

Presented to Technical Committee 4/6/14

Decision:

1. *That the results from this report be used to inform the monitoring component of the air quality management strategy being developed this year.*
2. *That the results be shared with the communities.*
3. *That this report be noted.*

REPORT

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Prepared By: Deborah Mills, Air Quality Scientist

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Subject: **Spatial Variability of air quality in Arrowtown and Wanaka**

1. **Precis**

The National Environmental Standard for Air Quality (NESAQ) requires Councils to monitor PM₁₀ in their regions where exceedances of the NESAQ limit are expected to occur. To that end, ORC identified 22 cities and towns where it was thought that PM₁₀ levels may be high enough to exceed the NESAQ's threshold concentration of 50µg/m³ over a 24-hour period. As a secondary requirement, PM₁₀ should be monitored where levels are expected to be their highest and/or where the most people are affected.

ORC's spatial monitoring programme identifies and quantifies spatial PM₁₀ patterns within selected cities and towns in real-time, providing information for decision-making by:

- identifying the 'worst' area of particle pollution in a town,
- confirming the suitability of the location of existing monitors, and
- providing preliminary analysis on the potential for the NESAQ to be exceeded within the city/town.

In a programmed rotation, spatial air quality studies were completed in Arrowtown and Wanaka during winter 2013. Arrowtown currently has a continuous air quality monitor; Wanaka does not. Studies have previously been conducted in Dunedin and Mosgiel (2009), Balclutha and Milton (2010), Palmerston (2011), and Queenstown and Lawrence (2012).

Results in Wanaka reveal that there are some localised areas where PM₁₀ is elevated for relatively short periods of the day.

Results indicate the Council's monitoring site in Arrowtown (at the Arrowtown School) is generally well-positioned to characterise ambient air quality in town. However, the highest PM₁₀ levels are generally found closer to the river in the older section of town. Due to construction at the school in 2013, the monitor has been moved to a new site which will reflect these higher PM₁₀ values.

2. Introduction

Arrowtown is designated as Air Zone 1 in the Otago Regional Plan: Air (Air Plan) along with Alexandra, Clyde and Cromwell. These towns have similar climates and topographies, and they frequently exceed the NESAQ during winter months.

Continuous PM₁₀ monitoring began in Arrowtown during July 2006. Since that time, the NESAQ for PM₁₀ has been exceeded anywhere from 39 days in 2007 to 17 days in 2013. Graphs of key indicators are given in Appendix 1. A trend analysis done for Arrowtown showed that since 2007, PM₁₀ concentrations have reduced by about 25% during winter.¹

Wanaka is designated as Air Zone 2 primarily on the basis of limited monitoring done in 2003. Results of that monitoring indicated that while it is possible that the NESAQ may be breached, it is not expected to happen under normal winter conditions. Since 2003 there has been significant population and housing growth in the Wanaka airshed but, to date, there has been no further monitoring done in Wanaka.

Results from these spatial monitoring studies provide additional information regarding air quality in the Arrowtown and Wanaka airsheds which will assist in the development of a larger monitoring strategy.

3. Spatial variation in PM₁₀

3.1 Arrowtown

For the spatial monitoring programme, 15 locations were chosen to provide representative spatial coverage of Arrowtown (Figure 1).

¹ 2013 Air Quality Results, Report No 2013/1105.

