr>
<td>Reduction to meet 24-hour average PM$_{10}$ NES of 50 µg/m$^3$</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

5.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM$_{10}$ is 20 µg/m$^3$. Data suggests Airshed B2 is likely to be compliant with this guideline.

The WHO annual average guideline for PM$_{2.5}$ is 10 µg/m$^3$. Data for 2015 suggests Airshed B2 is compliant with this guideline. However, a number of assumptions are used in the estimated concentrations and monitoring to clarify is recommended.

5.3 24-hour average PM$_{2.5}$ concentrations

Daily winter concentrations of PM$_{2.5}$ were estimated for 2010 and 2015 using a ratio of PM$_{2.5}$ to PM$_{10}$ of 0.86 based on the Airshed A wintertime relationship between the two size fractions.

Table 3.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) PM$_{2.5}$ concentration per year for Airshed B2 based on the PM$_{10}$ data. This suggests the Airshed may comply with a daily guideline for PM$_{2.5}$ of 25 µg/m$^3$. 
Table 5.2: Estimated/indicative PM$_{2.5}$ daily concentrations for Airshed B2

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth highest PM10 µg/m3</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Estimated fourth highest PM$_{2.5}$ (24-hour average)</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>Difference compared to 24-hour average PM$_{2.5}$ of 25 µg/m3</td>
<td>17%</td>
<td></td>
</tr>
<tr>
<td>Reduction to meet current PM$_{10}$ NES</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

5.4 Comparison of 24-hour average PM$_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for PM$_{2.5}$ is 25 µg/m$^3$. It is possible that Airshed B2 complies with this guideline. Monitoring is recommended to confirm should a PM$_{2.5}$ standard be introduced.
6 AIRSHED C

6.1 Annual average PM$_{2.5}$ concentrations

No monitoring for PM$_{2.5}$ has been carried out in Airshed C. As with Airshed B2 an estimate of indicative PM$_{2.5}$ concentrations was made using the ratio of PM$_{2.5}$ to PM$_{10}$ from Airshed A.

Estimates of annual average concentrations of PM$_{2.5}$ were made for 2008, 2009 and 2015 by multiplying winter concentrations of PM$_{10}$ by a ratio of 86% (median ratios for Airshed A). Airshed A ratios were used because the relative contributions of sources are similar in Airshed C to Airshed A with domestic heating dominating the winter contribution. Summer PM$_{2.5}$ concentrations from the months January to April 2015 were used to estimate the average non May to August PM$_{10}$ and PM$_{2.5}$ concentrations for the years 2008 and 2009.

Table 6.1 shows the estimated annual average PM$_{2.5}$ concentration for Airshed C. This suggests PM$_{2.5}$ is likely to be compliant with the WHO annual average guideline for PM$_{2.5}$ in Airshed C. Monitoring of PM$_{2.5}$ in this Airshed is recommended should an annual average guideline or standard be introduced.

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average PM$_{2.5}$ (estimated)</td>
<td>9</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Annual average PM$_{10}$</td>
<td>13</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Reduction to meet annual average PM$_{2.5}$ of 10 µg/m$^3$</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Second highest PM$_{10}$ (24-hour average)</td>
<td>35</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>Reduction to meet 24-hour average PM$_{10}$ NES of 50 µg/m$^3$</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

6.2 Comparison of annual average concentrations to WHO guidelines

The WHO annual average guideline for PM$_{10}$ is 20 µg/m$^3$. Data suggests Airshed C is likely to be compliant with this guideline.

The WHO annual average guideline for PM$_{2.5}$ is 10 µg/m$^3$. Estimated annual average concentrations of PM$_{2.5}$ are 8-9 µg/m$^3$ and it is likely that this Airshed is compliant with this guideline. If the annual average PM$_{2.5}$ guideline were reviewed to less than 8 µg/m$^3$ Airshed C would be unlikely to be compliant.

Airshed C is compliant with the 24-hour average NES for PM$_{10}$ with maximum concentrations consistently less than 40 µg/m$^3$.

