Waikato Regional Council Technical Report 2014/05

Air quality monitoring report for Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi – 2013

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Acknowledgement

The efforts of the Environmental Monitoring team, particularly Kane Lynn, are gratefully acknowledged for collection of the monitoring data used in this report and servicing and maintenance of the monitoring stations used. Ian Buchanan is also thanked for coordinating laboratory services.

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Executive summary

Air quality monitoring in the Waikato Region focuses primarily on concentrations of PM_{10}, the main air contaminant of concern. The National Environmental Standards for Air Quality (NESAQ) has set a maximum concentration limit for PM_{10} of 50 $\mu g/m^3$ when averaged over 24 hours (referred to as an ambient air quality standard). The NESAQ allows for one exceedance of this standard per rolling 12 month period. More than one exceedance within a rolling 12-month period is a breach of the standard. The NESAQ requires air quality monitoring to take place in areas that are likely to exceed the standard for PM_{10}.

The 2011 amendment to the NESAQ has introduced extended timeframes for Airsheds[1] to comply with the standard for PM_{10}. Airsheds are split in to three categories depending on the average number of exceedances the airshed has for the previous five year period.

1. The first category includes airsheds with 10 or more exceedances a year. These airsheds must achieve no more than three exceedances by 1 September 2016 and no more than one exceedance by 1 September 2020. The Waikato Region has one such airshed that falls within this category, namely Tokoroa.
2. The second category includes airsheds with more than one exceedance but less than 10 exceedances. This category of airshed must achieve no more than one exceedance by 1 September 2016. Based on the air quality monitoring data collected up to the end of 2013, the Waikato Region has three airsheds that fall within this category, namely Taupo, Te Kuiti and Putaruru.
3. The third category includes all other airsheds which are currently complying and must continue to achieve no more than one exceedance of the standard.

During 2013, concentrations of PM_{10} were measured by Waikato Regional Council in eight out of the region's 20 gazetted airsheds with two stations located in the Hamilton airshed and one each in the Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi airsheds. Carbon monoxide (CO), nitrogen dioxide (NO_2), benzene, toluene, ethylbenzene and xylenes were also measured by Waikato Regional Council in Hamilton during 2013.

This report compares contaminant concentrations measured in these airsheds to the NESAQ standards and to the Ministry for the Environment's air quality guidelines and indicator categories.

There were three airsheds which breached the NESAQ PM_{10} standard over the winter of 2013.

1. Tokoroa – Ten exceedances were recorded in Tokoroa (the lowest number since 2007) with a maximum concentration of 59 $\mu g/m^3$ recorded.
2. Hamilton – Eight exceedances were recorded at Hamilton's Peachgrove Rd site over a three week period from May to early June with a maximum concentration of 135 $\mu g/m^3$ recorded. The exceedances were caused by roadworks. An "Exceptional Circumstances" application to the Minister for the Environment has resulted in an official exemption by the Minister for these eight exceedances. As a result of this decision, Hamilton retains its non-polluted (third category) status.
3. Taupo – Two exceedances were also recorded in Taupo with a maximum concentration of 65 $\mu g/m^3$ recorded, resulting in a five-year extension of the airshed's polluted (secondary category) status.

[1] An airshed is an air quality management area that has been defined by a regional council or unitary authority as an area that potentially could or is known to breach the standards for air quality. These airshed designations must be gazetted by the Ministry for the Environment.

Te Kuiti and Putaruru continue to indicate a significant improvement with no exceedances recorded this year.

A statistical analysis of seasonal PM_{10} data collected in Hamilton, Te Kuiti, Taupo and Putaruru indicates that concentrations have decreased over the previous six or more year period. However, the evidence for decreases for Taupo and Hamilton are weak based on the 2013 data and should be treated with caution. No decrease has been identified for Tokoroa.

In Hamilton, concentrations of CO were well below the NESAQ standard of 10 mg/m^3 (8-hour average) during 2013. While concentrations of NO_2 in Hamilton were below the NESAQ standard of 200 $\mu g/m^3$, concentrations did reach around 50% of the standard during 2013.

Concentrations of benzene in Hamilton were within the national guideline of 3.6 $\mu g/m^3$ and an improving or "levelling" trend is evident for annual average concentrations at all sites. The highest annual concentration was measured at the Greenwood Street monitoring site and was 2.7 $\mu g/m^3$, the same maximum and location as recorded for 2012. Concentrations of toluene, ethylbenzene and xylene were also well within acceptable international criteria.

1 Introduction

The National Environmental Standards for Air Quality (NESAQ) has mandated ambient air quality standards (maximum concentration limits) for five contaminants along with averaging periods and number of allowable exceedances (refer to Table 1.1). A breach of the standards occurs when more than the allowable number of exceedances occurs within the specified period.

The concept of an "airshed" is defined by the NESAQ regulations as an "air quality management area" that has been identified by Regional Councils and Unitary Authorities and made public. The Waikato Region has 20 such "airsheds" which typically have boundaries that approximate the town boundaries of urban centres (refer to Figure 1.1).

In the Waikato Region the main air contaminant of concern is PM_{10} (particles in the air less than 10 microns in diameter). PM_{10} is generated from burning fuels such as wood, coal or oil from domestic fires, vehicles and industry, as well as natural sources such as sea salt, dust, pollens and volcanic activity.

A standard for PM_{10} has been set at 50 micrograms per cubic metre of air (50 $\mu g/m^3$) when averaged over 24-hours. The standard allows for one exceedence per 12 month period. More than one exceedance over this period triggers a breach of the standard. Concentrations of PM_{10} have historically exceeded the ambient air quality standard in Hamilton, Tokoroa, Taupo, Te Kuiti and Putaruru during winter months. The main source of PM_{10} concentrations in these areas during the winter months is solid fuel burning for domestic home heating.

Under the NESAQ an airshed is classified as a polluted airshed if it has average PM_{10} exceedances of more than one per 12 month period, for the immediately prior five year period. To get re-classified as non-polluted, a polluted airshed needs to have no more than 1 exceedance per 12 months for a period of 5 years.

The NESAQ requires a ban on the use of any new open fireplaces installed inside domestic dwellings 12 months after an airshed first becomes classified as polluted. Restrictions are also imposed on air discharges from industry that have significant PM_{10} discharges within a polluted airshed.

In 2013, PM_{10} concentrations were measured in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi. In Hamilton additional monitoring was carried out for carbon monoxide, oxides of nitrogen as well as benzene, ethyl benzene, toluene and xylenes. Prior to April 2013, monitoring of PM_{10} has also taken place in Matamata, Ngaruawahia and Waihi[2]. Monitoring of PM_{10}, sulphur dioxide and oxides of nitrogen were also monitored at two locations within Huntly airshed in 2013 by Genesis Energy. Both monitoring sites are owned and operated by Genesis Energy Ltd as part of the Huntly Power Station resource consent monitoring requirements.

The required target date for compliance with the NESAQ for PM_{10} was reviewed in 2011 and revised from 2013 to 2016 for most airsheds in New Zealand. Airsheds with more than one exceedance but less than 10 exceedances of the 50 $\mu g/m^3$ standard have to achieve no more than one exceedance by 1 September 2016. Airsheds that have 10 or more exceedances of 50 $\mu g/m^3$ have an interim target of no more than three exceedances by 1 September 2016 and a final target of no more than one exceedance

[2] The Waihi air quality monitoring site was disestablished at the beginning of 2012 and the Matamata and Ngaruawahia monitoring stations were disestablished in April 2013. Previous monitoring of PM_{10} in these three airsheds over a period of four or more years indicates that PM_{10} concentrations are well below the NESAQ 24-hour standard of 50 $\mu g/m^3$ (apart from Australian dust storm related exceedances in 2009). This disestablishment of monitoring sites where three or more years of monitoring has indicated no exceedances of the NESAQ is part of an ongoing monitoring strategy to re-deploy monitoring equipment in airsheds where air quality has not yet been monitored.

by 1 September 2020. Based on monitoring data collected up to 2013, Tokoroa has to meet the interim 2016 target of no more than three exceedances and the 2020 target of no more than one exceedance. Taupo, Te Kuiti and Putaruru must achieve no more than one exceedance by 2016. All other airsheds within the Waikato region must always meet the standard of no more than one exceedance per rolling 12 month period i.e. the requirement for compliance is current.

Based on previous monitoring, most other contaminants are unlikely to be in breach of their respective NESAQ standards or ambient air quality guidelines in urban areas of the Waikato. Generally, the majority of resources for air quality monitoring in the Waikato Region has focused on PM_{10}. However, there is evidence that nitrogen dioxide can be reasonably elevated in urban areas of Hamilton where there is a high density of traffic.

Figure 1-1: Map of Waikato Region indicating the 20 urban centres that have been gazetted as airsheds.

Table 1-1 National Environmental Standards for Air Quality (MfE, 2004).

Contaminant	NESAQ values		
	Concentration[a]	Averaging period	Allowable exceedances per year
Carbon monoxide	10 mg m^{-3}	8-hour	1
Particles (PM_{10})	50 µg m^{-3}	24-hour	1
Nitrogen dioxide	200 µg m^{-3}	1-hour	9
Sulphur dioxide[b]	350 µg m^{-3}	1-hour	9
Sulphur dioxide[b]	570 µg m^{-3}	1-hour	0
Ozone	150 µg m^{-3}	1-hour	0

The Ministry for the Environment provides guidelines for ambient air quality (refer to Table 1.2) and air quality indicator categories to assist in the presentation and management of air quality in New Zealand (refer to Table 1.3). Air quality monitoring data in this report are presented relative to air quality guidelines and these indicator categories. These categories provide a useful perspective on the overall quality of the air and provide an indicative tool for evaluating trends in concentrations over time.

Table 1-2 Ambient air quality guidelines for New Zealand (MfE 2002).

Contaminant	2002 guideline values	
	Concentration[a]	Averaging Period
Carbon monoxide	30 mg m^{-3}	1-hour
	10 mg m^{-3}	8-hour
Particles (PM_{10})	50 µg m^{-3}	24-hour
	20 µg m^{-3}	Annual
Nitrogen dioxide	200 µg m^{-3}	1-hour
	100 µg m^{-3}	24-hour
Sulphur dioxide [b]	350 µg m^{-3}	1-hour
	120 µg m^{-3}	24-hour
Ozone	150 µg m^{-3}	1-hour
	100 µg m^{-3}	8-hour
Hydrogen sulphide [c]	7 µg m^{-3}	1-hour
Lead [d]	0.2 µg m^{-3} (lead content of PM_{10})	3-month moving (calc. monthly)
Benzene (year 2002)	10 µg m^{-3}	Annual
Benzene (year 2010)	3.6 µg m^{-3}	Annual
1,3-Butadiene	2.4 µg m^{-3}	Annual
Formaldehyde	100 µg m^{-3}	30-minutes
Acetaldehyde	30 µg m^{-3}	Annual
Benzo(a)pyrene	0.0003 µg m^{-3}	Annual
Mercury (inorganic) [d]	0.33 µg m^{-3}	Annual
Mercury (organic)	0.13 µg m^{-3}	Annual
Chromium VI [d]	0.0011 µg m^{-3}	Annual
Chromium metal & chromium III	0.11 µg m^{-3}	Annual
Arsenic (inorganic) [d]	0.0055 µg m^{-3}	Annual
Arsine	0.055 µg m^{-3}	Annual

Notes for Tables 1.1 and 1.2:

[a] All values apply to the gas measured at standard conditions of temperature (0° C) and pressure (1 atmosphere).

[b] The sulphur dioxide guideline values do not apply to sulphur acid mist.

[c] The hydrogen sulphide value is based on odour nuisance and may be unsuitable for use in geothermal areas.

[d] The guideline values for metals are for inhalation exposure only; they do not include exposure from other routes such as ingestion. These other routes should be considered in assessments where appropriate.

Table 1-3 Environmental Performance Indicator categories for air quality (MfE, 2002).

Category	Value relative to guideline	Comment
Excellent	Less than 10% of the guideline	Of little concern: if maximum values are less than a tenth of the guideline, average values are likely to be much less
Good	Between 10% and 33% of the guideline	Peak measurements in this range are unlikely to affect air quality
Acceptable	Between 33% and 66% of the guideline	A broad category, where maximum values might be of concern in some sensitive locations but generally they are at a level which does not warrant urgent action
Alert	Between 66% and 100% of the guideline	This is a warning level, which can lead to exceedances if trends are not curbed
Action	More than 100% of the guideline	Exceedances of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

Although the MfE categories are primarily used as air quality indicators, the Waikato Regional Plan takes a further regulatory step by specifying designated policy responses that should correspond to each zone. Policy 3 of the Air Module of the Waikato Regional Plan contains **r**egional ambient air quality categories and the designated response that the Council will take when developing air quality management framework. Policy 3 states that air quality in the "Excellent" category is to be protected, while "Good" air quality is to be maintained or protected. "Acceptable" air quality is to be maintained. Air quality in the "Alert" category is to be maintained or enhanced. For air quality in the "Action" category, the only designated policy response is to aim to enhance (improve) the situation.

1.1 Reporting period

The reporting period for PM_{10} was from 1 January to 31 December 2013 (a calendar year). In 2006 Waikato Regional Council introduced a September to August reporting period. This reporting period was introduced for a number of reasons including ensuring that results were reported as soon as possible after the peak winter PM_{10} concentrations. However, the 2011, 2012 and 2013 annual air quality reports have been prepared based on a reporting period of January to December. This is the same format as historical reports and is consistent with other regional council reporting around the country.

The reporting period for carbon monoxide was 1 October 2012 to 31 March 2013 and the reporting period for oxides of nitrogen was 4 April 2013 to 4 October 2013 (two consecutive six month surveys).

The reporting period for benzene, toluene, ethylbenzene and xylenes (BTEX) was 18 December 2012 to 18 December 2013. Aligning the reporting period for BTEX with the calendar year is not feasible as it would require staff to deploy passive sampling equipment on 1 January. This 10 day misalignment with the calendar year is of little concern when reporting annual averages and it is not expected that there would be any difference in the annual averages if the passive samplers were instead deployed on 1 January each year.

2 Methodology

Measured concentrations of PM_{10} can be influenced by the method used to monitor PM_{10}. From 2006 a number of air quality monitoring sites in the Waikato region have had gravimetric samplers run in conjunction with existing Beta Attenuation Monitors (BAMs). Waikato Regional Council staff have used the results to determine site specific differences between methods and data and have adjusted accordingly, where appropriate, for gravimetric equivalence. Prior to 2007, data were not adjusted. Some adjustment equations were updated in 2010 as a result of additional monitoring and these equations have been used in the 2011, 2012 and 2013 reports.

At the Peachgrove Road air quality monitoring site in Hamilton, PM_{10} concentrations were monitored using a Tapered Elemental Oscillation Microbalance (TEOM) with a sample temperature setting of 40 degrees centigrade. Concentrations of PM_{10} measured using the TEOM in 2013 were based on the same adjustment for 2009 reporting (equation 2.1).

Corrected PM_{10} = 1.19975 x RawTEOM - 3.9182 **Equation 2.1**

In Tokoroa, a ThermoAndersen FH62 C14 BAM has been used to monitor air quality since 2005. A Sequential Partisol gravimetric sampler was co-located at this site. Equation 2.2 shows the adjustments made to the FH62 data for consistency with the gravimetric method.

Corrected PM_{10} = $10^{(1.09945 \log BAM - 0.08595)}$ **Equation 2.2**

Gravimetric sampling was conducted at the Gillies Street site in Taupo from March 2007. Concentrations of PM_{10} measured using the FH62 C14 BAM during 2011 were adjusted based on equation 2.3.

Corrected PM_{10} = 1.255BAM – 1.538 **Equation 2.3**

Air quality data at the Putaruru site have been adjusted based on Equation 2.4. This equation was updated in 2010.

Corrected PM_{10} = 1.106BAM - 2.38 **Equation 2.4**

Concentrations of PM_{10} at Hamilton (Ohaupo Road), Te Kuiti, Matamata, Ngaruawahia and Turangi sites were measured using an FH62 C14 BAM. No adjustments have been made to concentrations measured at these sites. In the case of Te Kuiti and Matamata, reference method sampling has confirmed that no adjustment of BAM data is necessary. For the other towns, the possible need for any site-specific correction remains to be assessed.

At the Hamilton (Peachgrove Rd), Tokoroa, Taupo and Te Kuiti air quality monitoring sites, meteorological data, including temperature, wind speed and wind direction were collected. Relative humidity was also collected at Hamilton (Peachgrove Rd) and Taupo. Meteorological data were not available for the Putaruru, Turangi, Cambridge and Te Awamutu sites. At sites where it was available, meteorological data were compared with PM_{10} on days when pollution was elevated.

Waikato Regional Council staff has managed most sites in the Waikato air quality monitoring network since August 2005. Prior to that the monitoring network was operated and maintained by NIWA. The Partisol Model 2000 PM_{10} sampler at the Taupo site was operated by the Institute of Geological and Nuclear Sciences Ltd (GNS) on behalf of Waikato Regional Council.

Hourly data from the BAM monitors are recorded and logged by an iQuest iRIS 320 datalogger. Results are telemetered hourly to Waikato Regional Council and stored in the hydrotel database.

3 Hamilton

3.1 Air quality monitoring in Hamilton

In Hamilton air quality has been measured at a monitoring site in Peachgrove Road located on the south-east side of Hamilton City since November 1997. The site meets the requirements of the "Residential Peak" site classification as described in the '*Good Practice Guideline for Air Quality Monitoring and Data Management 2009'* report (MfE, 2009). During 2013, PM_{10}, benzene, ethyl-benzene, toluene and xylenes were measured at Peachgrove Road.

PM_{10} monitoring at Peachgrove Road was carried out using a Tapered Elemental Oscillating Microbalance (TEOM) with a sample temperature setting of 40°C. The PM_{10} data were collected at the Peachgrove Road site as ten minute averages and subsequently hourly averages and 24 hour averages were calculated from these data. Data were adjusted for gravimetric equivalency based on the equation outlined in section two.

The monitoring station at Peachgrove Road was decommissioned on 18 October 2013 because the property, previously owned by Mighty River Power, changed ownership in December 2013 and Waikato Regional Council was required to remove the station as part of the sale agreement. A replacement station has been installed, as of April 2014, in the grounds of Claudelands Events Centre on Heaphy Terrace. This new station will operate as the main "residential" monitoring site for Hamilton.

From March 2012, air quality has also been measured at a second monitoring site located adjacent to the NZ Blood Service at the Waikato Hospital on the corner of Ohaupo Road and Lorne Street. This site is traffic and industry focussed. During 2013, daily and hourly average PM_{10} concentrations were measured at the site using a FH 62 BAM. From October 2012 to October 2013 concentrations of carbon monoxide and oxides of nitrogen were measured at Ohaupo Road using an Ecotech ML/EC 9830 CO analyser (gas phase infrared) and a Ecotech ML/EC 9841 NOx analyser (gas phase chemiluminescence) respectively. Operational aspects of the carbon monoxide and oxides of nitrogen monitoring including maintenance, calibration and quality assurance were carried out by Watercare Ltd for Waikato Regional Council.

Benzene, ethyl-benzene, toluene and xylenes (BTEX) have, in addition to the monitoring undertaken at the Peachgrove Rd site, also been monitored during recent years at other sites around Hamilton. These include Bridge Street, Claudelands Road, Peachgrove Road Intermediate School, Greenwood Street and Tristram Street.

Passive sampling for the volatile organic compounds (VOCs) benzene, ethyl-benzene, toluene and xylenes was carried out using 3M Passive Diffusion Monitors. The method used is as described in Stevenson and Narsey (1999) with filters being deployed for periods of three months. The analysis was carried out by Hill Laboratories in Hamilton. While this type of passive sampling is recommended as a screening method only, it is the most common approach to benzene monitoring in New Zealand and is significantly more cost effective than the method recommended by the Ministry for the Environment's ambient air quality guidelines (MfE 2002).

Figure 3.1 shows the main Peachgrove Road air quality monitoring station site (Monitoring Station 1 on the eastern side of the Waikato River), its new replacement site, as of April 2014, at Claudelands Events Centre grounds and the Ohaupo Road monitoring station site (Monitoring Station 2 on the western side of the Waikato River).

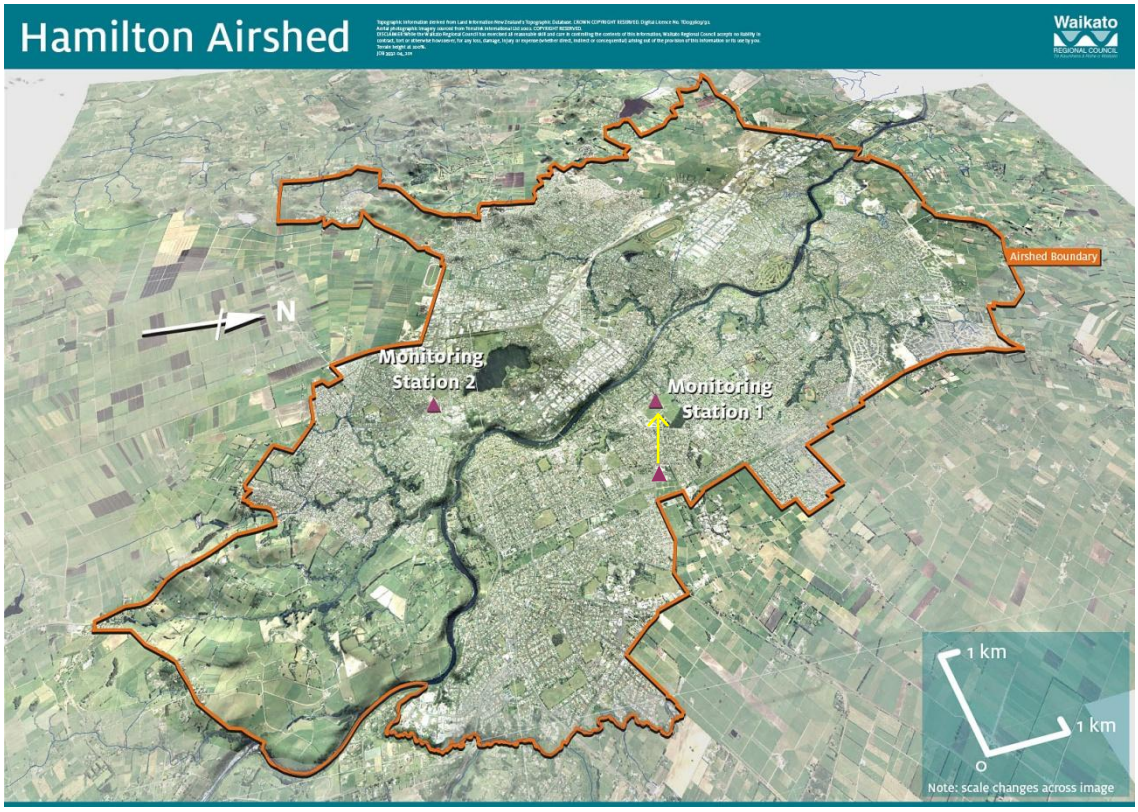

Figure 3-1: **Hamilton Airshed and air quality monitoring station sites. Monitoring Station 1 has previously been located at Peachgrove Rd but is now located at Claudelands Events Centre grounds (indicated by yellow arrow), and Monitoring Station 2 is located at Ohaupo Rd.**

3.2 PM_{10} concentrations for Hamilton

There were eight exceedances of 50 µg/m^3 (24-hour average) measured at the Peachgrove Road monitoring station in Hamilton during 2013. A maximum 24 hour average concentration of 135 µg/m^3 was measured on 29 May at the Peachgrove Road site and a maximum 24 hour average concentration of 32 µg/m^3 was measured on 30 May at the Ohaupo Road site. This compares with no exceedances during 2012, one exceedance during 2011, no exceedances during 2010 and two exceedances of 54 µg/m^3 measured during 2009. A further exceedance in 2009 and the previous maximum PM_{10} concentration recorded at Hamilton reached 101 µg/m^3 and coincided with a dust storm event in Australia.

These eight exceedances occurred over a three and a half week period from mid May to early June 2013 (refer to Table 3.1). These exceedances coincided with significant upgrading of the Peachgrove Road, Te Aroha Street and Ruakura Road intersection necessary to complete better access to the Hamilton city Ring Road. The station is approximately 80 metres north east north of this intersection.

Under the recent 2011 amendment to the NESAQ, an exceedance caused by exceptional events can qualify for an exemption as per the exceptional circumstances regulation of the NESAQ (regulation 16A). An application was made to the Minister for the Environment in August 2013 and an exemption for the eight exceedances was provided by the Minister in November 2013. As a result, the exceedances do not count towards determining the polluted status of the Hamilton airshed i.e. Hamilton remains a non-polluted airshed and the industry offset and open fire place ban regulations of the NESAQ are not triggered.

Table 3-1: Dates exceedances were recorded and maximum 24-hour average PM_{10} concentrations at Peachgrove Rd monitoring station in 2013.

Date	Concentration ($\mu g/m^3$)
12/05/13	60
13/05/13	57
15/05/13	69
23/05/13	127
24/05/13	73
29/05/13	135
30/05/13	95
06/06/13	75

Daily PM_{10} concentrations measured at Hamilton during 2013 are shown in Figures 3.2 and 3.3.

