Waikato Regional Council Technical Report 2016/10

Air quality monitoring report for Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge, Te Awamutu-Kihikihi and Morrinsville - 2015

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Executive summary

The main air contaminant of concern in the Waikato Region is PM_{10}, particles in the air less than 10 microns in diameter. The National Environmental Standards for Air Quality (NESAQ) has set a maximum concentration limit for PM_{10} of 50 µg/m^3 (24-hour average). 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 NESAQ splits airsheds[1] into three categories for achieving compliance depending on the average number of exceedances 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. Tokoroa falls within this category.
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. 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.

In 2015 concentrations of PM_{10} were measured in nine 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, Te Awamutu-Kihikihi and Morrinsville airsheds. Monitoring of $PM_{2.5}$ was carried out in Hamilton until April 2015 and in Tokoroa from the middle of July. Monitoring of benzene, toluene, ethylbenzene and xylenes was carried out in Hamilton during 2015.

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.

The only airshed in breach of the NES for 2015 was Tokoroa. Ten exceedences of 50 µg/m^3 occurred during 2015 resulting in nine breaches of the NES. The maximum 24-hour average PM_{10} concentration of 69 µg/m^3 was similar to the 2014 maximum. Tokoroa is unlikely to comply with the NES target of no more than three exceedences of 50 µg/m^3 by September 2016.

In Te Kuiti PM_{10} concentrations remained below 50 µg/m^3 for the third consecutive year with the preceding two years (2011 and 2012) recording only one exceedance of 50 µg/m^3 per year. Under the NESAQ a monitoring site must record no breaches of the NES for five years before it can be considered not "polluted". However, the exceedance for 2012 was within 12 months of the exceedance for 2011 meaning that the 2012 exceedence constituted a breach under the NES. Current "polluted" airsheds in the Waikato Region include Tokoroa, Taupo, Te Kuiti and Putaruru (as a result of the 2014 summer pollution episodes).

In Taupo PM_{10} concentrations indicate significant improvements with no exceedances recorded during 2014 or 2015. A statistical analysis of seasonal PM_{10} data collected in Hamilton, Te Kuiti and Taupo indicates that concentrations have decreased over the previous six or more year period. No statistically significant change has been identified for Tokoroa and the previous decreasing trend identified for Putaruru is no longer significant based on inclusion of the 2014 and 2015 data. Taupo and Putaruru may comply with the 2016 target for PM_{10} specified in the

[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.

NES. However, this is likely to depend on meteorological conditions and is unlikely to be sustained long term unless further decreases in emissions occur.

In Tokoroa, $PM_{2.5}$ concentrations exceeded the World Health Organisation (WHO) guideline of 25 $\mu g/m^3$ (24-hour average) on 17 occasions from 16 July 2015. It should be noted that the monitoring period did not include May, June and two weeks of July and that more exceedences during that period are likely.

Concentrations of benzene in Hamilton were within the national guideline of 3.6 $\mu g/m^3$ at all sites and show evidence of a decreasing trend. The highest annual concentration was measured at the Greenwood Street monitoring site and was 2.3 $\mu g/m^3$. Concentrations of toluene, ethylbenzene and xylene were also well within acceptable international criteria.

1 Introduction

Air quality monitoring has been carried out in the Waikato Region since the late 1990s. The main air contaminant of concern is particles in the air which are routinely monitored as PM_{10} (particles in the air less than 10 microns in diameter) but may also be represented by different size fractions including $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter). The main source of PM_{10} is the burning of 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. The $PM_{2.5}$ size fraction is a subset of PM_{10} and is typically dominated by combustion derived particulate.

The National Environmental Standards for Air Quality (NESAQ) for New Zealand includes an ambient air quality standard for PM_{10} as well as four other contaminants. The standards specify maximum concentration limits along with averaging periods and number of allowable exceedances (Table 1.1). A breach of the standards occurs when more than the allowable number of exceedances occurs within the specified period.

The Waikato Region has identified 20 air quality management areas referred to as "airsheds" under the NESAQ[2] (Figure 1.1).

The NESAQ for PM_{10} is 50 micrograms per cubic metre of air (50 $\mu g/m^3$, 24 hour average, midnight to midnight) with one allowable exceedance per 12 month period. If a breach occurs the airshed is classified as polluted until such time as it has been breach free for five years.

In the Waikato Region, Tokoroa, Te Kuiti, Putaruru, andTaupo have been classified as polluted airsheds. The main source of PM_{10} concentrations in these areas during the winter months is solid fuel burning for domestic home heating.

In 2015, air quality monitoring for PM_{10} was carried out in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge, Morrinsville and Te Awamutu-Kihikihi. In Hamilton and Tokoroa additional monitoring was carried out for $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter) with monitoring in Hamilton occurring from January to April and in Tokoroa from July to December. Monitoring of benzene, ethyl benzene, toluene and xylenes has been carried out in Hamilton since 2003.

Prior to April 2013, monitoring of PM_{10} has also taken place in Matamata, Ngaruawahia and Waihi[3]. Monitoring of PM_{10}, sulphur dioxide and oxides of nitrogen was also carried out at two locations within Huntly airshed in 2014 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.

Under the NESAQ specifications, Tokoroa has to meet an interim target of no more than three exceedances of 50 $\mu g/m^3$ for PM_{10} by September 2016 and the NES requirement of no more than one exceedence by September 2020. Taupo, Te Kuiti and Putaruru must achieve no more than one exceedance by September 2016. Ongoing compliance with the NESAQ for PM_{10} is required for all other airsheds in the Waikato region.

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.

[2] 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.

[3] 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.

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	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[a]
Nitrogen dioxide	200 µg m^{-3}	1-hour	9
Sulphur dioxide	350 µg m^{-3}	1-hour	9
Sulphur dioxide	570 µg m^{-3}	1-hour	0
Ozone	150 µg m^{-3}	1-hour	0

[a]Note that polluted airsheds with 10 or more exceedances have an interim target of 3 by 2016 and 1 by 2020.

The Ministry for the Environment ambient air quality guidelines (Table 1.2) and air quality indicator categories (Table 1.3) assist in the management of air quality in New Zealand. 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 (PM10)	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 PM10)	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

[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

Indicator categories have also been used for the development of air quality objectives in Air Plans in New Zealand. The Waikato Regional Plan specifies designated policy responses that should correspond to each zone. In particular, Policy 3 of the Air Module of the Waikato Regional Plan 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) air quality.

There are no national guidelines or standards for $PM_{2.5}$ (particles in the air less than 2.5 microns in diameter). The World Health Organisation (WHO) guidelines are used in this report to provide an indication of the significance of $PM_{2.5}$ concentrations measured in Hamilton and Tokoroa (Table 1.4).

Table 1-4 World Health Organisation guidelines for $PM_{2.5}$ (2005).

Concentration	Averaging Period
25 µg m^{-3}	24-hour
10 µg m^{-3}	Annual

1.1 Reporting period

The reporting period for PM_{10} was from 1 January to 31 December 2015 (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, subsequent 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 benzene, toluene, ethylbenzene and xylenes (BTEX) was 18 December 2014 to 18 December 2015. 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

Concentrations of PM_{10} can be influenced by the monitoring method. 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 (BAM). Waikato Regional Council staff have used the results to determine site specific differences between the reference method gravimetric sampler and the BAM (or other method). Differences in the methods have varied between sites. Monitoring data have been 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 subsequent reports.

Prior to 2014, PM_{10} concentrations were monitored in Hamilton at the now decommissioned Peachgrove Road air quality monitoring site using a Tapered Elemental Oscillation Microbalance (TEOM) with a sample temperature setting of 40 degrees centigrade. Concentrations of PM_{10} measured using the TEOM were adjusted based on 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**

An additional evaluation was carried out in 2014 to confirm this analysis. A sequential partisol was co-located with the FH62 BAM. Analysis of the data indicates that the correction factor being applied is still valid with a correction being required in the order of approximately 19% at a PM_{10} concentration of 50 $\mu g/m^3$ (Caldwell 2015).

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 and Claudelands Event Centre), 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 sites, the possible need for any site-specific correction remains to be assessed.

At the Hamilton (Claudelands Event Centre), 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 (Claudelands Event Centre) 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

Air quality in Hamilton was measured at a monitoring site in Peachgrove Road (south-east Hamilton) from 1997 to 2013. The site met 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). The site was decommissioned in October 2013 because the property changed ownership.