6.3 24-hour average PM$_{2.5}$ concentrations

Daily winter concentrations of PM$_{2.5}$ were estimated for 2008, 2009 and 2015 using a ratio of PM$_{2.5}$ to PM$_{10}$ of 0.86 based on the Airshed A wintertime relationship between the two size fractions.

Table 6.2 shows the estimated fourth highest (WHO guideline allows for three exceedences per year) PM$_{2.5}$ concentration per year for Airshed C based on the PM$_{10}$ data. This suggests the Airshed may comply with a daily guideline for PM$_{2.5}$ of 25 µg/m$^3$. 

Table 6.2: Estimated/indicative PM$_{2.5}$ daily concentrations for Airshed C

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourth highest PM$_{10}$ µg/m3</td>
<td>26</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Estimated fourth highest PM$_{2.5}$ (24-hour average)</td>
<td>22</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Difference compared to 24-hour average PM$_{2.5}$ of 25 µg/m3</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Reduction to meet current PM$_{10}$ NES</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

6.4 Comparison of 24-hour average PM$_{2.5}$ concentrations to WHO guidelines

The WHO 24-hour average guideline for PM$_{2.5}$ is 25 µg/m$^3$ with three allowable exceedences per year. It is likely that Airshed C complies with this guideline.
7 DOMESTIC HEATING CONTRIBUTION

The domestic heating contribution to annual average PM$_{10}$ and PM$_{2.5}$ concentrations has been estimated for Airsheds A and B1. Similar estimates for Airsheds B2 and C are not possible owing to the absence of monitoring data for the non-winter months. Airshed A data are likely to be indicative of contributions for Airsheds B2 and C, however.

7.1 Airshed A

The relative contribution of different sources to PM$_{10}$ for each month of the year was obtained from the 2014 emission inventory. The relative contributions vary with season (e.g., domestic heating is greater during the winter). Meteorological conditions also vary with season (conditions inhibiting dispersion are more prevalent during the winter months). It is therefore necessary to make an assessment of concentrations from each source for each month of the year in order to estimate the annual average contributions.

An evaluation of the source apportionment (receptor modelling) studies for Airshed A was carried out to identify the contribution of natural sources to PM$_{10}$ and PM$_{2.5}$ concentrations. This showed an average natural source contribution of 6.5 µg/m$^3$ for Airshed A PM$_{10}$ and 1.6 µg/m$^3$ for Airshed A PM$_{2.5}$.

To estimate the relative contribution of sources to annual average PM$_{10}$ and PM$_{2.5}$ concentrations the average contribution of natural sources to concentrations of each was subtracted from the monthly average concentration. The resulting monthly average concentration was allocated to anthropogenic sources based on the emission inventory distribution from the 2014 inventory. The monthly average concentration allocations to each source were then averaged to give an annual estimated concentration for domestic heating, motor vehicles and industry. The contribution from other Airsheds is based on data provided by Golder and Associates (Gimson, pers com, 2015). Industry contributions are likely to be slightly over estimated owing to different dispersion characteristics for many industry sources.

Figure 7.1 shows the estimated relative contribution of sources to annual average PM$_{10}$ and PM$_{2.5}$ concentrations.

![Figure 7.1: Estimated relative contribution of sources to annual average PM$_{10}$ and PM$_{2.5}$ concentrations for Airshed A](image)

7.2 Airshed B1

The relative contribution of different sources to PM$_{10}$ for each month of the year was obtained for Airshed B1 from the 2014 emission inventory. As indicated above, the relative contributions vary with season. Meteorological conditions also vary with season (conditions inhibiting dispersion are more prevalent during the winter months). The annual average contribution assessment is therefore made based on the averaging of monthly concentration contributions as described for Airshed A above.
An evaluation of the source apportionment (receptor modelling) studies for Airshed B1 was carried out to identify the contribution of natural sources to PM$_{10}$ and PM$_{2.5}$ concentrations. This showed an average natural source contribution of 6.6 µg/m$^3$ for Airshed B1 PM$_{10}$ and 1.2 µg/m$^3$ for Airshed B1 PM$_{2.5}$.

Figure 7.2 shows the estimated relative contribution of sources to annual average PM$_{10}$ and PM$_{2.5}$ concentrations.

