Annual air quality monitoring report for the Wellington region, 2010

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Contents

1. Introduction

Greater Wellington Regional Council (Greater Wellington) monitors ambient air quality at selected sites in the Wellington 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.

The core air quality 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 the 2010 calendar year. During this period, air quality was monitored at six stations and a short-term winter monitoring campaign was carried out in Carterton (Wairarapa) and in Raumati South (Kapiti Coast).

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 relocated in 2006). 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; and
- 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): Kapiti Coast, Porirua Basin (including Tawa valley and Pauatahanui Inlet), Wellington city, Karori, Lower Hutt Valley, Wainuiomata, Upper Hutt Valley, and Wairarapa Valley. Each airshed has a distinct microclimate, meteorological conditions and air quality pressures. These airsheds were formally Gazetted in 2005 in accordance with the NES-AQ[1] (Davy 2005).

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

[1] Resource Management (National Environmental Standards for Air Quality) Regulations 2004

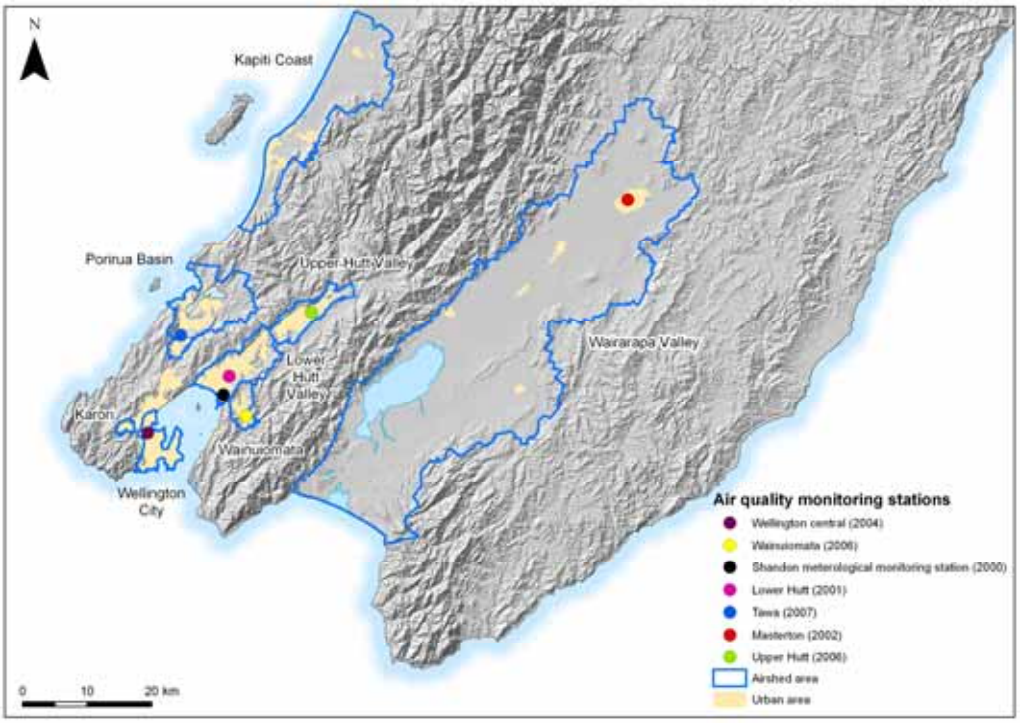


Figure 2.1: Location of Greater Wellington air quality and meteorological monitoring sites (as at 2010) and airshed boundaries established in 2006

Table 2.1: Air quality monitoring sites operated in the 2010 calendar year

Site	Station	Airshed	Location	Pollutants monitored	Valid data from
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	2006
Masterton	Wairarapa College	Wairarapa Valley	Cornwell Street	PM_{10}, CO, NOx	2002
Tawa	Duncan Park	Porirua	Linden Street	PM_{10}, CO, NOx	2007
Shandon	Shandon golf course	Lower Hutt Valley	Gear Island, Petone	Meteorological only	2000

2.4 Air pollutants and meteorological variables 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.

Meteorological instruments for recording variables 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 2010 at each monitoring site are presented in Appendix 1.

2.5 Air quality assessment criteria and reporting

Greater Wellington's air quality monitoring results for PM_{10} are provided to the Ministry for the Environment (MfE) as part of the national reporting framework (http://www.mfe.govt.nz/environmental-reporting/air/air-quality/pm10/nes/). Detailed information on how air quality monitoring results are reported is presented in Appendix 2.

2.5.1 National environmental standards and guidelines for air quality

National ambient air quality guidelines (NAAQG) were established by MfE in 1994 and 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 guidelines for pollutants measured in the Wellington 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).

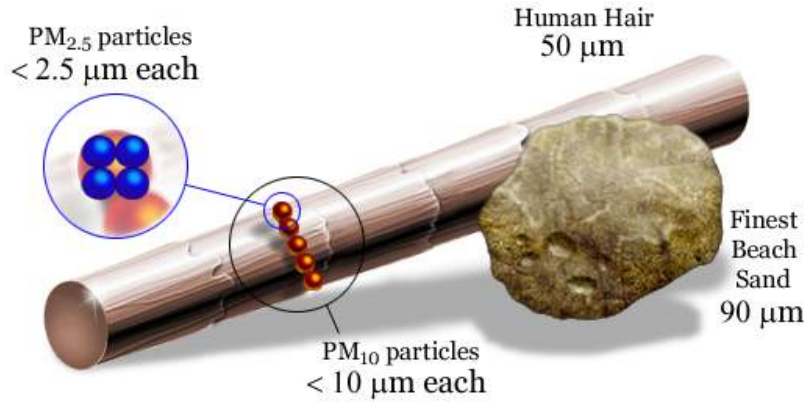
Table 2.2: Air quality categories for reporting monitoring results

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 (Figure 3.1). This size fraction is small enough to be inhaled into the respiratory system.



(Source: www.mfe.govt.nz)

Figure 3.1: Particle sizes relative to the width of a human hair and a grain of sand

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 ($PM_{2.5\text{-}10}$). $PM_{2.5}$ 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 Monitor at Lower Hutt; and by ThermoElectron Corp FH62 C14 beta attenuation monitors at the remainder of the air quality stations. Both of these instruments are designated as automated methods equivalent to the

United States Code of Federal Regulations[2] 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 NES-AQ 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 2010 are shown in Table 3.2. There were five days in the Wairarapa airshed and one day in the Wainuiomata airshed where PM_{10} concentrations failed to meet the limit set by the national standard during 2010.