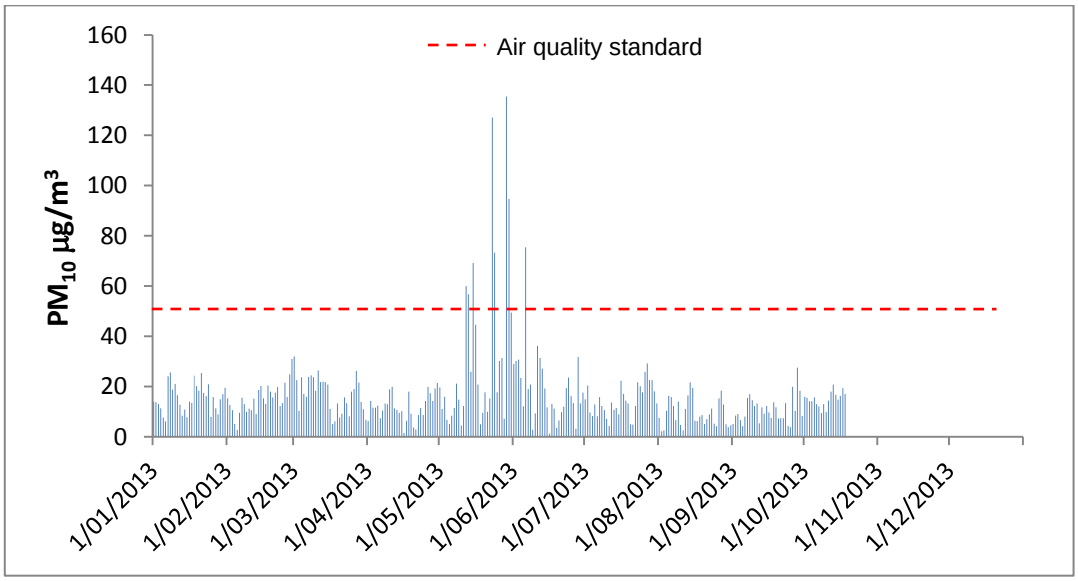

Figure 3-2: 24-hour average PM_{10} concentrations measured at Peachgrove Road during 2013.

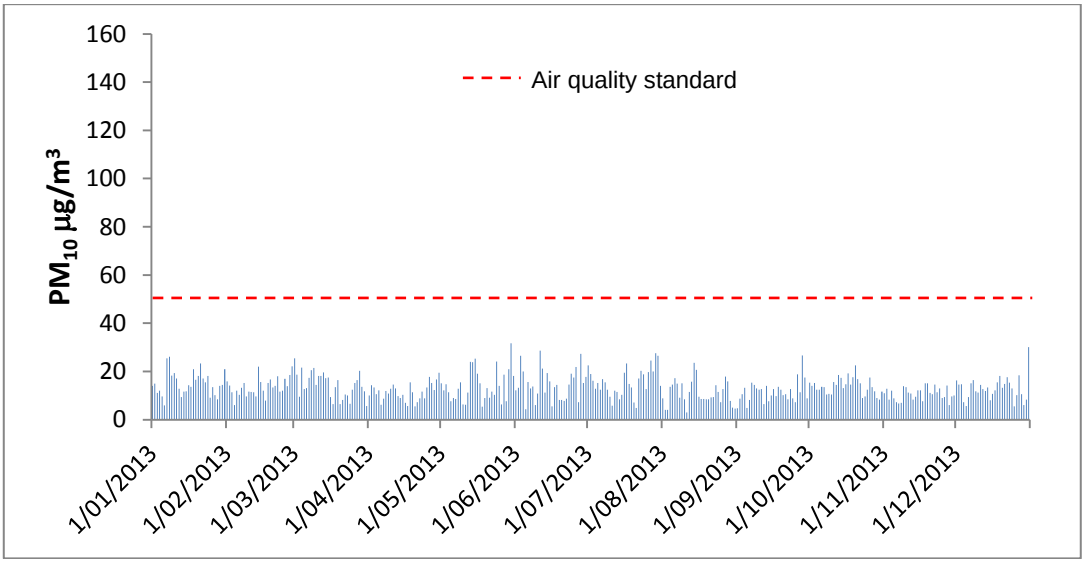

Figure 3-3: 24-hour average PM_{10} concentrations measured at Ohaupo Road during 2013.

Figure 3.4 compares daily PM_{10} concentrations measured from 2000 to 2013, for Peachgrove Road, to the MfE air quality indicator categories (shown in Table 1.3). During 2013 the majority of the PM_{10} concentrations measured were less than 33% of the air quality guideline.

Figure 3.5 shows the seasonal variations in the distribution of PM_{10} concentrations during 2013 for Peachgrove Road.

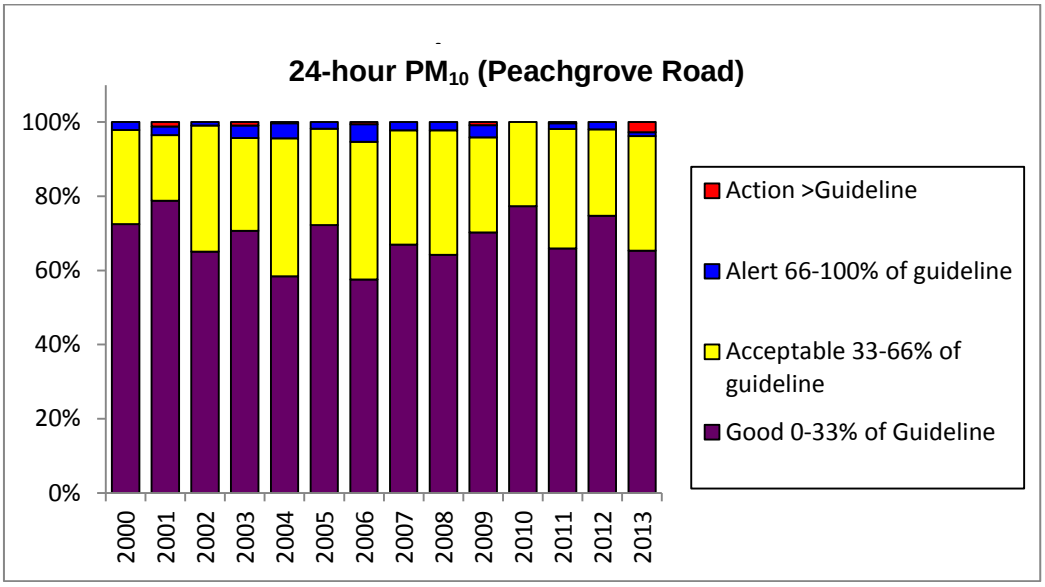

Figure 3-4: Comparison of PM_{10} concentrations measured at Peachgrove Road in Hamilton from 2000 to 2013 to air quality indicator categories.

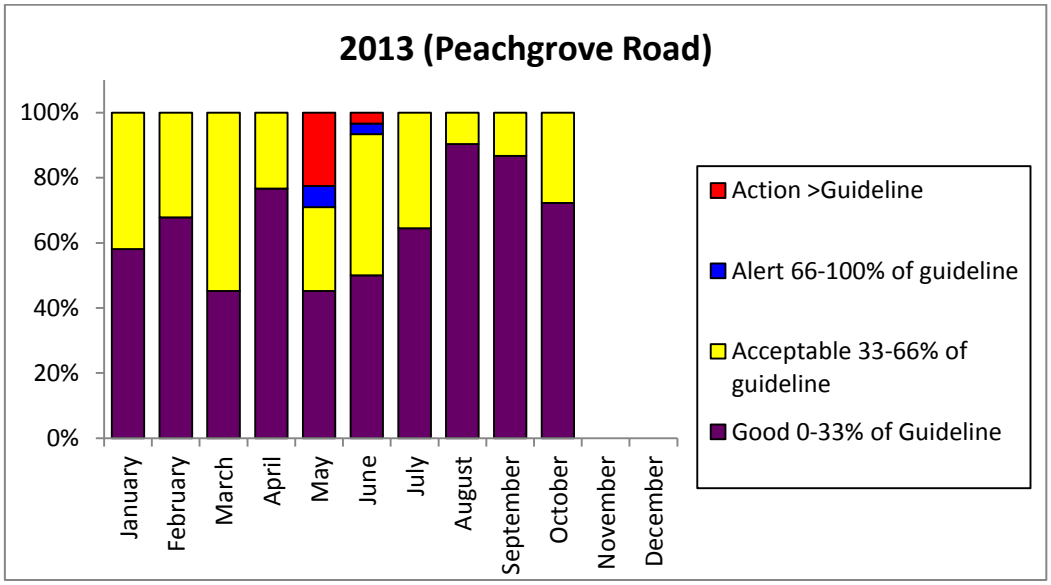

Figure 3-5: Comparison of daily PM_{10} concentrations measured at Peachgrove Road each month during 2013 to air quality indicator categories.

Figure 3.6 compares daily PM_{10} concentrations measured from 2012 and 2013, for Ohaupo Road, to the MfE air quality indicator categories (shown in Table 1.3). During 2013 the majority of the PM_{10} concentrations measured were less than 33% of the air quality guideline.

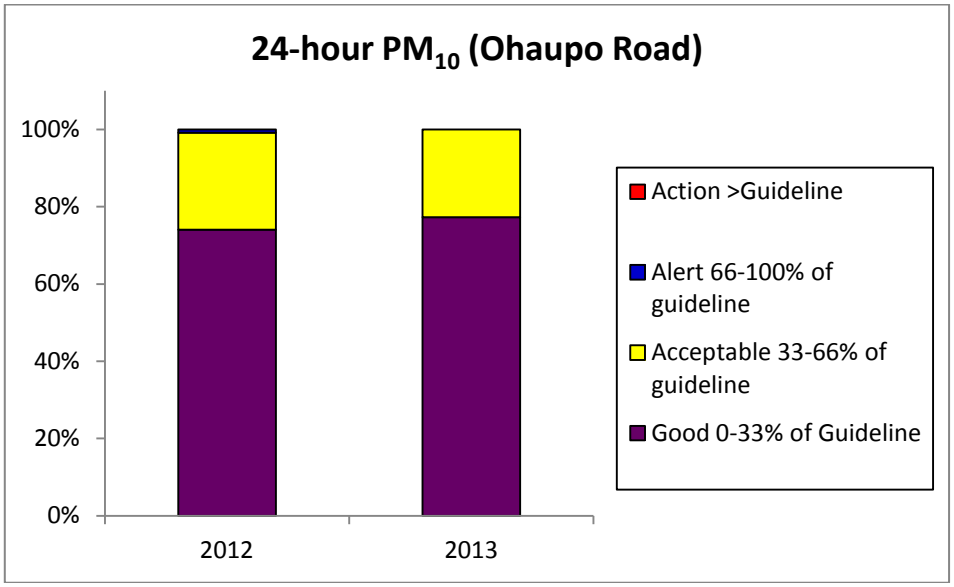

Figure 3-6: Comparison of PM_{10} concentrations measured at Ohaupo Road in Hamilton from 2012 to 2013 to air quality indicator categories.

Figure 3.7 shows the seasonal variations in the distribution of PM_{10} concentrations during 2013 for Ohaupo Road.

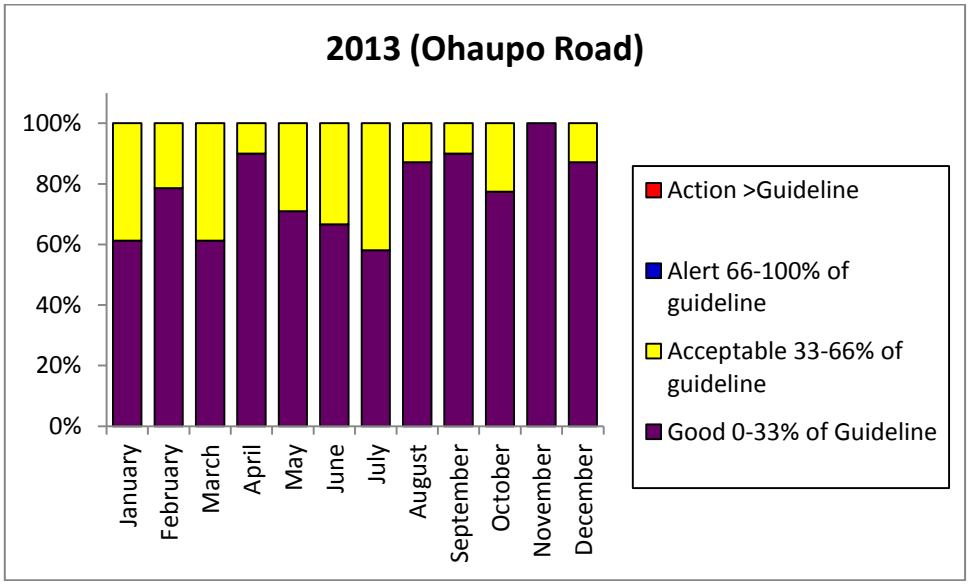

Figure 3-7: Comparison of daily PM_{10} concentrations measured at Ohaupo Road in Hamilton each month during 2013 to air quality indicator categories.

Figure 3.8 shows the variations in the monthly PM_{10} concentrations during 2013 for Peachgrove Road and Ohaupo Road. The monthly concentrations at Peachgrove Road and Ohaupo Road monitoring stations were very similar except over the brief period from May to June 2013 when the monthly average spiked at 33 $\mu g/m^3$ at the Peachgrove Rd site.

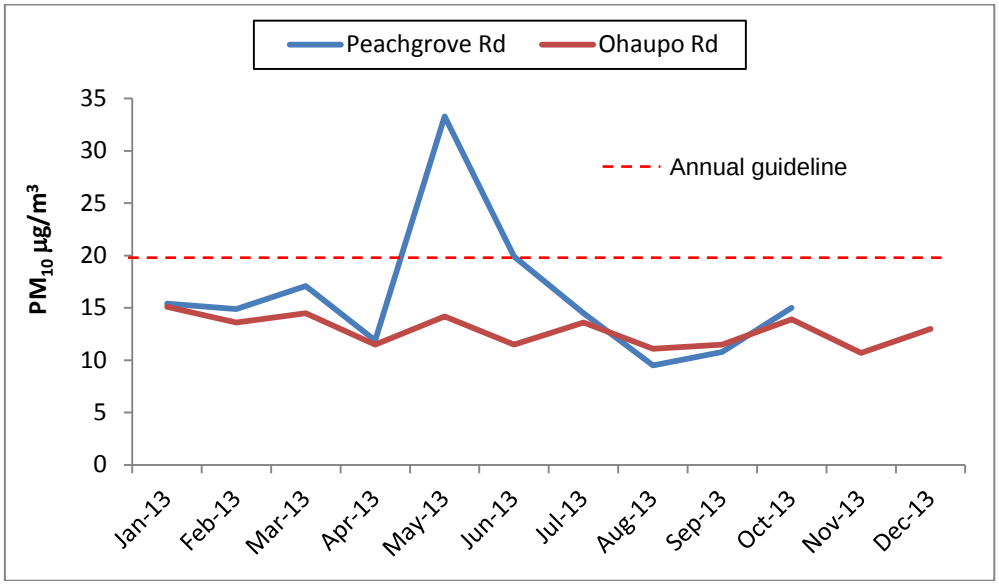

Figure 3-8: Comparison of monthly PM_{10} concentrations measured at Peachgrove Road and Ohaupo Road in Hamilton in 2013.

Figure 3.9 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 99.7 percentile concentration from 2007 to 2013 for Peachgrove Road. Apart from a maximum reading of around 100 µg/m^3 (24-hour average) in 2009 as a result of the Australian dust storm, maximum concentrations have been below 65 µg/m^3 prior to 2013.

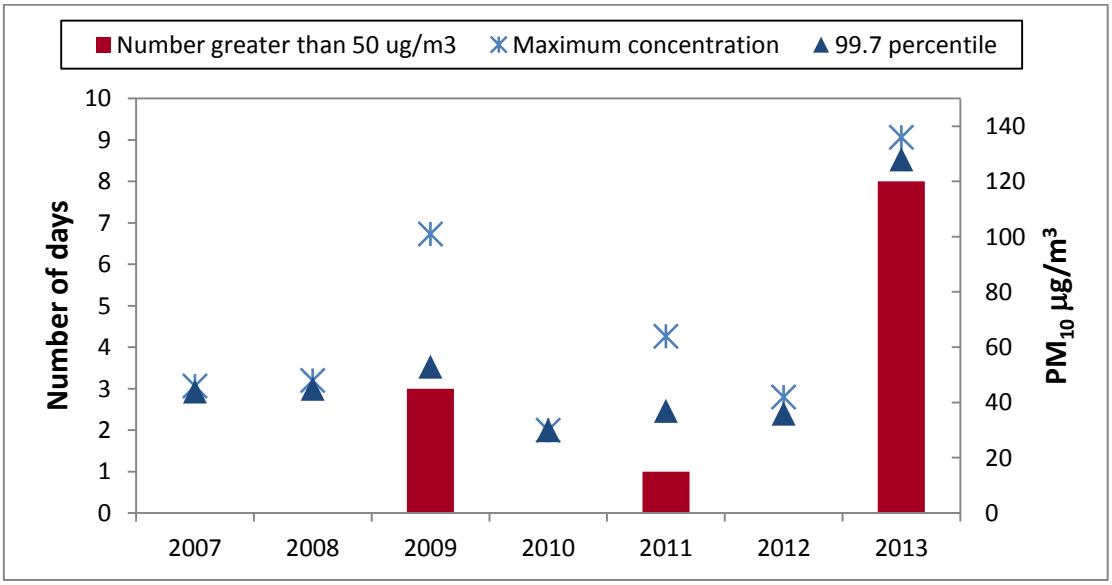

Figure 3-9: Number of days when 50 µg/m^3 was exceeded at Peachgrove Road compared with the maximum concentration and the 99.7 percentile concentration measured from 2007 to 2012.

The annual average PM_{10} concentration for Ohaupo Road for 2013 was 13 µg/m^3 which is similar in magnitude to previous years for both Ohaupo Road and Peachgrove Road. For Peachgrove Rd, a winter seasonal average is more appropriate to mitigate the bias of the missing data from October 2013 onwards and the elevated monitoring data during May caused by roadworks. The winter average (June to August) PM_{10} concentration for Peachgrove Road for 2013 was 14 µg/m^3 which is consistent with

previous years. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). An annual average PM_{10} concentration is not specified in the NES.

Summary statistics for PM_{10} monitoring data from the Ohuapo Road site for 2012 and 2013 and from the Peachgrove Road site from 2000 to 2013 are shown in Table 3.2 and 3.3 respectively. Since 2007 concentrations measured at the Peachgrove Road site have been adjusted for differences between the TEOM and gravimetric sampling methods as detailed in Section 2 of this report.

Table 3-2: Summary of PM_{10} concentrations measured at Ohaupo Road in Hamilton for 2012 to 2013.

Indicator	2012	2013
"Good" 0-33% of guideline	74%	77%
"Acceptable" 33-66% of guideline	25%	23%
"Alert" 66-100% of guideline	0.8%	0%
“Action” >Guideline	0%	0%
Percentage of valid data	73%	100%
Annual average (µg/m^3)	13	13
Measured exceedances	0	0
99.7 %ile PM_{10} concentration (µg/m^3)	37	30
Annual maximum (µg/m^3)	41	32
Number of records	266	365

Table 3-3: Summary of PM_{10} concentrations measured at Peachgrove Road in Hamilton from 2000 to 2013[1].

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
"Good" 0-33% of guideline	79%	65%	71%	58%	72%	58%	67%	64%	70%	77%	66%	75%	65%
"Acceptable" 33-66% of guideline	18%	34%	25%	37%	26%	37%	31%	34%	26%	23%	32%	23%	31%
"Alert" 66-100% of guideline	2%	0.9%	3%	4%	2%	5%	2%	2%	3%	0%	2%	2%	1%
“Action” >Guideline	1%	0%	0.9%	0.3%	0%	0.6%	0%	0%	0.8%	0%	0.3%	0%	3%
Percentage of valid data	70%	93%	90%	94%	77%	100%	100%	100%	100%	99%	100%	100%	80%
Annual average ($\mu g/m^3$)	14	15	15	16	14	17	15	15	14	13	14	13	14[3]
Measured exceedances	3	0	3	1	0	2	0	0	3	0	1	0	8
99.7 %ile PM_{10} conc. ($\mu g/m^3$)	64	37	61	48	37	64	44	45	53	30	37	36	128
Annual maximum ($\mu g/m^3$)	76	40	71	62	40	75	46	48	101	30	64	42	136
Number of records	256	338	328	344	281	363	364	364	363	361	364	364	291

1. Data post 2006 is adjusted for gravimetric equivalency.
2. Note: data for 1998, 1999 and 2000 has been excluded from table due to formatting constraints.
3. Winter average rather than annual average.

3.3 Concentrations of benzene, toluene and xylenes

In Hamilton, monitoring of benzene at the Peachgrove Road air monitoring site and at a high-density traffic area at Bridge Street has taken place since 2004. In 2005 an additional benzene sampling site was established at the intersection of Claudelands Road and Victoria Street (Claudelands Bridge). This is also a high density traffic area. Additional sites were established in 2006 in Tristram Street, Greenwood Street and at Hamilton Intermediate School.

Benzene concentrations measured at all locations in Hamilton during 2013 were within the Ministry for the Environment's 2010 annual guideline of 3.6 µg/m^3 (Table 3.4). The guideline prior to 2010 was 10 µg/m^3 (annual average). The highest annual concentration for 2013 was measured at the Greenwood Street monitoring site and was 2.7 µg/m^3, the same maximum and location as recorded for 2012. (Figure 3.10). An improving or "levelling" trend is evident for annual average concentrations of benzene at all sites.

Large decreases in benzene concentrations were observed over the period 2004 to 2007. Prior to 2011, benzene concentrations had tapered relative to decreases observed from 2004 to 2007 (Figure 3.10). These earlier decreases were attributed to changes in fuel specifications and improved vehicle technology (Smith, 2007). Results for 2013 indicate either small decreases or negligible change at all sites compared with previous years.

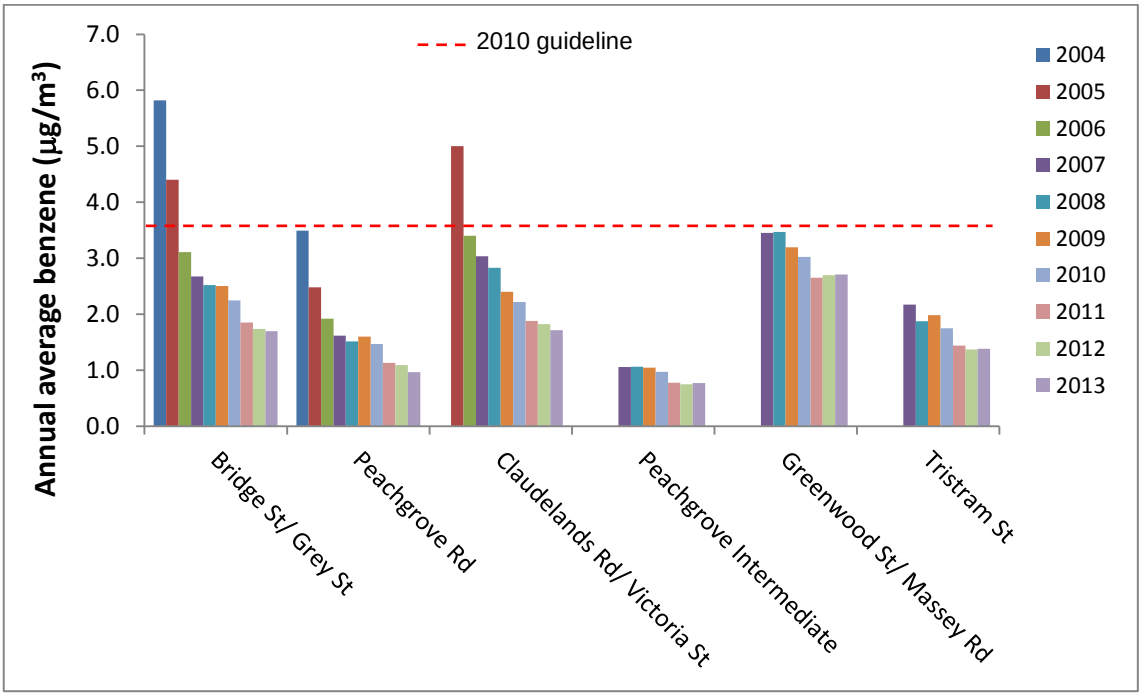

Figure 3-10: Annual average benzene measured at Hamilton sites (2004 to 2013).

Ethyl-benzene, toluene and xylene were also measured at the benzene monitoring sites for each year. An MfE document discussing amendments to the 1994 ambient air quality guidelines suggests an annual threshold of 190 µg/m^3 and 950 µg/m^3 for toluene and total xylenes respectively (MfE, 2000). The United States EPA Reference Concentration for ethyl-benzene is 1000 µg/m^3 as an annual average. Concentrations of toluene, total xylenes and ethyl-benzene measured in Hamilton at all sites were significantly lower than the suggested MfE thresholds and USEPA Reference Concentration.

Table 3-4: Annual average concentrations of volatile organic compounds (VOCs) at Hamilton sites between 18 December 2012 to 18 December 2013.

VOC	Bridge St µg/m^3	Peachgrove Rd µg/m^3	Claudelands Rd µg/m^3	Peachgrove Intermediate µg/m^3	Greenwood St µg/m^3	Tristram St µg/m^3	Guideline[a] µg/m^3
Benzene	1.7	1.0	1.7	0.8	2.7	1.4	3.6 (10[a])
Ethyl-benzene	1.3	0.7	1.5	0.7	2.2	1.2	1000[b]
Toluene	7.6	4.7	7.9	3.4	15.7	7.1	190[b]
Total Xylenes	6.0	3.6	6.1	2.9	9.3	5.5	950[b]

[a] The historical guideline for benzene of 10 µg/m^3 reduced to 3.6 µg/m^3 in 2010.

[b] There are currently no guideline values for ethyl-benzene, toluene and xylenes. Threshold values for toluene and total xylenes used here are from proposed amendments to the 1994 ambient air quality guidelines. For ethyl-benzene, the US EPA Reference Concentration has been used.