**Figure 7-2:** Estimated relative contribution of sources to annual average PM$_{10}$ and PM$_{2.5}$ concentrations for Airshed B1
IMPACT OF MANAGEMENT OPTIONS ON ANNUAL AVERAGE PM$_{2.5}$

8.1 Impact of reductions in 24-hour average PM$_{10}$ on annual average PM$_{2.5}$ concentrations.

A reduction of 14% in 24-hour average PM$_{10}$ concentrations has been recommended for Airshed A for compliance with the NES for PM$_{10}$. The impact of reducing winter concentrations by 14% (by targeting domestic heating) on annual average PM$_{2.5}$ concentrations was assessed for the years 2013 and 2014 by applying the reduction to PM$_{10}$ concentrations for the months May to August and estimating its impact on annual average PM$_{2.5}$.

For 2013 the estimated annual average PM$_{2.5}$ concentration reduced from around 12.5 $\mu$g/m$^3$ to 11.3 $\mu$g/m$^3$ (a 10% reduction).

For 2014 the estimated annual average PM$_{2.5}$ concentration reduced from an estimated 11.4 $\mu$g/m$^3$ to around 10.1 $\mu$g/m$^3$ (an 11% reduction).

It is possible that an annual average PM$_{2.5}$ guideline of 10 $\mu$g/m$^3$ may be met in Airshed A if wintertime concentrations in this Airshed are reduced by 14% as required to meet the current NES for PM$_{10}$. More intensive monitoring of PM$_{2.5}$ concentrations (e.g., daily or one day in two) is recommended to allow for a more robust assessment of likely compliance.

In Airshed B1 it is possible that the 24-hour average PM$_{10}$ concentrations already meet the NES for PM$_{10}$. Additional reductions of around 2-3% could occur through the replacement of older more polluting wood burners (either at the end of their useful life or through regulation). However, if current annual average concentrations were 12 $\mu$g/m$^3$ (as estimated for 2014) a 3% reduction in wintertime PM$_{10}$ is only likely to reduce annual PM$_{2.5}$ concentrations by around 2% and a reduction of around 15% would be required to meet a guideline/standard of 10 $\mu$g/m$^3$. It is possible that Airshed B1 would not meet an annual average PM$_{2.5}$ standard even with additional reductions in PM$_{10}$ concentrations associated with the phase out of older more polluting wood burners.

8.2 Impact of allowing new installations of burners in Airshed B2 and C on annual average PM$_{2.5}$ concentrations.

Data suggests that management of PM$_{10}$ in Airshed A to meet the current NES for PM$_{10}$ is likely to be sufficient for the management of annual average PM$_{2.5}$ and provided the assessment of impact of allowing new installations of burners (in new dwellings or existing dwellings using other heating methods) in either Airshed A or C does not compromise attainment of that standard a PM$_{2.5}$ limit of 10 $\mu$g/m$^3$ should be achievable. Further monitoring is recommended however to increase the robustness of the assessment.

Airshed B1 most probably wouldn’t comply with an annual average PM$_{2.5}$ standard of 10 $\mu$g/m$^3$. Allowing additional discharges of PM$_{2.5}$ into Airshed B1 is not recommended at this stage. Further monitoring of PM$_{2.5}$ will provide for a more robust assessment should a 10 $\mu$g/m$^3$ or lower PM$_{2.5}$ annual average NES be adopted.

Allowing new installations of wood burners into Airshed B2 may be possible provided the net impact is a decrease in emissions (e.g., increases in emissions associated with new installations are offset by the replacement of older more polluting burners with lower emission burners). However, given additional reductions in concentrations are likely to be required for Airshed B1 if an annual average PM$_{2.5}$ standard is introduced it is recommended that an evaluation of options for managing PM$_{2.5}$ concentrations in Airshed B1 be carried out prior to any decisions relating to allowing new burners in Airshed B2. It should be noted, however, that PM$_{2.5}$ concentrations in Airshed B1 are an estimate only and that monitoring of PM$_{2.5}$ in Airshed B1 is recommended to more accurately establish existing PM$_{2.5}$ concentrations.
9 SUMMARY