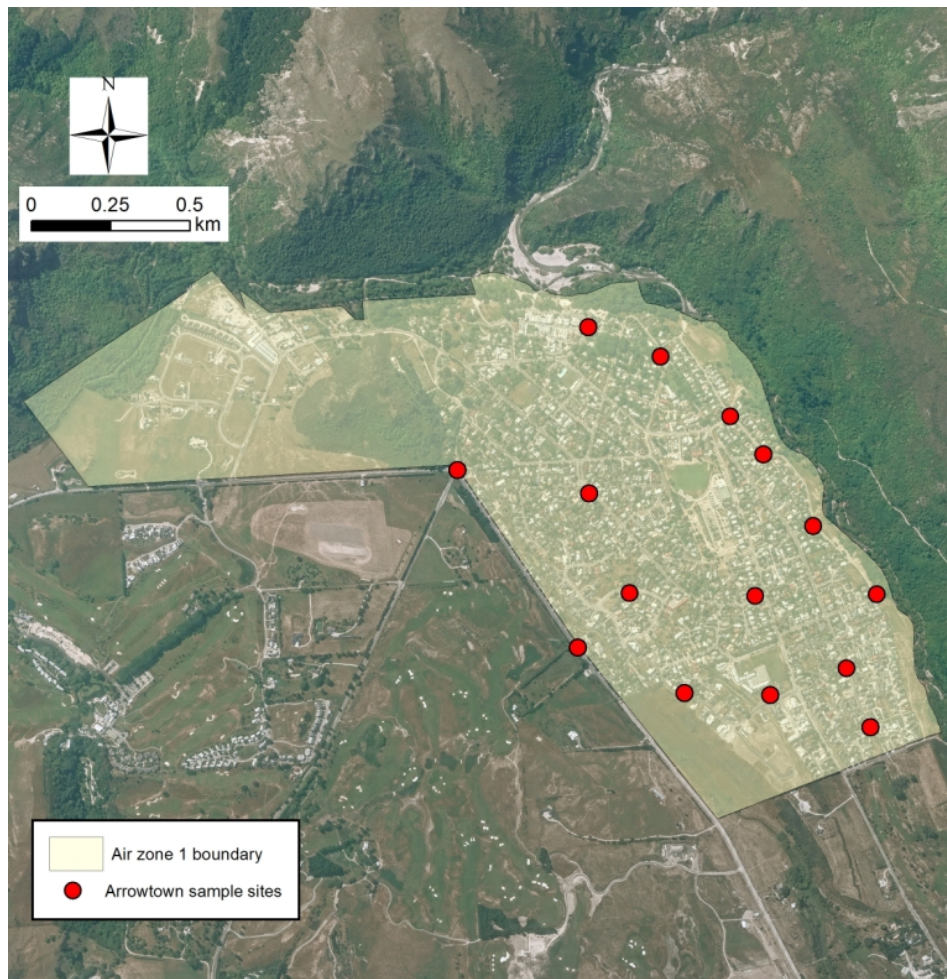


Figure 1. Sampling sites in Arrowtown.

The ORC's mobile monitor (DustTrak) was used to record real-time PM₁₀ levels at these sites over three winter nights and one morning at times when PM₁₀ levels were expected to be high². Weather conditions during sampling were cold and clear, with little to no wind.

An additional run was made on a spring day³ to record background values of ambient air quality.⁴ Background PM₁₀ levels are low, generally between 5 and 15µg/m³.

Individual monitoring results indicate that high PM₁₀ levels can and do occur in most parts of town. Figure 2 shows the overall average sampling result (excluding background). The highest concentrations were routinely measured to the east of Centennial Avenue (marked as a red line), in the older and lower part of town. Gentle nocturnal winds commonly flow in a southeast direction through town, pushing particulates towards this area.

² 28/29 June 2013, 10/11 July 2013

³ 21 September 2013

⁴ Background refers to the natural level of air quality without considering anthropogenic influences; sources include soil, pollen, marine aerosol, etc.