Table 3.2: PM_{10} statistics (24-hour average) for air quality monitoring stations in the Wellington region during the 2010 calendar year

PM_{10} (µg/m^3)	Wellington Central	Lower Hutt	Upper Hutt	Masterton	Tawa	Wainuiomata
Maximum	32	29	32	67	30	62
95th percentile	21	22	21	35	22	23
Mean	13	14	11	13	12	11
Median	12	13	10	10	11	10
Interquartile range	10 to 15	10 to 16	7 to 13	7 to 15	8 to 15	7 to 13
Valid data	97.5%	98.0%	99.5%	100%	95.9%	99.5%

3.4.2 National guideline (annual average

Figure 3.2 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.

[2] 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.

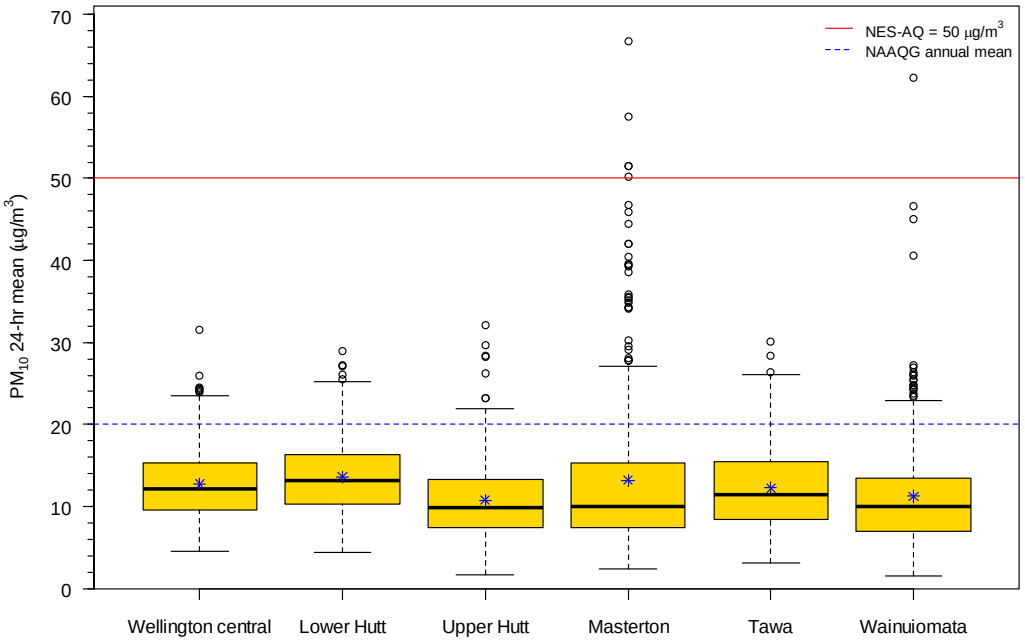


Figure 3.2: Box plot[3] showing the distribution of PM_{10} 24-hour average concentrations for the 2010 calendar year for each air quality monitoring station in the Wellington region. The blue stars on the box plot show the annual average for each site and the dashed blue line is national annual average 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 number of days per year in each air quality category described in Section 2.5 (Table 3.3). Air quality assessed this way was 'good' or better on average just over 80% of monitored days in 2010. In Masterton there were 23 days and in Wainuiomata four days when air quality was at or above 'alert' levels.

Table 3.3: PM_{10} (24-hour average) by air quality category in the 2010 calendar year

Monitoring site	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	356	1	301	54		
Lower Hutt	359	1	273	85		
Upper Hutt	363	29	292	42		
Masterton	365	28	257	57	19	4
Tawa	350	12	270	68		
Wainuiomata	363	31	278	50	3	1

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

3.5 PM_{10} exceedence days

During winter 2010 there were four exceedences of the PM_{10} NES-AQ recorded at Masterton (67 µg/m^3 on 22 June, 51 µg/m^3 on 23 June, 57 µg/m^3 on 4 July and 51 µg/m^3 on 26 July, Figure 3.3). There was also one exceedence in both Carterton (53 µg/m^3 on 21 July) and Wainuiomata (62 µg/m^3 on 2 July). All exceedence days were characterised by low overnight wind speeds and temperatures.

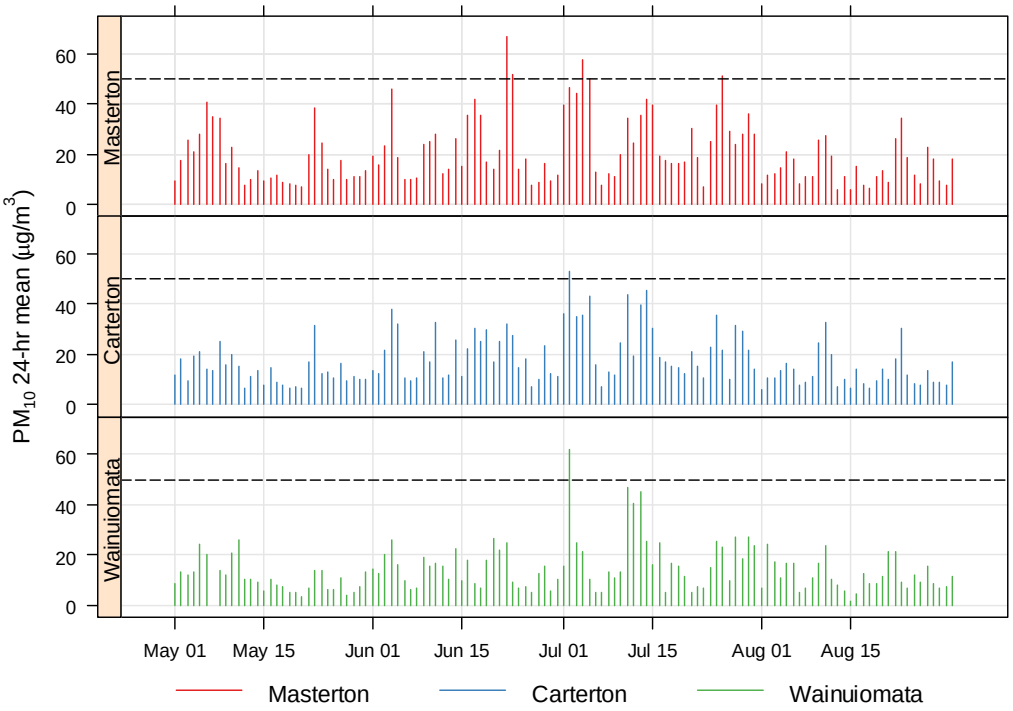


Figure 3.3: Daily PM_{10} averages measured at air quality monitoring sites in Masterton, Carterton and Wainuiomata during winter 2010. Concentrations above the dashed line represent exceedences of the NES-AQ limit of 50 µg/m^3.

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.

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 Wellington region during 2010 are shown in Table 4.2. All concentrations were well within the national standard for carbon monoxide during the reporting period.