3.4 Concentrations of carbon monoxide

During 1 October 2012 to 31 March 2013, eight hourly average concentrations of carbon monoxide (CO) as measured at the Ohaupo Road monitoring station were well below the NESAQ standard for CO. The NESAQ standard for CO is 10 mg/m^3 with one allowable exceedance per year (Refer to Figure 3.11). The eight-hour concentrations of CO were less than 33% of the NES and national and regional ambient air quality guidelines and therefore fall within the good air quality indicator category (Refer to Table 3.5).

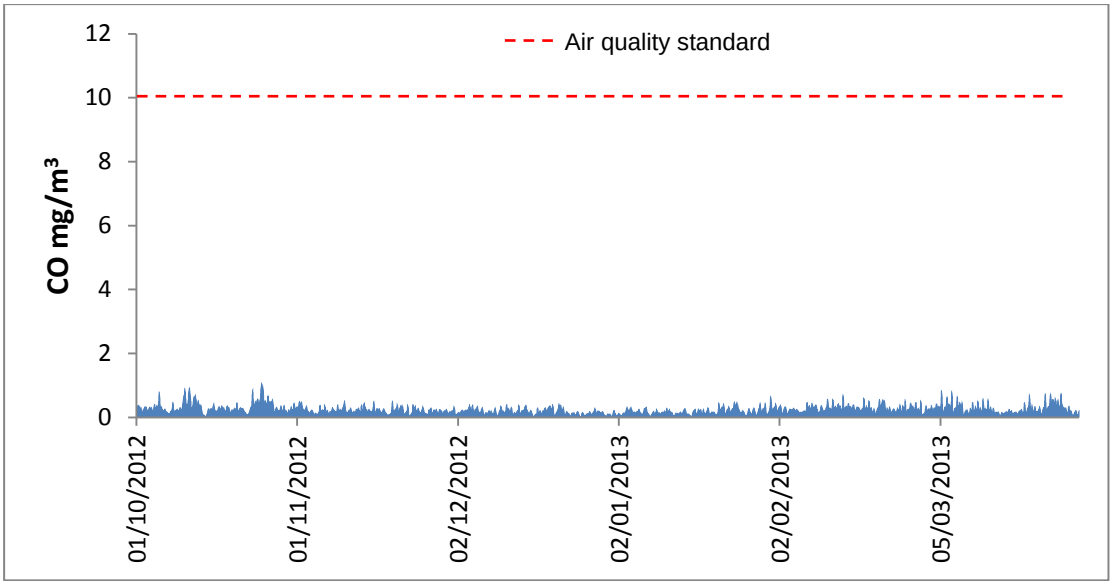

Figure 3-11: Eight hourly average CO concentrations measured during October 2012 to March 2013.

Table 3-5: Summary of 8-hour average CO concentrations measured during 2012 to 2013.

Indicator	2012 to 2013
"Good" 0-33% of guideline	100%
"Acceptable" 33-66% of guideline	0%
"Alert" 66-100% of guideline	0%
“Action” >Guideline	0%
Percentage of valid data	100%
Annual average (µg/m^3)	0.3
Measured exceedances	0
99.7 %ile PM10 concentration (µg/m3)	0.9
Annual maximum (µg/m3)	1.1
Number of records	4368

3.5 Concentrations of nitrogen dioxide

During 4 April 2013 to 4 October 2013, one hourly average concentrations of nitrogen dioxide (NO_2) as measured at the Ohaupo Road monitoring station were well below the NESAQ standard for NO_2. The NESAQ standard for NO_2 is 200 µg/m^3 with nine allowable exceedance per year (Refer to Figure 3.12). A maximum concentration of 101 µg/m^3, which is approximately 50% of the standard, was recorded on 13 June 2013. The one-hour concentrations of NO_2 were less than 66% of the NES and national and regional ambient air quality guidelines and therefore fall within the acceptable air quality indicator category (Refer to Table 3.6).

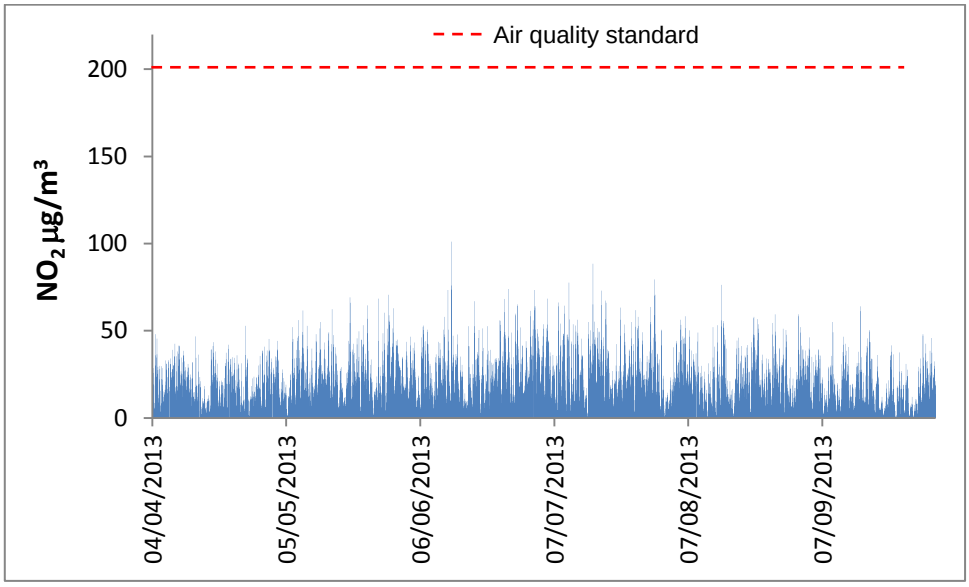

Figure 3-12: Hourly average NO_2 concentrations measured during April 2013 to October 2013.

Table 3-6: Summary of 1-hour average NO_2 concentrations measured during 2013.

Indicator	2013
"Good" 0-33% of guideline	99.5%
"Acceptable" 33-66% of guideline	0.5%
"Alert" 66-100% of guideline	0%
“Action” >Guideline	0%
Percentage of valid data	97%
Annual average (µg/m^3)	21
Measured exceedances	0
99.7 %ile PM_{10} concentration (µg/m^3)	70
Annual maximum (µg/m^3)	101
Number of records	4268

3.6 Comparison of meteorological conditions for 2013 to previous years

The frequency and extent of NES breaches from year to year depends largely on the prevalence of meteorological conditions conducive to elevated pollution, in particular low wind speeds, cooler temperatures and temperature inversions. Figure 3.13 and Figure 3.14 compare summary statistics for wind speed and temperature from 1998 to 2013. The significantly higher wind speed average of 8 m/s in 2009 indicates an anomaly with the data collected. Other Hamilton meteorological stations averaged around 3 m/s which is more consistent with that expected for the Peachgrove Rd data.

An evaluation of meteorological conditions and PM_{10} concentrations in Hamilton from 1998 to 2007 identified 24-hour average wind speed less than 0.74 m/s as the main meteorological characteristic of elevated PM_{10} concentrations (Wilton, 2007). Figure 3.15 compares the number of days during the winter months when these meteorological conditions occurred from 2000 to 2013 and the number of days each year when PM_{10} concentrations exceeded 50 µg/m^3. Even when excluding the results for 2009 (refer anomalous data issue discussed above) there does not appear to be any clear evidence in recent years that elevated concentrations are linked to years when there is an increased number of days with low wind speeds over the winter season.

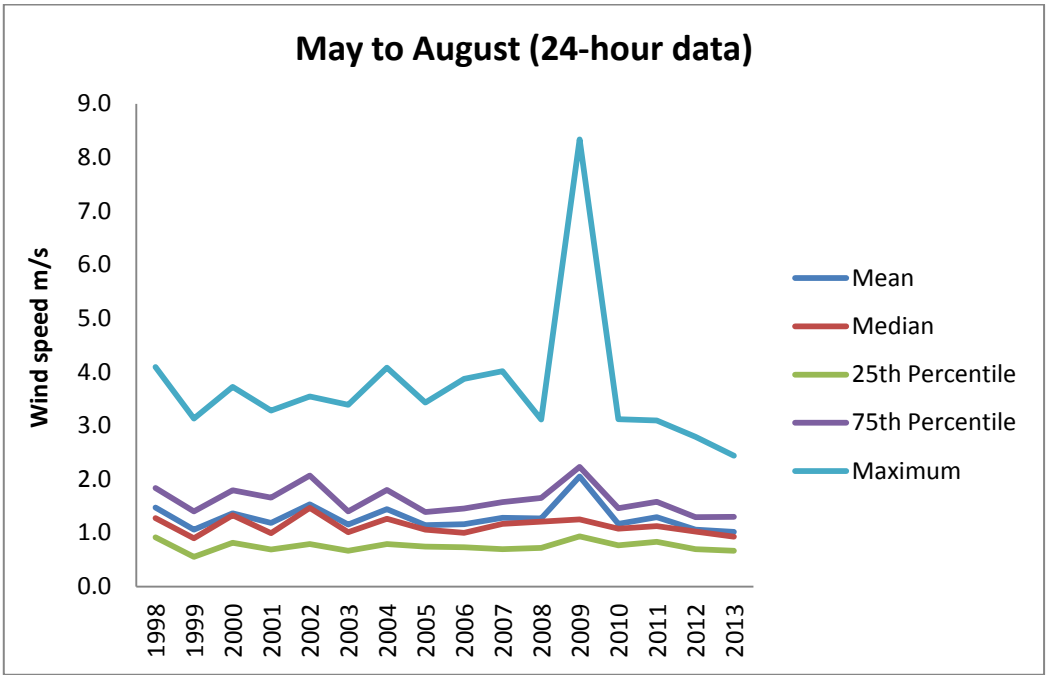

Figure 3-13: Summary wind speed data from 1998 to 2013 at the Peachgrove Road site.

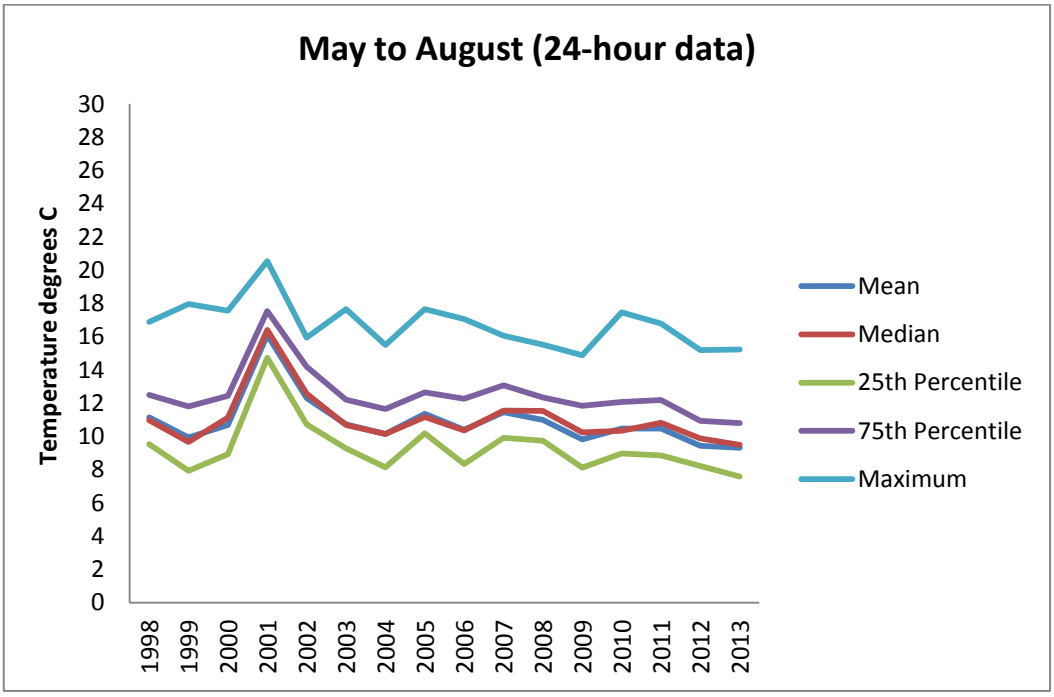

Figure 3-14: Summary temperature data from 1998 to 2013 at the Peachgrove Road site.

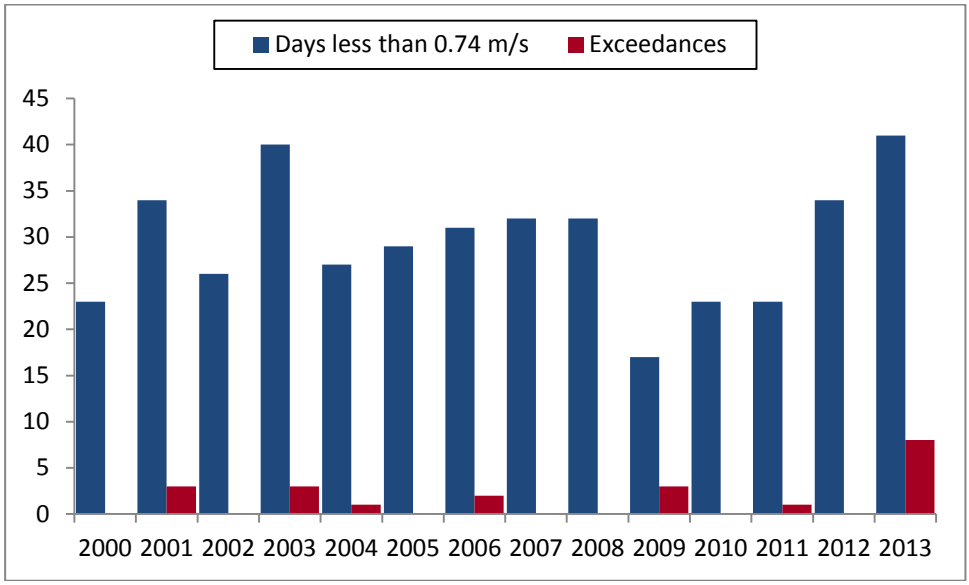

Figure 3-15: Number of days from May to August when the 24-hr average wind speed was less than 0.74 m/s and number of guideline exceedances per year.

3.7 Daily variations on high pollution days

Figure 3.16 shows the daily variations in PM_{10} concentrations and meteorological parameters on the eight days during 2013 when the daily average PM_{10} concentration exceeded 50 µg/m^3. The main PM_{10} peak tended to occur between 5 pm to 11 pm but there were some days when there was a secondary peak in the morning between 7 am to 9 am.

The PM_{10} profiles are different from the profile typically observed in situations where woodburner emissions dominate the emission sources. Profiles more typical of woodburner emissions show a broad peak that is centred around 11 pm to midnight which gradually reduces down over the early hours of the morning. In comparison, the PM_{10} profiles in Figure 3.16 show a peak at around 7 to 9 pm with a more dramatic reduction well before midnight and a very low and level concentration from midnight through to typically 7 am. In addition to this, on many of these days the concentrations increase in the afternoon often from around 1pm compared with a typical urban high pollution day where concentrations during the afternoon are low.

While wind speeds were low during the peak PM_{10} concentrations on these eight days in 2013, the air temperatures were not especially low (average daily temperatures of around 10 degrees) and meteorological conditions were therefore not typical of the conditions expected during high pollution events.

This all provides further evidence that the main source driving these exceedances observed in 2013 was unusual for the Hamilton airshed.

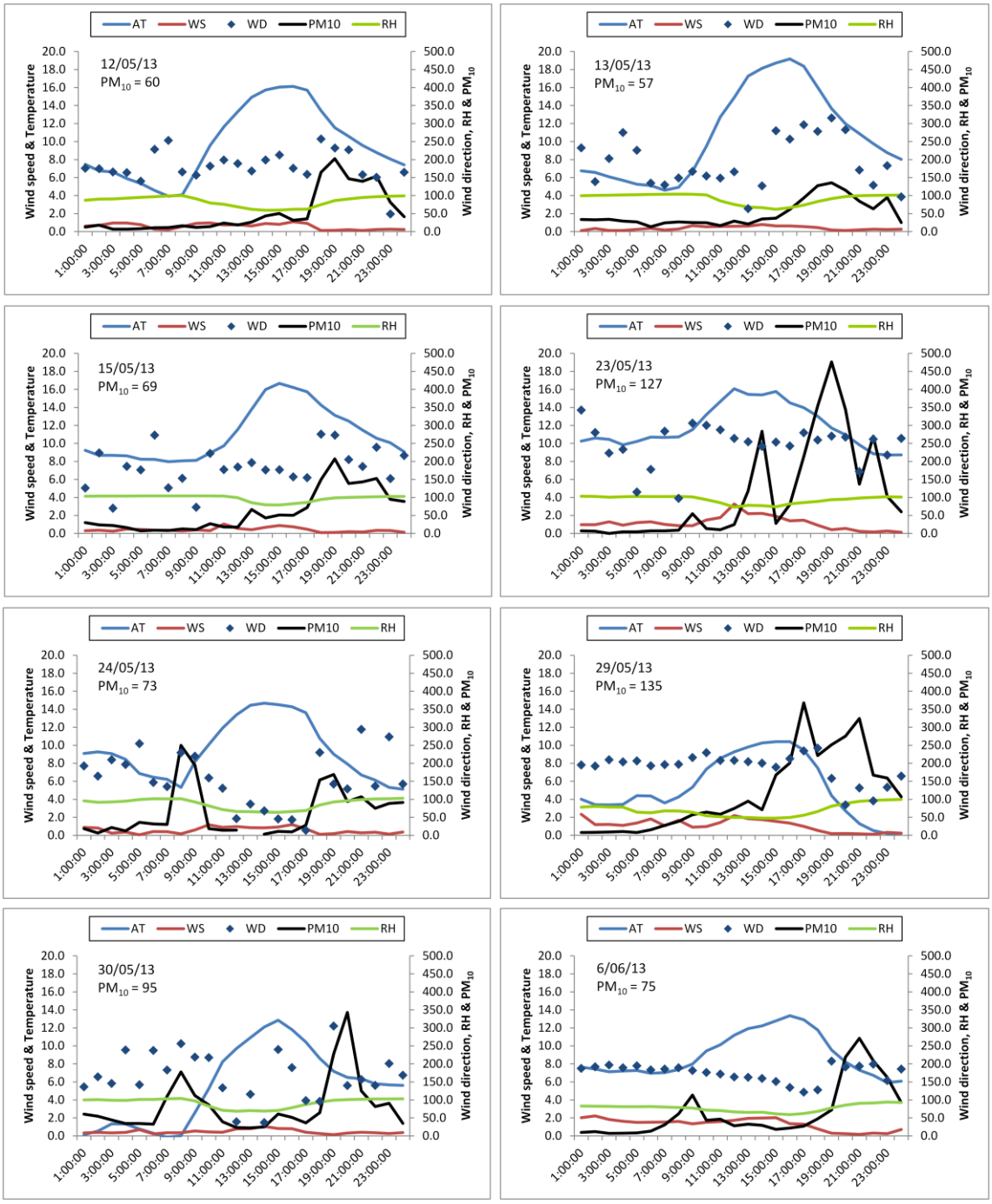

Figure 3-16: Daily variation in PM_{10} concentrations, wind speed, temperature and relative humidity on the eight days during 2013 when the daily average PM_{10} concentration exceeded 50 µg/m^3.

3.8 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM_{10} in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM_{10} and more exceedances might be expected if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM_{10} record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results for the Peachgrove Rd PM_{10} data (MK-Stat of -2.05 and p-value of 0.04) provides possible evidence that PM_{10} concentrations in Hamilton have been decreasing over the period 2006 to 2013 (data corrections made for ignoring the impact of the eight exempted exceedances during 2013). However, as the previous analysis for data measured over the period 2006 to 2012 had indicated no evidence that PM_{10} concentrations were getting either better or worse, the results of the 2006 to 2013 analysis should be treated with some caution.

Based on this analysis and the current previous five year exceedance average of 0.8 (2013 exceedances excluded), Hamilton could continue to meet the NES target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period resulting in Hamilton being classified as a polluted airshed.

4 Tokoroa

4.1 Air Quality Monitoring in Tokoroa

In Tokoroa, monitoring for PM_{10} has been carried out since 2001 at the Billah Street Reserve air quality monitoring site, located west of central Tokoroa. The monitoring site meets the requirements of the "Residential Neighbourhood" site classification as described in the *Good Practice Guideline for Air Quality Monitoring and Data Management 2009',* report (MfE, 2009).

In 1999, some air quality monitoring was carried out in Tokoroa at the South Waikato Council Offices, on the east side of the town. Results of the 1999 monitoring are not included in this air quality monitoring report due to uncertainties surrounding the monitoring method.

A MET ONE series 1020 BAM was used to monitor PM_{10} from 2001 to September 2005 at the Billah Street site. In September 2005 the MET ONE instrument was replaced with a ThermoAndersen FH62 C14 BAM due to unacceptable data loss caused by frequent tape failure from the MET ONE. The FH62 BAM records data at ten minute intervals. Figure 4.1 shows the Tokoroa Airshed and the location of the air quality monitor in Tokoroa.

Figure 4-1: Tokoroa Airshed and air quality monitoring site.

4.2 PM_{10} concentrations in Tokoroa

During 2013 there were 10 days when PM_{10} concentrations exceeded 50 µg/m^3. The dates and concentrations reached on these days are shown in Table 4.1. The maximum measured concentration was 59 µg/m^3 and compares with a maximum of 75 µg/m^3 and a total of 15 exceedances measured at the site during 2012. Daily PM_{10} concentrations measured at Tokoroa during 2013 are shown in Figure 4.2.

An analysis of the hourly profile (refer to Figure 4.7) for one of the exceedances that occurred on 9 July indicates a large spike between 9 to 11 am. This spike is suspected to have been caused by a house fire that occurred at the time in John Street. If the PM_{10} concentrations from the fire were removed from the data the concentration would decrease from 52 µg/m^3 to 42 µg/m^3 and therefore a breach would not have occurred. A similar analysis of the hourly profile (refer to Figure 4.7) for an exceedance that occurred on the 9 July (also a large spike between 9 to 11 am) is suspected to have been caused by lime dosing at the adjacent water treatment plant. If this contribution had not occurred the 24-hour average concentration would have reduced from 59 µg/m^3 to 49 µg/m^3. This is the first time that lime dosing has been identified to have made such a significant difference to the 24 hour average.

The exceedance day caused by the lime dosing cannot be excluded from the total breaches for Tokoroa because it does not meet the criteria for exceptional circumstances. While the exceedance day caused by an uncontrolled house fire could potentially qualify as an exceptional circumstance there would be no benefit gained by doing so. The Tokoroa airshed is already a polluted airshed and the reduction of exceedances from a total of ten down to nine for 2013 would not change this status.

Table 4-1: Dates and concentrations for exceedences of 50 µg/m^3 in Tokoroa during 2012.

Date	PM_{10} µg/m^3	Rank	Date	PM_{10} µg/m^3	Rank
2/07/2013	59	1	03/06/2013	51	9
19/07/2013	59[1]	2	16/07/2013	51	10
31/05/2013	55	3			
13/05/2013	54	4			
23/06/2013	54	5			
30/06/2013	53	6			
30/05/2013	52	7			
09/07/2013	52[2]	8			

1. Lime dosing suspected to have been the cause of a large spike (24 hour average with spike removed = 49).
2. House fire on John St suspected to have been the cause of a large spike (24 hour average with spike removed = 42).

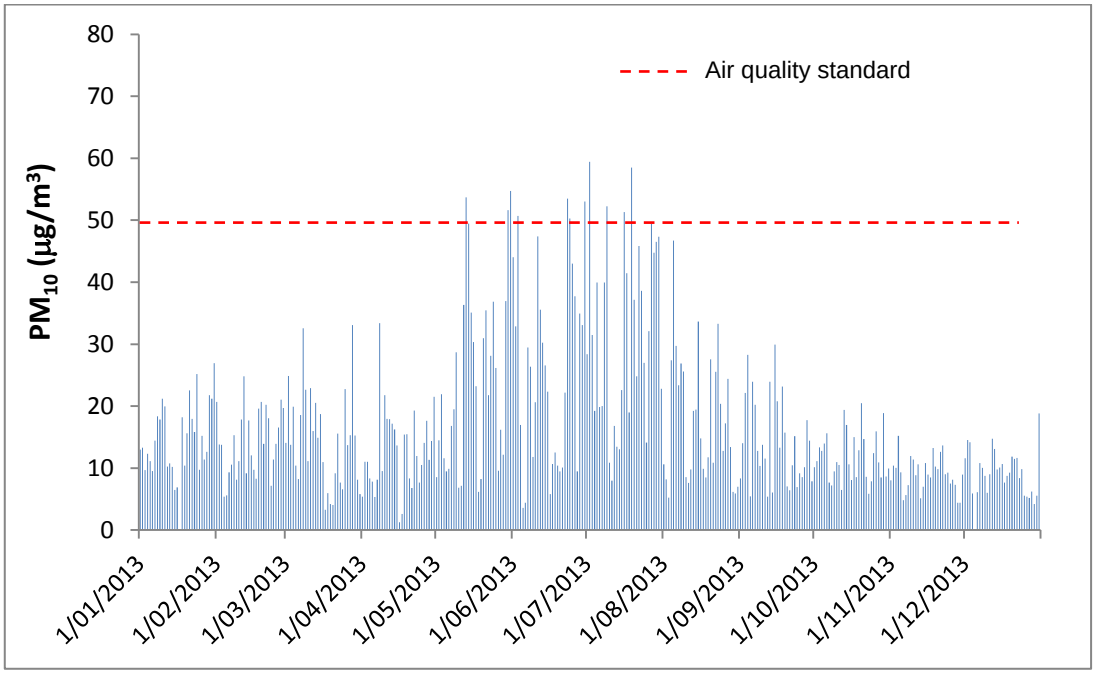

Figure 4-2: Daily winter PM_{10} concentrations measured in Tokoroa during 2013.