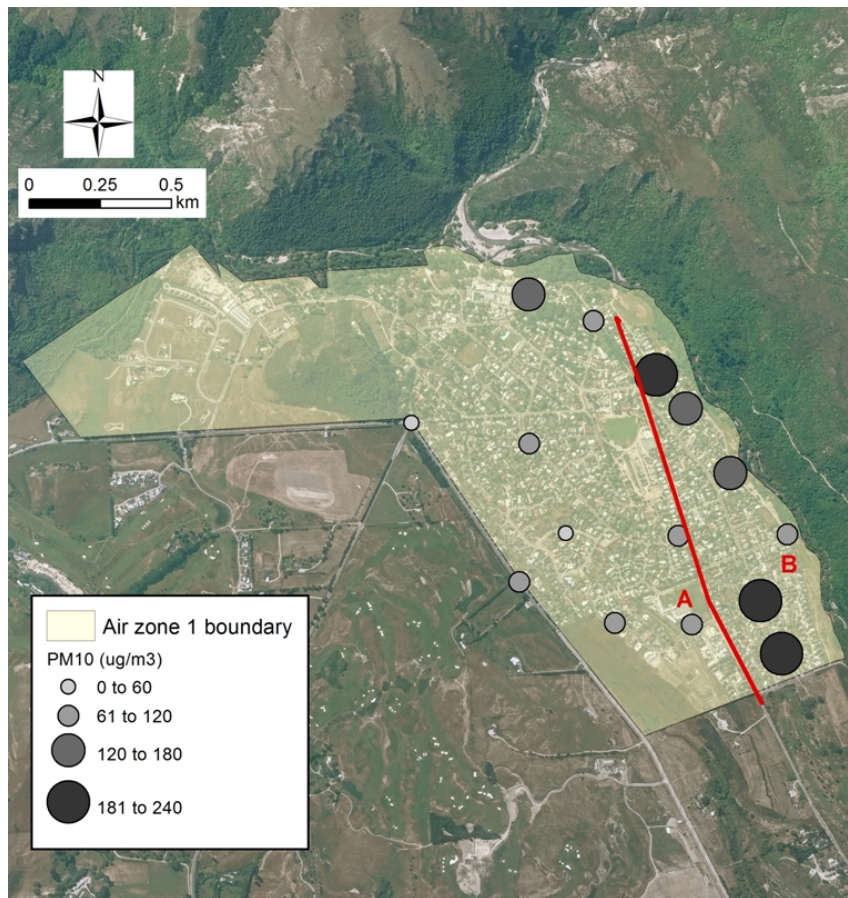


Figure 2. Average PM₁₀ in Arrowtown from all sampling runs.

The permanent air quality monitor has been located at the point labelled “A” from 2007-2013. As of the start of winter 2014, it will be located at the point labelled “B”.

It is expected that the monitor’s new location will more accurately record the town’s “worst” air quality, as required by the NESAQ. Unfortunately, due to the timing of the move from the original monitoring site, a co-location study could not be done between the two sites. Running two monitors, one at the original site and one at the new site, would have provided an understanding of the relationship between the two locations. However, for purposes of quantifying ambient air quality in Arrowtown, results from either site can be considered sufficient.

3.2 *Wanaka*

Mobile PM₁₀ sampling was performed at 20 sites over two winter nights and mornings during 2013⁵ when weather conditions were calm, cold and clear (Figure 3.). In addition, visual observations were made from several vantage points in order to observe patterns and trends in particulates across town.

⁵ Monitoring performed on 10, 11, and 24 July, 2013.