Average concentrations 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: Carbon monoxide statistics (8-hour moving average) for air quality monitoring stations in the Wellington region during the 2010 calendar year

Carbon monoxide (mg/m³)	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa
Maximum	3.2	2.5	2.4	3.2	2.4
95th percentile	1.5	0.6	0.9	0.9	0.9
Mean	0.6	0.2	0.3	0.3	0.2
Median	0.5	0.1	0.2	0.1	0.1
Interquartile range	0.3 to 0.8	0.1 to 0.2	0.1 to 0.3	0.1 to 0.3	0.1 to 0.2
Valid data	97.4%	98.6%	98.4%	99.1%	99.4%

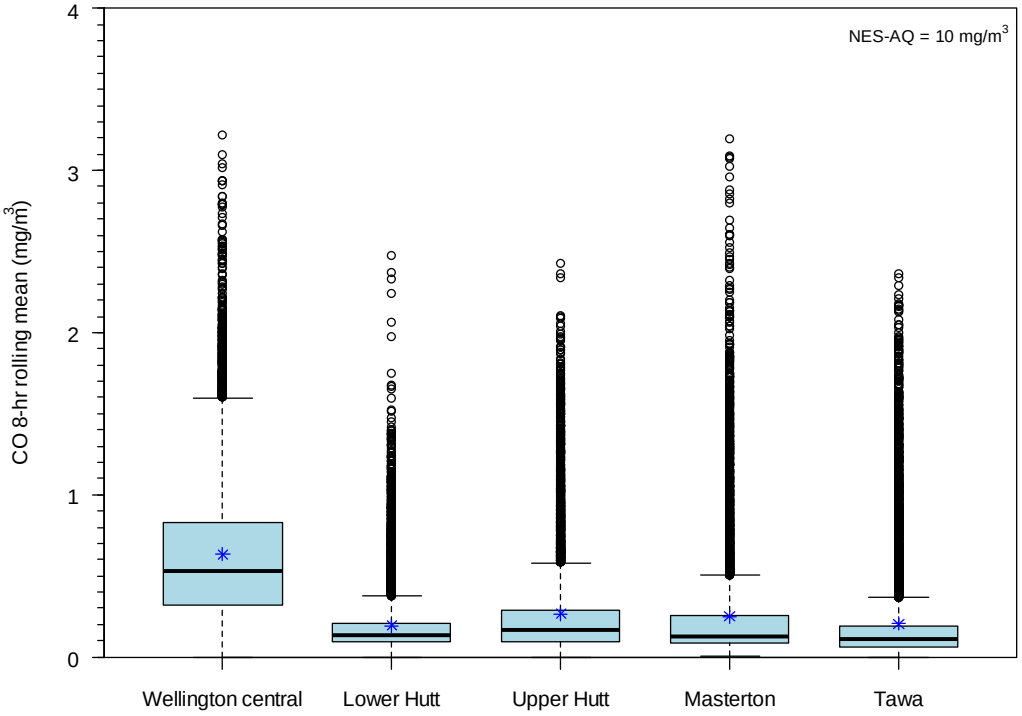


Figure 4.1: Box plot showing the distribution of carbon monoxide (8-hour moving average) concentrations for air quality monitoring stations in the Wellington region during the 2010 calendar year. The blue stars on the box plot show the annual average for each site.

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) for air quality monitoring stations in the Wellington region during the 2010 calendar year

Carbon monoxide (mg/m^3)	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa
Maximum	5.0	3.5	3.7	4.8	3.7
95th percentile	1.7	0.6	1.0	1.0	0.9
Mean	0.6	0.2	0.3	0.3	0.2
Median	0.5	0.1	0.2	0.1	0.1
Interquartile range	0.3 to 0.8	0.1 to 0.2	0.1 to 0.3	0.1 to 0.2	0.1 to 0.2
Valid data	97.6%	98.6%	98.5%	99.0%	99.5%

4.4.3 Air quality reporting categories

At all monitoring sites concentrations of carbon monoxide were mostly 'excellent' (Table 4.4), apart from Wellington central where concentrations were 'good' on 17% of the 8-hour averaging periods measured during 2010.

Table 4.4: Carbon monoxide (8-hour moving average) by air quality category for air quality monitoring stations in the Wellington region during the 2010 calendar year

Monitoring site	Total no. hours sampled	Excellent <1 mg/m^3	Good 1 to 3.3 mg/m^3	Acceptable 3.3 to 6.6 mg/m^3	Alert 6.6 to 10 mg/m^3	Action >10 mg/m^3
Wellington central	8,525	7,105	1,420			
Lower Hutt	8,521	8,510	11			
Upper Hutt	8,392	8,050	342			
Masterton	8,678	8,288	390			
Tawa	8,358	8,050	308			

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.

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/m^3	1-hour average	9 hours
Guideline	100 µg/m^3	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 Wellington region during 2010 is presented in Table 5.2. The national standard was not exceeded at any site or time during the reporting period.

Table 5.2: Nitrogen dioxide statistics (1-hour average) for air quality monitoring stations in the Wellington region during the 2010 calendar year

Nitrogen dioxide ($\mu g/m^3$)	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa
Maximum	105.4	63.8	51.0	59.7	47.3
95th percentile	57.3	33.3	25.0	20.5	26.3
Mean	25.8	11.3	7.2	5.9	8.1
Median	23.2	8.0	4.3	3.3	5.1
Interquartile range	12.5 to 36.5	4.5 to 14.9	1.7 to 9.7	1.6 to 7.3	2.4 to 11.2
Valid data	97.6%	98.2%	97.9%	98.0%	96.9%

Figure 5.1 displays the distribution of nitrogen dioxide data across all air quality monitoring sites in the region. There are no national guidelines or standards for annual average nitrogen dioxide concentrations, although Figure 5.1 shows that all annual concentrations were below the World Health Organisation (2006) guideline of 40 $\mu g/m^3$. The Wellington central site recorded the highest annual average nitrogen dioxide concentration.