A new site was established in April 2014, in the grounds of Claudelands Events Centre on Heaphy Terrace. This new station is currently operating as the main "residential" monitoring site for Hamilton. During 2014 and 2015, daily and hourly average PM_{10} and $PM_{2.5}$ concentrations were measured at the Claudelands site using two separate FH 62 BAMs. A second site was established adjacent to the NZ Blood Service at the Waikato Hospital on the corner of Ohaupo Road and Lorne Street in 2012. This site is traffic and industry focussed. During 2015, daily and hourly average PM_{10} concentrations were measured at the site using a FH 62 BAM.

Benzene, ethyl-benzene, toluene and xylenes (BTEX) have also been monitored at various locations of high traffic around Hamilton since 2003. The sites 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 Claudelands air quality monitoring station one site (eastern side of the Waikato River) and the Ohaupo Road monitoring station two site (western side of the Waikato River) as well as the location of the historical Peachgrove Road site (indicated by an *).

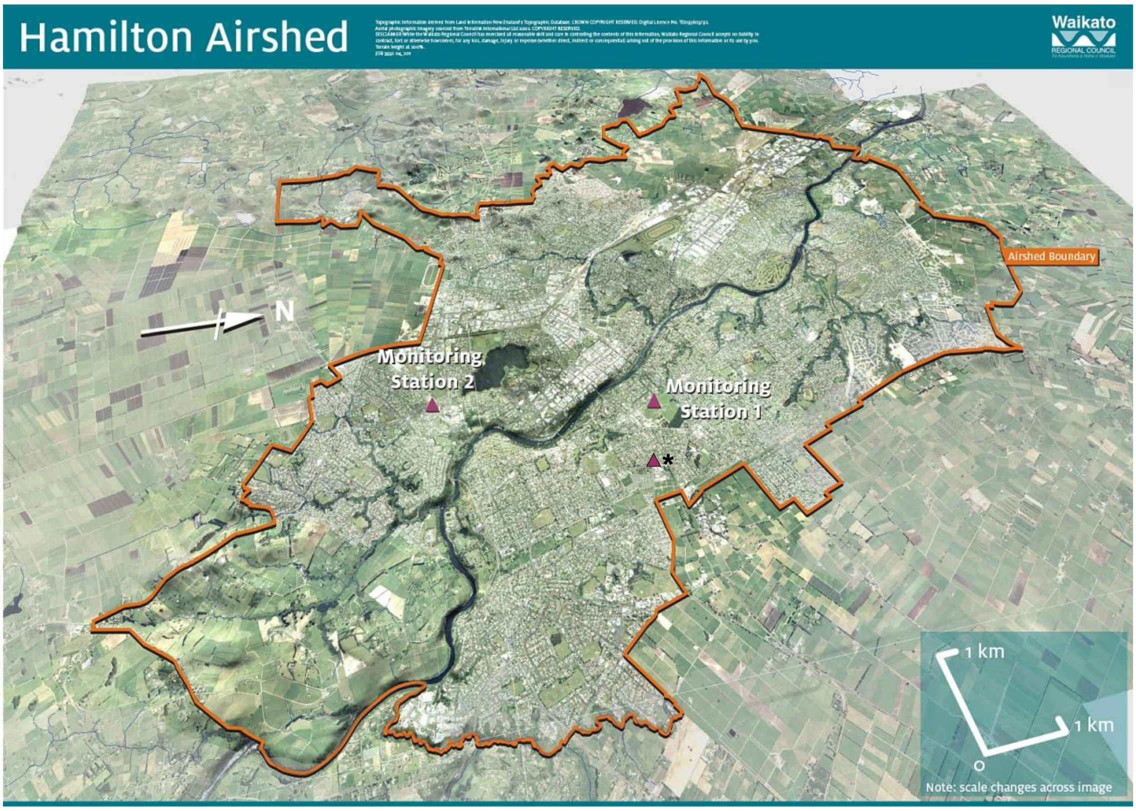

Figure 3-1: Hamilton Airshed and air quality monitoring station sites. Station 1 is located at Claudelands Events Centre grounds, and Station 2 is located at Ohaupo Rd (*Station 1 was previously located at Peachgrove Rd).

3.2 PM_{10} and $PM_{2.5}$ concentrations for Hamilton

Concentrations of PM_{10} measured in Hamilton in 2015 were all below the 50 µg/m^3 (24-hour average) threshold. The maximum PM_{10} concentrations measured were 35 µg/m^3 at the Claudelands site and 39 µg/m^3 at Ohaupo Road.

Concentrations of PM_{10} in Hamilton have not typically breached the NES since 2010. The exception is during 2013 when eight exceedances[4] of 50 µg/m^3 were measured and a maximum of 136 µg/m^3 was recorded. These breaches were atypical and occurred as a result of road works associated with the upgrading of the Peachgrove Road/Te Aroha Street/Ruakura Road intersection. Prior to this, in 2009, two exceedences of 50 µg/m^3 occurred giving rise to a breach of the NES. A further exceedance in 2009 (the previous maximum PM_{10} concentration recorded at Hamilton) with a concentration of 101 µg/m^3 coincided with a dust storm event in Australia.

During 2015 $PM_{2.5}$ concentrations were only measured in Hamilton until April 2015. Concentrations complied with the World Health Organisation (WHO) guideline of 25 µg/m^3 (24-hour average) at Claudelands over this time. However, no monitoring was carried out over the winter period. Figure 3.2 shows the relationship between PM_{10} and $PM_{2.5}$ concentrations at the Claudelands monitoring site from January to April 2015. This suggests two patterns in the relationship:

- Days when sources of PM_{10} include both coarse mode and combustion particulate.
- Days when PM_{10} is dominated by coarse mode particulate and there is almost no $PM_{2.5}$ present.

[4] 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.

The reduced major axis (RMA) regression line for the relationship (r^2 = 0.46) suggests around 43% of the PM_{10} is in the $PM_{2.5}$ fraction for days that fall close to the line.

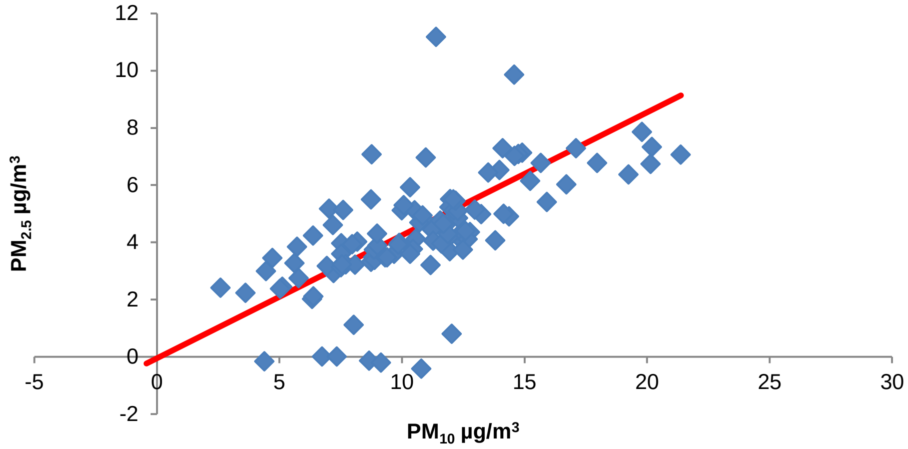

Figure 3-2: Relationship between PM_{10} and $PM_{2.5}$ concentrations measured in Hamilton in 2015

Daily PM_{10} and $PM_{2.5}$ concentrations measured at Hamilton during 2015 are shown in Figures 3.3, 3.4 and 3.5.