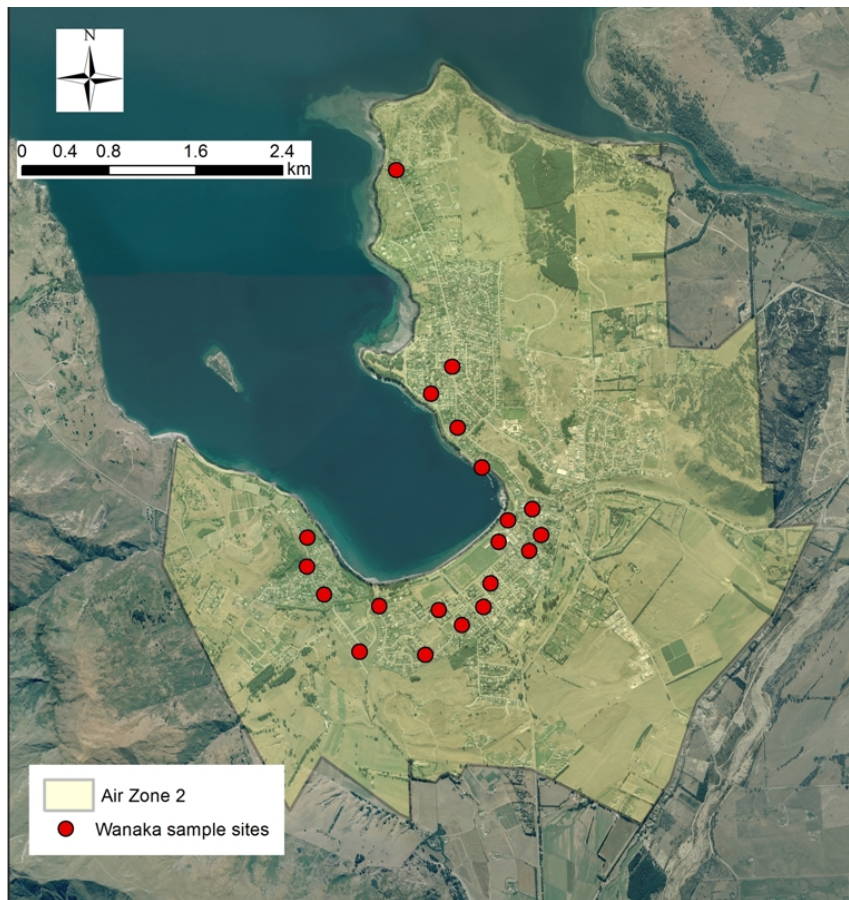


Figure 3. Sampling sites in Wanaka.

As with all other towns in Otago, topography and its subsequent effect on meteorology play a critical role in particle dispersion and the resultant air quality in Wanaka. The town is situated at the southern end of Roys Bay (Lake Wanaka), at the north end of the Cardrona River valley.

The presence of the lake and its surrounding topography generally serves to enhance particle dispersion in three ways:

1. The lake provides an ‘outlet’ for PM_{10} when night-time winds come down adjacent slopes. This facilitates the flushing of evening pollutants.
2. It sets up the temperature differential between land and water, providing for onshore and offshore breezes throughout the day, and
3. It allows for the sun, even at its lowest angle during winter, to hit the town early in the day. Warming of the surface of the Earth creates vertical turbulence which assists with the dispersion of morning emissions.

Figure 4 shows the average of all monitoring results. Measurements indicate that there are small, localised areas where PM_{10} is elevated during times of peak emissions (6-8pm).