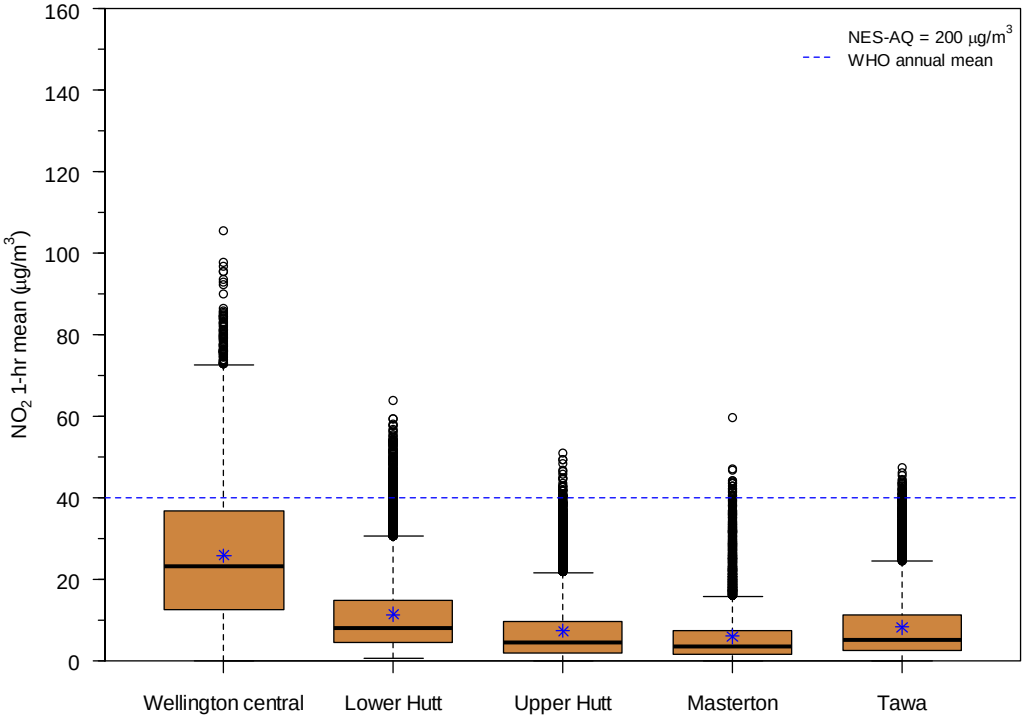


Figure 5.1: Box plot showing the distribution of nitrogen dioxide (1-hour average) concentrations for air quality monitoring stations in the Wellington region during the 2010 calendar year. The blue stars on the box plot show the annual average for each site and the dashed blue line is the WHO (2006) 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 air quality monitoring stations in the Wellington region during the 2010 calendar year

Nitrogen dioxide (µg/m^3)	Wellington central	Lower Hutt	Upper Hutt	Masterton	Tawa
Maximum	56.0	33.4	24.8	20.1	25.7
95th percentile	43.4	23.3	17.4	14.1	18.9
Mean	25.6	11.3	7.3	5.9	8.1
Median	25.3	9.3	5.8	4.6	6.9
Interquartile range	17.9 to 32.6	5.9 to 15.3	3.2 to 10.6	2.9 to 7.5	3.7 to 11.2
Valid data	99.7%	100%	100%	100%	98.9%

5.4.3 Air quality reporting categories

At all air quality monitoring sites concentrations of nitrogen dioxide were mostly 'excellent' during 2010 (Table 5.4). The main exception was Wellington central which had a greater proportion of hours in the 'good' category (and a small number of hours in the 'acceptable' category).

Table 5.4: Nitrogen dioxide (1-hour average) by air quality category for air quality monitoring stations in the Wellington region during the 2010 calendar year

Monitoring site	Total no. hours sampled	Excellent <20 µg/m^3	Good 20 to 66 µg/m^3	Acceptable 66 to 133 µg/m^3	Alert 133 to 200 µg/m^3	Action >200 µg/m^3
Wellington central	8,753	3,835	4,755	163		
Lower Hutt	8,605	7,284	1,321			
Upper Hutt	8,297	7,567	730			
Masterton	8,565	8,107	458			
Tawa	8,281	7,437	844			

6. Air quality investigations

Two air quality investigations were undertaken in winter 2010, one in Carterton and one in Raumati South. Information on the latter investigation is drawn from a more detailed report by Mitchell (2011).

6.1 Carterton winter PM_{10} investigation

Carterton is a small town within the Wairarapa airshed of about 1,701 households with a total population of around 4,122 (Statistics NZ 2006 Census). A two-week pilot study undertaken in winter 2009 (Mitchell 2010) showed the potential for high PM concentrations that were attributed to emissions from domestic heating (Davy et al. 2009). In order to more fully investigate PM_{10} concentrations, a short-term monitoring campaign was carried out in Carterton during winter 2010 (1 May to 31 August 2010) at the location shown in Figure 6.1 (13.2 km southwest of the permanent monitoring site at Wairarapa College in Masterton). Unlike in the 2009 pilot study, the 2010 investigation used a NES-AQ compliant method (FH62).

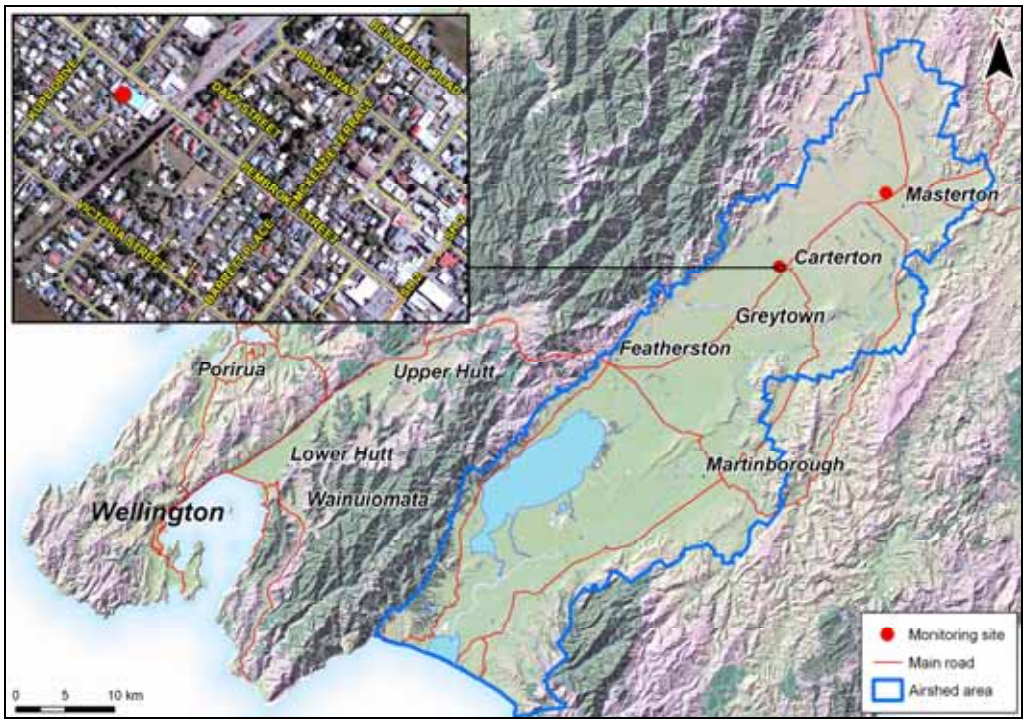


Figure 6.1: Map of the Wairarapa airshed (outlined in blue) showing the location of Greater Wellington's permanent air quality monitoring station in Masterton and the temporary site in Carterton during winter 2010. Photo inset shows the location of the temporary monitoring site at the Carterton public swimming pool.

