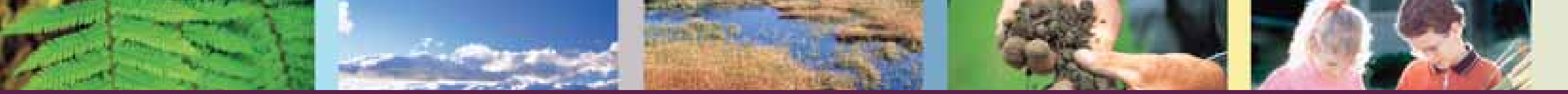

Annual air quality monitoring report for the Wellington region, 2009

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Annual air quality monitoring report for the Wellington region, 2009

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1. Introduction

Greater Wellington Regional Council (Greater Wellington) monitors ambient air quality at selected sites in the region to identify areas where air quality may be degraded and to compare air quality against national standards and guidelines designed to protect public health. Ambient air is outdoor air where people live, work and play (i.e., does not include air indoors or inside tunnels and vehicles). The region is divided into eight airsheds for air quality management and for reporting against the national environmental standard. In 2009, air quality was monitored at eight stations and a short-term winter monitoring campaign was carried out in the Wairarapa.

The core monitoring programme is focussed on monitoring three contaminants: carbon monoxide, nitrogen dioxide and particulate matter (PM_{10}). These three pollutants are emitted in the greatest quantities in the region and all have adverse health effects if concentrations in air are elevated.

Air quality depends not only on the amount and types of pollutants discharged to air from human activities, but also on whether meteorological conditions are favourable for dispersion of those pollutants. Monitoring alone cannot fully characterise air quality and complementary assessment tools such as source apportionment studies (including emission inventories and receptor modelling) are carried out as needed.

This report summarises the results of ambient air quality monitoring and targeted air quality investigations undertaken in the Wellington region during 2009 (1 January 2009 to 31 December 2009).

Figure 1.1: The morning after – smoke from domestic fires starting to clear after a cold winter night in 2004

2. Overview of ambient air quality monitoring programme

2.1 Background

Air quality has been monitored in the Wellington region since 1998, when a series of pilot investigations were carried out. The first long-term site was established in Upper Hutt in 2000 (this site was moved in 2005). Progressively other sites have been added to the monitoring network, which now comprises four long-term sites (Masterton, Lower Hutt, Upper Hutt and Wellington central) and is complemented by other stations which may be re-located as air quality monitoring priorities change.

2.2 Monitoring objectives

The objectives of Greater Wellington's ambient air quality monitoring programme are to:

- Determine compliance with national guidelines and standards designed to protect human health and the environment
- Identify areas where air quality may be degraded
- Assess spatial variability and temporal trends in air quality
- Determine 'background' air quality to assist with assessing the impact of resource consent proposals
- Provide scientifically defensible information about air quality for policy and decision makers to use when considering resource management issues.

2.3 Monitoring sites and regional airsheds

The Wellington region is divided into eight airsheds, constrained by valleys between steep hills or mountains (Figure 2.1). These airsheds are Wellington City, Karori, Porirua Basin (including Tawa valley and Pauatahanui Inlet), Lower Hutt Valley, Wainuiomata, Upper Hutt Valley, Wairarapa Valley and Kapiti Coast. Each airshed has a distinct microclimate, meteorological conditions and air quality pressures. These airsheds were formally Gazetted in 2005 in accordance with the national standard for air quality[1] (Davy 2005). Greater Wellington's air quality monitoring results for PM_{10} are provided to MfE as part of the national reporting framework (http://www.mfe.govt.nz/environmental-reporting/air/air-quality/pm10/nes/).

Currently seven of the eight airsheds are monitored (Table 2.1).

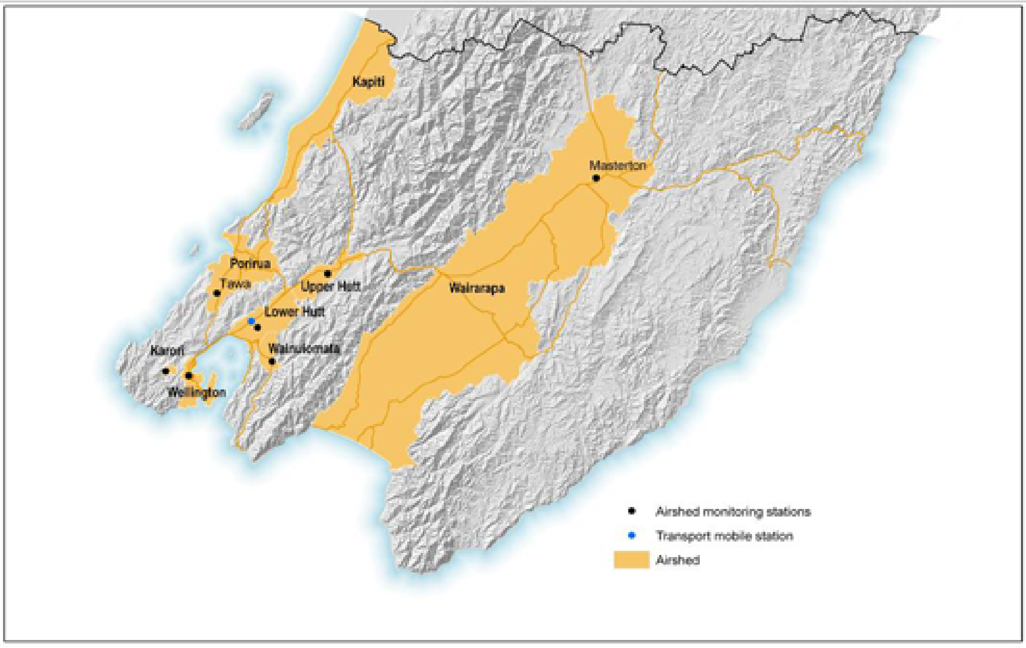

Figure 2.1: Location of air quality monitoring stations within airsheds in the Wellington region

Table 2.1: Air quality monitoring sites operated in the 2009 calendar year

Site	Station	Airshed	Location	Pollutants monitored	Site established
Wellington central	Corner V	Wellington City	Corner Victoria & Vivian Streets	PM_{10}, CO, NOx	2004
Lower Hutt	Birch Lane	Lower Hutt Valley	Phil Evans Reserve	PM_{10}, CO, NOx	2001
Wainuiomata	Wainuiomata Bowling Club	Wainuiomata	Moohan Street	PM_{10}	2006
Upper Hutt	Savage Park	Upper Hutt Valley	Savage Crescent	PM_{10}, CO, NOx	2005
Masterton	Wairarapa College	Wairarapa Valley	Cornwell Street	PM_{10}, CO, NOx	2002
Tawa	Duncan Park	Porirua	Linden Street	PM_{10}, CO, NOx	2007
Karori	Terawhiti Bowling Club	Karori	Karori Park	PM_{10}, CO, NOx	2007
Melling	Mobile monitoring	Lower Hutt Valley	SH2, Block Road	PM_{10}, CO, NOx	2006-2009
Shandon	Shandon golf course	Lower Hutt Valley	Gear Island, Petone	Meteorological only	2000

2.4 Air pollutants and meteorological parameters monitored

The pollutants currently monitored in the Wellington region are particulate matter (PM_{10}), carbon monoxide (CO) and nitrogen oxides (NOx) which include nitrogen dioxide (NO_2) and nitric oxide (NO). These are the contaminants emitted in the greatest amounts throughout the region and all have known adverse human health effects when concentrations in air are elevated. The two other pollutants regulated by the national standards, sulphur dioxide (SO_2) and ozone (O_3), are not presently monitored in the region. Meteorological conditions in the region are not usually conducive to the formation of ozone and there are no major point source emissions of sulphur dioxide. Information on how air quality monitoring results are reported is presented in Appendix 2.

Meteorological instruments for recording parameters such as wind speed, wind direction and temperature are co-located at each monitoring site to assist with the interpretation of air quality data. Wind roses showing wind speeds and wind direction in 2009 at each monitoring site are presented in Appendix 1.

2.5 Air quality assessment criteria

2.5.1 National environmental standards and guidelines for air quality

National ambient air quality guidelines (national guidelines) were established by the Ministry for the Environment (MfE) in 1994 and were revised in 2002. Some of these guideline values were adopted as national environmental standards in 2004. The national environmental standards for air quality specify minimum requirements for outdoor air quality that provide a consistent level of protection for human health and the environment.

The relevant national environmental standards and national guidelines for pollutants measured in the region are provided in sections 3 to 5 of this report.

2.5.2 Air quality reporting categories

A useful way to illustrate the significance of ambient air quality monitoring results is to show the percentage of time that monitoring results fall into different categories (Table 2.2). This method is described by MfE (1997).

Table 2.2: Air quality categories for reporting monitoring results

Category	Measured values	Comment
Action	Exceed guideline/standard	Completely unacceptable by national and international standards.
Alert	Between 66% and 100% of the guideline/standard	A warning level which can lead to guidelines being exceeded if trends are not curbed.
Acceptable	Between 33% and 66% of the guideline/standard	A broad category, where maximum values might be of concern in some sensitive locations, but are generally at a level that does not warrant dramatic action.
Good	Between 10% and 33% of the guideline/standard	Peak measurements in this range are unlikely to affect air quality.
Excellent	Less than 10% of the guideline/standard	Of little concern.

3. Particulate matter (PM_{10})

3.1 Sources and health effects

Particulate matter (PM) is a mixture of solid particles and liquid droplets that are dispersed in air. PM_{10} is that portion of particulate matter with an equivalent aerodynamic cross-section less than 10 micrometres. This size fraction is small enough to be inhaled into the respiratory system. Figure 3.1 shows particulate matter particle sizes relative to the width of a human hair and a grain of sand.