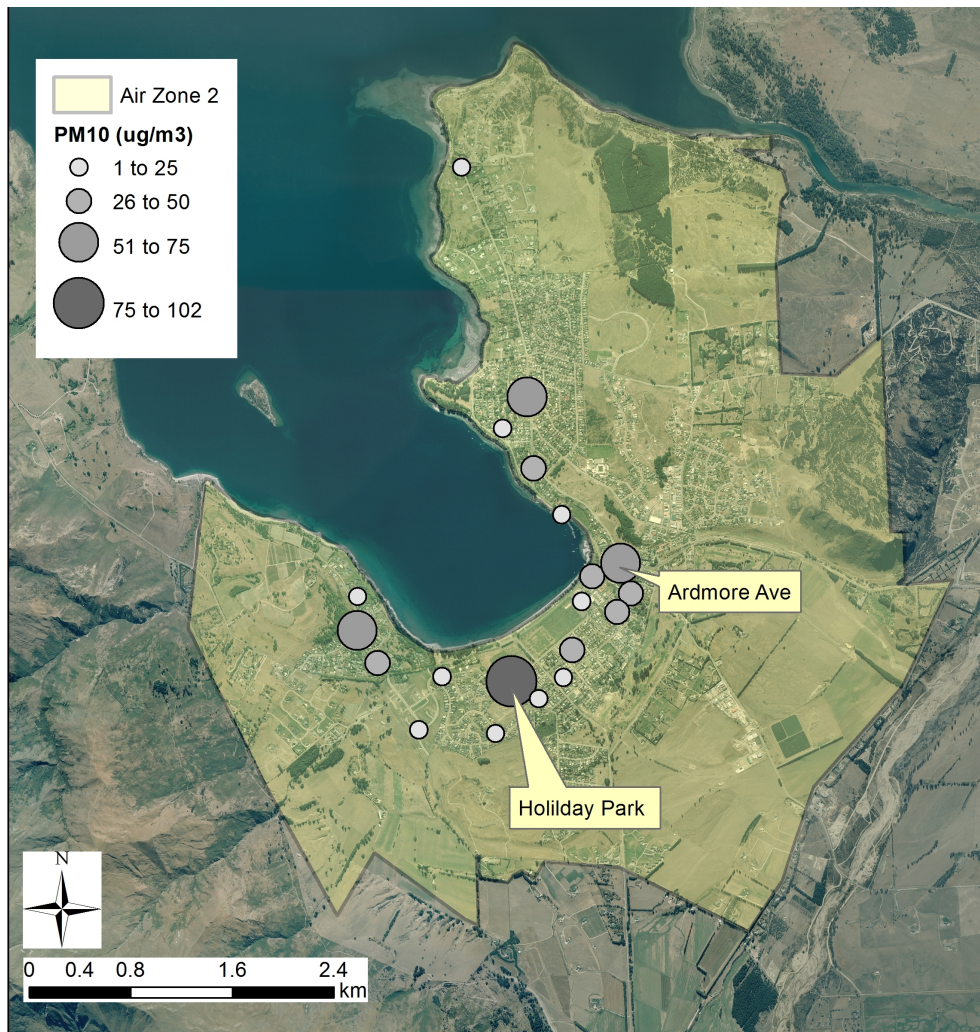


Figure 4. Average PM₁₀ in Wanaka from all sampling runs.

It was observed that between 4-5pm there is a noticeable start-up of restaurant emissions. One of the higher evening readings was taken on Ardmore Street in a commercial area where restaurant and bar emissions predominated.

Residential areas exhibited moderate concentrations which seemed to clear relatively quickly due to persistent offshore breezes. The one notable exception to that was around the Holiday Park where the highest concentrations were recorded.

To investigate this area further, the monitor was set up on the evening of 10 July at the Holiday Park to record overnight PM₁₀ in 10-minute averages from 5.30pm through to 8.30 the next morning. Figure 5 is a graph of overnight PM₁₀ values. While the evening does exhibit elevated PM₁₀, this is a very different signature to those seen in other Central Otago towns where PM₁₀ increases sharply through the evening.

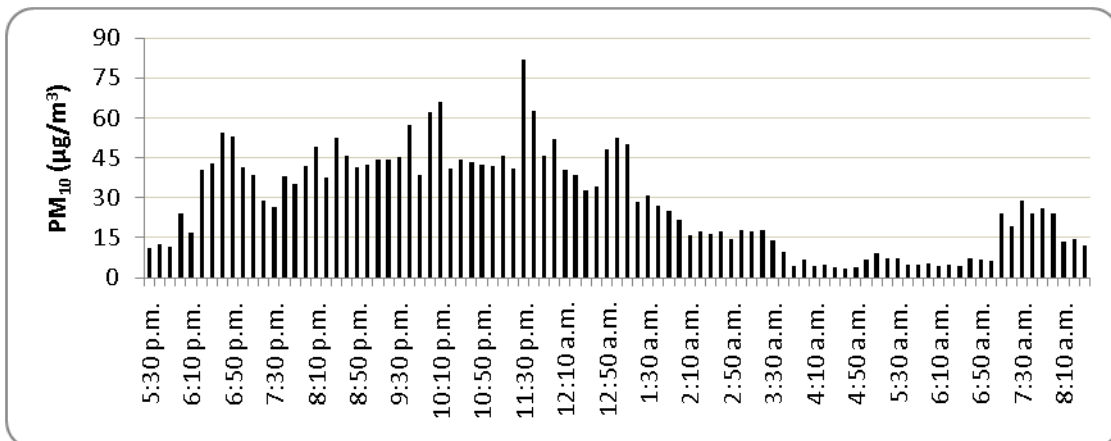


Figure 5. Ten-minute PM₁₀ data at the Holiday Park in Wanaka, July 10-11, 2013.

In Wanaka, it appears that as emissions are being added to the atmosphere, they are also being dispersed at about the same rate through the evening. After 1am, concentrations start to drop and are very low until about 7am when, presumably, fires are re-lit. However, the morning peak is not significant. Again, this is in sharp contrast to Arrowtown’s diurnal profile where morning peaks can be significant and prolonged due to the presence of an inversion layer which may not break up until 11am.

Figure 6 shows comparative PM₁₀ values in Wanaka and Arrowtown for the same sampling period. (NB: Wanaka’s 10-minute data have been converted to hourly averages to match the timescale of the Arrowtown data.)