Summary statistics comparing PM_{10} concentrations at Carterton and Masterton for the 2010 winter period are presented in Table 6.1. Typically 24-hour concentrations were lower at Carterton than in Masterton with an average difference of 2.9 $\mu g/m^3$ [1.6, 4.2][4]. The time variation plot (Figure 6.2) shows both sites exhibit comparable diurnal variation in concentrations – although Masterton experiences on average a higher evening peak – indicating that the

[4] 95% confidence interval.

sites are measuring local environments with similar emission source profiles. There are several days where high concentrations measured at Masterton were not found in Carterton (Figure 6.3). For daily PM_{10} averages above 40 ug/m^3 there appears to be little relationship between the sites which may be a reflection of the higher emissions density in the Masterton urban area coupled with different dispersal characteristics (e.g., position of the sites with respect to overnight cold-air drainage patterns).

Table 6.1: Summary statistics for PM_{10} 24-hour averages (µg/m^3) measured at Carterton and Masterton during winter 2010

Site	25th %ile	Median	Mean	75th %ile	95th %ile	Max	No. >50 µg/m^3
Carterton	10.3	14.4	17.6	22.2	36.4	52.9	1
Masterton	11.0	17.1	20.5	26.1	45.7	66.7	4

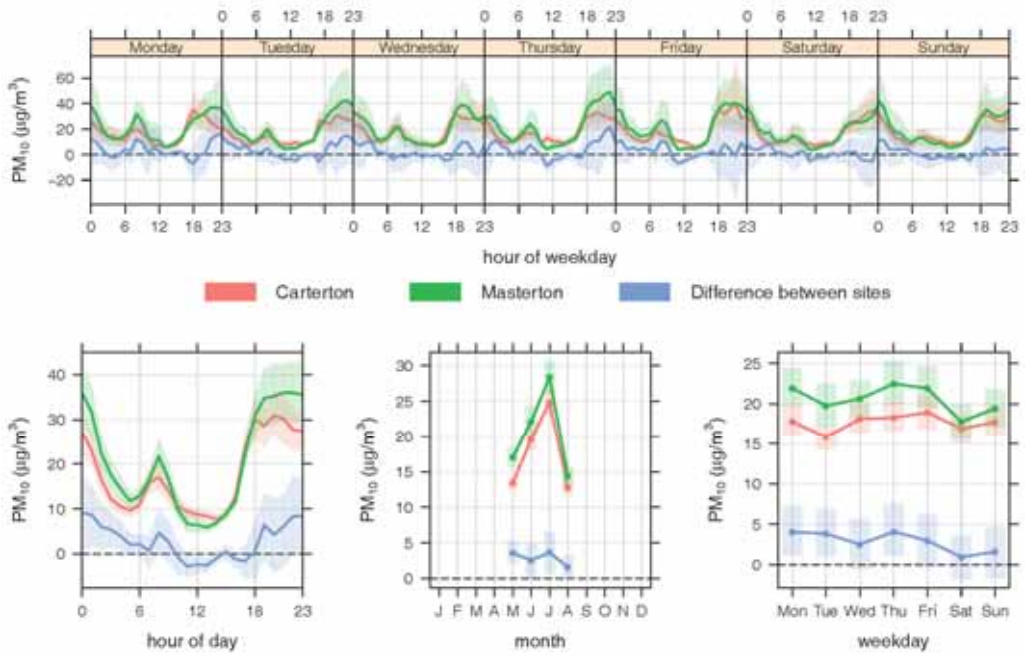


Figure 6.2: Temporal variation in PM_{10} concentrations measured at Carterton and at Masterton during winter 2010. The difference between the sites is shown in blue. The plots show variation in average concentration by: hour and day of the week (top); hour of all days (bottom left); month (bottom middle); and day of the week (bottom right). The 95% confidence interval in the mean is shown by the width of the coloured band around each solid line or point.

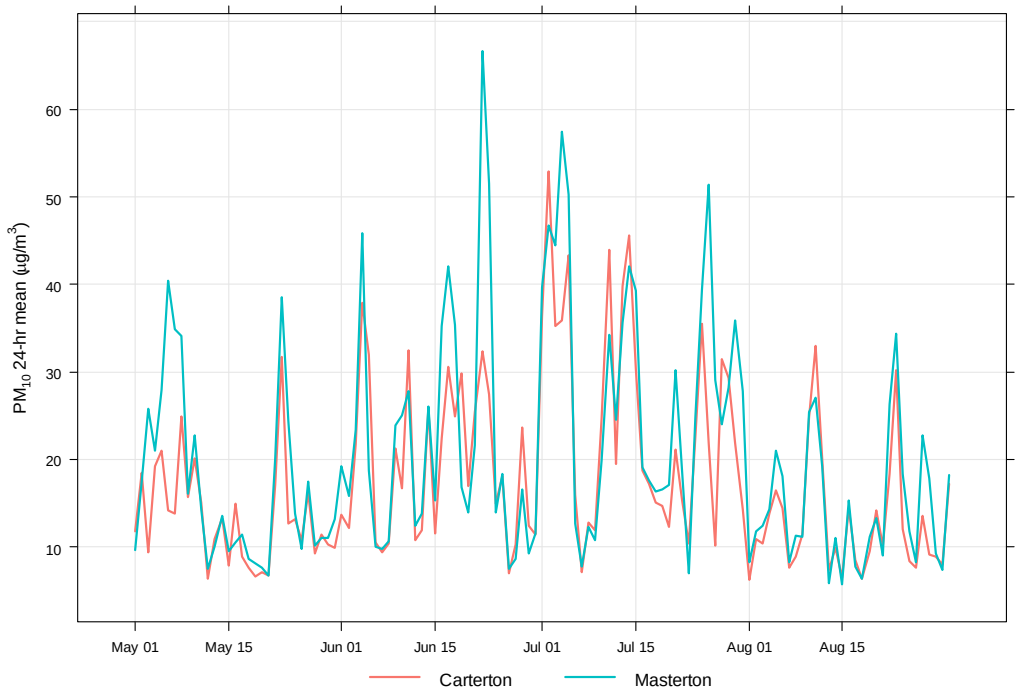


Figure 6.3: Time series of PM_{10} 24-hour average concentrations measured at Carterton and Masterton during winter 2010

6.2 Raumati South winter PM_{10} investigation

Raumati South is a small coastal settlement within the Kapiti Coast airshed with about 1,377 households and a total population of around 3,546 (Statistics NZ 2006 Census). In response to the concerns of some residents about the effects of wood burner emissions on air quality, an investigation was carried out during winter 2010 to provide information on the levels and sources of particulate matter (Mitchell 2011). Monitoring was carried out next to the Raumati South Bowling Club on Glen Road, Raumati South from 25 May to 2 August 2010 (Figure 6.4).