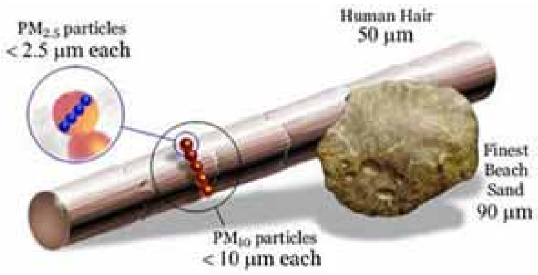

Figure 3.1: Relative particle sizes
(Source: www.mfe.govt.nz)

Particulate matter arises from human activities and from natural sources. Sources of PM_{10} in the Wellington region include:

- Domestic solid fuel heating (e.g., wood burners)
- Motor vehicles, particularly from diesel-fuelled vehicles
- Industrial combustion processes
- Quarrying activities
- Natural sources such as sea salt and wind-blown soil particles

Epidemiological studies show adverse health effects from both short-term and long-term exposure to PM_{10}. However, a threshold below which there are no observed adverse effects has not been reliably established to date. The adverse health effects associated with exposure to PM_{10} range from increases in the number of restricted activity days to increases in hospital admissions and premature deaths for people with existing lung and heart disease.

Domestic fires and vehicles produce very fine particles less than 2.5 microns in diameter ($PM_{2.5}$). Road dust and natural sources, such as sea salt and soils, produce coarser particles ($PM_{2.5-10}$). $PM_{2.5}$ causes the most harm to people's health because smaller particles can penetrate deeper into the lungs.

3.2 Monitoring method

PM_{10} is monitored by Rupprech & Patashnick TEOM series 1400AB Ambient Particulate Monitors at Tawa and Lower Hutt; and by ThermoElectron Corp FH62 C14 beta attenuation monitors at the remainder of the stations. Both of these instruments are designated as automated methods equivalent to the

United States Code of Federal Regulations[1] and therefore comply with the monitoring method specified by the national standard.

3.3 National standards and guidelines

The short-term daily average limit set by the national standard and the long-term annual average national guideline value are both designed to minimise (not eliminate) adverse health effects associated with PM_{10} exposure. Table 3.1 presents the national standard and guideline values for PM_{10}.

Table 3.1: National standard and guideline values for PM_{10}

PM_{10}	Threshold concentration	Averaging period	Permissible exceedences per year
Standard	50 µg/m^3	24-hour mean	One 24-hour period
Guideline	20 µg/m^3	Annual	-

3.4 Monitoring results

3.4.1 National standard (24-hour average)

Ambient 24-hour PM_{10} concentrations recorded at the various air quality monitoring sites within the Wellington region during 2009 are shown in Table 3.2. There was only one day in which PM_{10} concentrations failed to meet the limit set by the national standard during 2009 (Masterton on 25 June 2009).

Table 3.2: PM_{10} statistics (24-hour average) for the 2009 calendar year

PM_{10} µg/m^3	Wellington Central	Lower Hutt	Upper Hutt	Masterton	Tawa	Karori	Wainuiomata
Maximum	31	31	25	55	30	30	41
95th percentile	19	22	20	30	22	19	24
Mean	13	14	11	13	13	11	12
Median	12	13	10	11	12	10	11
Interquartile range	10 to 15	11 to 16	7 to 14	8 to 16	9 to 16	8 to 13	8 to 15
Valid data	100%	97.5%	95.9%	100%	92.1%	99.5%	98.4%

3.4.2 National guideline (annual average)

Figure 3.1 displays the distribution of monitoring results across all sites in the region. All annual averages were below the national guideline of 20 µg/m^3.

[1] Title 40 – Protection of the Environment, Volume 2, Part 50, Appendix J: Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere.

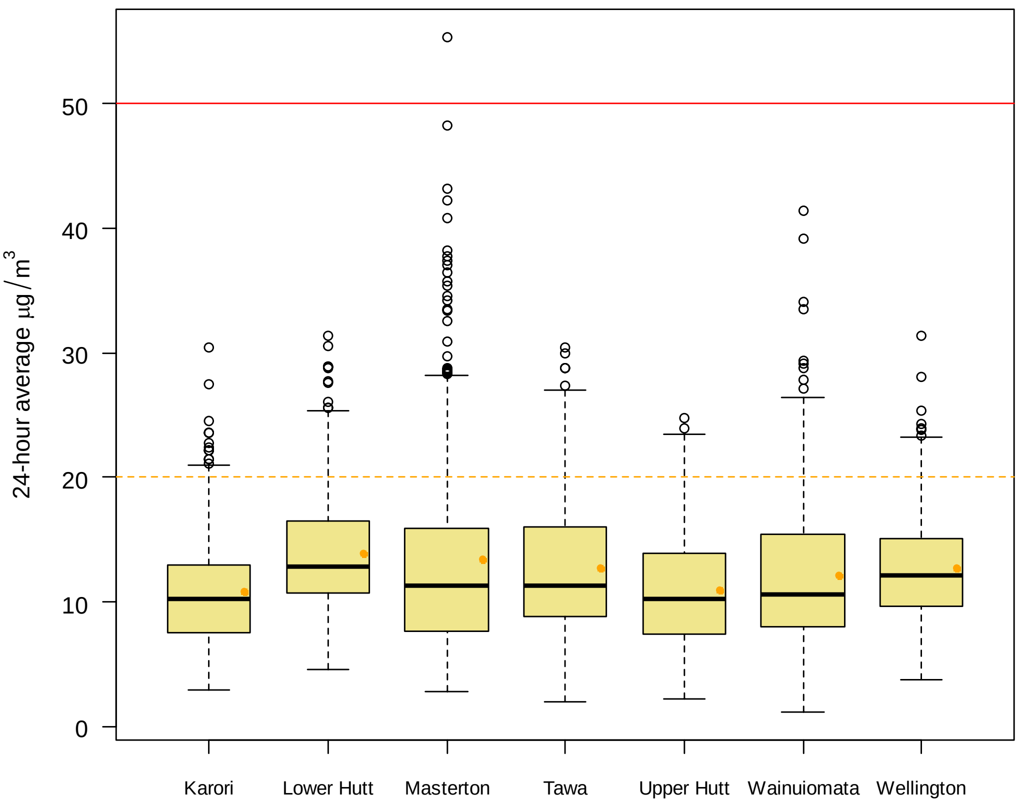

Figure 3.1: Boxplot[2] showing the distribution of PM_{10} 24-hour average concentrations for the 2009 calendar year. The orange points on the boxplot show the annual average for each site and the dashed orange line is the annual guideline value. The red line is the national environmental standard limit.

3.4.3 Air quality reporting categories (24-hour average)

Ambient PM_{10} daily averages are reported as the percentage of days per year in each air quality category described in Section 2.6 (Figure 3.2). A breakdown of the actual number of days in 2009 by air quality category is given in Appendix 3 (Table A3.1). There were four days in Wainuiomata and fifteen days in Masterton where the 'alert' level was reached. There was one day in Masterton where the 'action' level (equivalent to exceeding the national standard) was reached.

[2] Appendix 2 provides a key for the interpretation of boxplots used in this report.

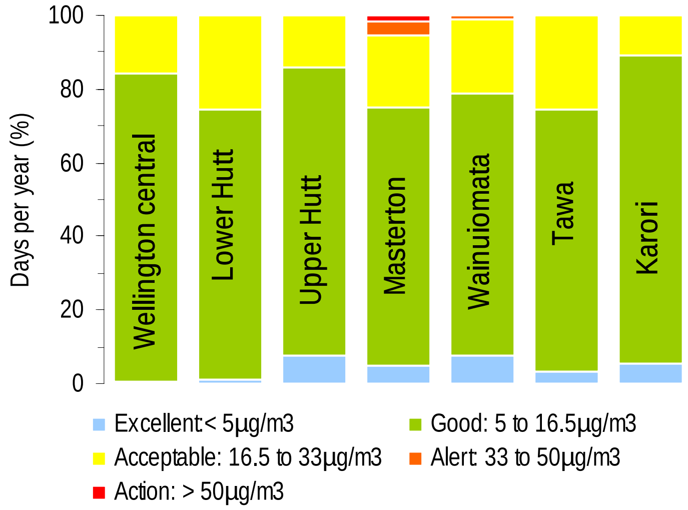

Figure 3.2: PM_{10} (24-hour average) by air quality reporting category for the 2009 calendar year

3.5 PM_{10} exceedence days

During the reporting period the national standard threshold concentration for PM_{10} was exceeded in Masterton on 25 June 2009 (55 µg/m^3). However, the Wairarapa airshed complied with the national environmental standard in 2009, as the standard allows one 24-hour period per 12-month period to exceed the 50 µg/m^3 threshold concentration.

PM_{10} exceedences are very dependent on winter meteorological conditions. Typically on cold, clear and still nights, dispersion of PM_{10} emitted by domestic fires is inhibited. Figure 3.3 shows the PM_{10} concentration profile for the exceedence recorded at Masterton on 25 June 2009. The peak hourly PM_{10} concentration measured at 10 pm coincided with low temperatures and low wind speed.

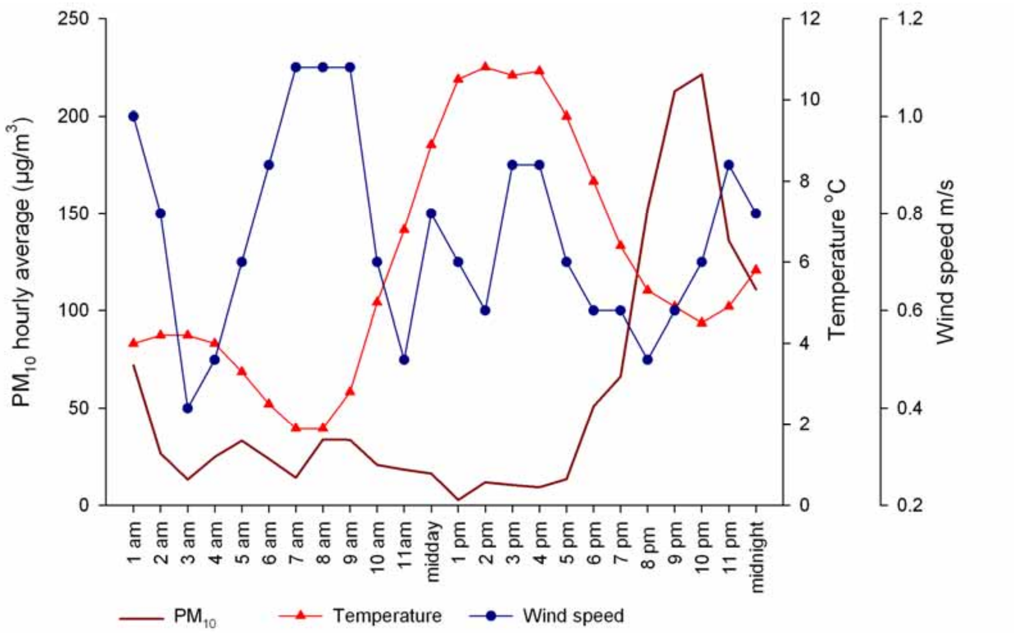

Figure 3.3: PM_{10} exceedence of 55 µg/m^3 measured at Masterton on 25 June 2009

3.6 Air quality management for particulate matter (PM_{10})

The national standard mandates regional councils to demonstrate that air quality will meet the standard for PM_{10} (i.e., no more than one exceedence per year) in their nominated airsheds by 2013 or face restrictions on the granting of resource consents to discharge particulate matter in non-complying airsheds.