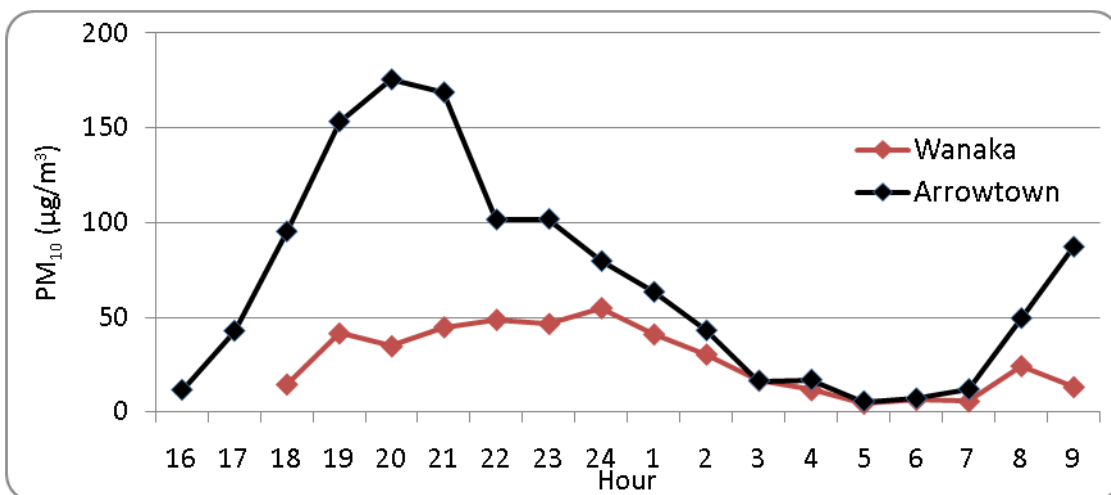


Figure 6. Hourly PM₁₀ for Wanaka and Arrowtown overnight on Wednesday evening into Thursday morning (10th to 11th of July 2013). This is a typical PM₁₀ pattern, regardless of the day of week, in areas where solid fuel is used to heat houses.

4. Conclusions

4.1 Arrowtown

1. Arrowtown’s highest PM₁₀ levels are consistently seen in the eastern part of the town. Burner age, fuel use and topography all contribute to these high figures.

2. The permanent air monitor's new location will reflect these highest numbers, satisfying the requirement of the NESAQ to monitor in the 'worst' location.

4.2 *Wanaka*

1. There are times and places within the Wanaka airshed when PM₁₀ is elevated; however, due to the location and layout of the area it is considered unlikely that the NESAQ limit of 50µg/m³ is exceeded under normal winter conditions.
2. If the number of burners were to remain steady, it is expected that over time PM₁₀ emissions and concentrations would reduce as older burners are replaced. However, since population growth is expected to continue in the Wanaka airshed, it is likely that emissions will increase accordingly.
3. Wanaka is currently in Air Zone 2 and the results from this study indicate that this is the correct zone designation.

5. Trends in domestic fuel use

The recent Census⁶ provides information on domestic fuel usage at several scales (meshblock, census area, district area, regional, and national) as well as providing trend information when compared against previous Census results. Since the majority of emissions come from domestic heating in Otago towns, this information is presented to provide some context to the air quality issues in Arrowtown and Wanaka.

A higher percentage of residents in both Arrowtown (59%) and Wanaka (67%) report using wood for domestic heating as compared to the national average (37% of all New Zealand households use wood). In terms of coal usage, about the same percentage of residents in Arrowtown and Wanaka report using coal as do residents nationally (4%).

Further details of wood and coal use at the town and district area levels are discussed in the following sections.

5.1 *Wood Use*

There is a strong reliance on wood as a fuel source for domestic heating in both Arrowtown and Wanaka. Figures indicate that over half of all households use wood as a primary form of heating. Table 1 lists the trends in wood use from 1996 to 2013.

Table 1. Percentage of total households that use wood for domestic heating (%).

Census Year	Queenstown Lakes District	Arrowtown	Wanaka
1996	67	70	77
2001	65	71	74
2006	58	62	67
2013	58%	59%	67%

⁶ NZ Statistics, Census, 2013.

As a comparison to the region as a whole, approximately 54% of all Otago households use wood for domestic heating.

While the *percentage* of total households using wood for heating purposes is slowly decreasing, the *actual numbers* of households using wood is increasing due to the increases in population and housing in the Queenstown Lakes District. Table 2 provides the actual number of households using wood as fuel for heating.