Although the results are not directly comparable to air quality guidelines – as a non-standard monitoring method was used – the results show the potential for exceedences in Raumati South (Mitchell 2011). Figure 6.5 shows the threshold concentrations of the national standard for PM_{10} and the WHO (2006) guideline for $PM_{2.5}$ applied to the Raumati South monitoring results. Elevated particulate matter concentrations occurred during periods of cold and calm weather. Glen Road is located within an area of low-lying topography and this may restrict the dispersion of wood smoke during certain meteorological conditions.

Receptor modelling carried out by GNS Science (Davy et al. 2011) found that, on average, emissions from wood burners and open fires dominated the fine fraction of particulate matter ($PM_{2.5}$) and marine aerosol dominated the coarse fraction ($PM_{2.5\text{-}10}$).

It is recommended that further monitoring be carried out in other parts of the Kapiti Coast airshed, as resources permit, to increase our understanding of the spatial variability in PM_{10} concentrations. The results of this study and any future

investigations in the Kapiti Coast will be used to decide whether establishing a permanent monitoring site in the Kapiti Coast airshed is warranted.

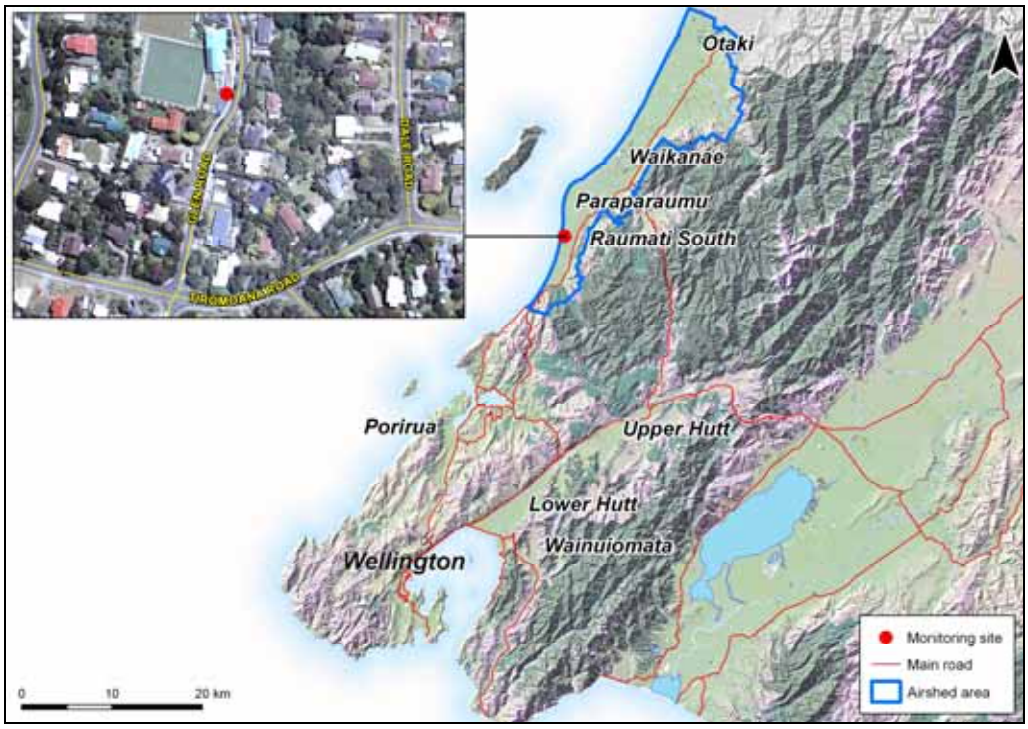
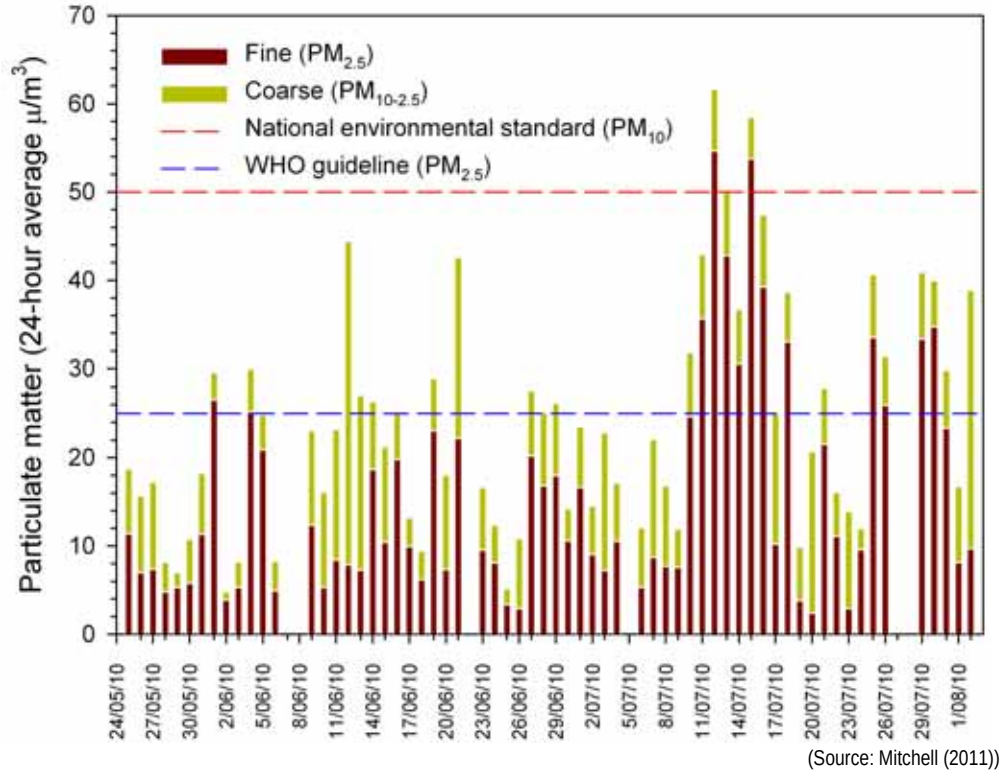


Figure 6.4: Location of Raumati South monitoring site (red dot) within the wider Kapiti Coast airshed. The inset shows the location of the air quality monitoring station on Glen Road.