The Wairarapa Valley and Wainuiomata Valley experience occasional exceedences and Greater Wellington must be assured that, given an unfavourable winter, the emissions in these airsheds will be low enough that the national standard is not breached in the years following 2013. Variation in air quality is driven by meteorology as well as by levels of domestic woodburner emissions. Therefore these airsheds have the potential to dip in and out of compliance from year to year, depending of the type of winter experienced.

Regional councils are required to develop emission reduction strategies to ensure an incremental year-on-year improvement in air quality until the standard is met by 2013. The national standard refers to this predicted annual improvement in air quality as the ‘straight line path’. Straight line paths for Masterton and Wainuiomata are shown in blue in Figures 3.4 and 3.5 respectively. These straight line paths represent the upper limit for the second highest 24-hour concentration in a given year for the airshed.

Wainuiomata is likely to comply with the national standard by 2013 as households replace their old woodburners at the end of their working life with modern low emission appliances (Wilton 2008). It is estimated that the Masterton urban area will require an eight per cent decrease in domestic emissions from 2008 levels to ensure that the national standard is not breached after 2013.

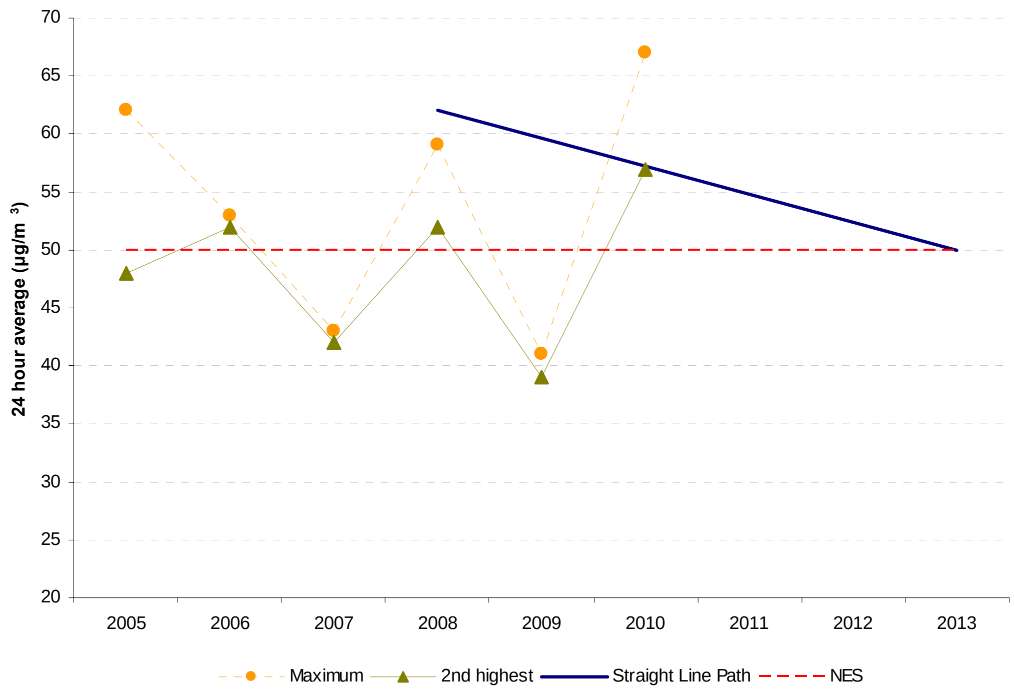

Figure 3.4: Masterton straight line path (blue) together with the second highest daily PM_{10} concentrations (green) and maximum daily PM_{10} concentrations (orange) for a given year. The dashed red line shows the national environmental standard (NES).

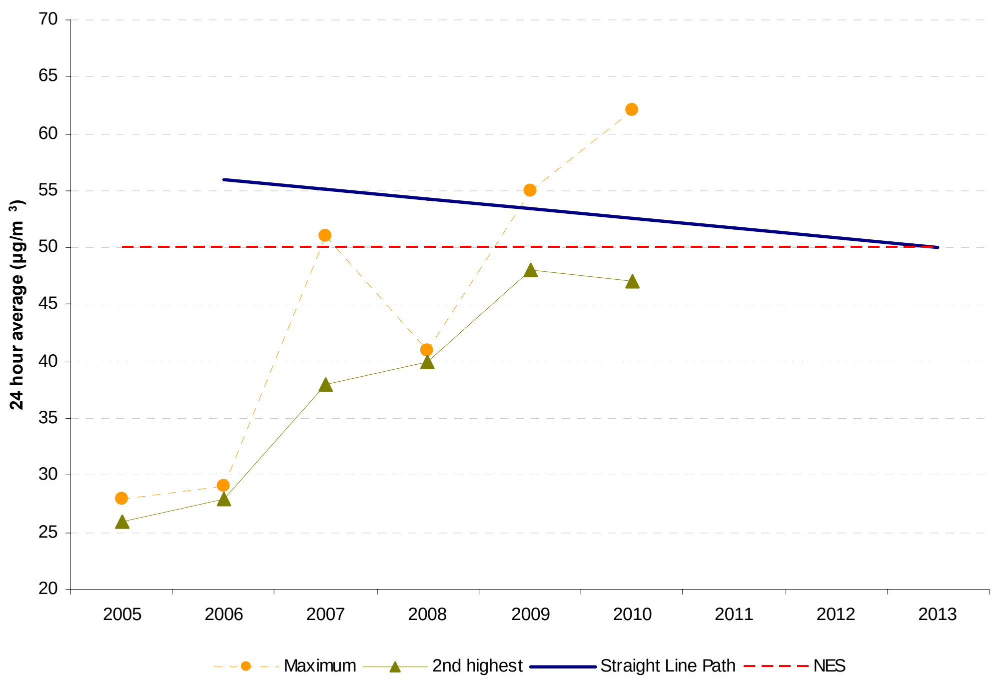

Figure 3.5 Wainuiomata straight line path (blue) together with the second highest daily PM_{10} concentrations (green) and maximum daily PM_{10} concentrations (orange) for a given year. The dashed red line shows the national environmental standard (NES).

4. Carbon monoxide

4.1 Sources and health effects

Carbon monoxide (CO) is a colourless and odourless gas produced by the incomplete combustion of carbon-containing fuels such as petrol and diesel used by motor vehicles, or wood and coal used by domestic appliances or industrial boilers. Motor vehicles are the main source of carbon monoxide in urban areas.

When inhaled, carbon monoxide reduces the oxygen carrying capacity of the blood and, depending on its concentration, causes a range of adverse health effects.

4.2 Monitoring method

Carbon monoxide is monitored using CO Gas Filter Correlation Infrared Analysers in accordance with AS3580.7.1:1992. API 300 series analysers are employed at all of Greater Wellington's air quality monitoring stations apart from Tawa where an Ecotech ML 9830 instrument is used.

4.3 National standards and guidelines

The national standards and guidelines for carbon monoxide (Table 4.1) are set at a level to protect susceptible people, such as those with existing heart disease, children and pregnant women.

Table 4.1: National standard and guideline values for carbon monoxide

Carbon monoxide	Threshold concentration	Averaging period	Permissible exceedences per year
Standard	10 mg/m^3	8-hour moving average	One 8-hour period
Guideline	30 mg/m^3	1-hour average	-

4.4 Monitoring results

4.4.1 National standard (8-hour moving average)

Ambient concentrations of carbon monoxide measured at the various air quality monitoring sites in the region during 2009 are shown in Table 4.2. All concentrations were well within the national standard for carbon monoxide during the reporting period.

Average levels of carbon monoxide in air were low and reflect the national trend for lower vehicle emissions due to improvements in emissions control technology brought about by modernisation of New Zealand's vehicle fleet.

Table 4.2: Annual statistics carbon monoxide (8-hour moving average) for the 2009 calendar year

Carbon monoxide mg/m^3	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa	Karori
Maximum	2.9	1.9	2.2	2.7	2.8	1.3
95th percentile	1.6	0.6	0.9	1.1	1.0	0.4
Mean	0.7	0.2	0.3	0.3	0.2	0.1
Median	0.5	0.1	0.2	0.1	0.1	0.0
Interquartile range	0.3 to 0.9	0.1 to 0.2	0.1 to 0.3	0.1 to 0.3	0.1 to 0.2	0.0 to 0.1
Valid data	99.5%	99.2%	99.6%	96.4%	99.6%	99.8%

4.4.2 National guideline (1-hour average)

All hourly average carbon monoxide concentrations were well within the national guideline of 30 mg/m^3 (1-hour average) as shown in Table 4.3.

Table 4.3: Carbon monoxide statistics (1-hour average mg/m^3) for the 2009 calendar year

Carbon monoxide mg/m^3	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa	Karori
Maximum	4.5	2.8	3.5	4.5	3.7	2.5
95th percentile	1.8	0.7	1.0	1.2	1.1	0.4
Mean	0.7	0.2	0.3	0.3	0.2	0.1
Median	0.5	0.1	0.1	0.1	0.1	0.0
Interquartile range	0.3 to 0.9	0.1 to 0.2	0.1 to 0.3	0.1 to 0.3	0.1 to 0.2	0.0 to 0.1
Valid data	99.5%	99.4%	99.7%	96.7%	99.5%	99.7%

Figure 4.1 compares carbon monoxide concentrations measured at Wellington central, a heavily trafficked site, with those measured at Masterton. Hourly concentrations of carbon monoxide measured at Wellington central show distinct peaks at the time of rush-hour traffic, while the Masterton site shows a lower peak later in the evening due to the influence of domestic fires in winter. The reason for the early morning peak in Masterton is less well-understood. Both sites show higher concentrations of carbon monoxide during the winter months.