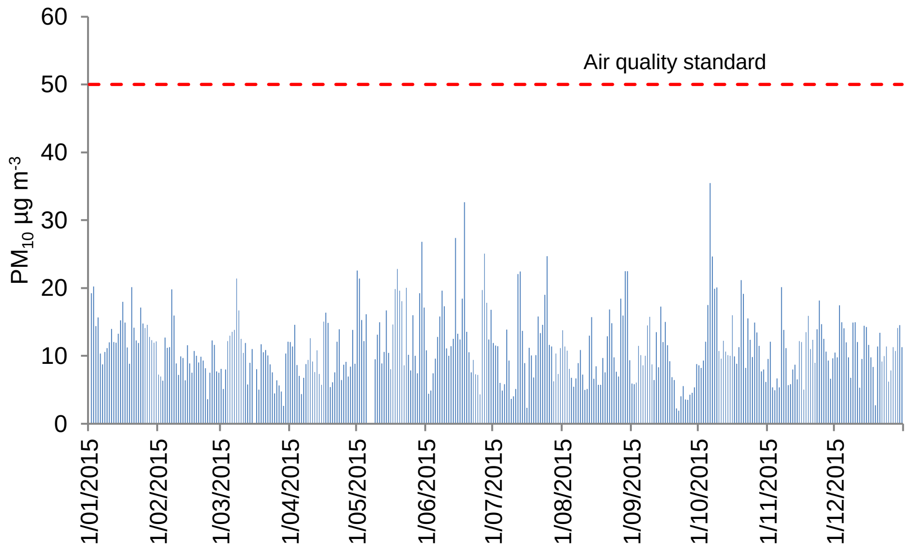

Figure 3-3: Daily average PM_{10} concentrations measured at Claudelands during 2015.

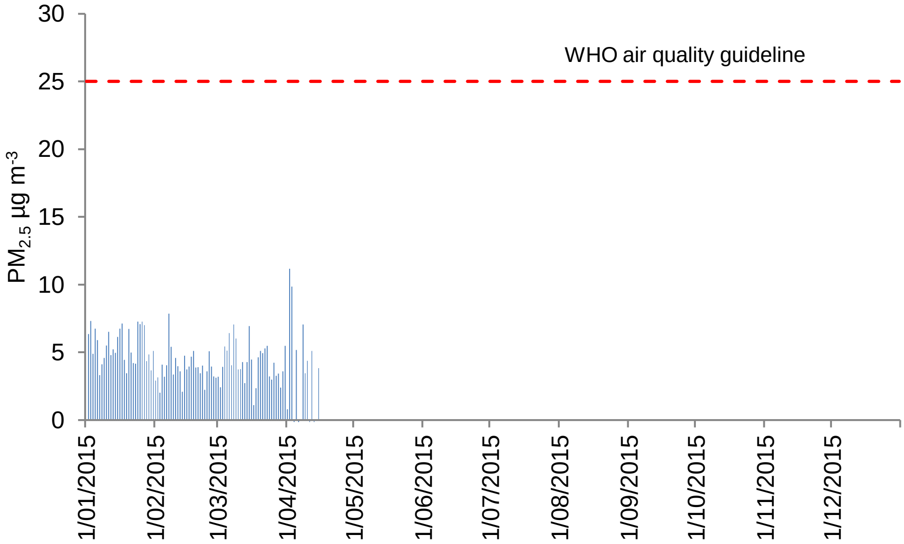

Figure 3-4: **Daily average $PM_{2.5}$ concentrations measured at Claudelands during 2015.**

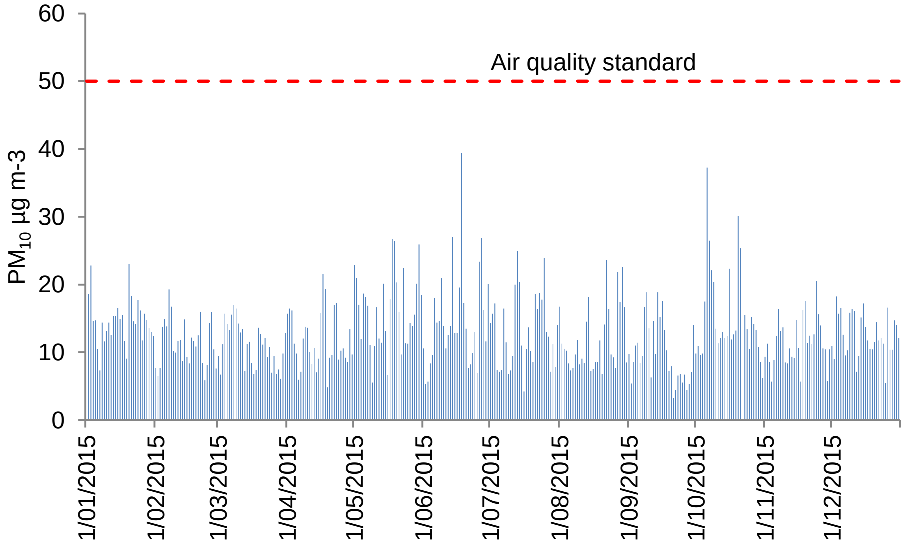

Figure 3-5: **Daily average PM_{10} concentrations measured at Ohaupo Road during 2015.**

Figure 3.5 shows year to year variability in PM_{10} concentrations (daily concentrations relative to air quality indicator categories) from 2000 to 2015, for the Peachgrove Road and Claudelands sites. Data for 2015 shows the greatest proportion of PM_{10} concentrations less than 33% of the guidelines since 2000.

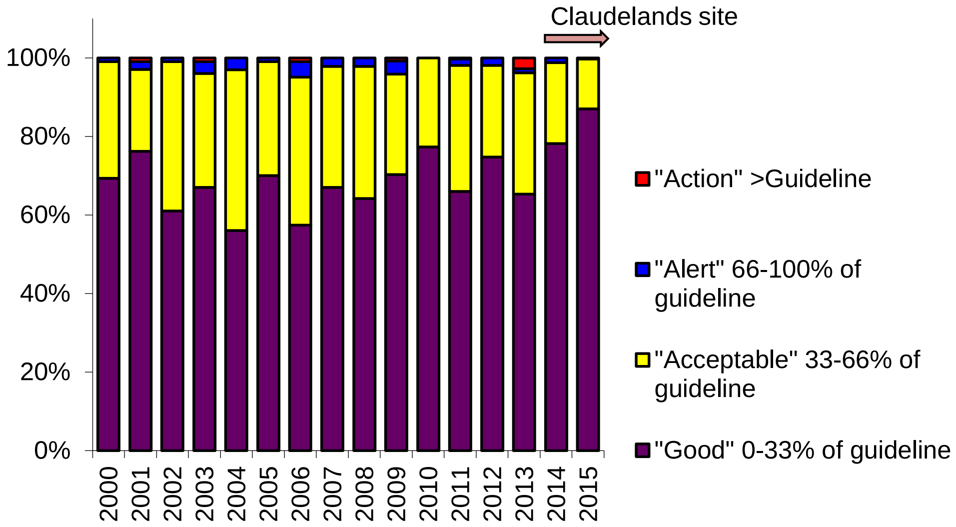

Figure 3-6 **Comparison of 24- hour average PM_{10} concentrations measured at Peachgrove Road/ Claudelands site in Hamilton from 2000 to 2015 to air quality indicator categories (annual summary).**

Figure 3.7 shows the seasonal variations in the distribution of PM_{10} concentrations during 2015 for Claudelands. An increase in the proportion of concentrations above 33% of the air quality category is observed for May and June. Highest PM_{10} concentrations were observed during October.

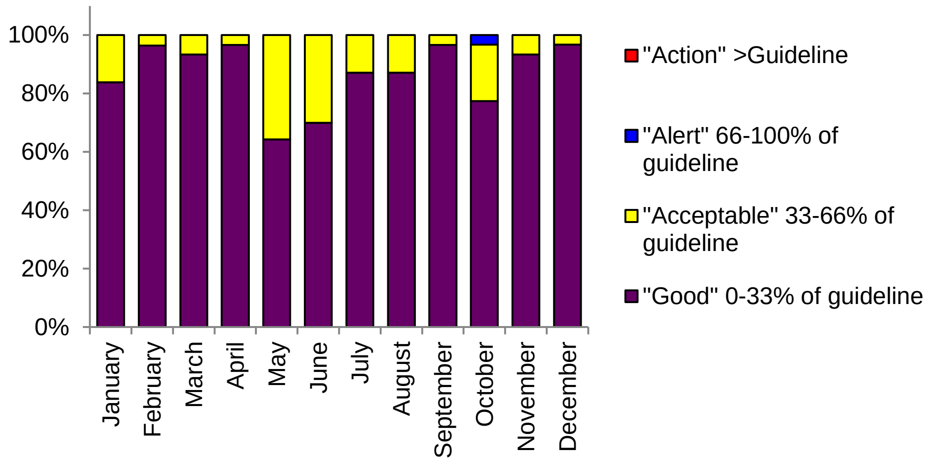

Figure 3-7: **Comparison of daily PM_{10} concentrations measured at Claudelands each month during 2015 to air quality indicator categories (monthly comparison).**

A comparison of PM_{10} concentrations at Ohaupo Road from 2012 – 2015 relative to the MfE air quality indicator categories (Table 1.2) are shown in Figure 3.8. As with previous years, the majority of the 2015 PM_{10} concentrations were less than 33% of the air quality guideline.