(Source: Mitchell (2011))

Figure 6.5: Time series of PM_{10} 24-hour average concentrations recorded at Glen Road, Raumati South between 25 May and 2 August 2010

7. Summary

- Apart from four days in Masterton, one day in Carterton and one day in Wainuiomata particulate matter (PM_{10}) concentrations measured in the Wellington region were below the national environmental standard during 2010.

- The Wairarapa airshed breached the national environmental standard in 2010 because there was more than one exceedence of the PM_{10} daily limit recorded in that airshed.

- During winter 2010 there were 19 days in Masterton and three 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).

- Concentrations of two pollutants produced by vehicles, carbon monoxide and nitrogen oxides, were highest at Wellington central but well within national environmental standards and guidelines at all air quality monitoring stations.

- A winter monitoring programme in the Wairarapa airshed investigating air quality outside the Masterton urban area found that Carterton's air quality, while degraded at times due to domestic heating emissions, was better than that measured at the existing Masterton air quality monitoring station.

- A winter investigation in the Kapiti airshed found elevated concentrations of PM_{10} and $PM_{2.5}$ in Raumati South caused by emissions from domestic heating during cold and calm conditions.

References

Carslaw D and Ropkins K. 2012. *Openair – an R package for air quality data analysis.* Environmental Modelling & Software. Vol. 27-28, 52-61.

Davy P. 2005. *Nominated airsheds for the Wellington region.* Greater Wellington Regional Council, Publication No. GW/RINV-T-05/113, Wellington.

Davy P, Trompetter B and Markwitz A. 2009. *Wairarapa air particulate matter screening surveys 2009: Elemental analysis and mass reconstruction*. Report prepared for Greater Wellington Regional Council by GNS Science, Report 2009/365, Lower Hutt.

Davy P, Trompetter B and Markwitz A. 2011. *Source apportionment of airborne particles at Raumati, Kapiti Coast.* GNS Science Consultancy Report 2011/83 prepared for Greater Wellington Regional Council.

Ministry for the Environment. 1997. *Environmental performance indicators: Proposals for air, fresh water, and land*. Ministry for the Environment, Wellington.

Ministry for the Environment. 2009. *Good-practice guide for air quality monitoring and data management 2009.* ME 933. Ministry for the Environment, Wellington.

Mitchell T. 2010. *Annual air quality monitoring report for the Wellington region, 2009*. Greater Wellington Regional Council, Publication No. GW/EMI-G-10/160, Wellington.

Mitchell T. 2011. *Raumati South air quality investigation*. Greater Wellington Regional Council, Publication No. GW/EMI-T-11/52, Wellington.

R Development Core Team. 2011. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. Retrieved from http://www.R-project.org/

World Health Organization. 2006. *WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide – global update 2005.* Retrieved from http://www.who.int/phe/health_topics/outdoorair_aqg/en/

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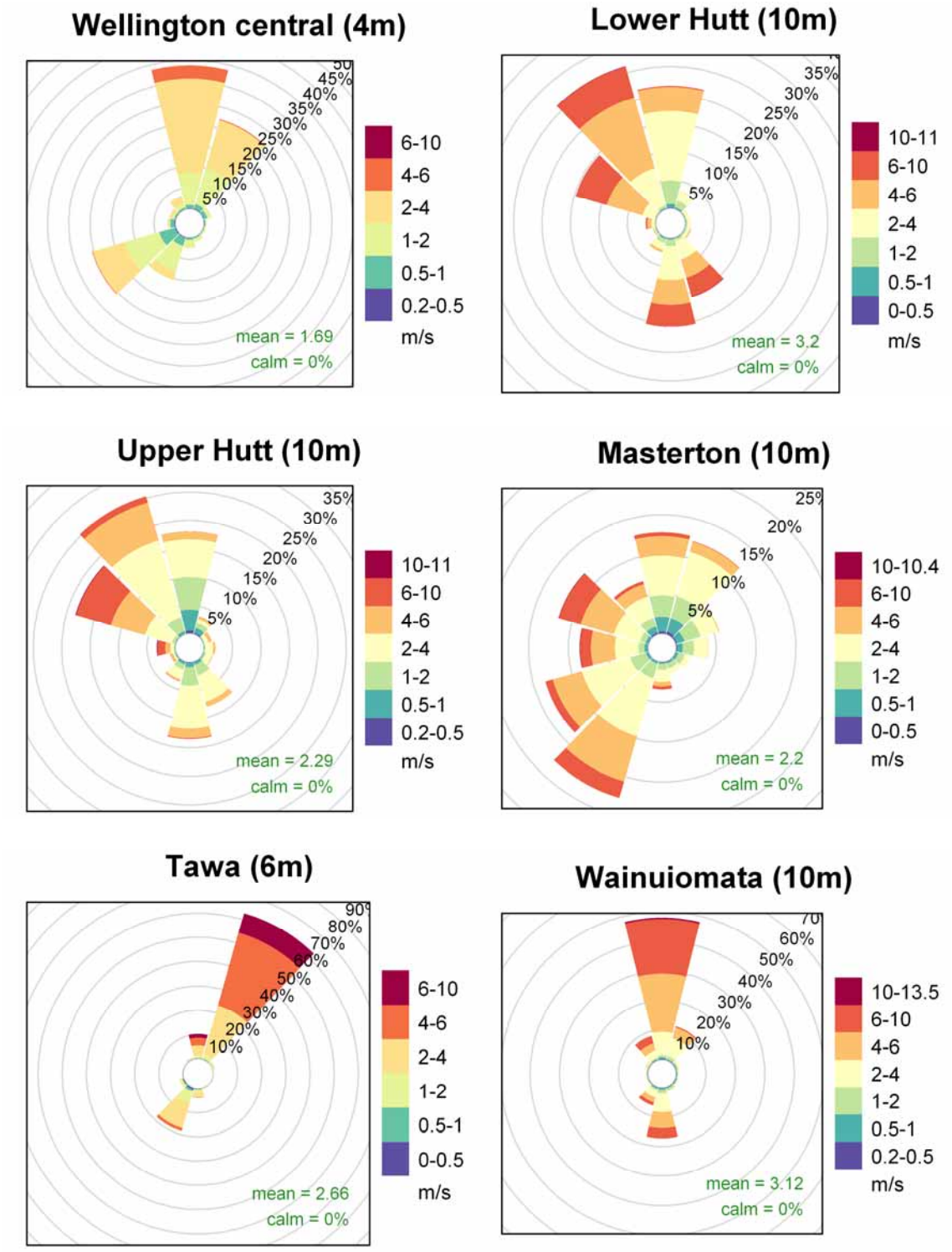
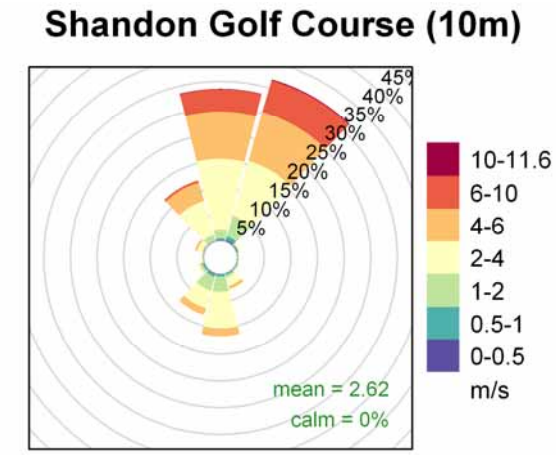
Appendix 1: Wind roses by monitoring site

See Appendix 2 for interpretation.