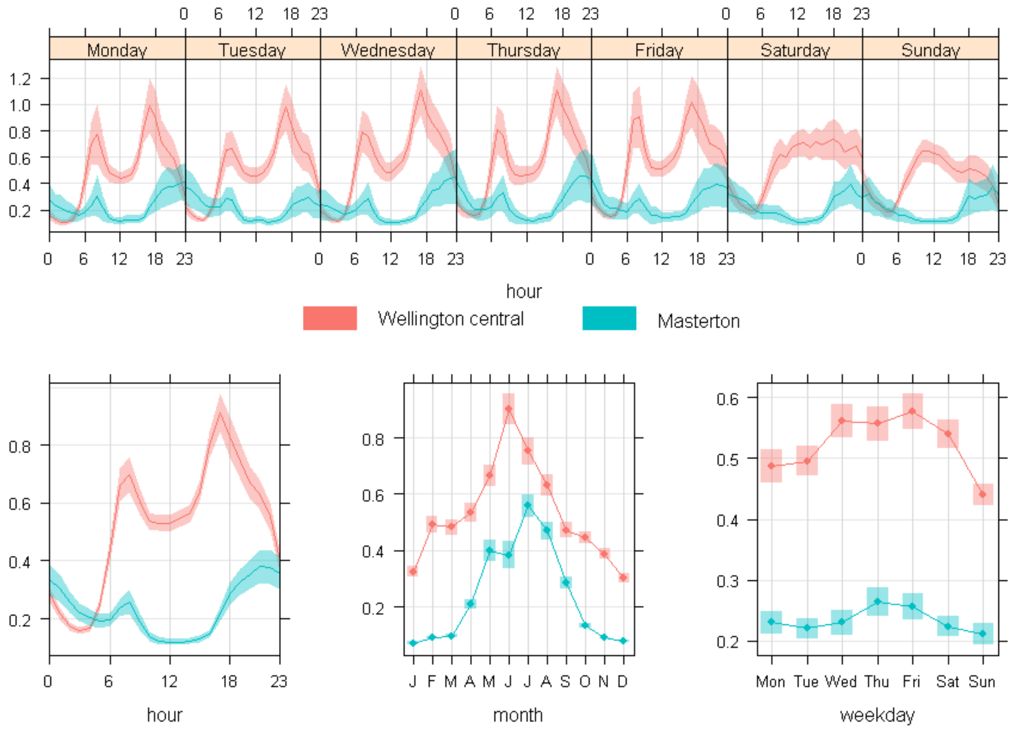

Figure 4.1: Carbon monoxide concentrations (mg/m³) at Wellington central and Masterton for the 2009 calendar year. The plots show an ensemble of hourly averages by day of the week and by hour of the day, together with monthly and weekday averages. The 95% confidence interval in the mean is shown by the width of the coloured band around the solid line or point.

4.4.3 Air quality reporting categories

The concentrations of carbon monoxide in air are reported as a percentage of the number of 8-hour moving averages per year in each air quality category (Figure 4.2). At all monitoring sites concentrations of carbon monoxide were mostly 'excellent'. A breakdown of the number of hours in each category is given in Appendix 3 (Table A3.2).

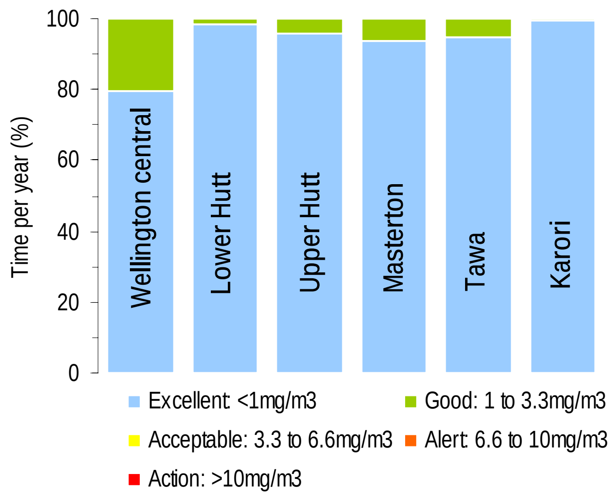

Figure 4.2: Carbon monoxide (8-hour moving average) by air quality category for the 2009 calendar year

5. Nitrogen dioxide

5.1 Sources and health effects

Nitrogen dioxide (NO_2) arises from combustion processes, with vehicle emissions being the main source in urban areas. Vehicle exhausts contain a mixture of nitrogen dioxide and nitric oxide (NO), collectively known as oxides of nitrogen (NOx). Most of the NOx discharged from vehicle exhausts is in the form of nitric oxide which is subsequently converted to nitrogen dioxide by oxidation.

Nitrogen dioxide appears as a brown and acidic gas in the atmosphere and can be seen as a haze over some cities during periods of calm weather and heavy traffic congestion. As well as contributing to poor visibility, nitrogen dioxide has adverse health effects such as lung inflammation and eye, nose and throat irritation.

5.2 Monitoring method

Nitrogen dioxide is monitored using NOx Chemiluminscence Analysers in accordance with AS3580.5.1:1993. API 200 series analysers are used at all air quality monitoring stations apart from Tawa where an Ecotech ML 9841B instrument is used.

5.3 National standards and guidelines

The national standard and national guideline concentration thresholds (Table 5.1) are designed to protect children, asthmatics and adults with chronic respiratory and cardiac conditions.

Table 5.1: National standard and guideline values for nitrogen dioxide

Nitrogen dioxide	Threshold concentration	Averaging period	Permissible exceedences per year
Standard	200 µg/m³	1-hour average	9 hours
Guideline	100 µg/m³	24-hour average	-

5.4 Monitoring results

5.4.1 National standard (1-hour average)

A summary of 1-hour average concentrations of nitrogen dioxide measured throughout the region during 2009 is presented in Table 5.2. The national standard was not exceeded at any time during the reporting period.

Table 5.2: Nitrogen dioxide statistics (1-hour average) for the 2009 calendar year

Nitrogen dioxide µg/m³	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa	Karori
Maximum	100.1	69.7	52.0	55.3	48.5	47.1
95th percentile	57.2	31.2	25.2	23.5	26.6	13.1
Mean	27.5	11.1	8.2	7.1	9.7	2.9
Median	25.1	7.9	5.5	4.5	7.1	1.4
Interquartile range	14.5 to 39.5	4.2 to 15.1	2.6 to 11.2	2.1 to 8.8	4.2 to 13.1	0.5 to 3.3
Valid data	96.9%	97.4%	97.5%	92.1%	97.1%	98.1%

Figure 5.1 displays the distribution of nitrogen dioxide data across all monitoring sites in the region. There are no national guidelines or standards for annual nitrogen dioxide concentrations. Figure 5.1 shows that all annual concentrations were below the WHO (2006) guideline of 40 µg/m³. The Wellington central site recorded the highest annual nitrogen dioxide concentration.

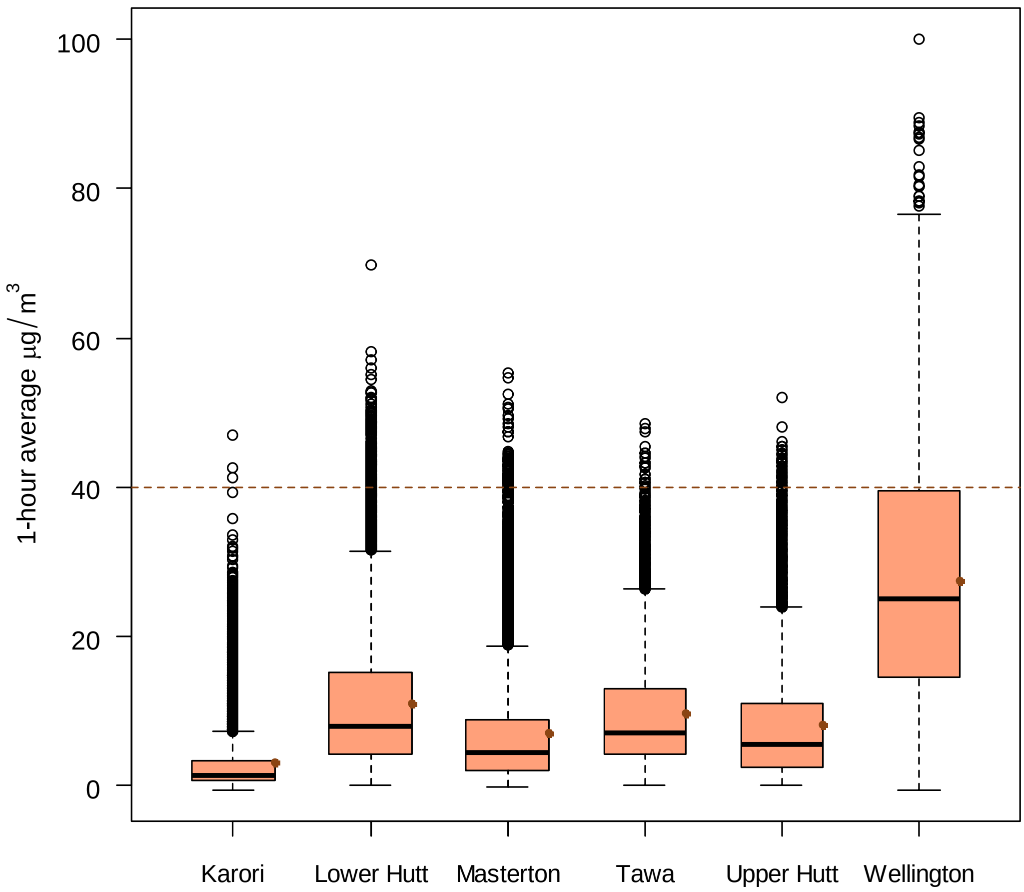

Figure 5.1: Boxplot showing the distribution of NO_2 1-hour average concentrations for the 2009 calendar year. The brown points on the boxplots show the annual averages and the dashed brown line is the WHO (2006) annual average guideline value.

5.4.2 National guideline (24-hour average)

A summary of 24-hour concentrations of nitrogen dioxide measured during 2009 is presented in Table 5.3. Concentrations were well within the national guideline at all times during the reporting period.