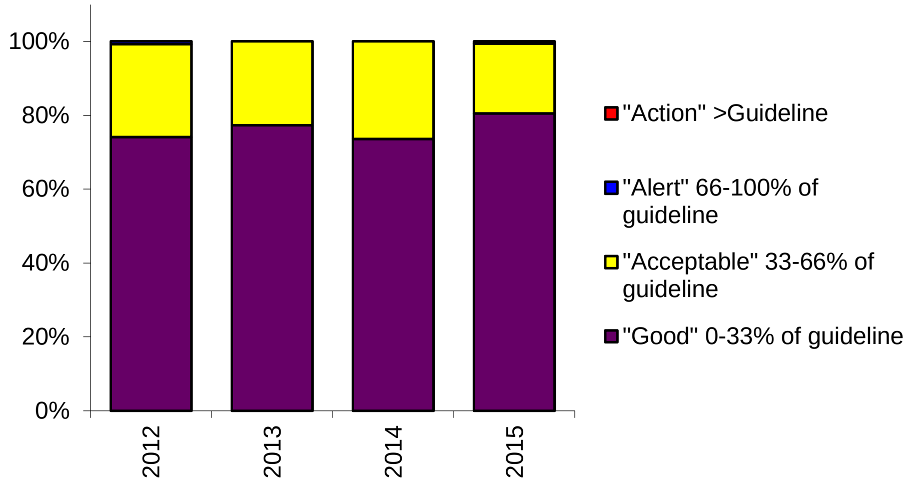

Figure 3-8: Comparison of PM_{10} concentrations measured at Ohaupo Road in Hamilton from 2012 to 2015 to air quality indicator categories (annual comparison).

Figure 3.9 shows the seasonal variations in the distribution of PM_{10} concentrations during 2015 for Ohaupo Road. There is a slight increase in the proportion of concentrations above 33% of the air quality category during the winter season (May – August) although March and October also show a reasonable proportion of concentrations in the “acceptable” category.

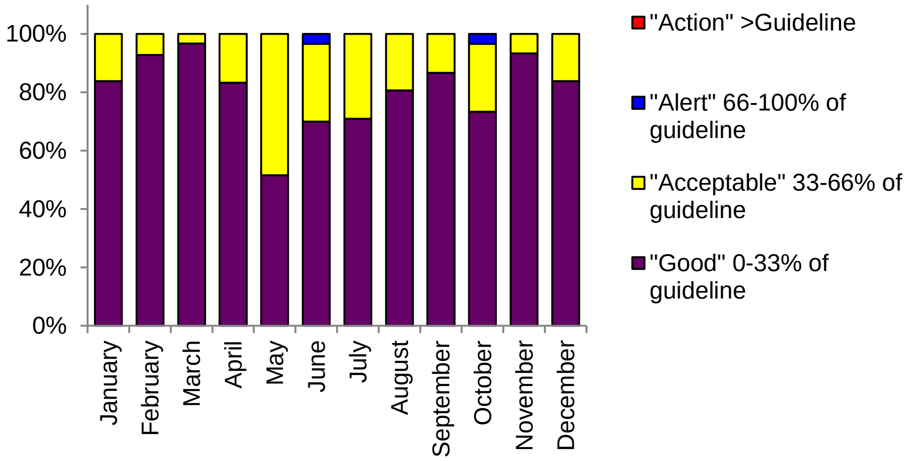

Figure 3-9: Comparison of daily PM_{10} concentrations measured at Ohaupo Road in Hamilton each month during 2015 to air quality indicator categories (monthly comparison).

A comparison of monthly average PM_{10} concentrations at Ohaupo Road and Claudelands for 2015 (Figure 3.10) indicates higher overall concentrations at the Ohaupo Road site and similar seasonal distribution.

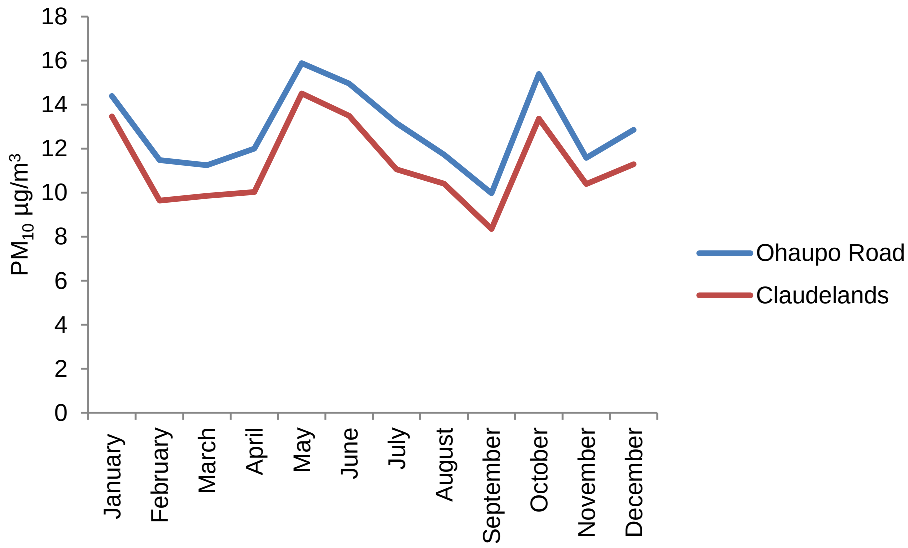

Figure 3-10: Comparison of monthly average PM_{10} concentrations measured at Claudelands and Ohaupo Road in Hamilton in 2015.

The intermittent nature of exceedances from 2006 to 2015 in Hamilton (Peachgrove Road/ Claudelands) is shown in Figure 3.11 as well as the maximum and second highest concentration per year.

Exceedences during the years 2009 and 2013 occurred as a result of atypical sources. In 2009 an elevated exceedance with a concentration of 101 µg/m³ occurred as result of the Australian dust storm. During 2013 road works associated with the upgrading of the Peachgrove Road/Te Aroha Street/Ruakura Road intersection caused eight exceedances of 50 µg/m³ including a maximum concentration of 136 µg/m³. These latter exceedences have been classified as exceptional activities under the NESAQ and therefore do not constitute a breach of the NES. Consequently, Hamilton is not classified as a "polluted" airshed under the NES.

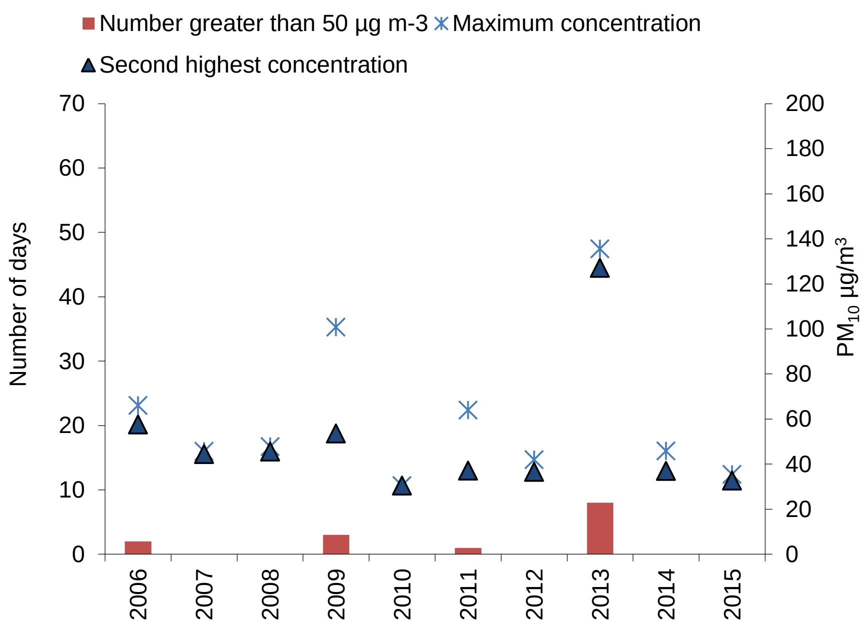

Figure 3-11: Number of days (left axis) when 50 µg/m³ was exceeded at Peachgrove Road/ Claudelands compared with the maximum concentration and the 2nd highest concentration (right axis) measured from 2006 to 2015.