It is noted that the Met One BAM was changed to an FH62 BAM in September 2005, and a change in baseline readings was observed at that point (Smith, 2006). In 2007 and 2008, site-specific calibration against a gravimetric method was carried out. Comparison of results from the two co-located instruments now suggest that:

- The previous BAM was recording an artificially high baseline reading, because the new instrument is accurate[3] at low PM_{10} concentrations, and
- The new BAM requires a significant upward correction across the mid and upper ranges, in the order of approximately 19% at a PM_{10} concentration of 50 µg/m^3. Although site-specific calibration data is only available for the newer instrument, it is also likely that the older BAM would have required a similar range correction to bring its results into line with gravimetric results in Tokoroa (pers comm., Nick Kim, Environment Waikato, 2008).

The net result of these two corrections for all data collected in Tokoroa prior to September 2005 would be to reduce the annual average, but increase the peaks (and the non-compliance frequency).

In this report the approach taken has been to report only calibration-corrected data collected on the newer FH62 BAM during the monitoring years from 2006. Retrospective estimates of air quality in Tokoroa from 2001 to 2005 may form a part of future work involving analysis of trends.

Figure 4.3 shows changes in PM_{10} concentrations relative to air quality indicator categories at the Tokoroa site from 2006 to 2013 with typically around 3 to 6% of daily averages falling within the action category.

[3] The newer BAM is more accurate when compared with the gravimetric reference method.

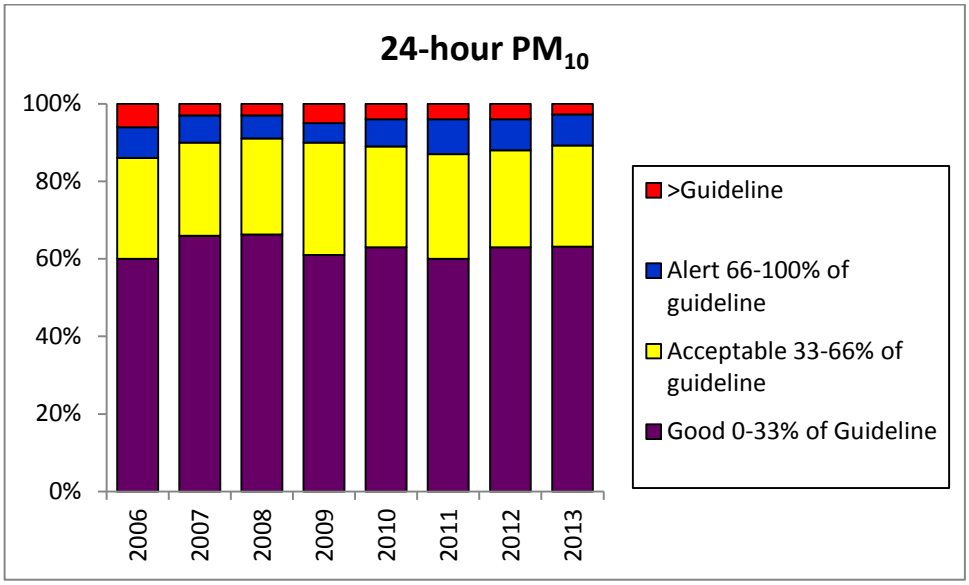

Figure 4-3: Comparison of PM_{10} concentrations measured in Tokoroa from 2006 to 2013 to air quality indicator categories.

Figure 4.4 shows the seasonal variations in the distribution of PM_{10} concentrations during 2013. There is a very evident seasonal pattern with regards winter versus summer daily averages with around four months of the year where the annual PM_{10} standard is exceeded.

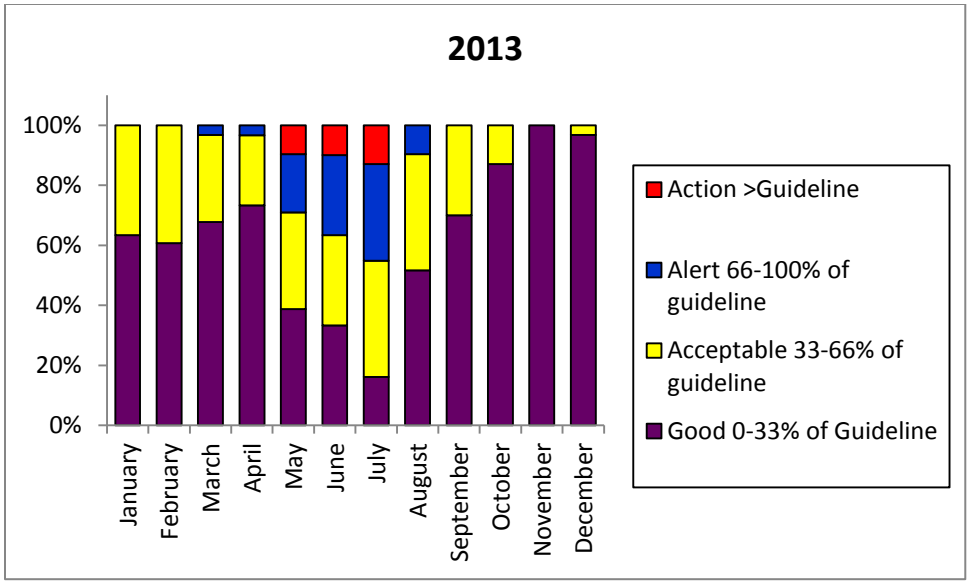

Figure 4-4: Comparison of daily PM_{10} concentrations each month during 2013 to air quality indicator categories.

The number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 99.7 percentile concentration over the period 2006 to 2013 is presented in Figure 4.5. There is no indication of an improving trend with regards either the number of exceedances or the maximum and 99.7 percentile concentrations when a comparison is made with monitoring data collected since 2006.

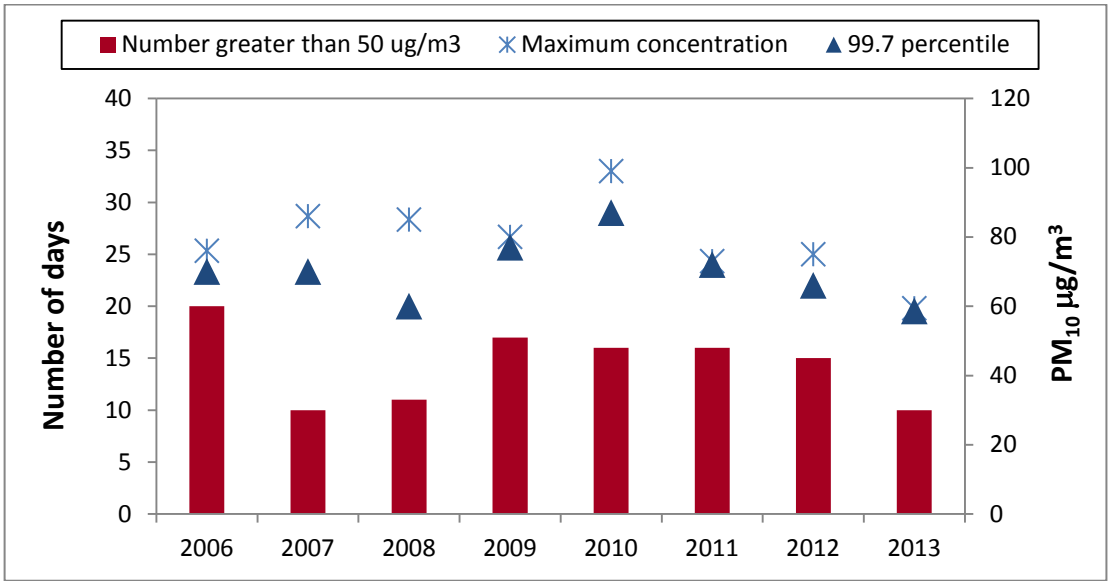

Figure 4-5: Number of days when 50 µgm^3 was exceeded compared with the maximum concentration and the 99.7 percentile concentration measured from 2006 to 2013.

The annual average PM_{10} concentration for Tokoroa for 2013 was 17 µg/m^3. This is similar to other annual average concentrations over the last six years. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Table 4.2 shows the summary statistics for PM_{10} monitoring results.

Table 4-2: Summary of PM_{10} concentrations measured at the Tokoroa monitoring site from 2001 to 2013[1].

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
"Good" 0-33% of guideline	12%	15%	25%	12%	28%	60%	66%	67%	61%	63%	60%	63%	63%
"Acceptable" 33-66% of guideline	64%	71%	58%	54%	49%	26%	24%	25%	29%	26%	27%	25%	26%
"Alert" 66-100% of guideline	17%	9%	13%	23%	13%	8%	7%	6%	5%	7%	9%	8%	8%
“Action” >Guideline	8%	4%	4%	11%	9%	6%	3%	3%	5%	4%	4%	4%	3%
Percentage of valid data	47%	97%	55	96	88%	99%	99%	99%	100%	99%	99%	100%	100%
Annual average ($\mu g/m^3$)	27	24	24	31	25	19	16	17	18	18	18	17	17
Measured exceedances	13	14	8	38	33	20	10	11	17	16	16	15	10[2]
99.7 %ile PM10 conc. ($\mu g/m^3$)	70	66	59	92	83	70	70	60	77	87	72	66	58
Annual maximum ($\mu g/m^3$)	75	70	62	97	89	76	86	85	80	99	73	75	59
Number of records	173	353	199	349	321	360	360	360	364	360	362	366	364

1. Data post 2005 is adjusted for gravimetric equivalency.
2. Number of exceedances drops to 8 if spikes are removed for house fire on 9 July and lime dosing on 19 July.

4.3 Daily variations in PM_{10} and meteorology on high pollution days

Figure 4.6 compares summary statistics for wind speed and temperature from 2006 to 2013. The data summary indicates a decreasing trend in wintertime wind speed data over this monitoring period, particularly with respect to the maximum wind speed. The maximum, mean and median wintertime air temperature shows a small decrease over the period 2008 to 2009 followed by a small increase over the period 2010 to 2011.

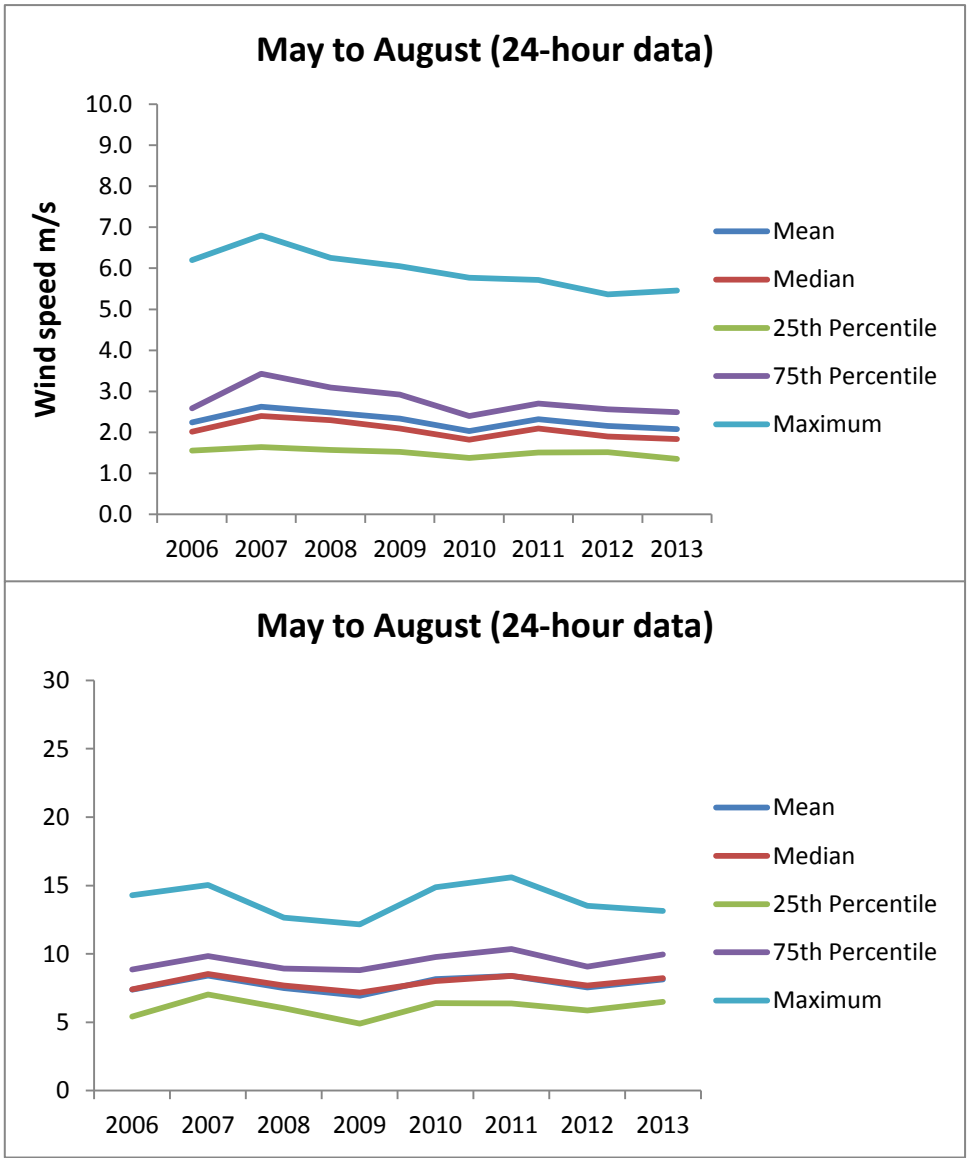

Figure 4-6: Summary wind speed and temperature data from 2006 to 2013 in Tokoroa.

Figure 4.7 shows the variations in meteorological conditions and hourly average PM_{10} concentrations on the 10 days when the 24-hour average for PM_{10} measured at Tokoroa exceeded 50 µg/m^3.

Generally, PM_{10} concentrations showed typical diurnal variations with a decrease in concentrations from midnight to 7am, a small peak around 9am and a more substantial increase in concentrations from 5pm. The two exceptions to this occurred on 9 July (large spike between 9 to 11 am suspected to have been caused by a house fire) and 19 July (large spike between 9 to 11 am suspected to have been caused by lime dosing at the adjacent water treatment plant).

High concentrations typically occur when the wind speeds and air temperature are low and the wind direction is from the south east.

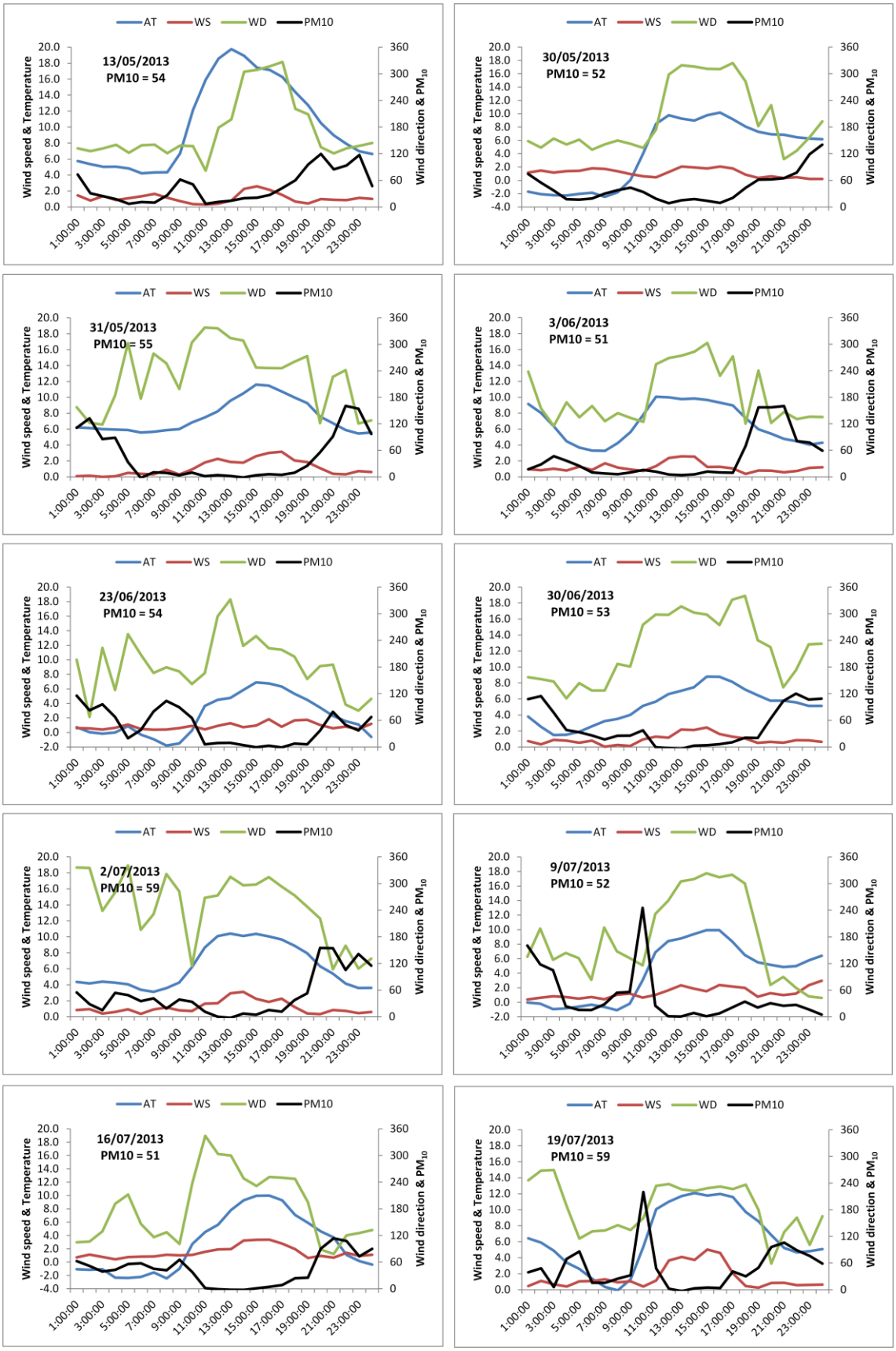

Figure 4-7: Hourly average PM_{10}, wind speed, wind direction and temperature on days when PM_{10} concentrations exceeded the NES in Tokoroa.

4.4 Trend Analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM_{10} in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example, higher PM_{10} and more exceedances might be expected during a colder winter if more wood is burned. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM_{10} record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -0.3 and a p-value of 0.8) provide no evidence that PM_{10} concentrations in Tokoroa have been getting either better or worse over the period 2006 to 2013.

Additional analysis has also been undertaken using methodologies developed by Environet Ltd which account for the impacts of varying meteorology in Tokoroa (Wilton, 2013a). Meteorological conditions conducive to high pollution in Tokoroa include days which have both low windspeeds and low temperatures over a specific period of the day, namely:

- Days with more than 15 hours when the hourly average wind speed was less than 2 metres per second; and
- Days where the average temperature from 8 pm to midnight is less than 5.36 degrees Celsius; and
- Days with a maximum windspeed between 5 pm to midnight of less than 1.62 metres per second.

In summary, if all these criteria are met then these are the days you would expect exceedances to occur. Figure 4.8 provides a summary of the year-to-year variation of the proportion of high pollution potential days which resulted in exceedances in Tokoroa. Figure 4.9 provides a summary of the year-to-year variation of the absolute number of high pollution potential days compared with the number of exceedance days.

If PM_{10} concentrations were decreasing, a consistent reduction in the proportion of high pollution potential days that resulted in breaches would be evident. In 2006 exceedances occurred on around 70% of days when meteorological conditions conducive to elevated PM_{10} occurred. This reduced to around 40% in 2007 and 2008, then stabilised around 50% from 2009 to 2012 before dropping again to 25% in 2013. This analysis indicates that there may have been a reduction in PM_{10} emissions between 2006 and 2007 in Tokoroa. There has been an even more dramatic decrease in 2013 of the percentage of days with exceedances while the absolute number of high pollution potential days has remained comparatively high and similar to previous years where the total number of days with exceedances has been higher (refer to Figure 4.9). However, we would need to see similar percentages maintained over the next two years to be confident that the trend analysis was indicating a reduction in PM_{10} emissions since 2012.

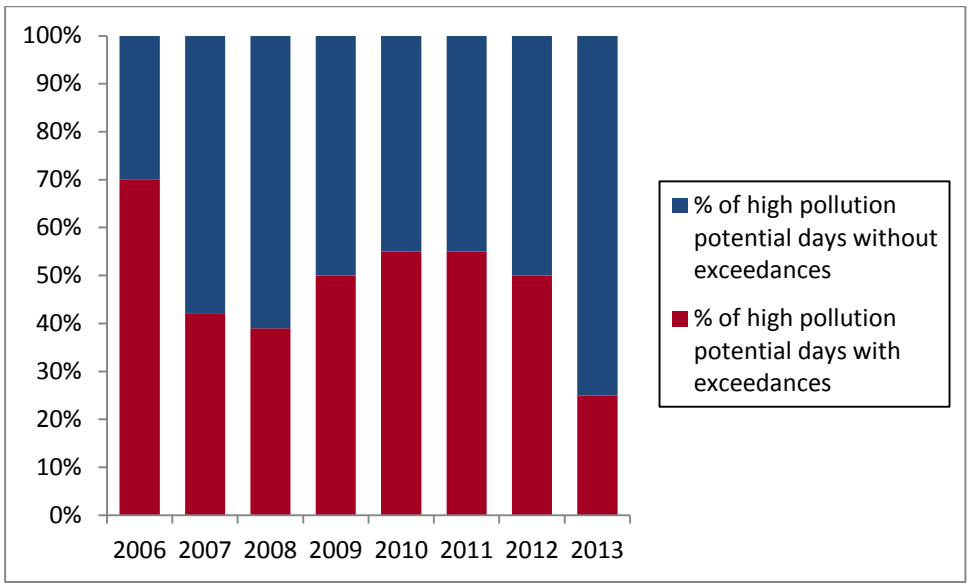

Figure 4-8: Year-to-year variation of the proportion of high pollution potential days which resulted in exceedances.

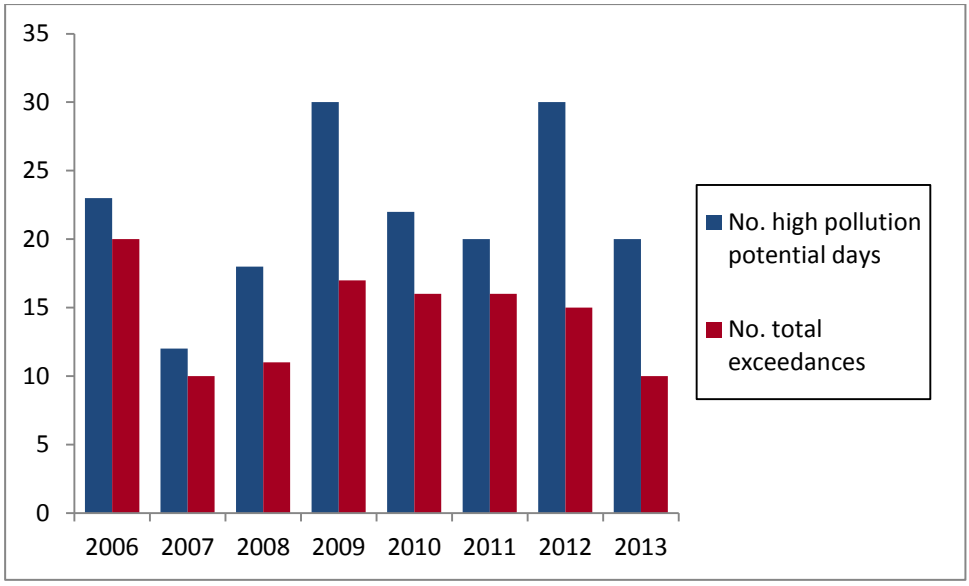

Figure 4-9: Year-to-year variation of the absolute number of high pollution potential days compared with the total number of exceedance days.

The analysis tool developed by Environet Ltd also provides the ability to minimise the impact of varying meteorology. This methodology is referred to as normalising the PM_{10} concentrations so that the influence of varying meteorology is minimised. The graph of normalised PM_{10} concentrations presented in Figure 4.10 provides no evidence that PM_{10} concentrations have decreased.

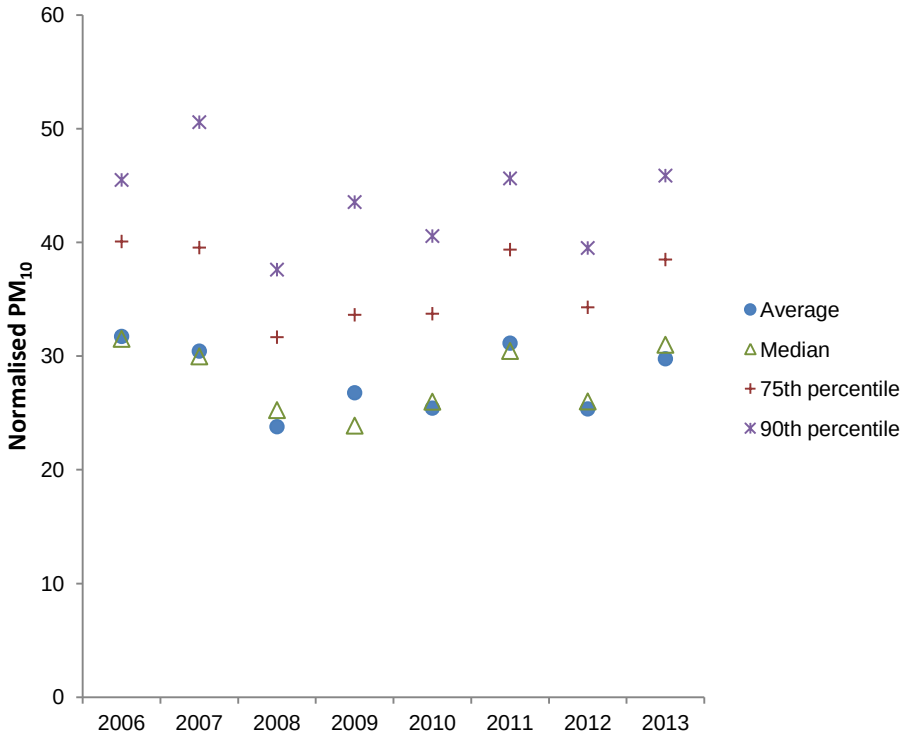

Figure 4-10: Average, 75th percentile, 90th percentile and median PM_{10} concentrations for the days when the impacts of meteorological variability have been minimised.