Table 5.3: Nitrogen dioxide statistics (24-hour average) for the 2009 calendar year

Nitrogen dioxide µg/m3	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa	Karori
Maximum	48.7	30.1	22.6	24.3	25.9	14.5
95th percentile	42.0	22.7	18.7	16.0	20.2	9.2
Mean	27.5	11.1	8.2	7.1	9.7	2.9
Median	27.2	10.2	6.9	5.7	8.6	2.1
Interquartile range	19.9 to 35.9	5.9 to 15.2	3.9 to 11.8	3.7 to 9.6	5.5 to 13.1	0.7 to 4.6
Valid data	98.1%	98.6%	98.9%	94.0%	96.4%	99.7%

5.4.3 Air quality reporting categories

The concentrations of nitrogen dioxide in air are reported as a percentage of the number of hours per year in each air quality category (Figure 5.2). At all monitoring sites except Wellington central, concentrations of nitrogen dioxide were mostly 'excellent'. A breakdown of the number of hours in each category is given in Appendix 3 (Table A3.3).

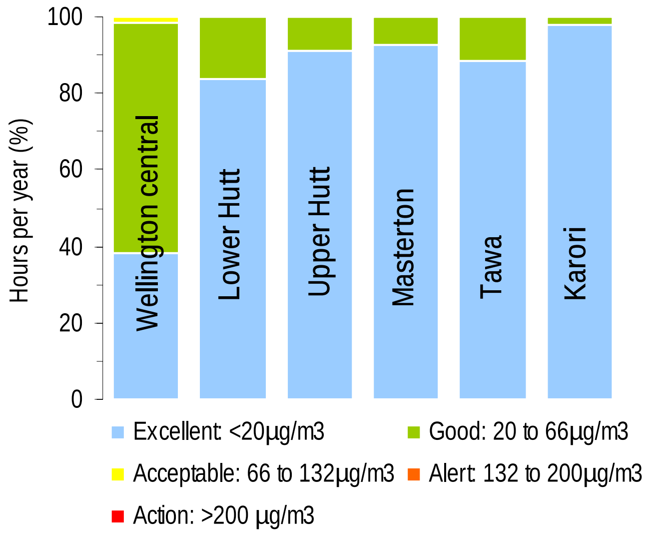

Figure 5.2: Nitrogen dioxide (1-hour average) by air quality category for the 2009 calendar year

6. Air quality investigations

6.1 Roadside air quality at Melling intersection, Lower Hutt

6.1.1 Site details and summary statistics

In conjunction with Greater Wellington's Transport Strategy Development Department mobile air quality stations are used to monitor air quality near busy roads to assess the impact of traffic emissions on local air quality. Air quality has been measured at the Melling bridge intersection (SH 2, Lower Hutt) from mid to late 2006 to the end of 2009 (Figure 6.1). The monitoring station has now been decommissioned for deployment elsewhere in the region.

Figure 6.1: Aerial view of the Melling air quality monitoring site and inset photo shows the monitoring and station photo

During the three-year period of monitoring all pollutants measured were below the allowable limits set by the national standards and guidelines for air quality. Summary statistics for the period are provided in Table 6.1.

Table 6.1: Descriptive statistics for Melling site (May 2006 to December 2009)

	Carbon monoxide (mg/m³)		Nitrogen dioxide (µg/m³)		PM_{10} (µg/m³)
Averaging time	8-hr moving	1-hour	1-hour	24-hour	24-hour
Upper limit	10 (standard)	30 (guideline)	200 (standard)	100 (guideline)	50 (standard)
Maximum	3.6	6.3	113.6	48.7	34
95th %ile	1.5	1.8	47.8	35.4	21
Mean	0.4	0.4	19.6	19.6	13
Median	0.3	0.2	16	18.7	12
IQR	0.1 – 0.6	0.05 – 0.6	8.7 – 27.1	12.3 - 25.6	10 - 16

6.1.2 Pollutant patterns – diurnal, week day and seasonal variation

Average pollutant concentrations vary considerably by time of day, day of the week and by month. Figure 6.2 shows levels of nitrogen dioxide and carbon monoxide that have been normalised so that the diurnal trends can be compared for these two pollutants which have very different scales. Both pollutants show similar weekday patterns with two distinct daily peaks coinciding with commuter rush hour. Carbon monoxide levels are noticeably elevated on Thursday evenings. Saturdays and Sundays show a later and more subdued morning peak and a less pronounced evening peak for both pollutants. Carbon monoxide and nitrogen dioxide monthly average concentrations show a distinct seasonal effect, being higher from May through to July. These higher winter concentrations are attributed to winter meteorological conditions which are less conducive for dispersion of pollutants.

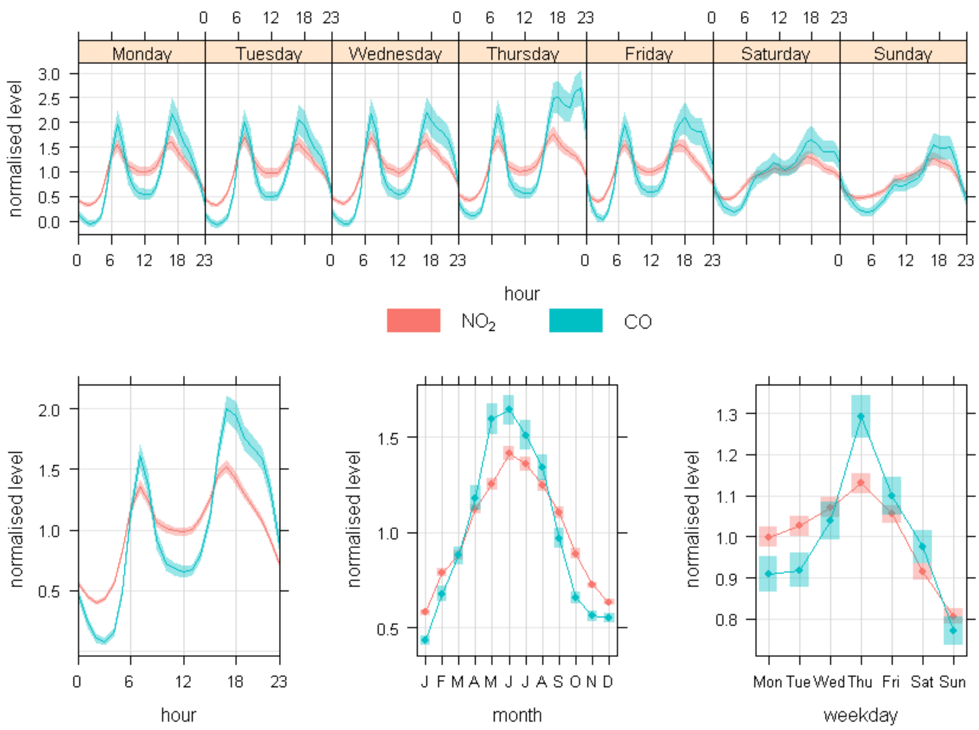

Figure 6.2: Carbon monoxide and nitrogen dioxide concentrations measured at Melling (2006 to 2009). Concentrations have been normalised by dividing by their mean values. The bands show the 95% confidence interval for the mean.

6.2 Sources of air pollution in the Wairarapa airshed

6.2.1 Background

Good information is available on the levels and sources of air pollution in central Masterton, but little is known about air quality in some of the other Wairarapa towns. As a result, a pilot study looking at air quality in Featherston, Carterton and on the outskirts of Masterton (Solway) was carried out in winter 2009. The location of the monitoring sites is shown in Figure 6.3.

For approximately two weeks at each site, daily samples of PM_{10} were collected on two filters – fine ($PM_{2.5}$) and coarse ($PM_{2.5-10}$) – using a Partisol (Model 2025) dichotomous sequential air sampler housed within a mobile monitoring station (as shown in Figure 6.3 photo inset). GNS Science determined the elemental concentrations for each filter using ion beam analysis (IBA). A mass reconstruction technique was then employed to identify the likely sources of the particulate matter measured in air (Davy et al. 2009).

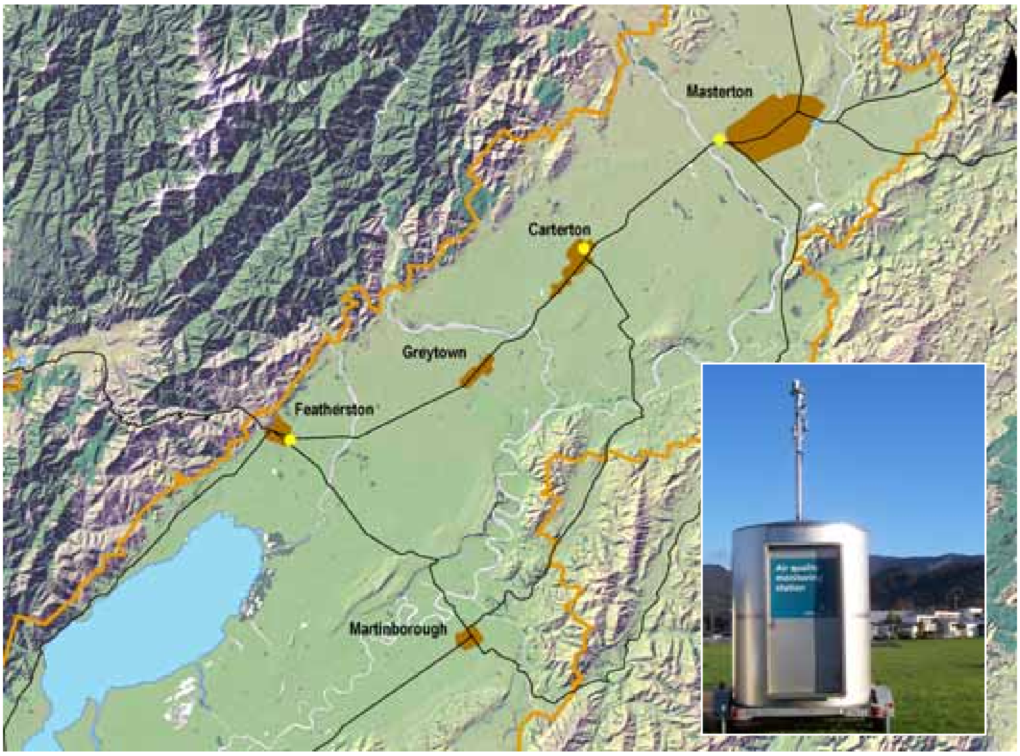

Figure 6.3: Map of the Wairarapa airshed (outlined in orange) showing the location of temporary monitoring sites (yellow dots) in winter 2009. Photo inset shows mobile monitoring station located at Featherston Primary School.