Table 2. Number of households that use wood for domestic heating.

Census Year	Queenstown Lakes District	Arrowtown	Wanaka
1996	5,610	405	843
2001	6,789	483	1,026
2006	9,087	549	1,413
2013	10,566	558	1,764

With the introduction of strict emission limits on new wood burners in 2005, even though the total amount of emissions is increasing with housing growth, the *rate* of increase has slowed. A more detailed analysis at the meshblock level is required to understand the potential impact of newer houses on overall air quality in both towns.

5.2 Coal use

Regionally, West Coast has the highest percentage of coal usage in the country (56%), followed by Southland (36%). Otago ranks as third-highest in terms of the percentage of households using coal for domestic heating with 14%; the remaining regions all report less than 4% household coal usage.

Within the Otago region, the Queenstown Lakes District reported the lowest coal usage (7%) and Clutha District the highest (40%). Figure 7 shows that all district areas rank above New Zealand's average percentage of coal use which is about 4%.

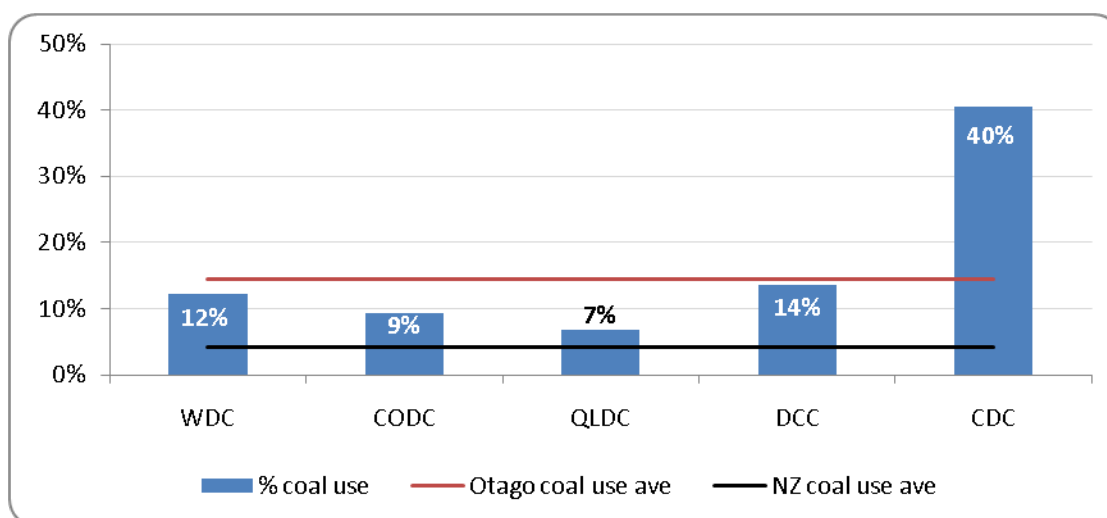


Figure 7. Percentage of coal usage by district area, region, and nationwide averages.

According to the Census results, coal use in Arrowtown and Wanaka is well below the regional average of 14%. Table 3 shows the downward trend in both percentage and number of households using coal.

Table 3. Percentages and numbers of households using coal for domestic heating.

Census Year	Queenstown Lakes District		Arrowtown		Wanaka	
	%	Number	%	Number	%	Number
2001	23	1509	34	234	10	144
2006	15	1299	21	180	7	150
2013	7	723	3	27	4	96

When a coal-using multi-fuel burner is removed from a house and replaced with a no-emission heating appliance (e.g. heat pump or gas), approximately 300g of PM₁₀ a day is removed from the atmosphere, a significant reduction.

When a coal-using multi-fuel burner is replaced with an Air Zone 1 ORC-compliant wood burner (0.7g/kg), it is reasonable to assume that anywhere from 120g to 200g of PM₁₀ is removed from the atmosphere.

6. Recommendations

4. That the results from this report be used to inform the monitoring component of the air quality management strategy being developed this year.
5. That the results be shared with the communities.
6. That this report be noted.

Gavin Palmer
Director Engineering, Hazards and Science

APPENDIX 1. Arrowtown PM₁₀ summary (monitoring began 1 July 2006)