Based on these analyses and the current five year exceedance average of 14.8, it is not expected that Tokoroa will meet the interim NES 2016 target of no more than three exceedances without significant emission reductions. It has been estimated that an emission reduction of around 24% is required to meet the 2016 target and around 43% to meet the 2020 target (Wilton, 2011). These required emission reductions are based on the estimated emissions as of mid 2007.

5 Taupo

5.1 Air quality monitoring in Taupo

The air quality monitoring site for Taupo is located at Gillies Avenue Reserve in central Taupo and was established in November 2000. The site meets the requirements of the "Residential Neighbourhood" site classification as described in the '*Good Practice Guideline for Air Quality Monitoring and Data Management 2009'* report (MfE, 2009).

A FH62 C14 BAM has measured PM_{10} concentrations since March 2007. Gravimetric sampling using a Rupprecht and Patashnick Partisol Model 2000 PM_{10} sampler also took place at the Gillies Avenue Site during 2007 and 2008. Figure 5.1 shows the Taupo Airshed and the location of the monitoring site at Gillies Avenue in Taupo.

Prior to 2005, PM_{10} was monitored in Taupo on a one day in three basis at the Gillies Avenue Reserve site using a Rupprecht and Patashnick Partisol Model 2000 PM_{10} sampler. In January 2006 a FH62 C14 BAM continuous PM_{10} monitoring station along with meteorological instrumentation was established at Taupo Primary School. The meteorological instruments measured wind speed, wind direction, air temperature, and relative humidity. The site meets the requirements of the "Residential Neighbourhood" site classification (MfE, 2000).

Operation of the Gillies Avenue Reserve Partisol Model 2000 PM_{10} sampler continued throughout 2006 to March 2007 to evaluate the spatial variation of PM_{10} concentrations between Gillies Avenue and Taupo Primary School.

The maximum recorded 24-hour PM_{10} concentration at the Taupo Primary School site in 2006 was 25 $\mu g/m^3$ whereas the maximum recorded 24-hour PM_{10} concentration at the Gillies Avenue Reserve site (based on one day in three Partisol monitoring) was 89 $\mu g/m^3$. The results from the 2006 Monitoring Report (Smith, 2006) found that the Taupo Primary School site was not a suitable site for compliance with NES Regulation 15 that requires monitoring at the location where contaminant concentrations (or frequency of exceedances) are greatest. The 2006 data reported in this report use the partisol sampling results for Gillies Avenue. On 17 March 2007 the FH62 C14 BAM and meteorological instrumentation was moved from Taupo Primary School to the Gillies Avenue Reserve site.

Gravimetric sampling using the Partisol Model 2000 PM_{10} sampler also took place at the Gillies Avenue Site during 2008. The sampling regime was approximately one day in three, with a midnight to midnight filter exposure period. The sampling was carried out by the Institute of Geological & Nuclear Sciences (GNS) on behalf of Environment Waikato.

Figure 5-1: Taupo Airshed and air quality monitoring site.

5.2 PM_{10} concentrations in Taupo

Average daily PM_{10} concentrations measured at the Taupo Gillies Ave site during 2013 are shown in Figure 5.2. Two exceedances of 50 µg/m^3 were recorded during 2013 and measured 62 µg/m^3 on the 26th of June and 65 µg/m^3 on the 30 July. This compares with only one exceedance (53 µg/m^3) recorded during 2012 and one exceedance in 2011 and 2012.

The changes in PM_{10} concentrations relative to air quality indicator categories at the Taupo site from 2006 to 2013 are shown in Figure 5.3. Data are adjusted for gravimetric equivalency only since 2007 so comparison of trends with pre 2006 data are limited[4]. A slight increase in the proportion of PM_{10} concentrations in the 'good' category may have occurred since 2007.

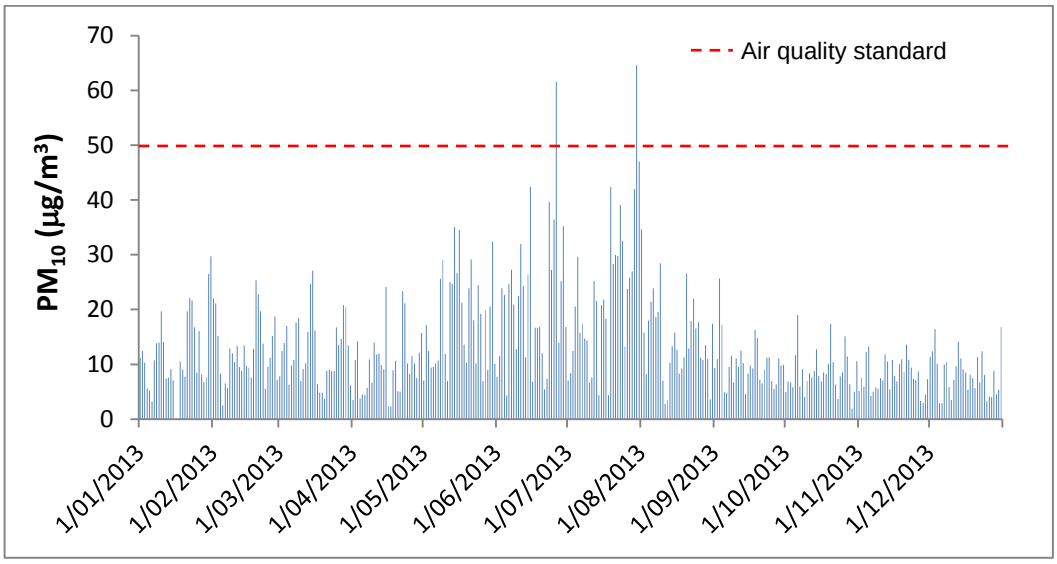

Figure 5-2: Daily winter PM_{10} concentrations measured at Taupo during 2013.

[4] For 2006 the gravimetric partisol data from Gillies Ave were used in preference to the BAM primary school data.

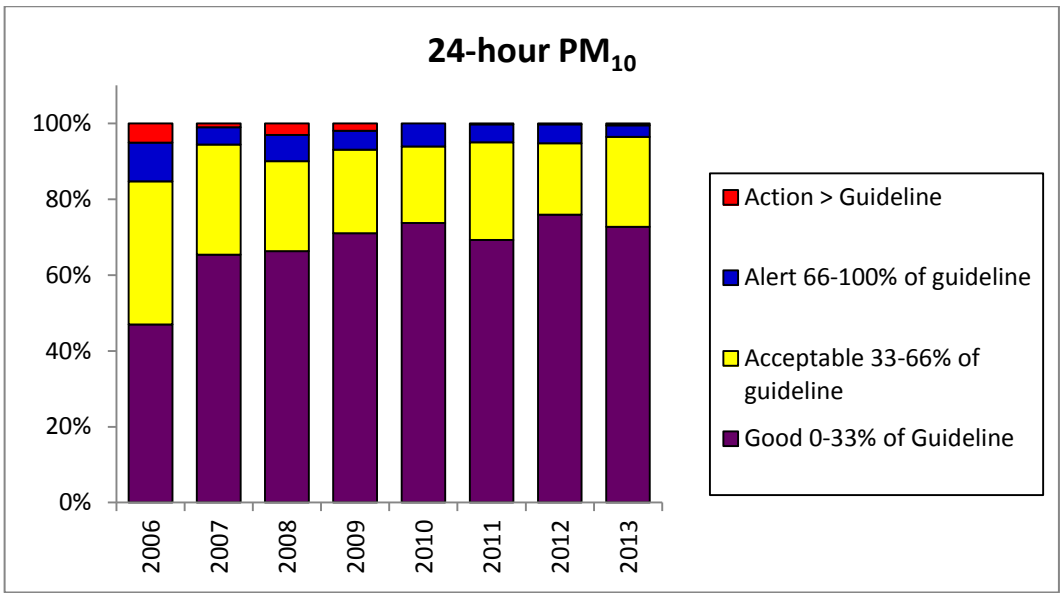

Figure 5-3: Comparison of PM_{10} concentrations measured at the Taupo site from 2006 to 2013 to air quality indicator categories.

Figure 5.4 shows the seasonal variations in the distribution of PM_{10} concentrations for 2013. Figure 5.5 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 99.7 percentile for 2006 to 2013. The trend line slope for exceedances per year is negative with an R^2 value of 0.56. The trend line slope for 99.7 percentile concentrations per year is also negative with an R^2 value of 0.49. These indicators suggest that air quality has improved over the period 2006 to 2013 although the inclusion of the 2013 data has reduced the strength of this trend. Further discussion of this is provided in the trend analysis presented in Section 5.4 of this report.

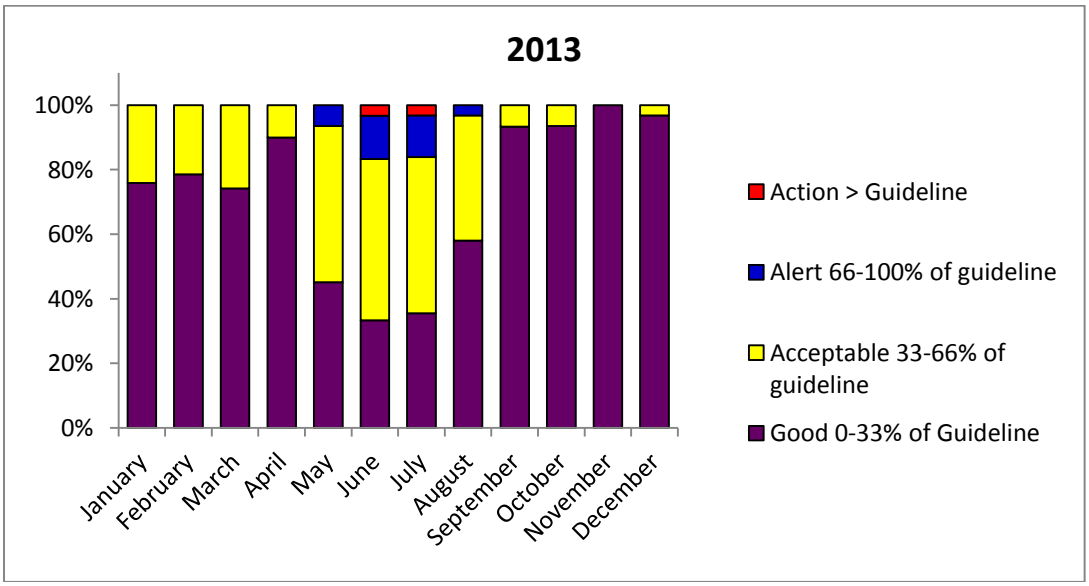

Figure 5-4: Comparison of daily PM_{10} concentrations each month during 2013 to air quality indicator categories.

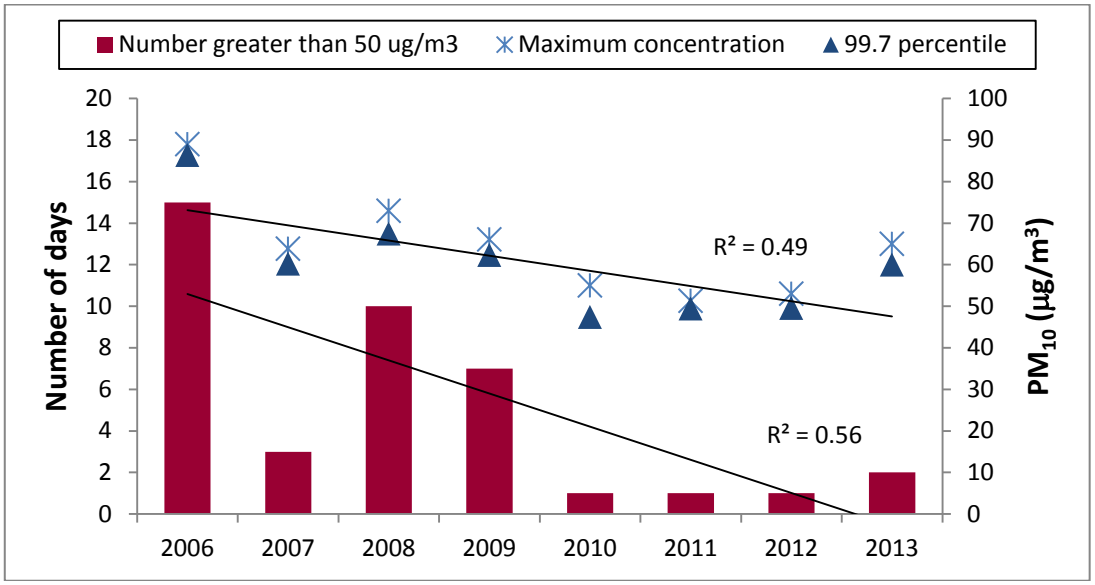

Figure 5-5: Number of days when 50 µg/m^3 was exceeded compared with the maximum concentration and the 99.7 percentile concentration measured from 2006 to 2013.

The annual average PM_{10} concentration for 2012 of 13 µg/m^3 is consistent with the average for 2012 and lower than the 14 µg/m^3 average for 2010 and 2011. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Summary statistics for PM_{10} monitoring results for the period 2001 to 2013 are shown in Table 5.1.

Table 5-1: Summary of PM_{10} concentrations measured at the Taupo monitoring site from 2001 to 2013[1].

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
"Good" 0-33% of guideline	43%	59%	52%	55%	56%	47%	65%	66%	71%	73%	69%	76%	73%
"Acceptable" 33-66% of guideline	36%	33%	32%	30%	36%	38%	29%	24%	22%	20%	26%	19%	24%
"Alert" 66-100% of guideline	18%	7%	12%	12%	7%	10%	5%	7%	5%	6%	5%	5%	3%
"Action" >Guideline	2%	1%	4%	2%	1%	5%	1%	3%	2%	0%	0%	0%	1%
Percentage of valid data	12%	21%	29%	29%	30%	27%	83%	99%	99%	100%	99%	99%	99%
Annual average[2] ($\mu g/m^3$)	20	17	18	17	16	19	15	17	15	14	14	13	13
Measured exceedances	1	3	12	6	3	15	3	10	7	1	1	1	2
99.7 %ile PM10 conc. ($\mu g/m^3$)	55	51	62	62	50	86	60	67	62	47	49	50	60
Annual maximum ($\mu g/m^3$)	57	54	62	65	52	89	64	73	66	55	51	53	65
Number of records	44	76	106	105	111	98	303	362	363	364	361	362	363

1. 2007 - 2008 data have been updated from that reported in the 2007 and 2008 reports based on a more recent (2009) adjustment factor. 2006 data were gravimetric at Gillies Ave. Data post 2006 has been adjusted for gravimetric equivalency. Note the 2008 monitoring report used a different equation and reported six exceedances of 50 $\mu g\ m^{-3}$ for 2007 compared with three exceedances reported here.
2. To avoid seasonal bias in missing data, annual averages for gravimetric data collected prior to 2007 have been calculated based on the average of the individual seasonal averages (i.e. Jan to Apr, May to Aug, Sep to Dec). Annual average calculations from 2007 onwards have been based on averaging of all data (it makes no difference which method is used because there is very little missing data).

5.3 Daily variations in PM_{10} and meteorology on high pollution days

Figure 5.6 and Figure 5.7 show variations in PM_{10} concentrations and meteorological data on 26 June and 30 July respectively when the 24-hour average PM_{10} measured at Taupo exceeded 50 µg/m^3.

The pattern in hourly PM_{10} concentrations for 30 July (Figure 5.7) is reasonably typical of high pollution episodes in urban areas of New Zealand. In particular there is a small morning peak in concentrations around 9am followed by a decrease for the majority of the daytime then an increase in concentrations around 6 pm. Concentrations were also elevated during the early morning period (midnight to 3 am) as a result of the evening pollution episode from the previous day. The hourly pattern for the 26 June (Figure 5.6) is less typical with a much larger morning peak centred around 9 am.

In Taupo, high PM_{10} concentrations typically occur when the wind is from an easterly or south easterly direction and wind speeds are low. During the daytime the wind shifts to westerly, returning to east/south east during the evening (Wilton & Baynes, 2010). Both 2013 high pollution events were consistent with these wind patterns.

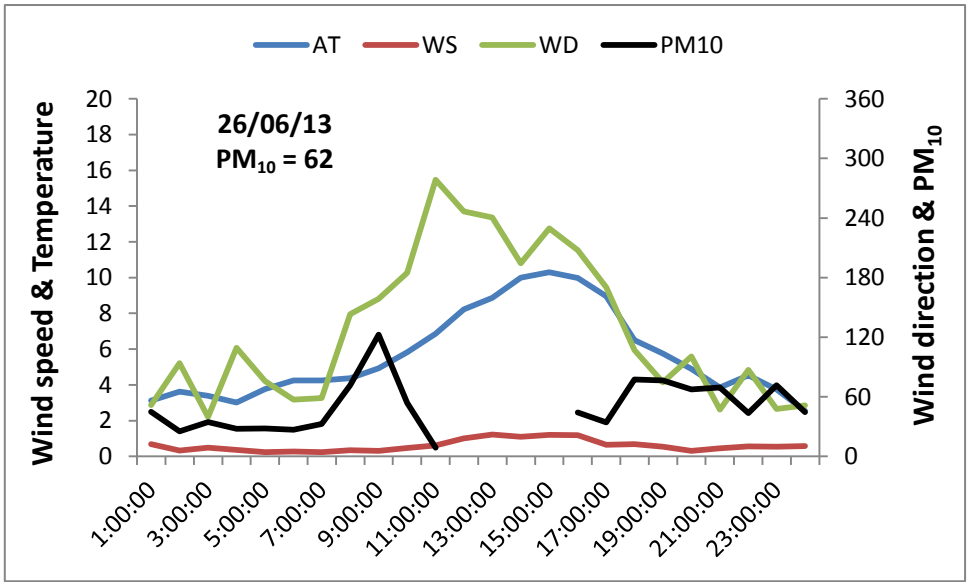

Figure 5-6: Hourly average PM_{10}, wind speed, wind direction and temperature on the 26th of June when the second highest 24-hour average PM_{10} concentration of 62 µg/m^3 was recorded at Taupo (gap in data is due to missing data).

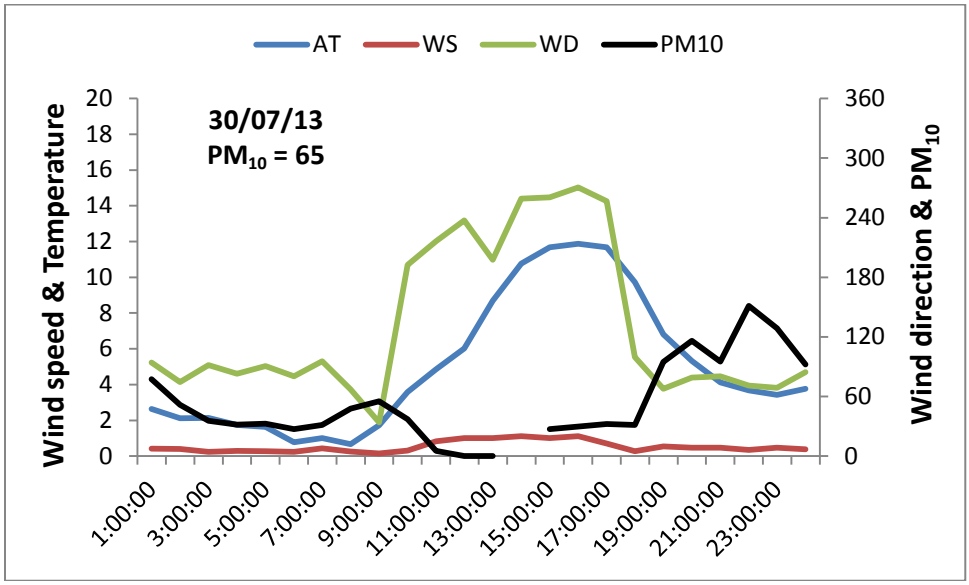

Figure 5-7: Hourly average PM_{10}, wind speed, wind direction and temperature on the 30th of July when the highest 24-hour averagePM_{10} concentrations of 65 µg/m^3 was recorded at Taupo (gap in data is due to missing data).

5.4 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM_{10} in any given airshed vary from winter to winter depending on meteorological conditions and human responses. For example,if a winter has a greater number of days when the wind speed is low and there is vertical stability in the lower atmosphere then there is likely to be a greater frequency of elevated PM_{10} concentrations. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM_{10} record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of p = 0.05 or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -1.8 and p-value of 0.07) does not provide sufficient evidence that PM_{10} concentrations in Taupo have been decreasing over the period 2007 to 2013. If the same analysis is applied to the period 2001 to 2013 there is stronger evidence that PM_{10} concentrations in Taupo are decreasing as the p-value reduces to 0.003 which is less than 0.05. However, caution should be applied to interpreting a trend analysis over the period 2001 to 2013 because gravimetric sampling based on a one day in three sampling regime was used prior to 2006.

Additional analysis has also been undertaken using methodologies developed by Environet Ltd which account for the impacts of varying meteorology in Taupo (Wilton, 2013b). Meteorological conditions conducive to high pollution in Taupo include days which have both low windspeeds and low temperatures over a specific period of the day, namely:

- Days with more than 16 hours when the hourly average wind speed was less than 1 metres per second; and
- Days where the average temperature between 5 pm to midnight is less than 7.7 degrees Celsius.

In summary, if both of these criteria are met then these are the days you would expect exceedances to occur. Figure 5.8 provides a summary of the year-to-year variation of the proportion of high pollution potential days which resulted in exceedances in Taupo. Figure 5.9 provides a summary of the year-to-year variation of the absolute number of high pollution potential days compared with the number of exceedance days.

In 2007 exceedances occurred on around 21% of days when meteorological conditions conducive to elevated PM_{10} occurred. This increased to around 28% in 2008 and 25% in 2009, then dropped significantly to around 4 to 6% from 2010 to 2012 before increasing to around 12% in 2013. This decrease in the percentage of days with exceedances on high pollution potential days since 2009 also coincides with a marked reduction in the total number of days during 2013 that resulted in exceedances (refer to Figure 5.9). This analysis indicates that there may have been a reduction in PM_{10} emissions between 2009 and 2010 in Taupo. However, the small increase observed again in 2013 indicates that this is a tentative conclusion at this stage. We would need to see percentages maintained at or below this 2013 level for at least the next two years to be confident that the trend analysis was indicating a reduction in PM_{10} emissions since 2009.

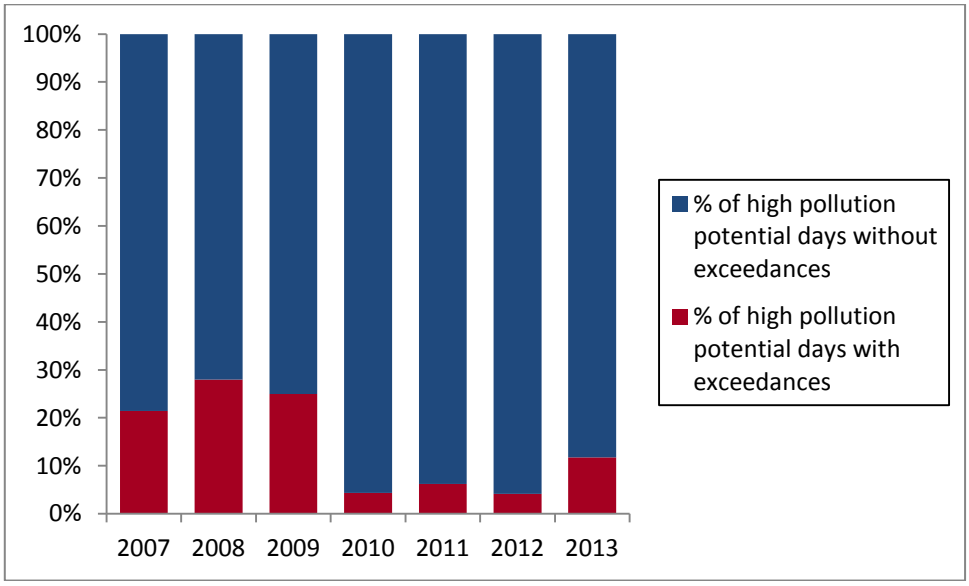

Figure 5-8: Year-to-year variation of the proportion of high potential pollution days which resulted in exceedances.