6.2.2 Air quality and sources of particulate matter

Figure 6.4 shows daily $PM_{2.5}$ and $PM_{2.5-10}$ average concentrations measured at the temporary monitoring site at Carterton centennial swimming pool from 3 to 15 June 2009, at Solway Primary School in Masterton from 20 June to 2 July 2009, and at Featherston Primary School from 4 to 19 July 2009. Adding together the two size fractions gives the daily average PM_{10}.

In Carterton, the PM_{10} threshold of 50 µg/m^3 set by the national air quality standard was exceeded on one day. On five days the WHO (2006) $PM_{2.5}$ guideline of 25µg/m^3 was exceeded. On average 85% of the daily PM_{10} was composed of $PM_{2.5}$. The majority of the $PM_{2.5}$ contained organic compounds and black carbon (soot) typically associated with emissions from woodburners. Natural sources (such as sea salt and soil) made only a minor contribution to PM_{10} levels in air.

In Solway, all days monitored were below the PM_{10} threshold of 50 µg/m^3 and below the WHO (2006) $PM_{2.5}$ guideline of 25µg/m^3. On average about half of the daily PM_{10} was made up of $PM_{2.5}$, most likely from combustion sources. It is unclear whether these combustion sources were domestic fires, motor vehicle emissions or industrial. Sea salt and soil contributed the remainder of the PM_{10} measured in air.

In Featherston, all dates monitored were below the PM_{10} threshold of 50 µg/m^3. On two days the WHO (2006) $PM_{2.5}$ guideline of 25µg/m^3 was exceeded. On average 73% of the daily PM_{10} was composed of $PM_{2.5}$, most likely from solid fuel domestic fires. Natural sources (such as soil and sea salt) made only a minor contribution to measured PM_{10}.

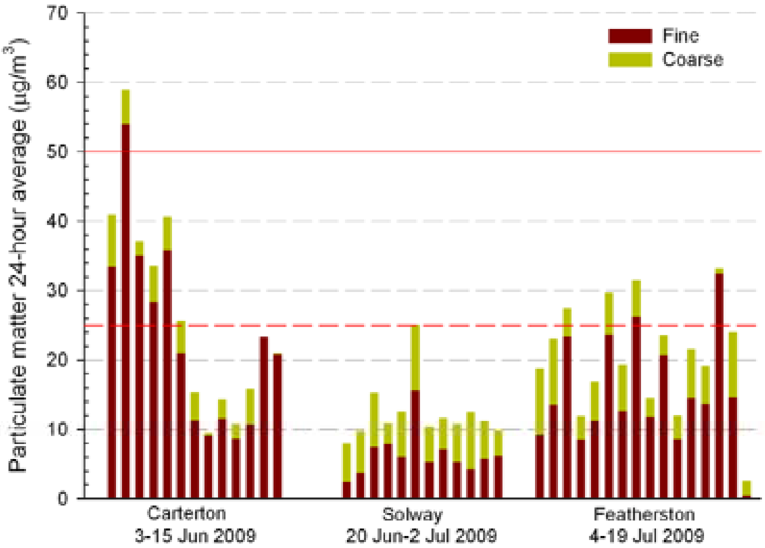

Figure 6.4: Daily particulate matter concentrations measured by Partisol during winter 2009. The red line shows the national environmental standard limit for PM_{10} and the red dashed line shows the WHO (2006) guideline for $PM_{2.5}$.

6.2.3 Conclusions

The 2009 winter PM_{10} monitoring results indicate potential for episodes of degraded winter air quality in Carterton due to domestic winter burning. A winter monitoring programme using a reference air quality monitor (Beta Attenuation Monitor FH62 model) was carried out in winter 2010 to assess concentrations of PM_{10} over a longer period. The results will be reported in 2011 and used to assess compliance with the national environmental standard.

7. Summary

- Apart from one day in Masterton, particulate matter (PM_{10}) concentrations measured in the region were below the national environmental standard during 2009.

- The Wairarapa airshed complied with the national environmental standard in 2009 because there was only one exceedence of the PM_{10} daily limit at the Masterton monitoring station which is permitted. An estimated eight per cent reduction in domestic emissions in the Masterton urban area, from 2008 levels, is needed to ensure that the national environmental standard will be met by 2013.

- During winter there were 15 days in Masterton and four days in Wainuiomata where the 'alert' level for PM_{10} was reached (i.e., daily concentrations are above 66% of the limit allowed by the national standard). On 'alert' days most of the PM_{10} in air is made up of fine particulate matter ($PM_{2.5}$). $PM_{2.5}$ causes the most harm to people's health because smaller particles can penetrate deeper into the lungs.

- Concentrations of two pollutants produced by vehicles, carbon monoxide and nitrogen oxides, were well within national environmental standards and guidelines at all monitoring stations. As expected, roadside air quality measured in central Wellington and at Melling intersection (SH 2, Lower Hutt) was poorest during peak commuter times.

- An air pollution pilot study in the Wairarapa airshed investigating air quality outside the Masterton urban area found that Carterton's air quality is degraded by PM_{10} emissions from domestic woodburners. Results from the Carterton winter 2010 air quality monitoring programme will be reported in 2011.

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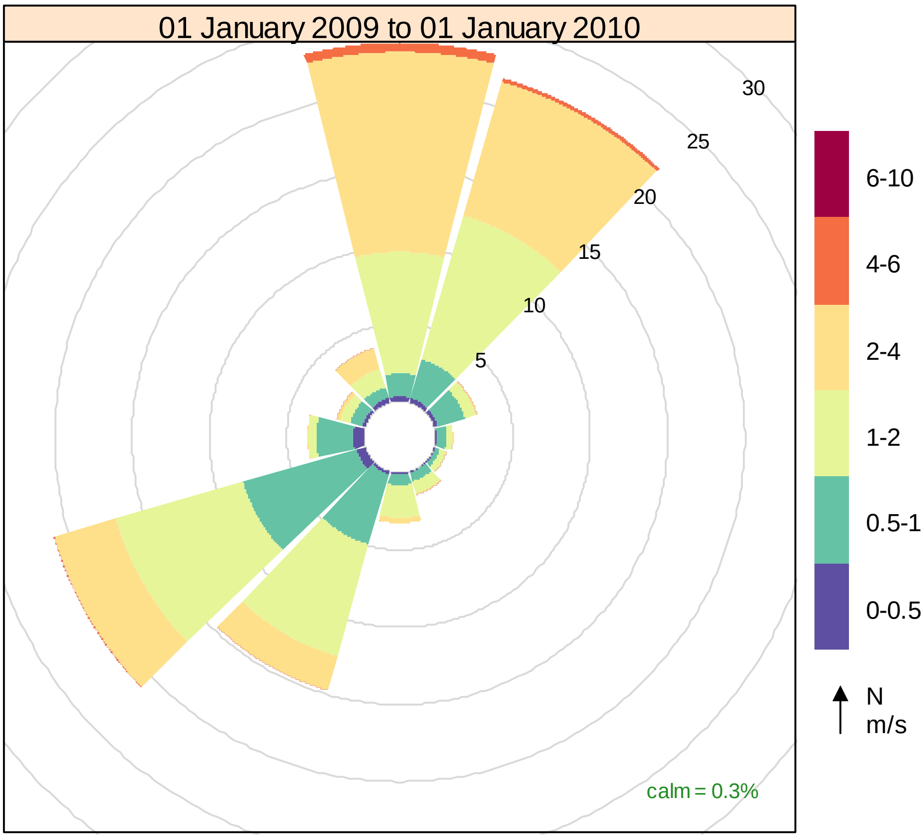
The work of Darren Li and Karl Watson in operating and maintaining monitoring equipment and stations is gratefully acknowledged. Thanks also to Jon Marks and his team for installing and maintaining the meteorological and communications equipment.

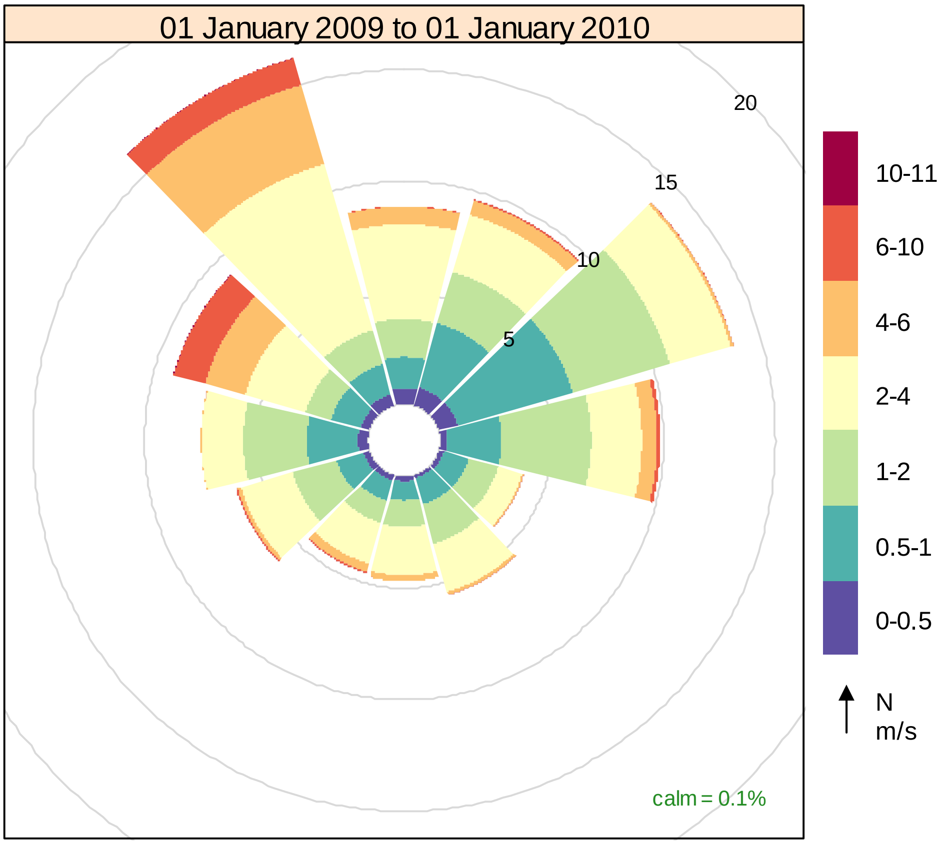
Appendix 1: Wind roses by monitoring site

Wind speed and direction were recorded at all permanent air quality monitoring stations during the 2009 calendar year. The wind roses below show the proportion of time (represented as a percentage on the grey circles) that the wind is from a particular angle (30^{o} increments) and wind speed range (shown on the right hand scale in metres per second). The wedge points towards the direction the wind is blowing from. No wind rose is presented for Karori due to poor data quality.