The annual average PM_{10} concentrations for Ohaupo Road and Claudelands for 2015 were 13 µg/m^3 and 11 µg/m^3 respectively. 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 Ohaupo Road site for 2012 to 2015 and from the Peachgrove Road/ Claudelands site from 2002 to 2015 are shown in Table 3.2 and 3.3 respectively. Since 2007 concentrations measured at the Peachgrove Road site were adjusted for differences between the TEOM and gravimetric sampling methods as detailed in Section 2 of this report.

Table 3-1: Summary of PM_{10} concentrations measured at Ohaupo Road in Hamilton for 2012 to 2015.

Indicator	2012	2013	2014	2015
"Good" 0-33% of guideline	74%	77%	74%	80%
"Acceptable" 33-66% of guideline	25%	23%	26%	19%
"Alert" 66-100% of guideline	0.8%	0%	0%	1%
“Action” >Guideline	0%	0%	0%	0%
Percentage of valid data	73%	100%	100%	100%
Annual average (µg/m^3)	13.5	13.3	13.4	12.9
Measured exceedances	0	0	0	0
99.7 %ile PM_{10} concentration (µg/m^3)	37	30	31	37
2nd High PM_{10} concentration (µg/m^3)	35	30	31	37
Annual maximum (µg/m^3)	41	32	32	39
Number of records	266	365	364	364

Table 3-2: Summary of PM_{10} concentrations measured at Peachgrove Road/ Claudelands in Hamilton from 2002 to 2015[1].

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Monitoring Method	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	TEOM	BAM	BAM
Monitoring Site	Peach -grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Peach-grove	Claude-lands	Claude-lands
"Good" 0-33% of guideline	61%	67%	56%	70%	58%	67%	64%	70%	77%	66%	75%	65%	78%	87%
"Acceptable" 33-66% of guideline	38%	29%	41%	29%	38%	31%	34%	26%	23%	32%	23%	31%	21%	13%
"Alert" 66-100% of guideline	1%	3%	3%	1%	4%	2%	2%	3%	0%	2%	2%	1%	1%	0%
"Action" >Guideline	0%	1%	0%	0%	1%	0%	0%	0.8%	0%	0.3%	0%	3%	0%	0%
Percentage of valid data	93%	91%	94%	77%	99%	100%	100%	100%	99%	100%	100%	80%	69%	99%
Annual average (µg/m³)	16	16	17	15	17	14.7	15.3	14.4	13.1	14.4	13.4	13.7[3]	14.1[3]	11
Measured exceedances	0	4	1	0	2	0	0	3	0	1	0	8	0	0
99.7 %ile PM_{10} conc. (µg/m³)	34	54	43	34	56	44	45	53	30	37	36	128	39	32
2nd Highest PM_{10} conc. (µg/m³)	34	54	43	34	58	45	46	52	30	37	37	127	37	33
Annual maximum (µg/m³)	36	62	55	37	66	46	48	101	30	64	42	136	46	35
Number of records	340	331	344	281	363	364	364	363	361	364	364	291	252	361

1. Data from 2006 to 2013 inclusive is adjusted for gravimetric equivalency. Data from 2014 onwards is collected at the Claudelands site.
2. Note: data prior to 2002 has been excluded from table due to formatting constraints.
3. Winter average rather than annual average due to limited datasets.

3.3 Concentrations of benzene, toluene and xylenes

Monitoring of benzene has been carried out in Hamilton at the Peachgrove Road site and at a high-density traffic area at Bridge Street since 2003. An additional high density traffic site was established at the intersection of Claudelands Road and Victoria Street (Claudelands Bridge) in 2005 and in 2006 sites were established in Tristram Street, Greenwood Street and at Hamilton Intermediate School.

Benzene concentrations measured at all locations in Hamilton during 2015 were lower than the Ministry for the Environment's annual average guideline of 3.6 µg/m^3 (Table 3.4). The guideline prior to 2010 was 10 µg/m^3 (annual average).

In Hamilton, the highest annual average benzene concentrations are measured at the Greenwood Street monitoring site. In 2015 a maximum concentration of 2.3 µg/m^3 was recorded at this site and is consistent with a gradual decrease in concentrations. An improving or "levelling" trend was evident for annual average concentrations of benzene at all sites particularly between 2011 and 2013. However, data for 2014 and 2015 suggest an ongoing downward trend at most sites (Figure 3.12)

Large decreases in benzene concentrations were observed over the period 2004 to 2007. These earlier decreases were attributed to changes in fuel specifications and improved vehicle technology (Smith, 2007).

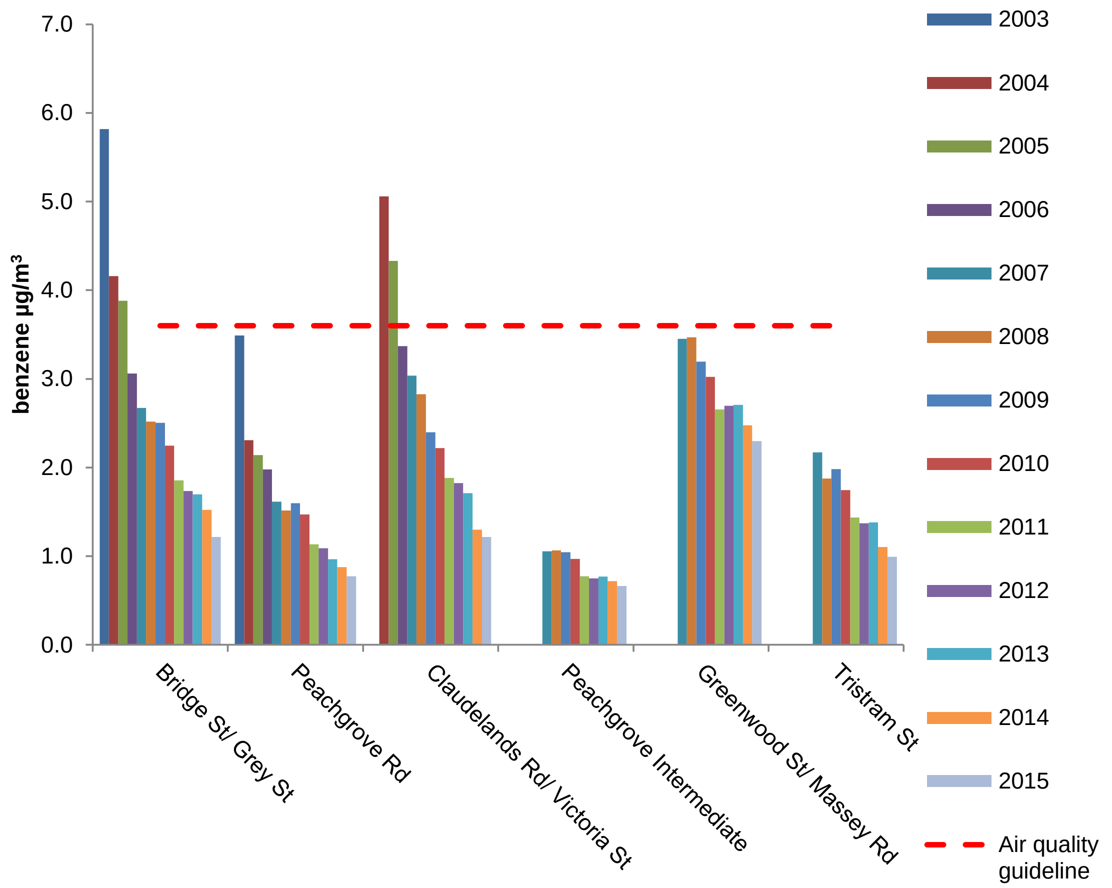

Figure 3-12: Annual average benzene measured at Hamilton sites (2004 to 2015).

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 2014 to 18 December 2015.