The purpose of this report was to evaluate:

- The likely annual average PM$_{2.5}$ concentrations in Nelson relative to existing and possible future annual average PM$_{2.5}$ standards.
- The likely relative contribution of domestic heating to annual average PM$_{2.5}$ concentrations in Nelson.
- The likely implications of a 24-hour average NES for PM$_{2.5}$ (relative to the existing PM$_{10}$ NES) in Nelson based on the current WHO value of 25 µg/m$^3$.
- The likely implications of an annual average NES for PM$_{2.5}$ (relative to the existing 24-hour average PM$_{10}$ NES) in Nelson based on the current WHO value of 10 µg/m$^3$.
- The likely impact of management measures to reduce 24-hour average PM$_{10}$ concentrations to meet the NES in Airsheds A and B1 on annual average PM$_{2.5}$ concentrations.
- The likely impact of allowing installations of solid fuel burners in new houses and existing dwellings currently using other heating methods in Airsheds B2 and C on annual average PM$_{2.5}$ concentrations.

The analysis suggests that Airshed A is unlikely to comply with the existing WHO guideline for annual average PM$_{2.5}$ and it is possible that Airshed B1 may also not comply. Airsheds B2 and C are likely to comply with the existing WHO annual average guideline for PM$_{2.5}$. If the guideline were reduced to 8 µg/m$^3$ Airsheds A, B1 and B2 are all likely to be non-compliant. Airshed C may be compliant.

In Airshed A domestic heating within the Airshed is likely to contribute around 42% of the annual average PM$_{10}$ concentrations and around 65% of the annual average PM$_{2.5}$ concentrations. Thus this source would need to be the focus of any reduction in PM$_{2.5}$ concentrations to meet an annual average concentration of 10 µg/m$^3$.

The relative contribution in Airsheds B2 and C is likely to be similar to Airshed A. In Airshed B1 domestic heating is estimated to contribute around 22% (including other Airshed contributions) of the annual average PM$_{10}$ and 38% of the annual average PM$_{2.5}$ concentrations. In this Airshed industry is estimated to be the main contributor to annual average concentrations for both PM$_{10}$ and PM$_{2.5}$ based on a mass emissions approach. However, this does not account for the increased dispersion associated with some industrial sources and it is there likely that the industry contribution is overestimated.

If PM$_{10}$ concentrations are reduced by 14% in Airshed A to meet the NES, it is likely that annual average PM$_{2.5}$ concentrations would reduce to below 10 µg/m$^3$. However, more intensive monitoring is recommended to increase certainty around current annual average PM$_{2.5}$ concentrations.

In Airshed B1 it is likely that the 24-hour average PM$_{10}$ concentrations already meet the NES for PM$_{10}$. However, if current annual average PM$_{2.5}$ concentrations were 12 µg/m$^3$ (as estimated for 2014) reductions in PM$_{10}$ concentrations associated with the natural attrition replacement of older burners is unlikely to reduce annual PM$_{2.5}$ concentrations by sufficient amounts to achieve an annual standard of 10 µg/m$^3$ for PM$_{2.5}$.

Airsheds A and B1 are unlikely to comply with a 24-hour average PM$_{2.5}$ standard with reductions of around 20-30% in Airshed A and possibly up to around 15% in Airshed B1 to achieve compliance. Airshed B2 may be compliant although monitoring is required to confirm this. It is likely that Airshed C would comply with a 24-hour average PM$_{2.5}$ standard of 25 µg/m$^3$.

Based on the relative risks identified, it is recommended that priority be given to monitoring of PM$_{2.5}$ in Airshed B1 and that the monitoring period include both seasons to enable calculation of annual average concentrations. Should a standard for PM$_{2.5}$ be introduced it is likely that continuous monitoring of PM$_{2.5}$ at Airshed A would also be required as well as investigative monitoring for PM$_{2.5}$ of at least two years in each of Airsheds B2 and C.
10 REFERENCES


APPENDIX A: DISTRIBUTION IN PM$_{10}$ EMISSIONS ACROSS NELSON