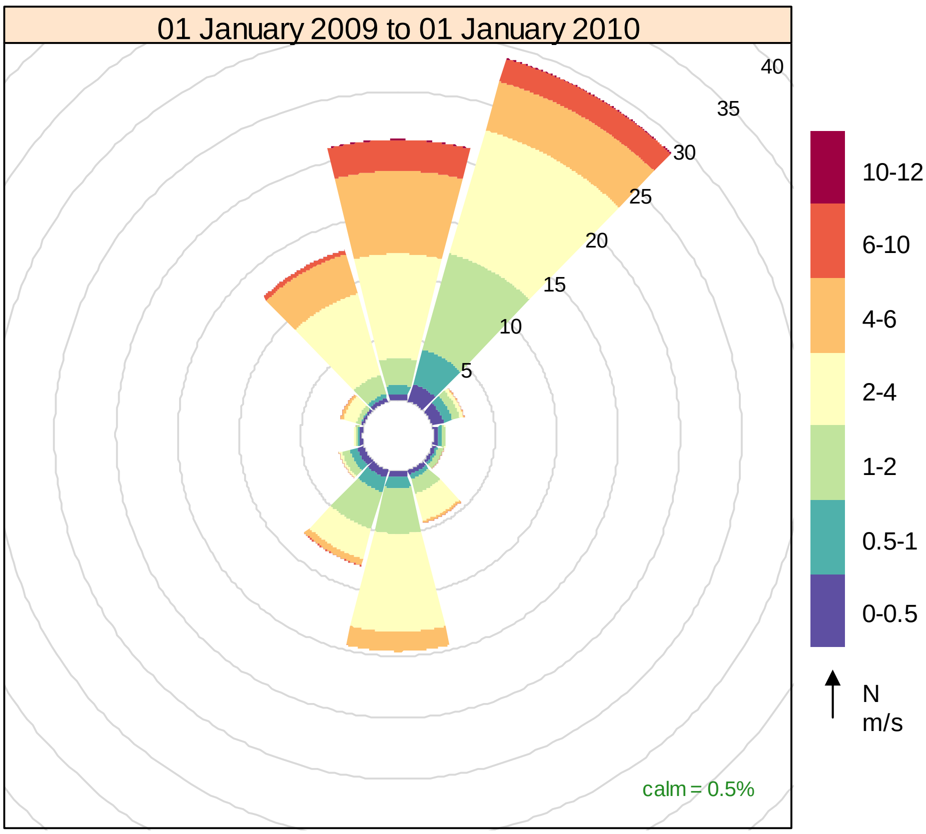
Wellington central (4 m mast height)



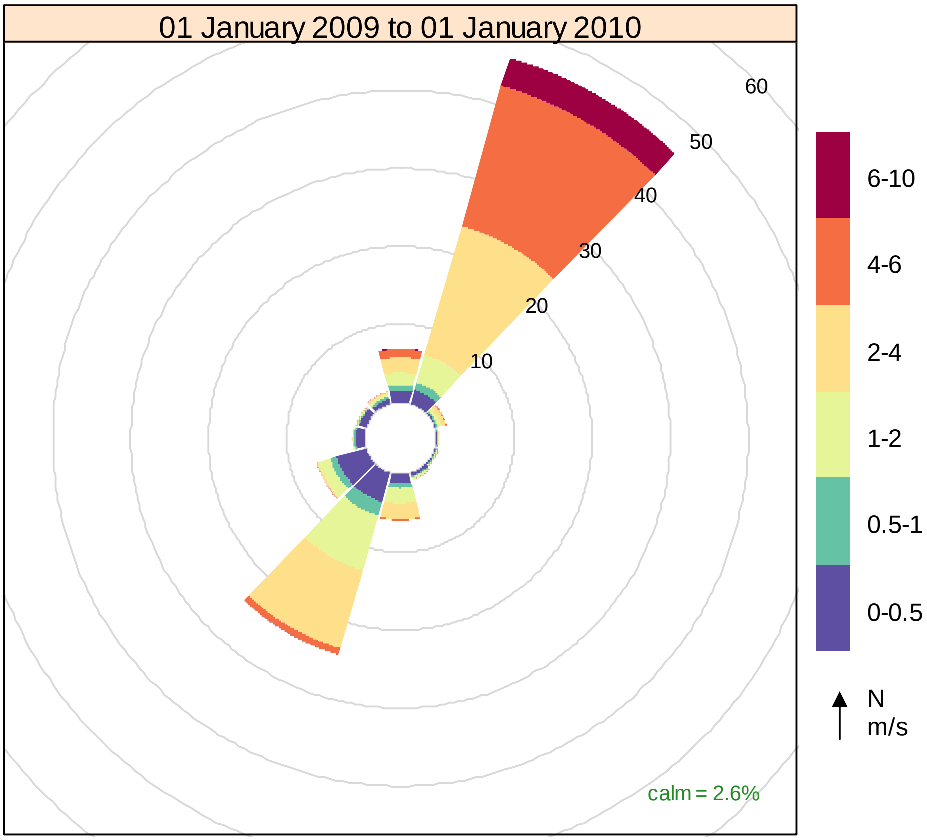
Upper Hutt (10 m mast height)



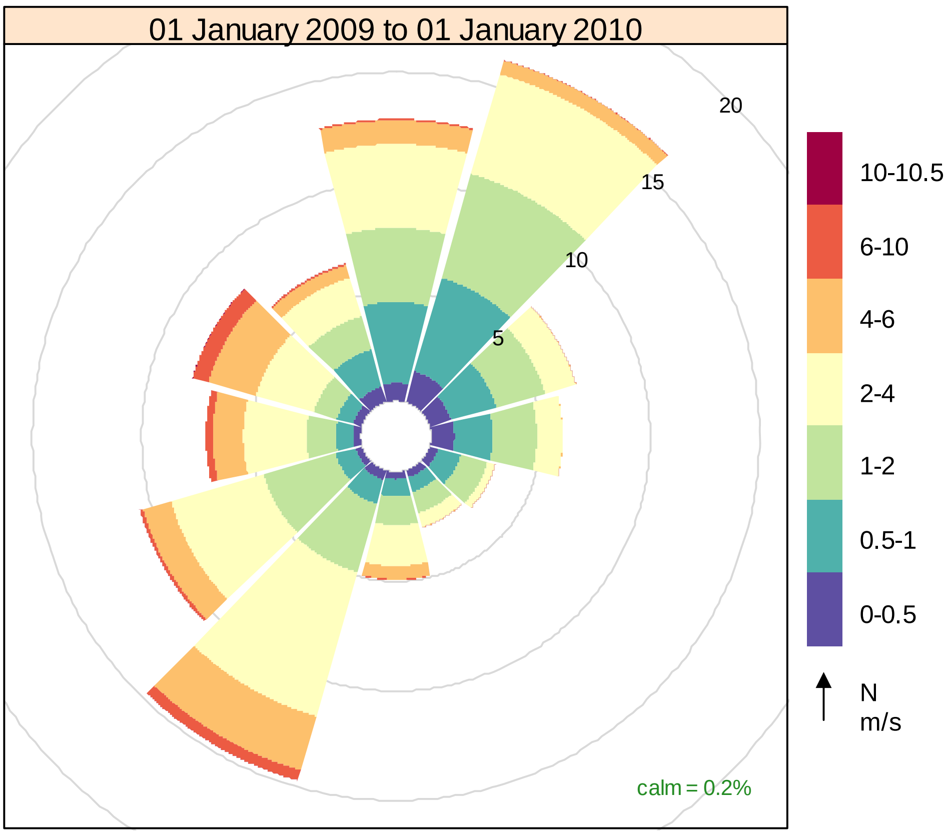
Shandon Golf Course (10 m mast height)



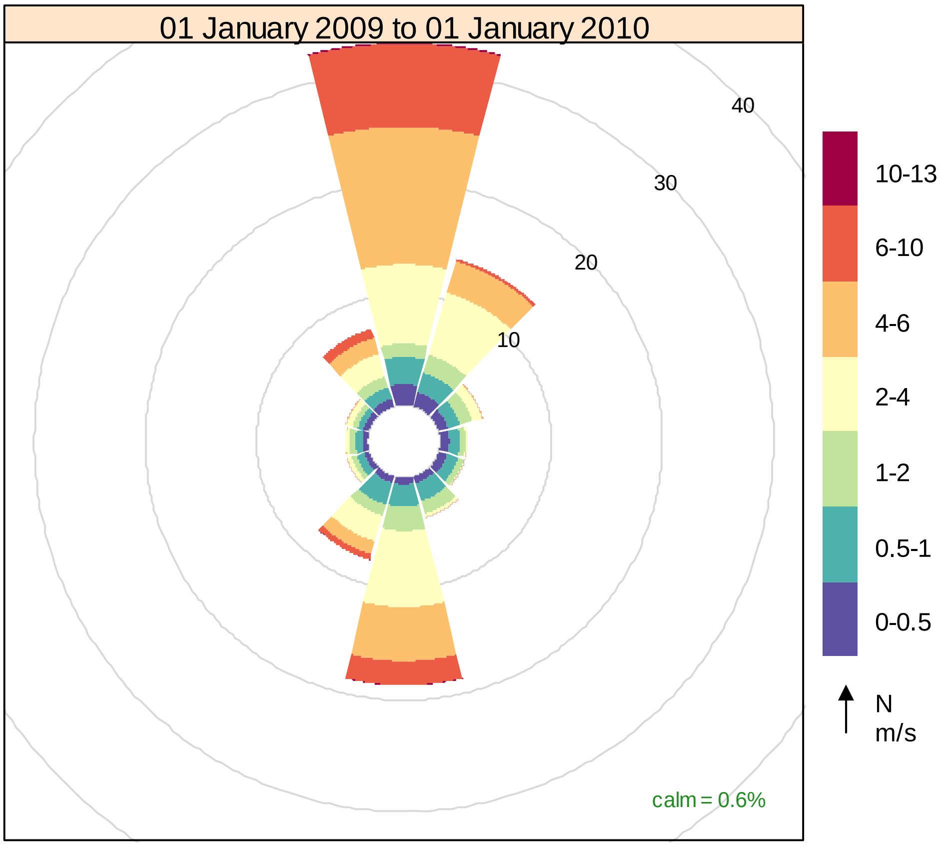
Tawa (6 m mast height)