VOC	Bridge St	Peachgrove Rd	Claudelands Rd	Peachgrove Intermediate	Greenwood St	Tristram St	Guideline[a]
	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
Benzene	1.22	0.77	1.22	0.66	2.30	0.99	3.6
Ethyl-benzene	5.90	5.32	5.54	2.75	12.88	5.14	1000[a]
Toluene	1.01	0.69	1.02	0.58	1.56	0.91	190[a]
Total Xylenes	4.60	2.98	4.45	2.08	6.68	3.95	950[a]

[a] 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 Comparison of meteorological conditions for 2015 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.

A comparison of meteorological conditions during 2015 to previous years was not considered appropriate owing to the change in monitoring site. An evaluation of 2015 data from the new Claudelands site suggests that the location may be susceptible to higher wind speeds than the Peachgrove Road site.

3.5 Daily variations on high pollution days

Figure 3.13 shows the daily variations in PM_{10} concentrations and meteorological parameters on the three highest PM_{10} days during 2015. These were 29 May, 13 June and 17 June (PM_{10} = 27 µg/m^3, 27 µg/m^3 and 33 µg/m^3).

Concentrations of PM_{10} on the 29 May and the 17 June are typical of daily variations in concentrations in concentrations that occur in urban areas of New Zealand primarily as a result of solid fuel burning for domestic heating. The average wind speeds on these days were less than 1 m/s. In comparison on 13 June (PM_{10} = 27 µg/m^3) concentrations were slightly elevated throughout the day and the 24-hour average wind speed was 4.7 µg/m^3. The temperature was also warmer with an average 24-hour average temperature of 13 degrees compared with 7 and 6 degrees Celsius on the 29 May and 17 June respectively. It is likely that the source of PM_{10} concentrations on 13 June occurred as a result of dusts or other windblown sources.

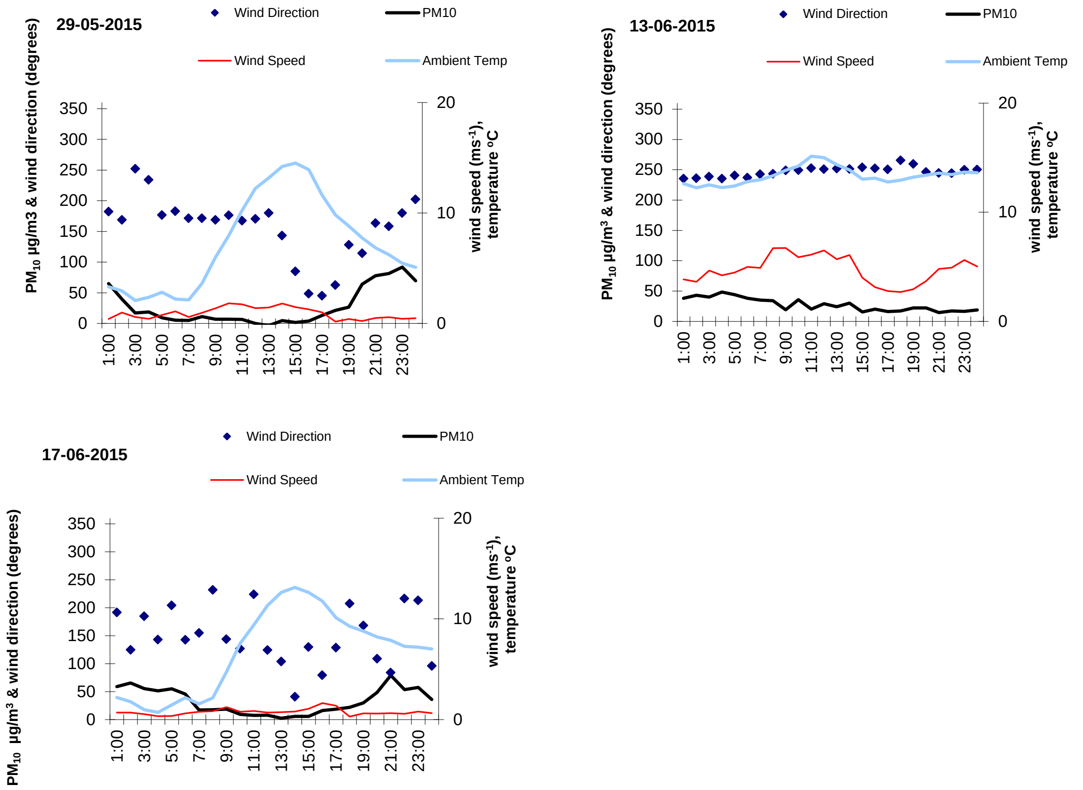

Figure 3-13: Daily variation in PM_{10} concentrations, wind speed, wind direction and temperature on 29 May, 13 June and 17 June 2015.

3.6 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 Road PM_{10} data (MK-Stat of -2.05 and p-value of 0.04) provides possible evidence that PM_{10} concentrations in Hamilton were decreasing over the period 2006 to 2013 (Caldwell 2015). The analysis has not been updated to include the Claudelands site PM_{10} data (2014 and 2015). Analsysis of trends for this site will commence once four years of PM_{10} data is available.

Data suggests that Hamilton is likely to continue to meet the NES target of no more than one exceedance per 12 month period. However, it is possible that poor meteorological conditions i.e., a particularly cold and calm winter could still result in more than one exceedance with in a 12 month period. This would result 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).

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. A shift in the baseline data noted following the installation of the new BAM is detailed in previous monitoring reports (e.g., Caldwell 2015). Given issues around the pre 2006 data, previous reporting of 2001-2005 data and the large amount of subsequent data collected this analysis includes only data from 2006.

In April 2015, the FH62 BAM was shifted (within the same site) to a new enclosure 25 metres from its previous location because of concern about potential impacts from the lime dosing process used on site by South Waikato District Council for treating drinking water at the Billah Street reservoir. In July 2015 a 5014i BAM was also installed at this new location for monitoring $PM_{2.5}$.

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

Concentrations of PM_{10} in Tokoroa exceeded 50 µg/m^3 on ten occasions during 2015 (Table 4.1). The maximum measured concentration was 69 µg/m^3 and is equivalent to the maximum concentration for 2014 when nine exceedences of 50 µg/m^3 occurred. The seasonal distribution of the exceedences and the daily average PM_{10} concentrations measured at Tokoroa during 2015 are shown in Figure 4.3.

Table 4-1: Dates and concentrations for exceedences of 50 µg/m3 in Tokoroa during 2015.

Date	PM_{10} µg/m^3	Rank	Date	PM_{10} µg/m^3	Rank
25-06-15	69	1	24-06-15	53	6
17-06-15	66	2	11-07-15	53	7
24-07-15	60	3	17-05-15	52	8
26-06-15	55	4	25-07-15	52	9
10-05-15	53	5	12-08-15	51	10

During 2015 $PM_{2.5}$ concentrations in Tokoroa exceeded the World Health Organisation (WHO) guideline of 25 µg/m^3 (24-hour average) on 17 occasions (Table 4.2). It is likely that the true number of exceedences of 25 µg/m^3 is more than double this as monitoring commenced over half way through the winter and 70% of the PM_{10} breaches occurred before $PM_{2.5}$ monitoring started. The maximum 24 hour average $PM_{2.5}$ concentration of 50 µg/m^3 was measured on 24 July. The corresponding PM_{10} concentration was 60 µg/m^3 indicating that more than 80% of the PM_{10} was in the $PM_{2.5}$ size fraction.

Table 4-2: Comparison of PM_{10} and $PM_{2.5}$ on days when 24-hour average $PM_{2.5}$ exceeded 25 µg/m3 (24-hour average)

Date	PM_{10} concentration (?g/m^3)	$PM_{2.5}$ concentration (?g/m^3)
24-07-15	60	50
25-07-15	52	43
12-08-15	51	40
31-07-15	46	39
23-07-15	45	39
22-07-15	44	38
13-08-15	39	33
21-08-15	35	33
28-08-15	38	32
20-07-15		32
21-07-15	37	29
30-07-15	35	29
26-07-15	32	27
20-08-15	31	27
01-08-15	29	27
13-09-15	30	26
08-09-15	32	26

Daily PM_{10} and $PM_{2.5}$ concentrations measured at Tokoroa during 2015 are shown in Figures 4.2 and 4.3. Figure 4.4 shows the relationship between PM_{10} and $PM_{2.5}$ concentrations for Tokoroa. This suggests a relatively consistent relationship between $PM_{2.5}$ and PM_{10} concentrations with 83% of the variability in concentrations explained by the relationship between $PM_{2.5}$ and PM_{10}. The presence of coarse mode particulate is evident in around 10 days when PM_{10} concentrations are above 20 µg/m^3 and $PM_{2.5}$ concentrations remain around or below 10 µg/m^3.