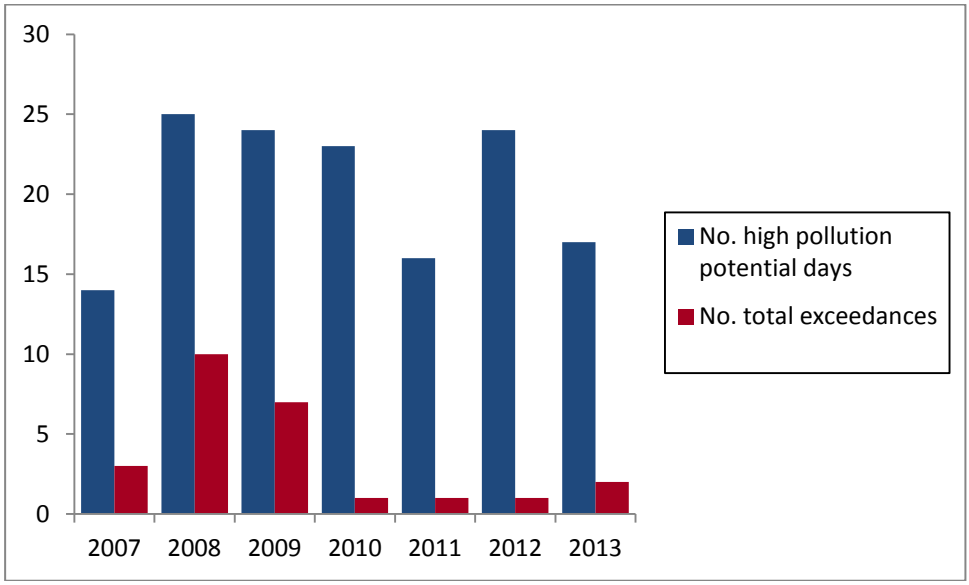

Figure 5-9: Year-to-year variation of the absolute number of high pollution potential days compared with the total number of exceedance days.

The analysis tool developed by Environet Ltd also provides the ability to minimise the impact of varying meteorology. This methodology is referred to as normalising the PM_{10} concentrations so that the influence of varying meteorology is removed. The graph of normalised PM_{10} concentrations presented in Figure 5.10 provides some evidence that PM_{10} concentrations have been decreasing since 2009. However, the results for 2013 have weakened this evidence.

Management measures to further reductions of PM_{10} by around 20% are recommended for on-going NES compliance (Wilton, 2014).

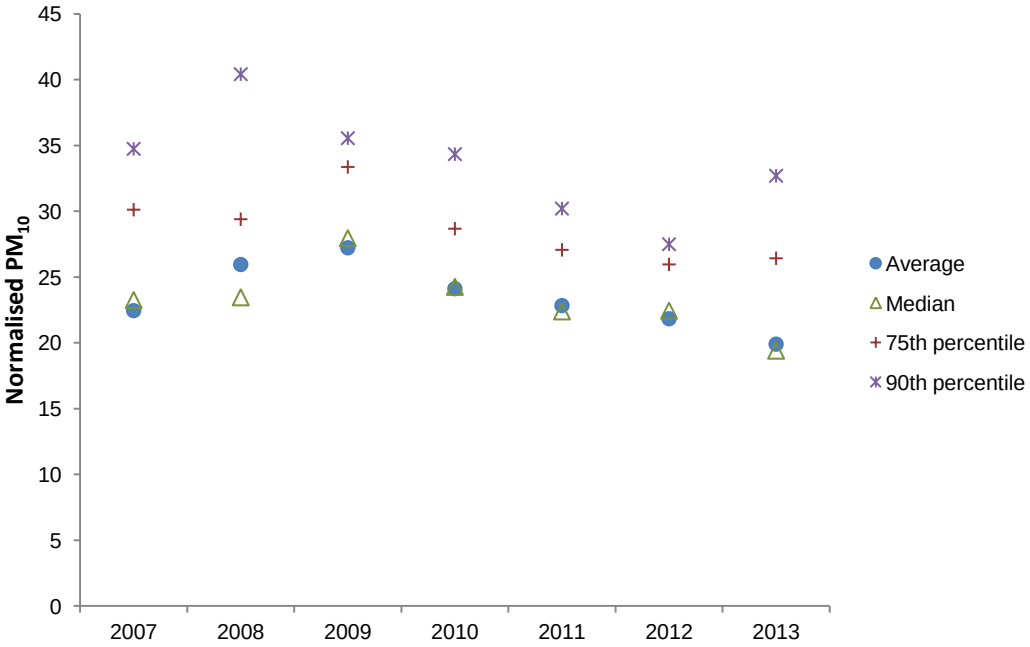

Figure 5-10: Average, 75th percentile, 90th percentile and median PM_{10} concentrations for the days when the impacts of meteorological variability have been minimised.

Based on this analysis and the current previous five year exceedance average of 2.4, it is possible that Taupo will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period. Further reductions in emissions would provide a “safeguard” against future impacts of changes in meteorology.

6 Te Kuiti

6.1 Air quality monitoring in Te Kuiti

The Te Kuiti air quality monitoring site is located at the Te Kuiti City Council Offices off Queen Street. This site has been used continuously since 2003 to monitor PM_{10} and was also used for short term monitoring in 1998 to monitor PM_{10}. Results of the 1998 monitoring are not included in this air quality monitoring report due to the short term duration of the monitoring and uncertainties surrounding the data.

Wilton, (2002) provides further descriptions of the air quality monitoring site, including a map and site layout in the *'Air Quality Monitoring Report – Waikato Region*' report. The site meets the requirements of the "Residential Neighbourhood" site classification as described in the '*Good Practice Guideline for Air Quality Monitoring and Data Management 2009'* report (MfE, 2009).

A ThermoAndersen FH62 C14 BAM is used at this site. Data are recorded at 10 minute intervals. Figure 6.1 shows the Te Kuiti Airshed and the location of the monitoring station in Te Kuiti.

Figure 6-1: Te Kuiti Airshed and air quality monitoring site.

6.2 PM_{10} concentrations in Te Kuiti

Figure 6.2 shows daily average PM_{10} concentrations measured in Te Kuiti during 2013. The maximum concentration in Te Kuiti was 47 µg/m^3 (24-hour average) recorded on 2 July. No exceedances of 50 µg/m^3 were recorded during 2013. This compares with one exceedance (61 µg/m^3) recorded during 2012 and one exceedance (51 µg/m^3) in 2011. Prior to this, the number of exceedances ranged between three to four per year.

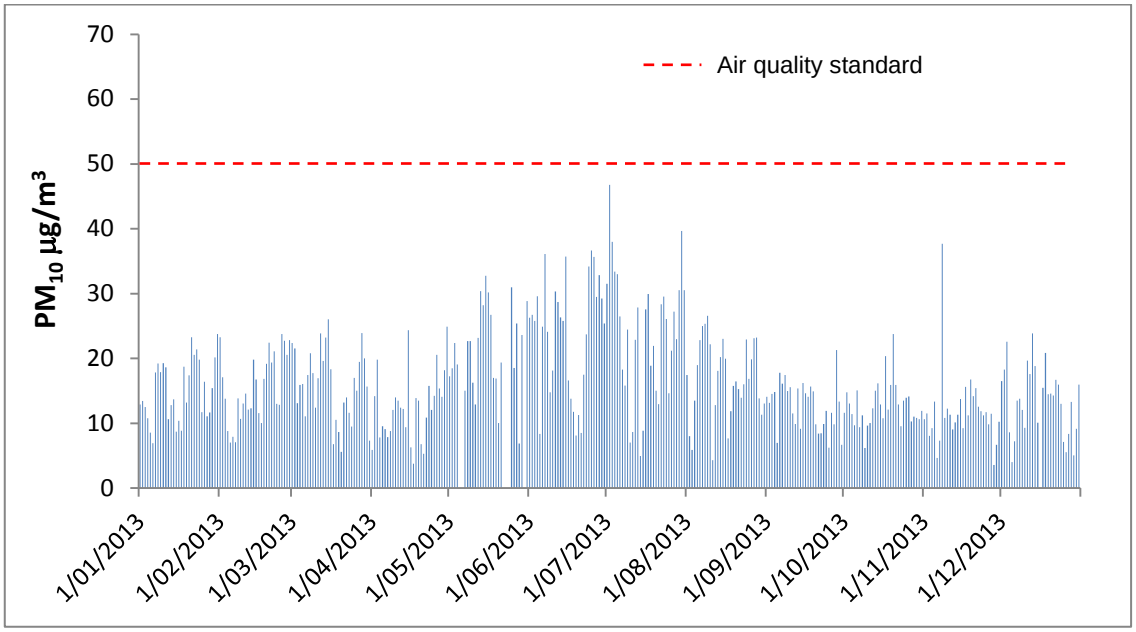

Figure 6-2: Daily winter PM_{10} concentrations measured at the Te Kuiti site during 2013.

A comparison of PM_{10} concentrations to air quality indicator categories from 2003 to 2013 in Te Kuiti is shown in Figure 6.3 and the seasonal variations in the distribution of PM_{10} concentrations for 2013 are shown in Figure 6.4.

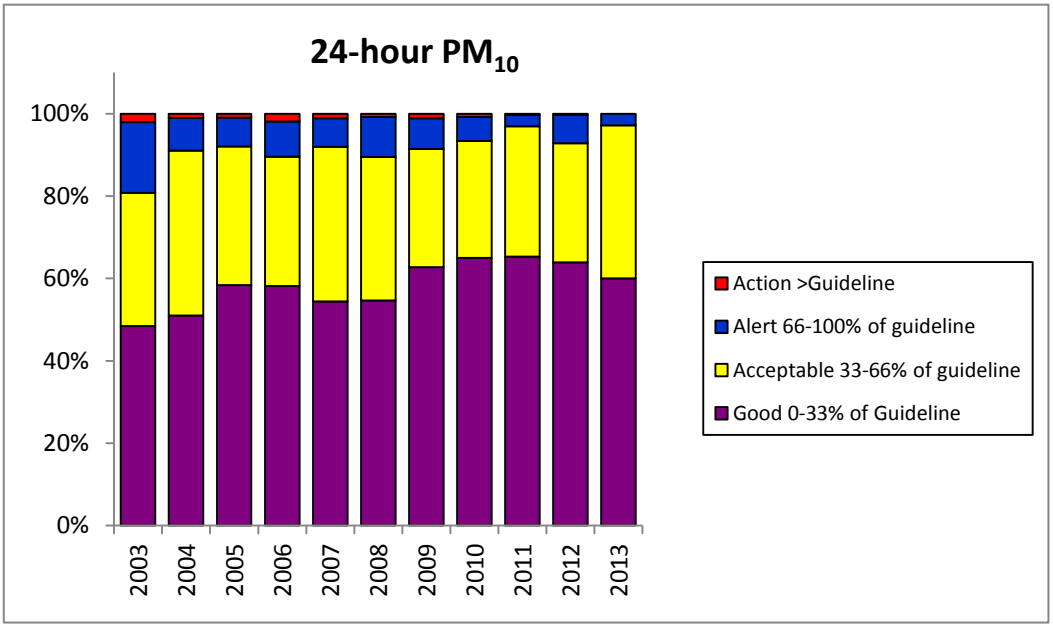

Figure 6-3: Comparison of PM_{10} concentrations measured at the Te Kuiti site from 2003 to 2013 to air quality indicator categories.

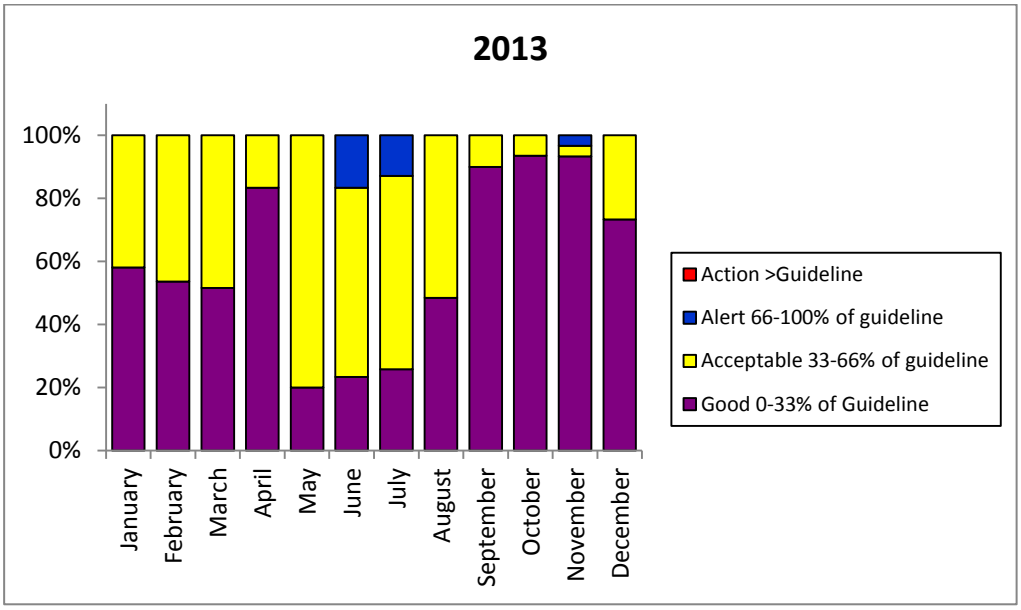

Figure 6-4: Comparison of daily PM_{10} concentrations each month during 2013 to air quality indicator categories.

Figure 6.5 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 99.7 percentile concentration from 2006 to 2013. The trend line slope for exceedances per year is negative with an R^2 value of 0.86. The trend line slope for 99.7 percentile concentrations per year is also negative with an R^2 value of 0.74. These indicators suggest that air quality has improved over the period 2006 to 2013. This is further supported by the trend analysis presented in Section 6.4 of this report.

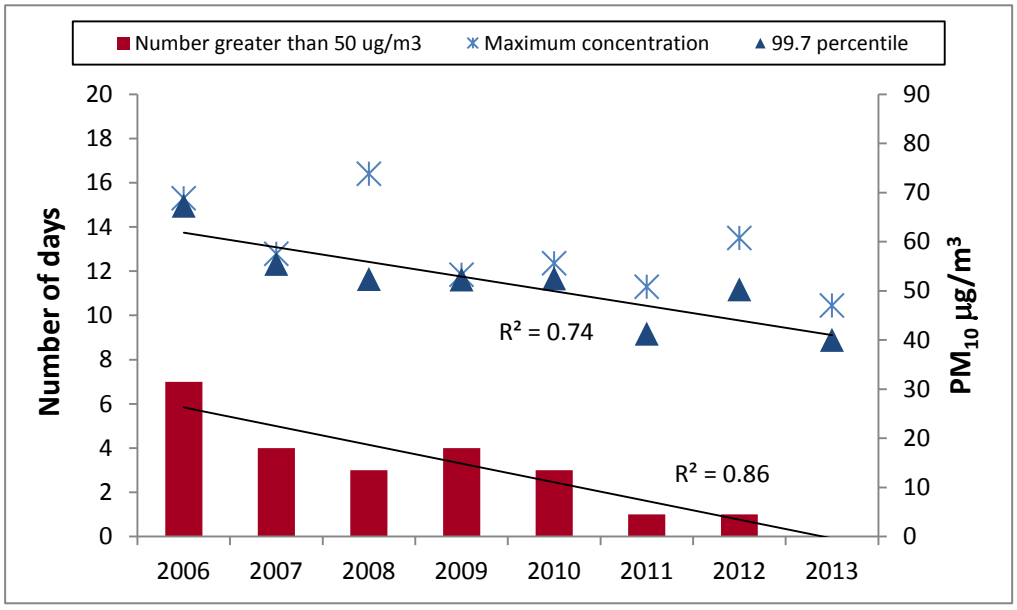

Figure 6-5: Number of days when 50 µg/m^3 was exceeded compared with the maximum concentration and the 99.7 percentile concentration measured from 2006 to 2013.

Summary statistics for PM_{10} monitoring data from the Te Kuiti site from 2003 to 2013 are shown in Table 6.1. In 2013 the annual average PM_{10} concentration in Te Kuiti was

16 µg/m^3 which is consistent with the last three years and lower than the previous annual average of around 18 µg/m^3 for the period 2003 to 2009. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). An annual average PM_{10} concentration is not specified in the NES. The summary also shows that since 2009 a greater proportion of PM_{10} data falls within the good indicator category (0 to 33% of guideline) compared with the period prior to 2009. This provides further evidence of improvements in PM_{10} concentrations in Te Kuiti since around 2009.

Table 6-1: Summary of PM_{10} concentrations measured at the Te Kuiti monitoring site from 2003 to 2013.

Indicator	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Good 0-33% of Guideline	48%	51%	59%	58%	54%	55%	63%	65%	65%	64%	60%
Acceptable 33-66% of guideline	32%	40%	34%	31%	38%	35%	29%	28%	32%	29%	37%
Alert 66-100% of guideline	17%	8%	7%	9%	7%	9%	8%	6%	3%	7%	3%
Action >Guideline	2%	1%	1%	2%	1%	1%	1%	1%	0%	0%	0%
Percentage of valid data	63%	95%	92%	100%	99%	99%	99%	99%	100%	99%	98%
Annual average ($\mu g/m^3$)	18	18	17	18	18	18	17	16	15	16	16
Number exceedances	4	5	2	7	4	3	4	3	1	1	0
99.7 %ile concentration ($\mu g/m^3$)	56	56	52	67	55	52	52	53	41	50	40
Annual maximum ($\mu g/m^3$)	59	61	54	69	58	74	53	56	51	61	47
Number records	229	346	337	363	360	362	360	360	363	363	358

6.3 Daily variations in PM_{10} and meteorology on high pollution days

Figure 6.6 shows hourly variations in PM_{10} concentrations and meteorological variables on 2 July when the 24-hour average PM_{10} concentration reached a maximum of 47 µg/m^3. The hourly PM_{10} profile is fairly typical of an urban PM_{10} pollution event with a broad peak that is centred around 9 pm which gradually reduces down over the early hours of the morning and a smaller peak around 9 to 10 am. The wind speed and temperature are low during the period of peak PM_{10} concentration. During the middle of the day wind speed and temperature become elevated, coinciding with a decrease in PM_{10} concentrations.

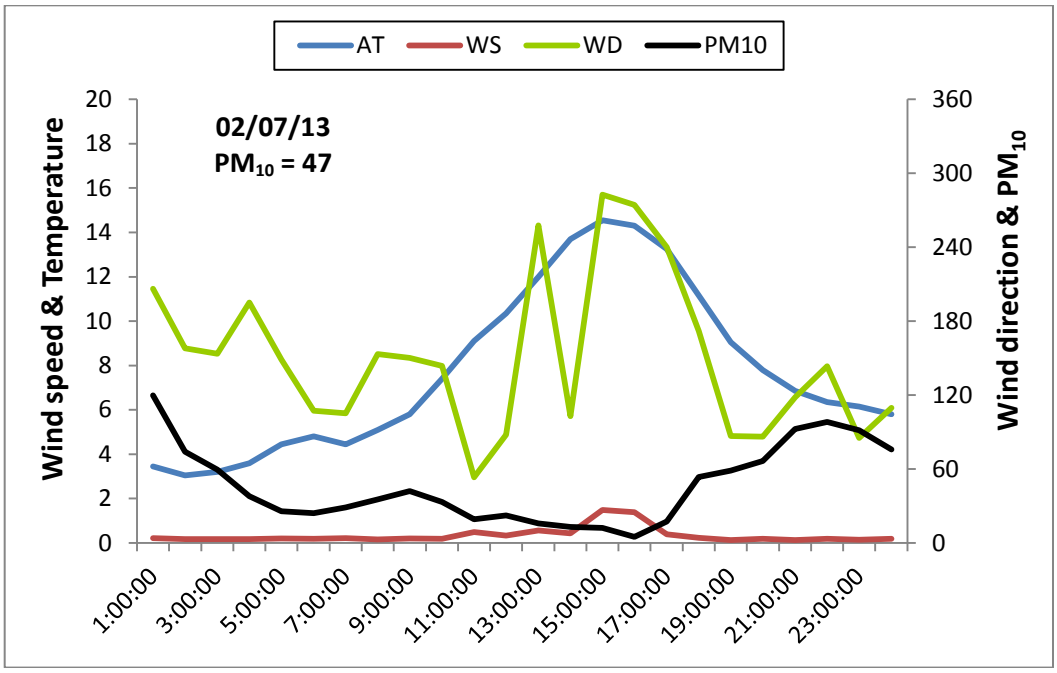

Figure 6-6: Hourly average PM_{10}, wind speed, wind direction, and temperature on 2 July when the highest 24-hour average PM_{10} concentration of 47 µg/m^3 was recorded at Te Kuiti.

6.4 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM_{10} in any given airshed vary from winter to winter depending on meteorological conditions and human responses. Over the short term inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM_{10} record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of p = 0.05 or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -3.02 and p-value of 0.002) provides strong evidence that PM_{10} concentrations in Te Kuiti have been decreasing over the period 2003 to 2013.

Based on this analysis and the current previous five year exceedance average of 1.8, it is likely that Te Kuiti will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period.

7 Putaruru

7.1 Air quality monitoring in Putaruru

Putaruru is located 65 kilometres southeast of Hamilton and is close to Lake Arapuni on the Waikato River. It is situated mid way between Tokoroa and Tirau on State Highway One, in the South Waikato District and has a population of around 3000. Putaruru occupies a flat to gently undulating site, and to the east the land rises to the Mamaku Range.

A monitoring site was established at the Bowling Club on Arapuni Street in Putaruru, in July 2006 (refer to Figure 7.1). The map reference for the site is NZMS260 T15:533-457. Daily concentrations of PM_{10} have been measured since the site was established. Data is adjusted for gravimetric equivalency.

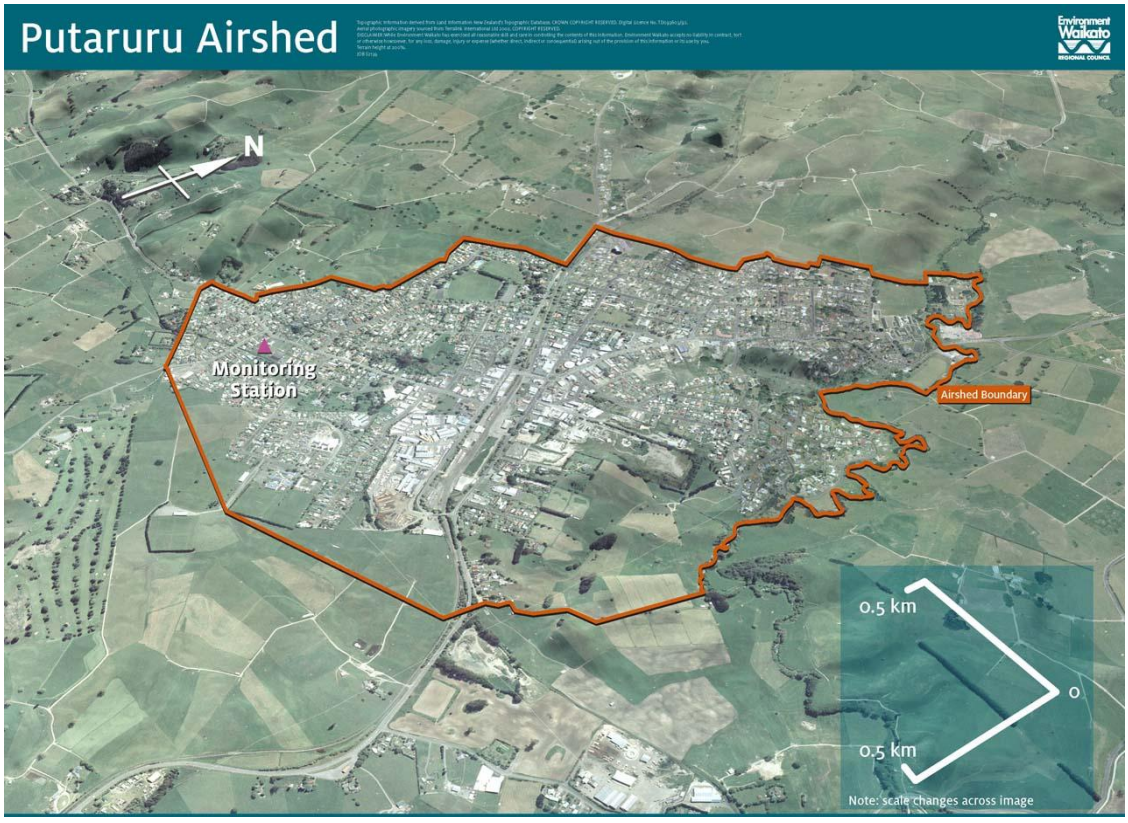

Figure 7-1: Putaruru Airshed and air quality monitoring site.

A ThermoAndersen FH62 C14 BAM is used at this site. Data is recorded at ten minute intervals (refer to Figure 7.2).

Figure 7-2: Putaruru air quality monitor.

7.2 PM_{10} concentrations in Putaruru

There were no exceedances of 50 µg/m^3 (24-hour average) measured in Putaruru during 2013. A maximum 24 hour average concentration of 46 µg/m^3 was measured on 11 June. This compares with a maximum 24 hour average concentration of 38 µg/m^3 during 2012. Daily average PM_{10} concentrations measured at Putaruru during 2013 are shown in Figure 7.3.