Shandon Golf Course (10m)
45%
40%
35%
30%
25%
20%
15%
10%
5%
mean = 2.62
calm = 0%
10-11.6
6-10
4-6
2-4
1-2
0.5-1
0-0.5
m/s

Appendix 2: Data analysis presentation methods

Reporting units

All pollutants at Greater Wellington's long-term air quality SoE monitoring sites are measured continuously with instruments that are connected by digital interface to data loggers. Ambient air is sampled at 10 to 20 second intervals (depending on the number of instruments at a site) and these measurements are averaged and reported as 10-minute averages at New Zealand Standard Time (NZST). These 10-minute values are then aggregated to hourly averages where there is at least 75% data capture (i.e., at least five 10-minute means must be present for a 1-hour average to be considered valid and included in the data set). The hourly averages apply to the preceding hour (e.g., a 1-hour average at 17:00 refers to data collected between 16:00 and 16:59).

Carbon monoxide is measured in parts per million (ppm) and is converted to mg/m^3 by multiplying by 1.25 (0^oC). For comparison with the NES-AQ, 8-hour moving means are calculated on the hour for the preceding 8-hour period using 1-hour averages. At least 6 hours (i.e., 75% or greater data capture) must be present for an 8-hour mean to be considered valid and included in the data set. Carbon monoxide values are rounded to one significant figure for reporting purposes in accordance with MfE (2009) recommendations.

Nitrogen dioxide is measured in parts per billion (ppb) and is converted to $\mu g/m^3$ by multiplying by 2.05 (0^oC) NES-AQ. Nitrogen dioxide 1-hour averages are rounded to one significant figure for reporting purposes in accordance with MfE (2009) recommendations.

PM_{10} is measured as $\mu g/m^3$ which is the same unit as the NES-AQ limit. 24-hour averages are calculated from 1-hour averages between midnight to midnight (00:00 to 23:59) and require at least 18 hours of data for each 24-hour period to be included in the data set. PM_{10} values are rounded up to the nearest whole number for reporting purposes in accordance with MfE (2009) recommendations. An exceedence of the NES-AQ is therefore 51 $\mu g/m^3$ or higher.

Box plots

The box plots presented in this report were produced using R Statistical Software version 2.13.0 (R Development Core Team 2011). Details of the construction of the box plots are presented in Figure A2.1.

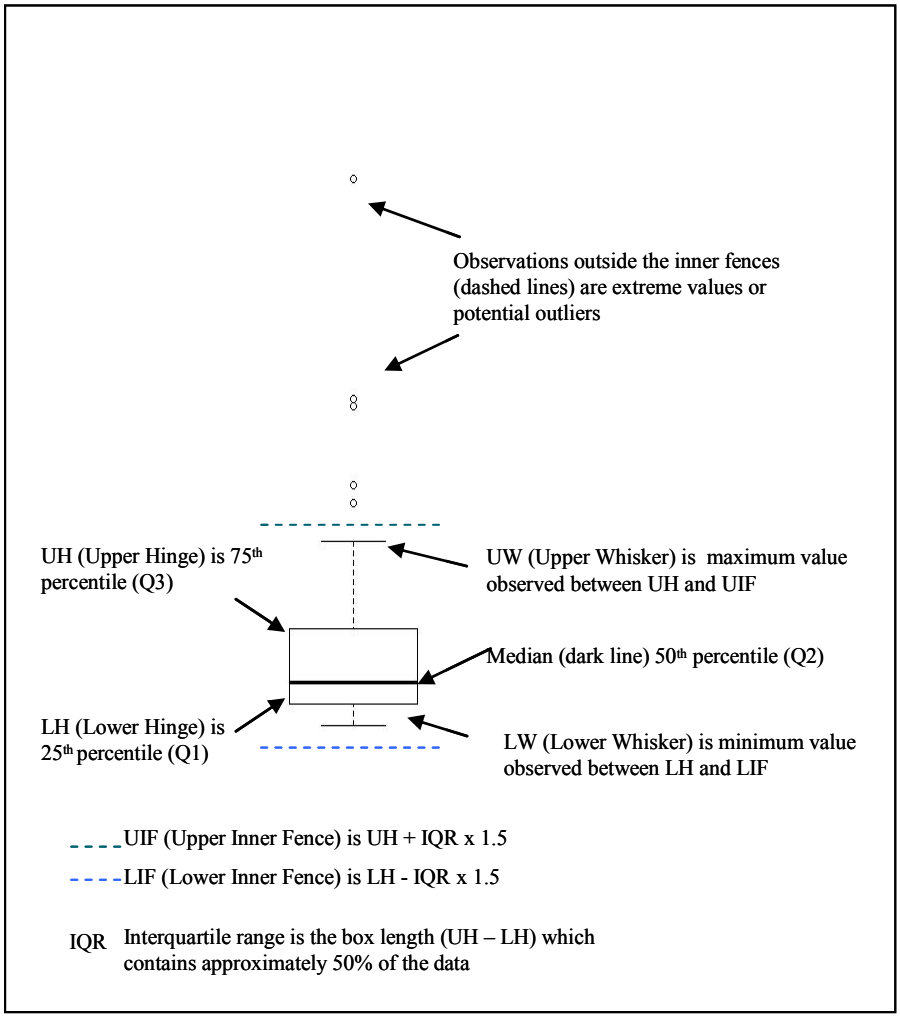


Figure A2.1: Interpretation of Tukey box plot as implemented in R

Temporal variation

The time variation plot presented in Section 6.1 of this report (Figure 6.2) was produced in R statistical software (R Development Core Team. 2011) using the 'openair' package version 05-16 (Carslaw & Ropkins 2012). Four plots: day of the week variation, mean hour of day variation and a combined hour of day – day of week plot and a monthly plot were produced using hourly averages with a least 75% data capture. Also shown on the plots is the 95% confidence interval in the mean calculated through bootstrap re-sampling.

Wind roses

The wind roses presented in Appendix 1 were created using R statistical software (R Development Core Team. 2011) using the 'openair' package version 05-16 (Carslaw & Ropkins 2012). The wind roses 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.

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