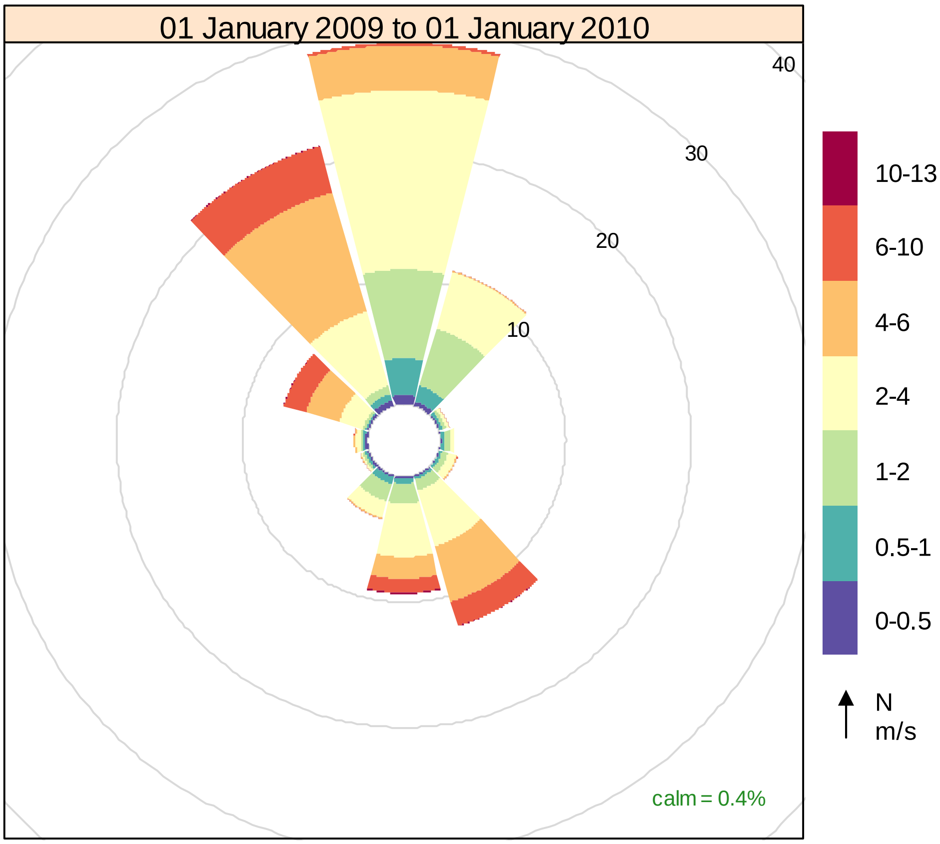
Masterton (10 m mast height)



Wainuiomata (10 m mast height)



Lower Hutt (10 m mast height)



Appendix 2: Data presentation methods

Quality assurance

Greater Wellington's Environmental Monitoring and Investigations Department collects, checks and archives air quality data in accordance with a Quality Management System. This report is based on the best data currently available. We endeavour to continuously improve data quality and so we may amend the data on which this information is based, where necessary and without notice, at any time.

Data averaging

All pollutants are monitored continuously with instruments that are connected by digital interface to dataloggers. All logged data are stored as five or 10 minute averages at New Zealand Standard Time (NZST).

- Daily means are defined as the period from midnight to midnight.
- 8-hour moving means are calculated on the hour for the preceding eight hour period

Percentiles

The reported percentiles for each pollutant are interpolated from the data and therefore do not necessarily represent actual values.

Valid data

A 75 per cent data capture threshold is required for an averaging period to be considered valid and therefore be included in the calculation of summary statistics. Therefore, an hourly average requires at least four 10 minute averages and a 24-hour mean requires at least 18 one-hour averages.

Data precision

In accordance with MfE (2009) good practice, reported PM_{10} values have been rounded up to the nearest whole number and carbon dioxide and nitrogen dioxide values are reported to one significant figure.

Statistics and plots

Statistical summaries and the plot shown in Figures 4.1, 6.2 and Appendix 1 were produced using the *Openair* package which contains R-language implementations of the methods developed and described by Carslaw & Ropkins (2010). The package was downloaded from http://www.openair-project.org and used with R Version 2.11.1 (2010).

Details of the construction of box plots used in this report are presented in Figure A2.1.

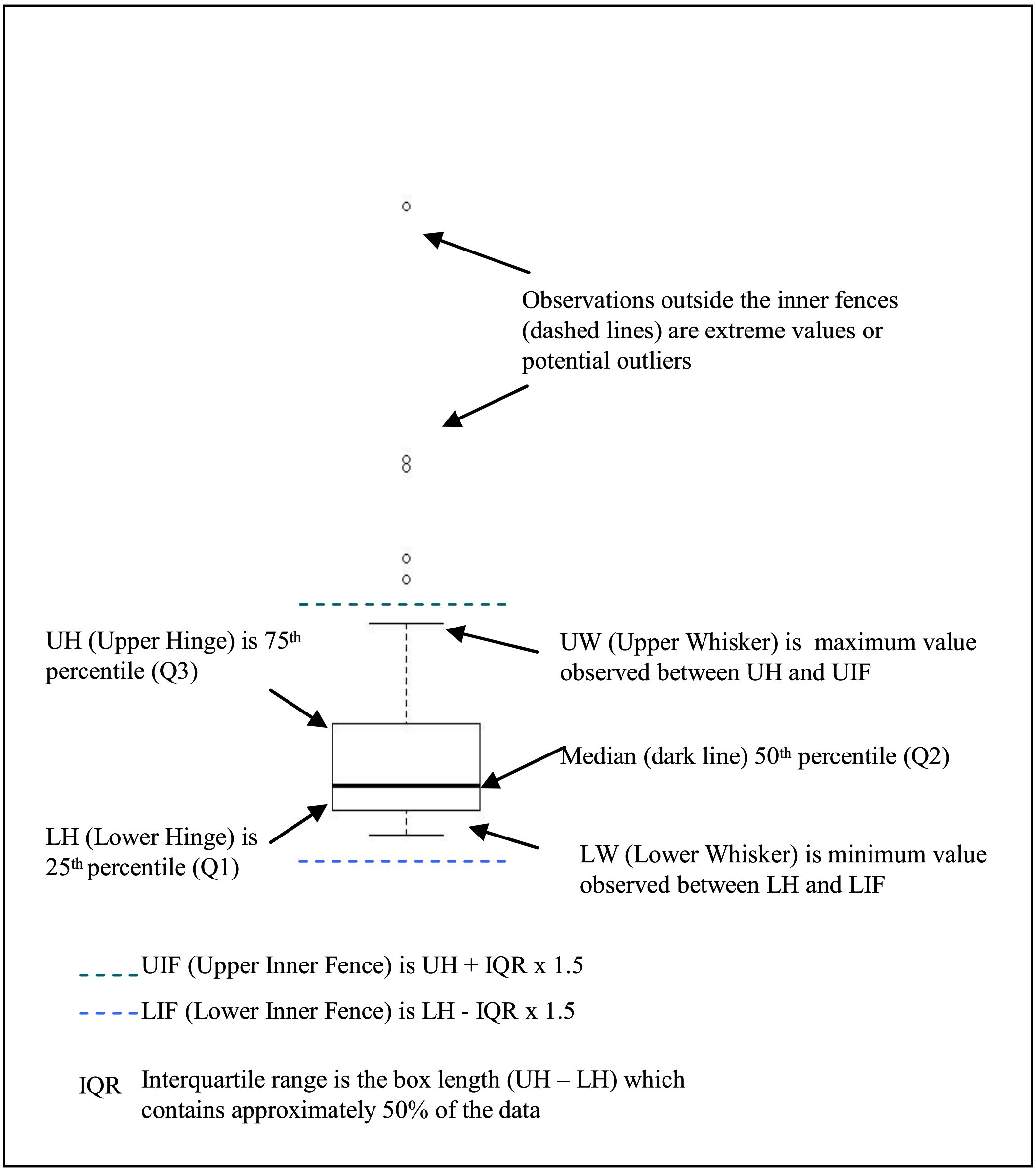


Figure A2.1: Interpretation of box plot

Appendix 3: Air quality reporting categories

Table A3.1: PM_{10} – number of days (24-hour average) in 2009 by air quality category

Monitoring sites	Total days sampled	Excellent <5 µg/m³	Good 5 to 16.5 µg/m³	Acceptable 16.5 to 33 µg/m³	Alert 33 to 50 µg/m³	Action >50 µg/m³
Wellington central	365	2	306	57		
Lower Hutt	356	4	261	91		
Wainuiomata	359	28	255	72	4	
Upper Hutt	350	26	274	50		
Masterton	365	18	259	72	15	1
Tawa	336	11	240	85		
Karori	363	20	304	39		

Table A3.2: CO – number of hours (8-hour moving average) in 2009 by air quality category

Monitoring sites	Total no. hours sampled	Excellent <1 mg/m³	Good 1 to 3.3 mg/m³	Acceptable 3.3 to 6.6 mg/m³	Alert 6.6 to 10 mg/m³	Action >10 mg/m³
Wellington central	8,711	6,952	1,759			
Lower Hutt	8,477	8,363	114			
Upper Hutt	8,606	8,231	375			
Masterton	8,360	7,815	545			
Tawa	8,451	8,029	422			
Karori	7,357	7,324	33			

Table A3.3: NO_2 – number of hours (1-hour average) in 2009 by air quality category

Monitoring sites	Total no. hours sampled	Excellent <20 µg/m³	Good 20 to 66 µg/m³	Acceptable 66 to 133 µg/m³	Alert 133 to 200 µg/m³	Action >200 µg/m³
Wellington central	8,487	3,259	5,101	127		
Lower Hutt	8,533	7,157	1,375	1		
Upper Hutt	8,541	7,785	756			
Masterton	8,060	7,482	578			
Tawa	8,510	7,544	966			
Karori	7,332	7,178	154			

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Photo
Winter smoke from woodburners in Featherston

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