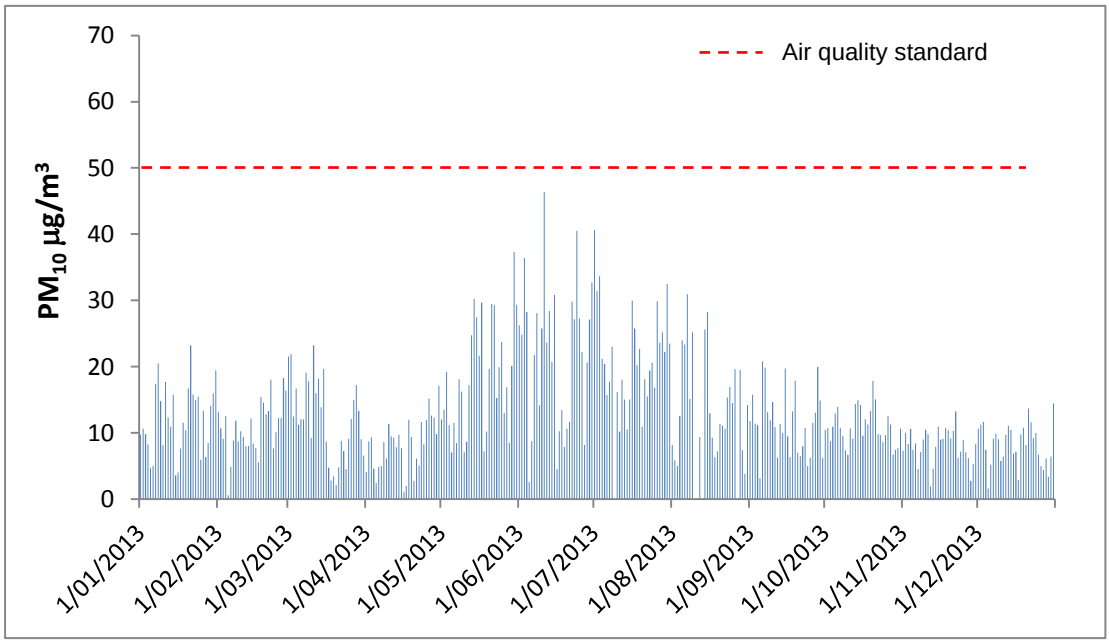

Figure 7-3: Daily winter PM_{10} concentrations measured at the Putaruru site during 2013.

Figure 7.4 compares PM_{10} concentrations measured at Putaruru from 2006 to 2013 to the MfE (2000) air quality indicator categories.

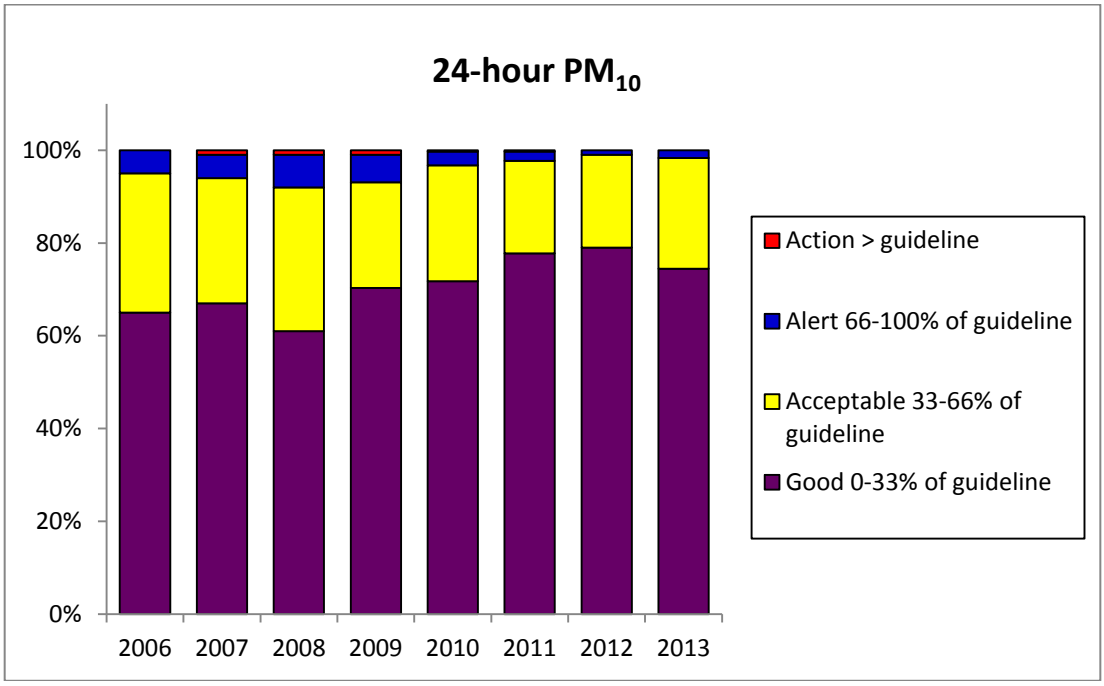

Figure 7-4: Comparison of PM_{10} concentrations measured at the Putaruru site from 2006 to 2013 to air quality indicator categories.

Figure 7.5 shows seasonal variations in the distribution of PM_{10} concentrations for 2013. Like most urban areas of New Zealand the most degraded air quality occurs during the months May to August. Despite there being no exceedances of the guideline, only 4.5% of data fell within the Good category (0-33% of the guideline) during the month of May which is an unusually low percentage for that category compared with previous years and other airsheds.

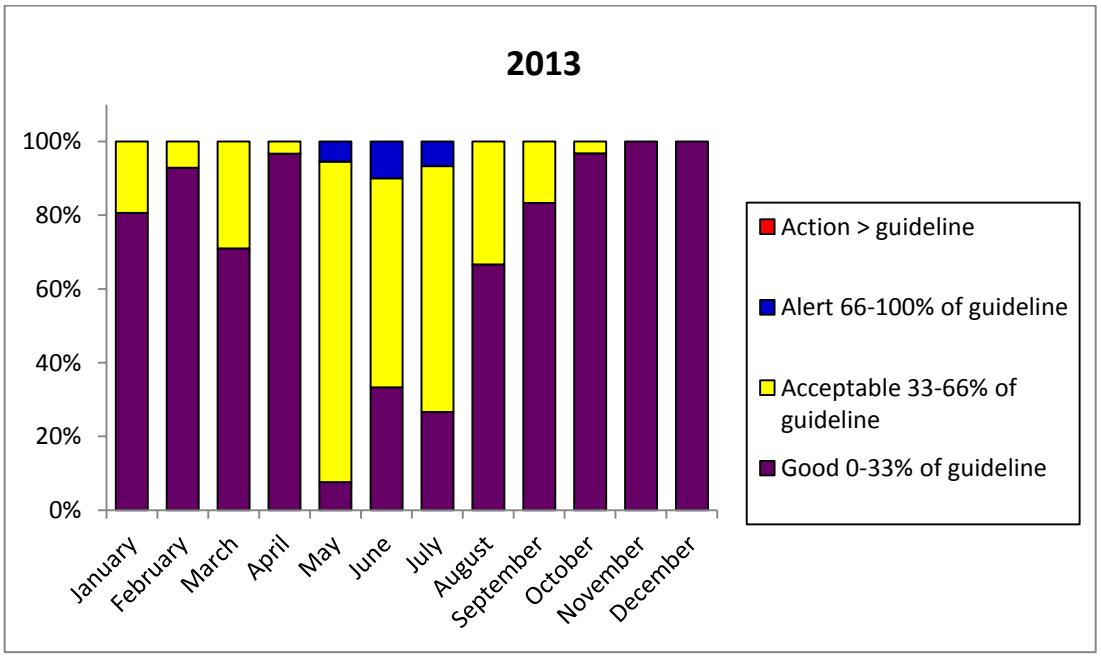

Figure 7-5: Comparison of daily PM_{10} concentrations for 2013 to air quality indicator categories.

Figure 7.6 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 99.7 percentile concentration from 2007 to 2013. The 2006 data has been excluded from the comparison as monitoring only began half way through the

winter season. A trend line analysis of the annual number of exceedances and the 99.7 percentile indicates a decrease in concentrations and this is further supported by the trend analysis presented in Section 7.3 of this report. The greatest number of exceedances and the highest PM_{10} concentrations occurred during 2008. However it is worth noting that in 2008, two of the four recorded exceedances were in summer (February) and came about as a result of dust created by roadworks during the unusual drought conditions.

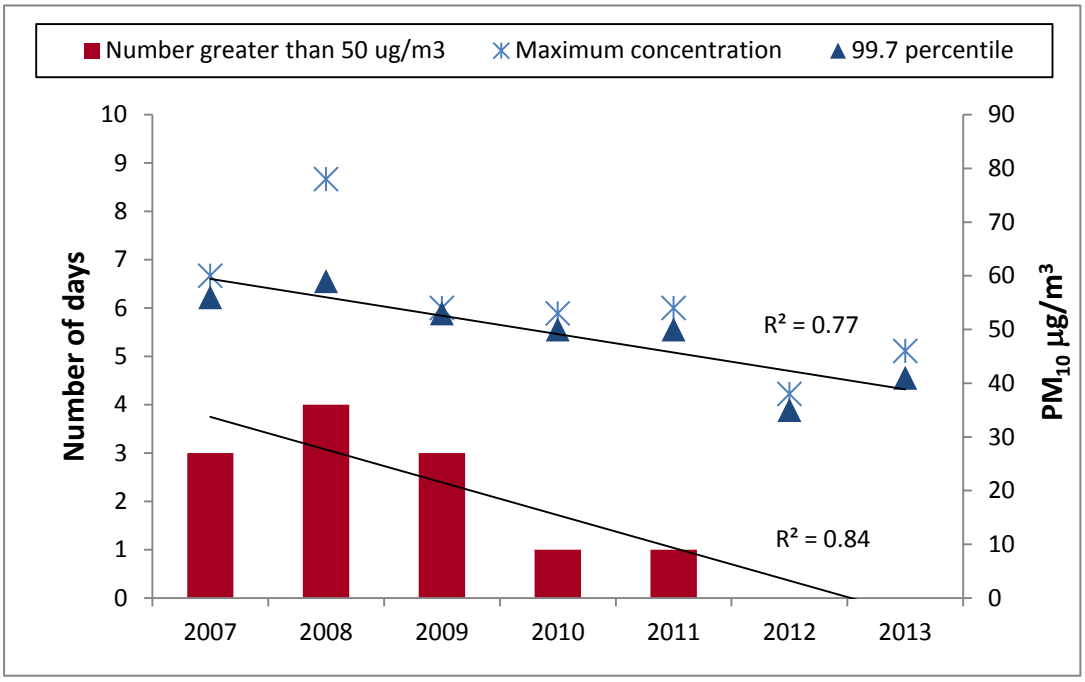

Figure 7-6: Number of days when 50 µg/m^3 was exceeded compared with the maximum concentration and the 99.7 percentile concentration measured from 2007 to 2013.

The annual average PM_{10} concentration for Putaruru for 2013 was 13 µg/m^3 which is consistent with a reduction observed in the annual average over the last three years compared with the higher annual averages observed prior to 2011. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Summary statistics for PM_{10} monitoring results are shown in Table 7.1.

Table 7-1: Summary of PM_{10} concentrations measured at the Putaruru monitoring site from 2006 to 2013.

Indicator	2006	2007	2008	2009	2010	2011	2012	2013
Good 0-33% of Guideline	65%	67%	61%	71%	72%	78%	79%	74%
Acceptable 33-66% of guideline	30%	27%	31%	23%	25%	20%	20%	24%
Alert 66-100% of guideline	5%	5%	7%	6%	3%	2%	1%	2%
Action > Guideline	0%	1%	1%	1%	0.3%	0.3%	0%	0%
Percentage of valid data	46%	100%	100%	100%	100%	95%	99%	99%
Annual average ($\mu g/m^3$)	n/a	15	17	14	14	13	12	13
Number exceedances	0	3	4	3	1	1	0	0
99.7 %ile ($\mu g/m^3$)	41	56	59	53	50	50	35	41
Annual maximum ($\mu g/m^3$)	42	60	78	54	53	54	38	46
Number records	166	365	364	364	363	346	361	360

7.3 Trend analysis

Over time, air quality may improve, get worse, or remain the same. Peak levels of PM_{10} in any given airshed vary from winter to winter depending on meteorological conditions and human responses. Over the short term this inter-annual variability will mask any genuine underlying trend toward better or worse air quality. A reasonably long monitoring record is needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) is the preferred approach for detecting underlying trends in variable environmental time-series data sets, and may suggest presence of an underlying trend which is not evident from visual inspection of the PM_{10} record or summary statistics. This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is genuine, or comes about fortuitously as a result of a random alignment of variables. The conventional threshold for deciding whether a relationship is likely to be genuine is at a probability value of $p = 0.05$ or lower, which corresponds to a 95% confidence level and greater. A negative MK-Stat indicates a decreasing trend.

Seasonal Mann Kendall test results (MK-Stat of -1.98 and p-value of 0.048) provides evidence that PM_{10} concentrations in Putaruru have been decreasing over the period 2007 to 2012.

Based on this analysis and the current previous five year exceedance average of 1.0, it is likely that Putaruru will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will be dependent on meteorological conditions i.e. a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period.

8 Turangi

8.1 Air quality monitoring in Turangi

Turangi is located on the banks of the Tongariro River near the southern end of Lake Taupo and is 50 kilometres south west of Taupo. Turangi has a population of around 3500 and is the second largest population centre in the Taupo District. It is near the edge of the Kaimanawa Ranges.

A monitoring site was established at 16 Ohuanga Road, Turangi (refer to Figure 8.1) on 11 March 2009. Daily and hourly average PM_{10} concentrations are measured at the site using a FH 62 BAM.

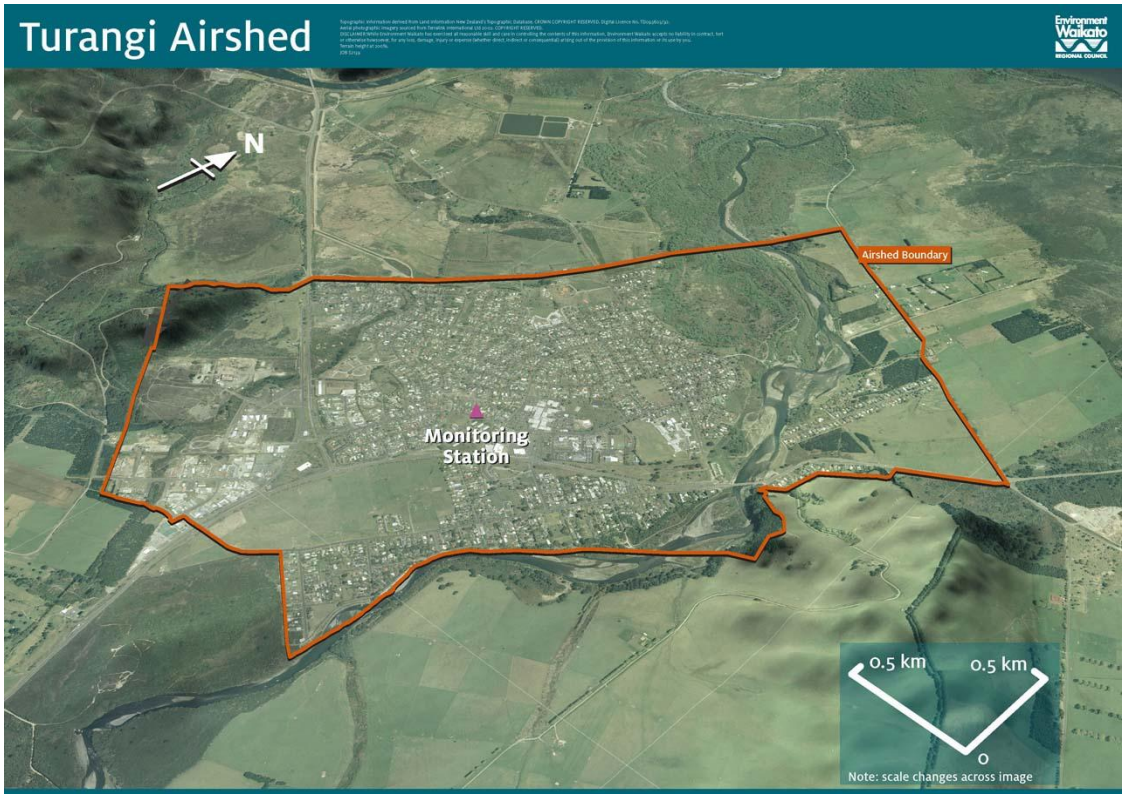

Figure 8-1: Turangi Airshed and air quality monitoring site.

8.2 PM_{10} concentrations in Turangi

The maximum PM_{10} concentration in Turangi was 33 µg m^{-3} (24-hour average) and was recorded on 13th of July. Consistent with the monitoring records for previous years since monitoring began in 2009, there have been no exceedances of 50 µg m^{3} measured at Turangi during 2013. Daily average PM_{10} concentrations measured at the Turangi site during 2013 are shown in Figure 8.2.

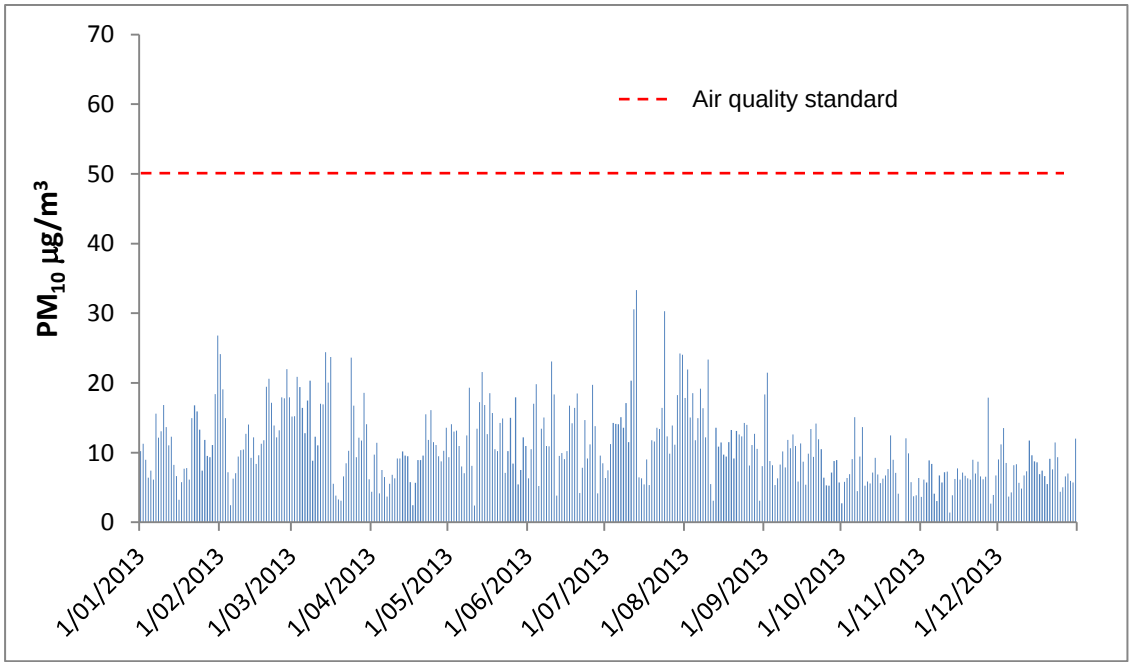

Figure 8-2: Daily average PM_{10} concentrations measured at the Turangi site for 2013.

Figure 8.3 shows concentrations of PM_{10} relative to air quality indicator categories at Turangi from 2009 to 2013. In 2013, 85% of days experienced PM_{10} concentrations

within the 'good' category. On all other days PM_{10} was within the "acceptable" category apart from 0.3% of days falling within the "alert" category.

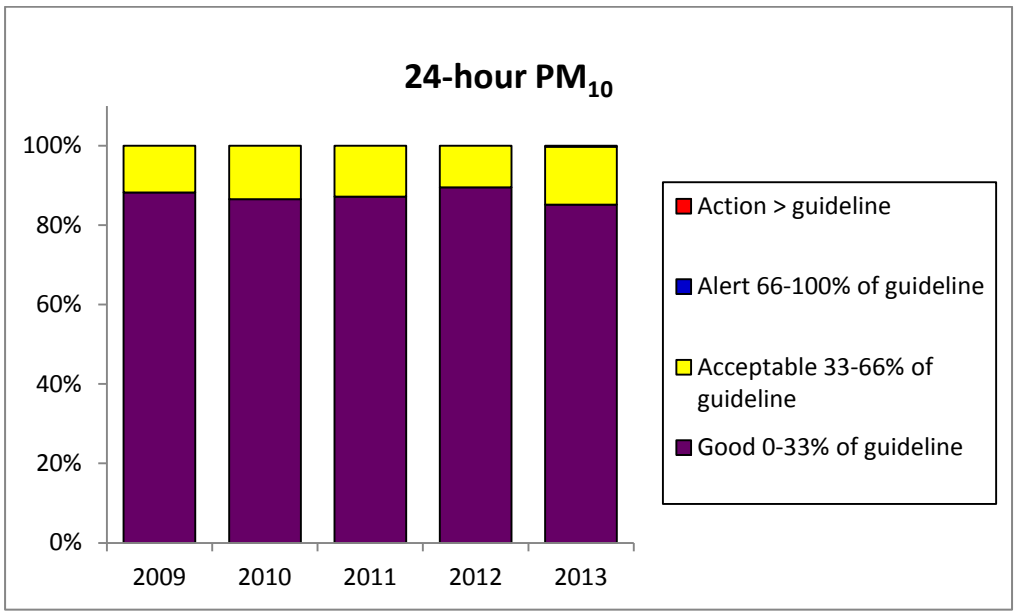

Figure 8-3: Comparison of PM_{10} concentrations measured at the Turangi site from 2009 to 2013 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations for 2013 are shown in Figure 8.4.

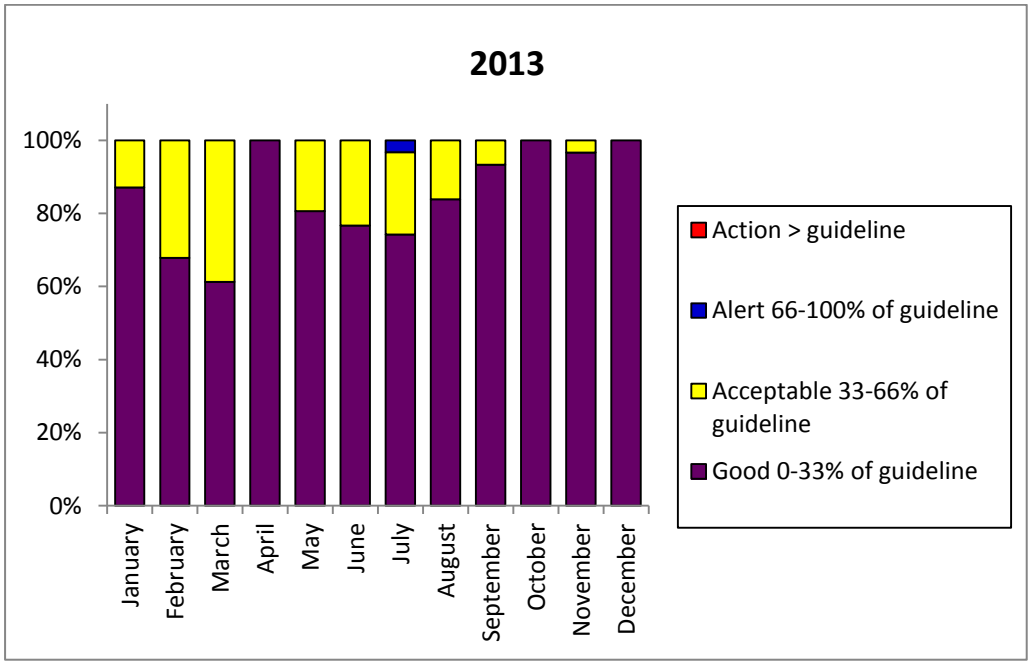

Figure 8-4: Comparison of daily PM_{10} concentrations each month for 2013 to air quality indicator categories.

Figure 8.5 shows there were no exceedances of 50 µg/m^3 from 2009 to 2013. It also shows the maximum concentration and the second highest concentration for each year which has remained consistently around 30 µg/m^3.

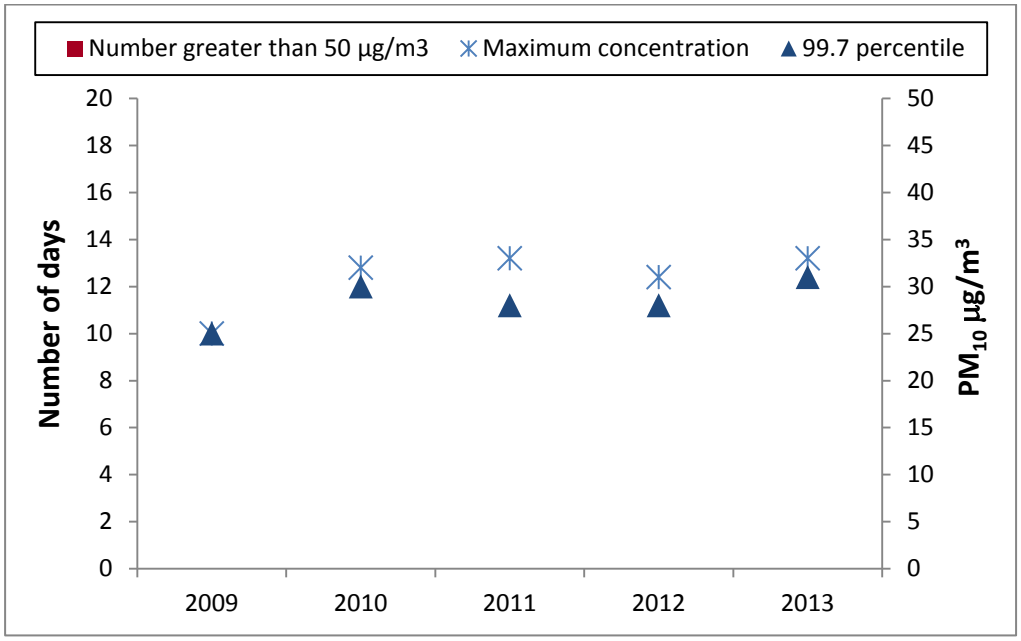

Figure 8-5: Number of days when 50 µg/m^3 was exceeded compared with the maximum concentration and the 99.7 percentile concentration measured from 2009 to 2013.