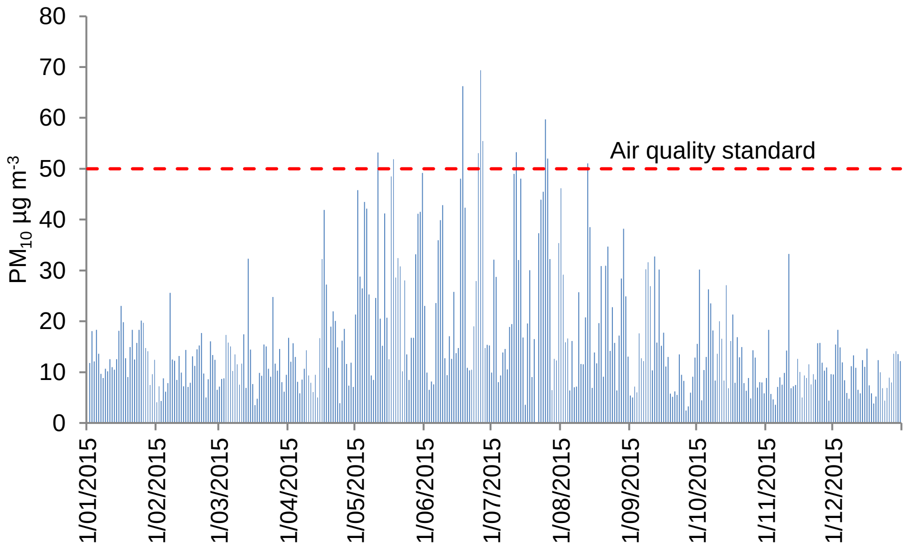

Figure 4-2: **Daily average PM_{10} concentrations measured in Tokoroa during 2015.**

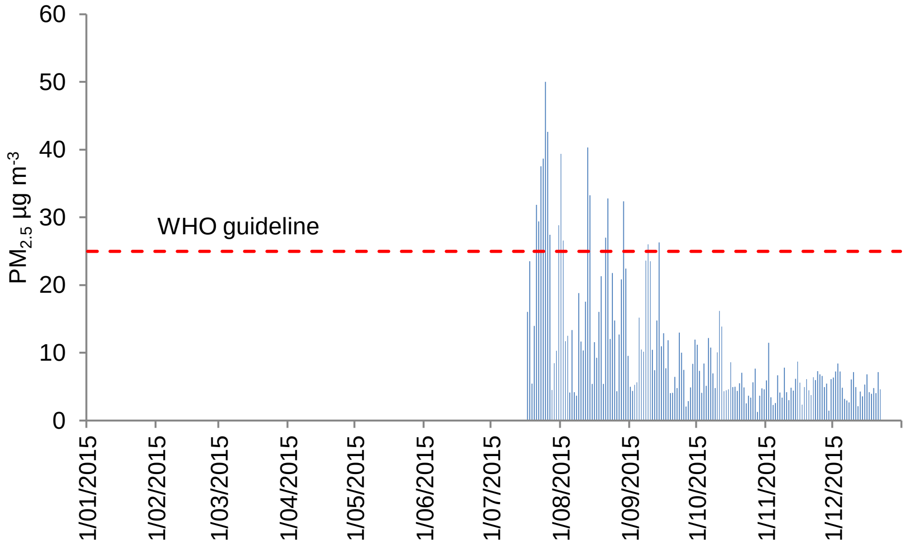

Figure 4-3: **Daily average $PM_{2.5}$ concentrations measured in Tokoroa during 2015.**

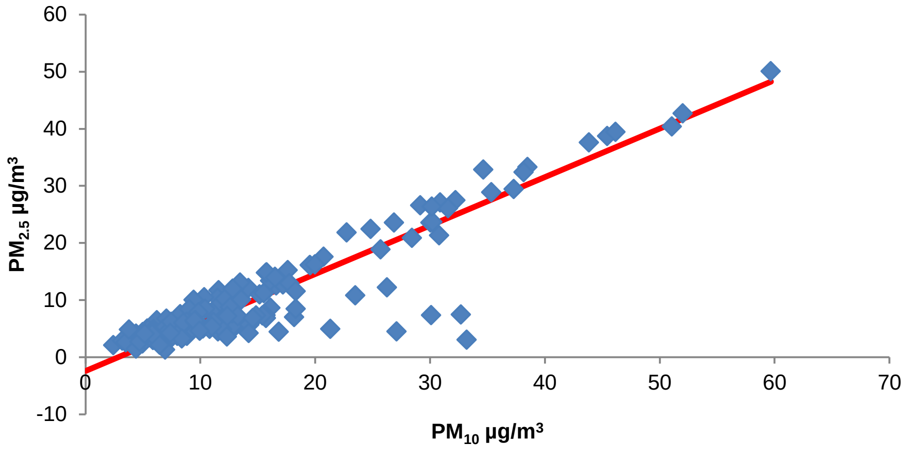

Figure 4-4: **Relationship between PM_{10} and $PM_{2.5}$ concentrations measured in Tokoroa in 2015**

Concentrations of PM_{10} measured at Tokoroa relative to air quality indicator categories from 2006 to 2015 are shown in Figure 4.5. The proportion of concentrations within the "action" category typically ranges between 3% and 6% of the daily averages. In 2015 it was at the lower end at 3% of concentrations exceeding 50 µg/m³.

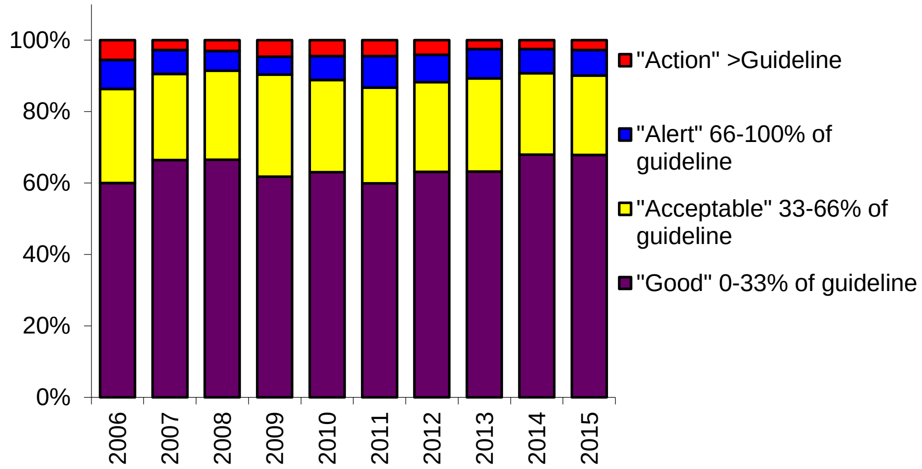

Figure 4-5: Comparison of PM_{10} concentrations measured in Tokoroa from 2006 to 2015 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations during 2015 relative to the air quality indicator categories are shown in Figure 4.6. This shows concentrations of PM_{10} are worst during the winter months when emissions from solid fuel burning coincides with meteorological conditions conducive to elevated concentrations.

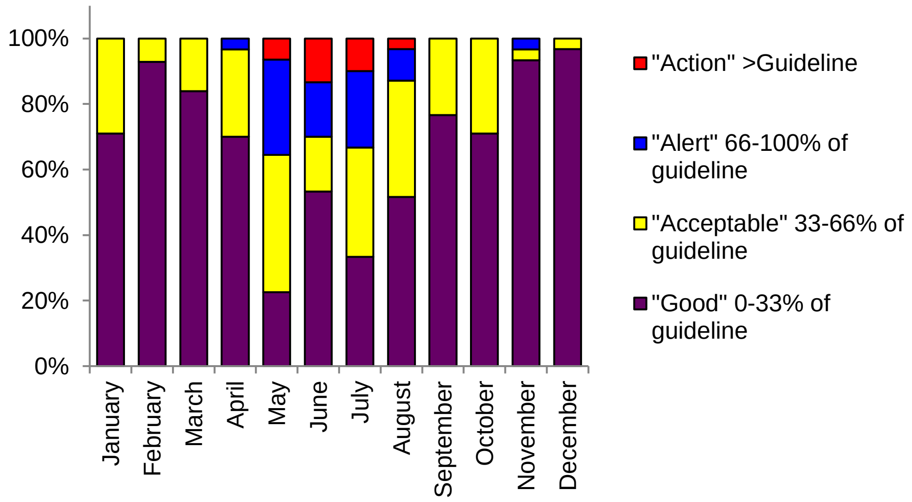

Figure 4-6: Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.