The annual average PM_{10} concentration for Turangi for 2013 is 11 µg/m^3 compared with previous annual averages of around 10 µg/m^3. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Table 8.1 shows summary statistics for PM_{10} monitoring results from 2009 to 2013.

Table 8-1: Summary of PM_{10} concentrations measured at the Turangi monitoring site from 2009 to 2013.

Indicator	2009	2010	2011	2012	2013
Good 0-33% of guideline	88%	87%	87%	90%	85%
Acceptable 33-66% of guideline	12%	13%	13%	10%	15%
Alert 66-100% of guideline	0%	0%	0%	0%	0%
Action > guideline	0%	0%	0%	0%	0%
Percentage of Valid data	79%	84%	85%	99%	100%
Annual Average (µg/m^3)	9	10	10	10	11
Measured exceedances	0	0	0	0	0
99.7 %ile concentration	25	30	28	28	31
Annual Maximum (µg/m^3)	25	32	33	31	33
Number of records	288	305	312	362	363

9 Cambridge

9.1 Air quality monitoring in Cambridge

Cambridge is located approximately 24 km southeast of Hamilton with a population of approximately 18,000.

The air quality monitoring site for Cambridge is located at Leamington Domain on Scott Street and was established in May 2013. The site meets the requirements of the "Residential Neighbourhood" site classification as described in the '*Good Practice Guideline for Air Quality Monitoring and Data Management 2009'* report (MfE, 2009).

A FH62 C14 BAM has measured PM_{10} concentrations since May 2013. Figure 9.1 shows the Cambridge Airshed and the location of the monitoring site at Scott Street in Cambridge.

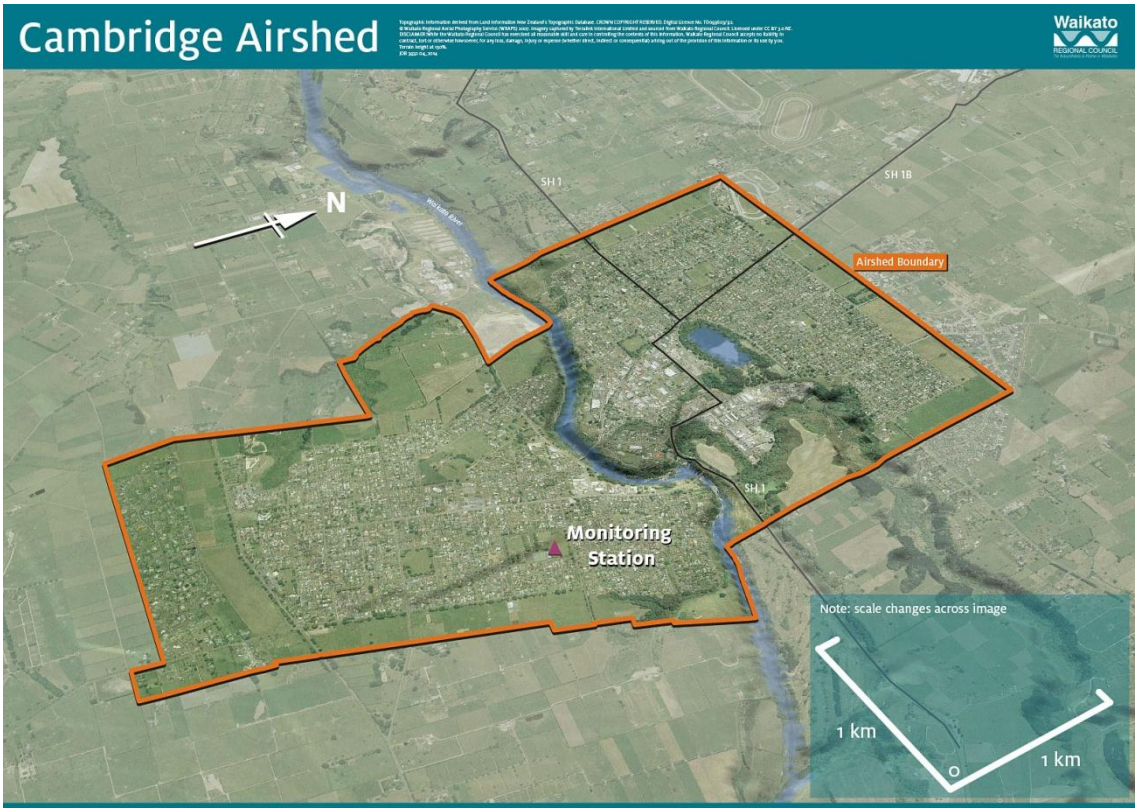

Figure 9-1: Cambridge Airshed and air quality monitoring site.

9.2 PM_{10} concentrations in Cambridge

Daily average PM_{10} concentrations measured at the Leamington Domain site during 2013 are shown in Figure 9.2. The maximum concentration in Cambridge was 28 µg/m^3 (24-hour average) recorded on 16 July. No exceedances of 50 µg/m^3 were recorded during 2013.

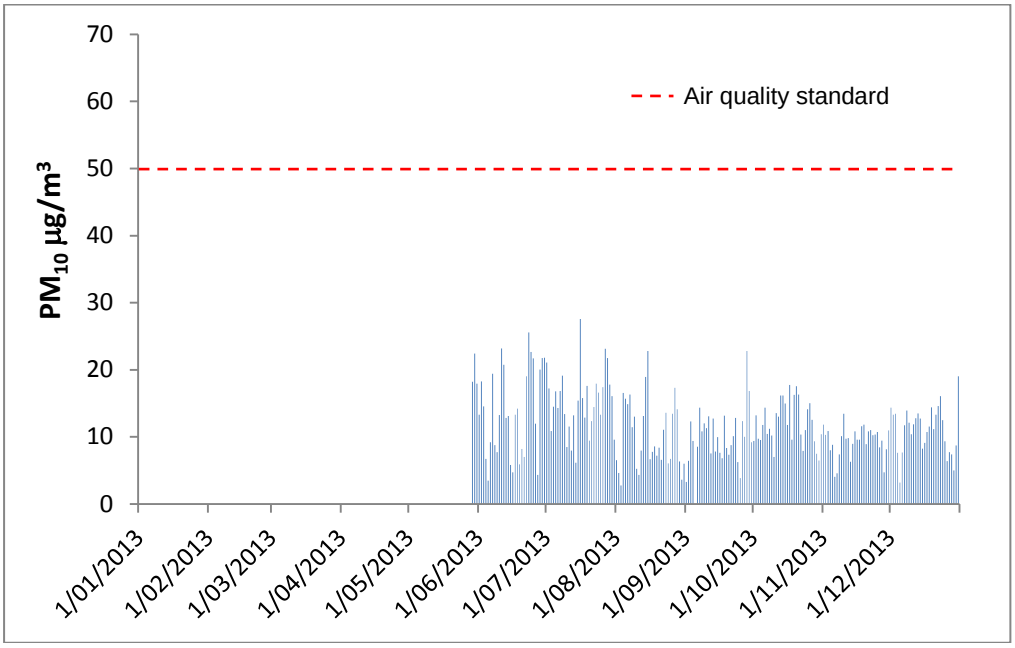

Figure 9-2: Daily winter PM_{10} concentrations measured at Cambridge during 2013.

Seasonal variations in the distribution of PM_{10} concentrations for 2013 are shown in Figure 9.3.

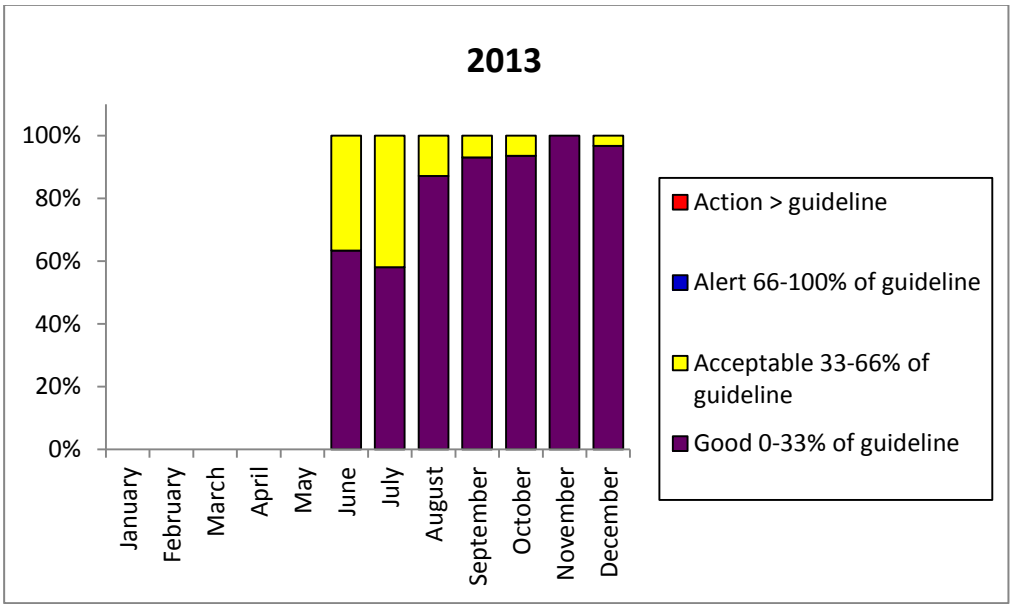

Figure 9-3: Comparison of daily PM_{10} concentrations each month during 2013 to air quality indicator categories.

The annual average PM_{10} concentration for 2013 of 12 µg/m^3 is at the low end of the range of annual averages determined for airsheds in the Waikato region. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Summary statistics for PM_{10} monitoring results for 2013 are shown in Table 9.1.

Table 9-1: Summary of PM_{10} concentrations measured at the Cambridge monitoring site during 2013.

Indicator	2013
Good 0-33% of guideline	83%
Acceptable 33-66% of guideline	17%
Alert 66-100% of guideline	0%
Action > guideline	0%
Percentage of valid data	59%
Annual average (µg/m^3)	12
Measured exceedances	0
99.7 %ile PM_{10} conc. (µg/m^3)	26
Annual maximum (µg/m^3)	28
Number of records	216

10 Te Awamutu-Kihikihi

10.1 Air quality monitoring in Te Awamutu-Kihikihi

Te Awamutu is located approximately 30 km south of Hamilton with a population of approximately 12,000. The air quality monitoring site for Te Awamutu is located at Albert Park on Albert Park Drive and was established in June 2013. The site meets the requirements of the "Residential Neighbourhood" site classification as described in the '*Good Practice Guideline for Air Quality Monitoring and Data Management 2009'* report (MfE, 2009).

A FH62 C14 BAM has measured PM_{10} concentrations since June 2013. Figure 10.1 shows the Te Awamutu-Kihikihi Airshed and the location of the monitoring site at Albert Park Drive in Te Awamutu.

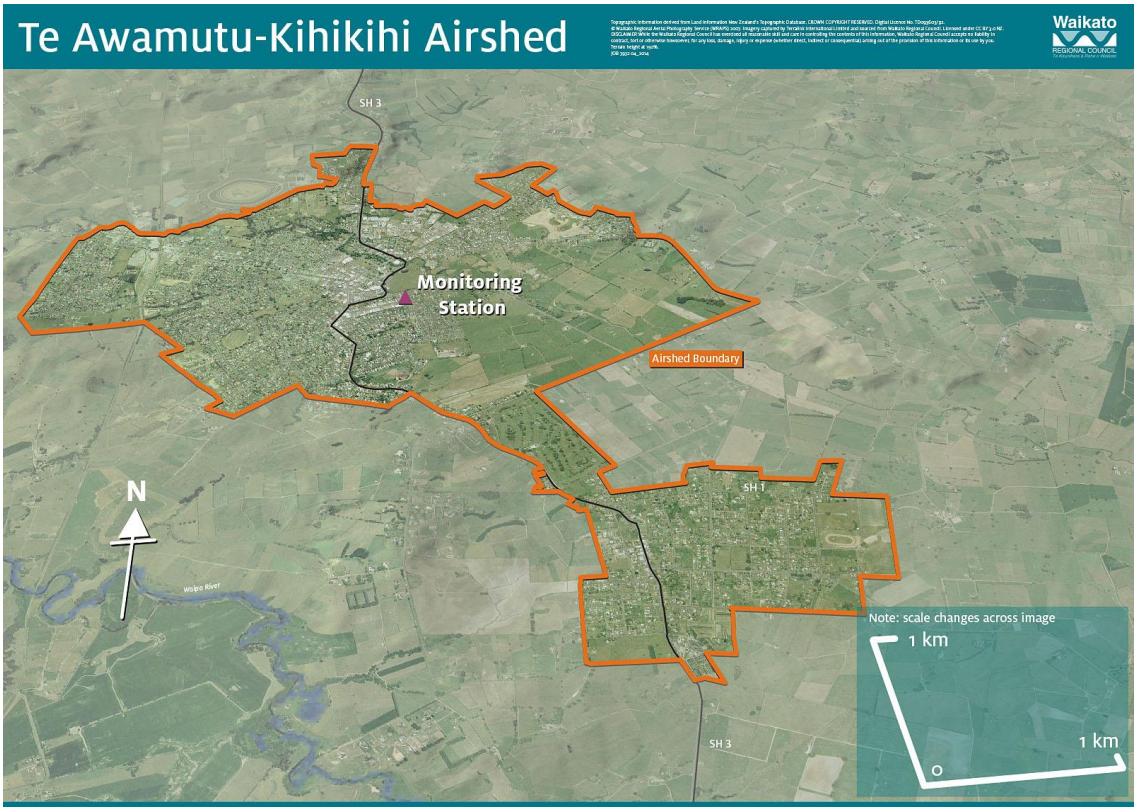

Figure 10-1: Te Awamutu-Kihikihi Airshed and air quality monitoring site.

10.2 PM_{10} concentrations in Te Awamutu-Kihikihi

Daily average PM_{10} concentrations measured at the Albert Park site during 2013 are shown in Figure 10.2. The maximum concentration in Te Awamutu was 32 µg/m^3 (24-hour average) recorded on 17 July. No exceedances of 50 µg/m^3 were recorded during 2013.

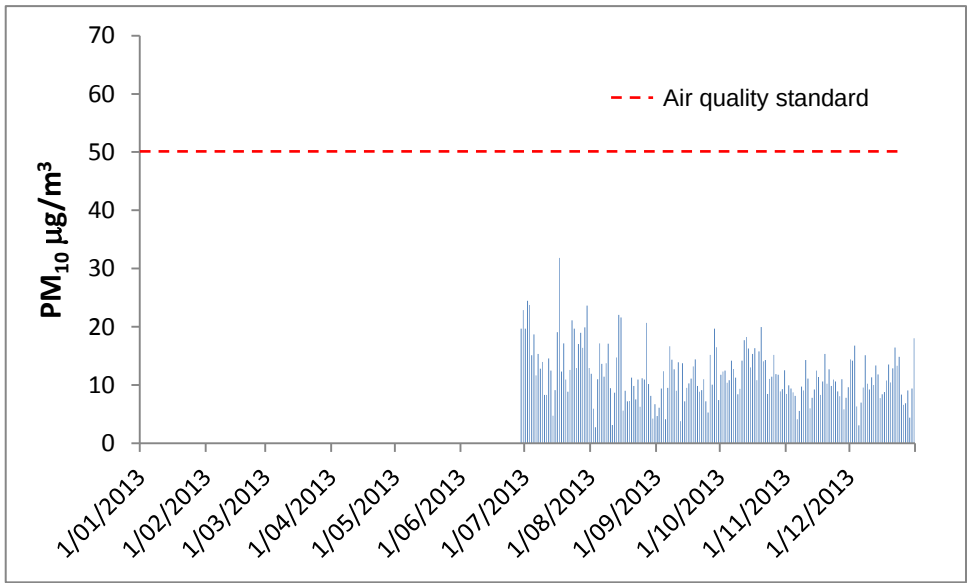

Figure 10-2: Daily winter PM_{10} concentrations measured at Te Awamutu during 2013.

Seasonal variations in the distribution of PM_{10} concentrations for 2013 are shown in Figure 10.3.

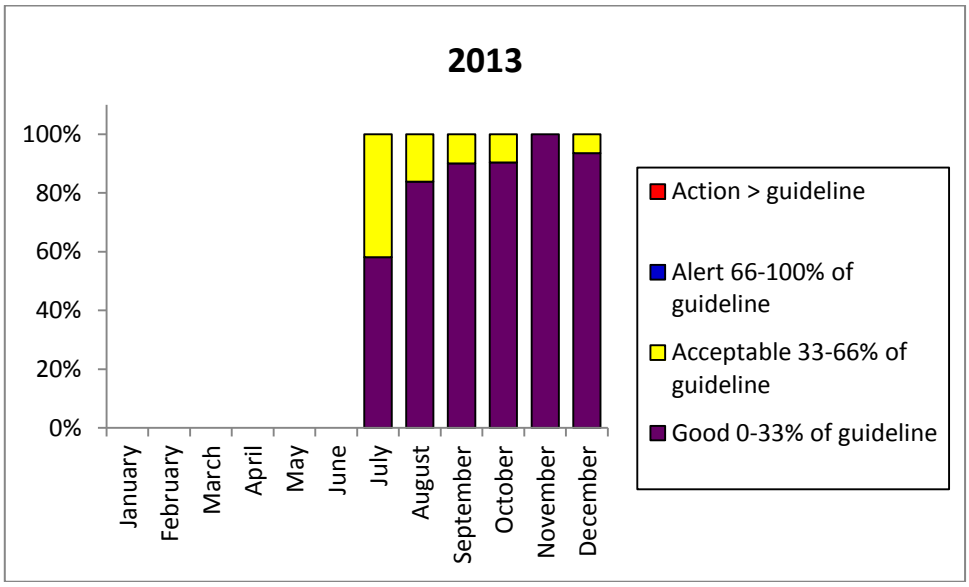

Figure 10-3: Comparison of daily PM_{10} concentrations each month during 2013 to air quality indicator categories.

The annual average PM_{10} concentration for 2013 of 12 µg/m^3 is at the low end of the range of annual averages determined for airsheds in the Waikato region. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Summary statistics for PM_{10} monitoring results for 2013 are shown in Table 10.1.

Table 10-1: Summary of PM_{10} concentrations measured at the Te Awamutu monitoring site during 2013.

Indicator	2013
Good 0-33% of guideline	85%
Acceptable 33-66% of guideline	15%
Alert 66-100% of guideline	0%
Action > guideline	0%
Percentage of valid data	51%
Annual average (µg/m^3)	12
Measured exceedances	0
99.7 %ile PM_{10} conc. (µg/m^3)	28
Annual maximum (µg/m^3)	32
Number of records	186

11 Summary

During 2013 concentrations of PM_{10} were measured at air quality monitoring sites in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge and Te Awamutu-Kihikihi. Oxides of nitrogen, carbon monoxide, benzene, toluene, xylenes and ethylbenzene were also measured in Hamilton.

More than one exceedance of 50 µg/m^3 as a 24-hour PM_{10} average within a rolling 12-month period constitutes a breach of the NESAQ. The standard for PM_{10} was breached in Tokoroa and Taupo in 2013. The eight exceedances in Hamilton were officially exempted by the Minister for the Environment and therefore did not represent a breach. There were no breaches in any of the other airsheds. There were also no exceedances of the annual average guideline of 20 µg/m^3 for PM_{10} in any of the airsheds. The maximum measured PM_{10} concentrations, number of exceedances of 50 µg/m^3 and the annual average PM_{10} concentrations in all airsheds are shown in Table 11.1.

Table 11-1: Summary of PM_{10} monitoring results for 2013.

Site	Maximum measured concentration (µg/m^3)	Measured exceedances	Number of NES breaches	Annual Average
Hamilton (Peachgrove)	135	8	0[1]	14 µg/m^3
Hamilton (Ohaupo Rd)	32	0	0	13 µg/m^3
Tokoroa	59	10	9	17 µg/m^3
Taupo	65	2	1	13 µg/m^3
Te Kuiti	47	0	0	16 µg/m^3
Putaruru	46	0	0	13 µg/m^3
Turangi	33	0	0	11 µg/m^3
Cambridge	28	0	0	12 µg/m^3
Te Awamutu-Kihikihi	32	0	0	12 µg/m^3

1. These exceedances were exempted by Ministry for the Environment.

Refer to Table 11.2 for a summary of trend and five year exceedance average for the four polluted airsheds and Hamilton airshed, which has had exceedances in the past and therefore has the potential to be classified as polluted should there be more than two exceedances within any 12 month period. A statistical analysis of seasonal PM_{10} data collected in Hamilton, Te Kuiti, Taupo and Putaruru indicates that concentrations have decreased over the previous six or more year period. However, the evidence for decreases for Taupo and Hamilton are weak based on the 2013 data and should be treated with caution. No decrease has been identified for Tokoroa. A trend analysis of Turangi, Cambridge and Te Awamutu-Kihikihi is unnecessary because there have been no exceedances and a visual assessment of the data does not indicate any potential for increasing concentrations based on data collected to date.

Table 11-2: Five year exceedance average and trend analysis for the five worst airsheds.

Airshed	Five year exceedance average (2009 to 2013)	Trend
Hamilton	0.8	Decrease[1]
Tokoroa	14.8	No change
Taupo	2.4	Decrease[1]
Te Kuiti	1.8	Decrease
Putaruru	1.0	Decrease

1. Evidence for this decrease is weak so should be treated with caution.

In Hamilton in 2013, the highest annual average concentration for benzene was measured at the Greenwood Street monitoring site and was 2.7 µg/m^3, the same

maximum and location as recorded for 2012. An improving or “levelling” trend is evident for annual average concentrations of benzene at all sites. Concentrations of toluene, xylene and ethylbenzene were also well within acceptable levels.

Both carbon monoxide and nitrogen dioxide as measured at the Ohaupo Road monitoring station were well below the NES standards for CO and NO_2. The 8-hour concentrations of CO were less than 33% of the NES and NZ and regional ambient air quality guidelines and therefore fall within the good air quality indicator category. The 1-hour concentrations of NO_2 were less than 66% of the NES and NZ and regional ambient air quality guidelines and therefore fall within the acceptable air quality indicator category

References

Fisher G, Rolfe K, Kjellstrom T, Woodward A, Hales S, Sturman A, Kingham S, Peterson J, Shrestha R, King D 2002. Health effects due to motor vehicle air pollution in New Zealand. Report to the Ministry of Transport. Wellington, Ministry of Transport.

Ministry for the Environment, 2002. Ambient air quality guidelines. Wellington, Ministry for the Environment.

Ministry for the Environment, 2004. The Resource Management (National Environmental Standards for Air Quality) Regulations 2004. Wellington, Ministry for the Environment.

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

Smith J, 2006. Air quality monitoring report 2006. Environment Waikato Technical Report 2006/52. Hamilton, Waikato Regional Council (Environment Waikato).

Smith J, Lee K 2003. Soil as a source of dust and implications for human health. Advances in Agronomy 80: 1-32.

Stevenson C, Narsey H 1999. Benzene and other toxic organics. Report prepared for the Ministry of Health. Wellington, Ministry of Health.

Wilton E, Baynes M 2008. Air quality monitoring 2007 for Hamilton, Tokoroa, Taupo,Te Kuiti, Matamata and Putaruru. Environment Waikato Technical Report 2008/11. Hamilton, Waikato Regional Council (Environment Waikato).

Wilton E, Baynes M 2009. Air quality monitoring 2008 for Hamilton, Tokoroa, Taupo,Te Kuiti, Matamata, Putaruru, Nguaruwahia, Waihi. Environment Waikato Technical Report TR 2009/04. Hamilton, Waikato Regional Council (Environment Waikato).

Wilton E, Baynes M 2010. Air quality monitoring 2009 for Hamilton, Tokoroa, Taupo,Te Kuiti, Matamata, Putaruru, Nguaruwahia, Waihi, and Turangi. Environment Waikato Report TR 2010/14. Hamilton, Waikato Regional Council (Environment Waikato).

Wilton E 2011 in press. Solid fuel replacements in Tokoroa, Taupo, Te Kuiti and Putaruru – meeting the NES for air quality. Report prepared for Waikato Regional Council, Hamilton.

Wilton E 2013a in press. Assessing trends in PM_{10} concentrations at Tokoroa. Report prepared for Waikato Regional Council, Hamilton.

Wilton E 2013b in press. Assessing trends in PM_{10} concentrations at Taupo. Report prepared for Waikato Regional Council, Hamilton.

Wilton E 2014. Personal Communication based on reassessment of Assessing trends in PM_{10} concentrations at Taupo Report using second highest concentration recorded in 2013. 14 April 2014

Appendices

The appendices to this report are the Excel spreadsheets of raw data and indicator calculations and are compiled in separate Waikato Regional Council documents which may be obtained on request from the Waikato Regional Council.

Description	Document Reference Number
Hamilton BTEX	1269117
Hamilton CO	1058703
Hamilton NOx	2899408
Hamilton (Peachgrove Rd) PM_{10}	2241995
Hamilton (Ohaupo Rd) PM_{10}	2866561
Hamilton Meteorology	1058711
Taupo PM_{10}	2289178
Taupo Normalisation	3024937
Taupo Meteorology	1218406
Tokoroa PM_{10}	2165753
Tokoroa Normalisation	2896020
Tokoroa Meteorology	1058722
Te Kuiti PM_{10}	1058720
Te Kuiti Meteorology	1058717
Cambridge PM_{10}	2824886
Te Awamutu PM_{10}	2824899
Putaruru PM_{10}	1219164
Turangi PM_{10}	1620622