Figure 4.7 shows the number of days when 50 µg/m³ was exceeded, the maximum concentration and the 2nd highest concentration over the period 2006 to 2015. The NES compliance targets for Tokoroa are no more than three exceedances after 1 September 2016 and no more than one exceedance after 1 September 2020. As no downward trend is evident in the data, it is unlikely that either target would be met in the absence of additional air quality management measures. A trend analysis of the data is provided in section 4.4.

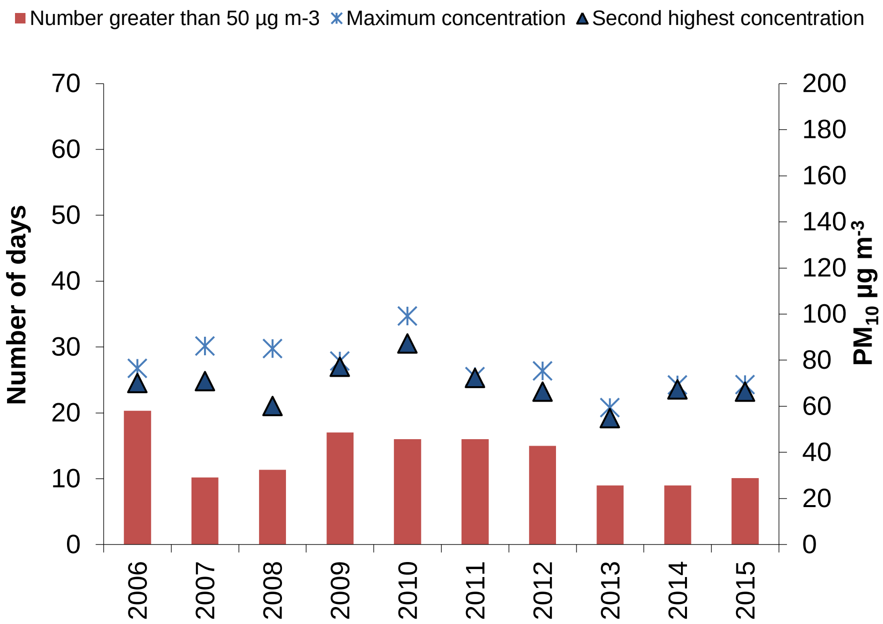

Figure 4-7: Number of days (left axis) when 50 µgm^3 was exceeded compared with the maximum concentration and the 2nd highest concentration (right axis) measured from 2006 to 2015.

The annual average PM_{10} concentration for Tokoroa for 2015 was 16.6 µg/m^3 and is similar to annual average concentrations recorded at the site since 2006 (range 15.8 to 18.8 µg/m^3). The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002). Table 4.3 shows the summary statistics for PM_{10} for Tokoroa from 2006 to 2015.

Table 4-3: Summary of PM_{10} concentrations measured at the Tokoroa monitoring site from 2006 to 2015.

Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
"Good" 0-33% of guideline	60%	66%	67%	61%	63%	60%	63%	63%	68%	68%
"Acceptable" 33-66% of guideline	26%	24%	25%	29%	26%	27%	25%	26%	23%	22%
"Alert" 66-100% of guideline	8%	7%	6%	5%	7%	9%	8%	8%	7%	7%
"Action" >Guideline	6%	3%	3%	5%	4%	4%	4%	3%	2%	3%
Percentage of valid data	99%	99%	99%	100%	99%	99%	100%	100%	100%	100%
Annual average (µg/m^3)	18.6	16.3	16.5	17.5	18.0	18.0	17.2	16.8	15.9	16.6
Measured exceedances	20	10	11	17	16	16	15	10	9	10
99.7 %ile PM_{10} conc. (µg/m^3)	70	70	60	77	87	72	66	58	67	66
2nd Highest PM_{10} con. (µg/m^3)	70	71	60	77	87	72	66	59	67	66
Annual maximum (µg/m^3)	76	86	85	80	99	73	75	59	69	69
Number of records	360	360	360	364	360	362	366	364	365	364

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

Summary statistics for wind speed and temperature from 2006 to 2015 are shown in Figure 4.8. Data suggest wind speeds for 2015 were similar to 2014 and reasonably consistent with most other years. The years 2010 and 2013 experienced the lowest average wind speeds for the years 2006 to 2015. Air temperature was also within the normal range for all indicators examined.

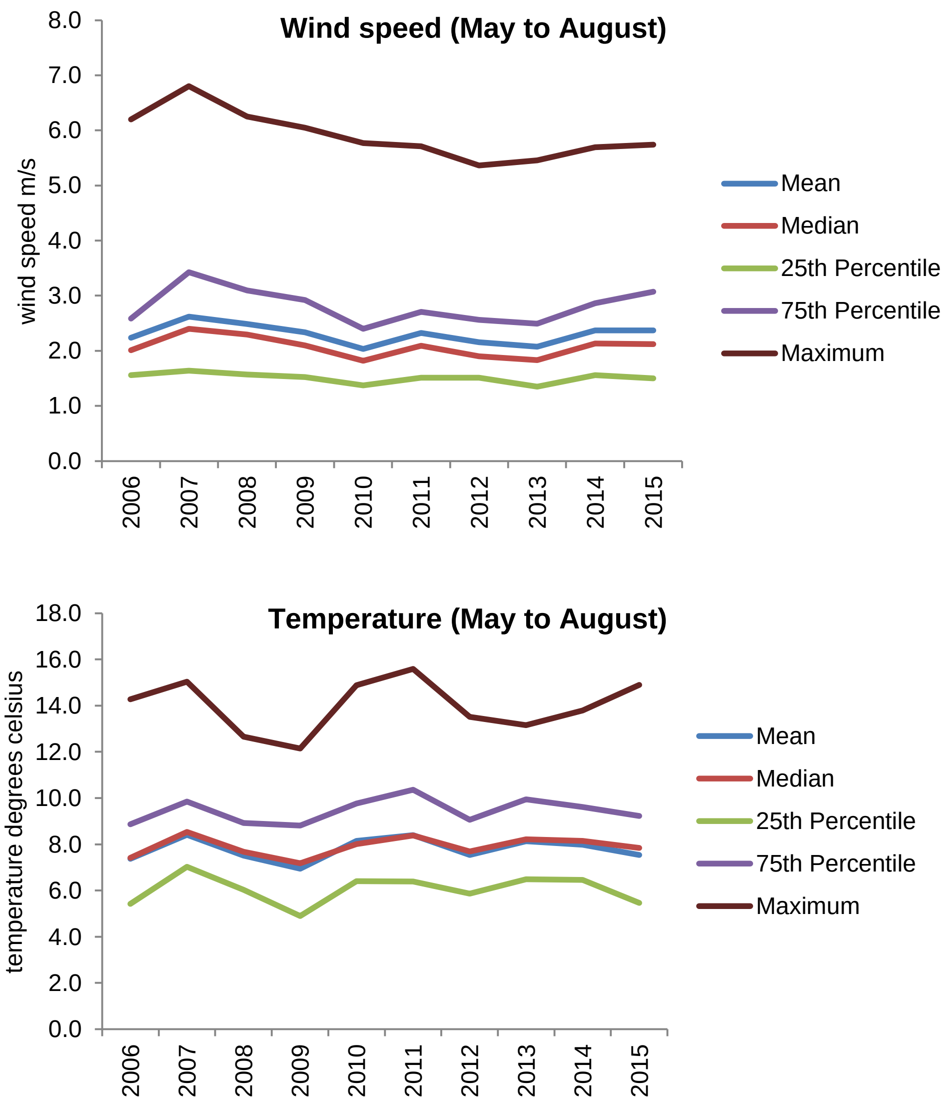

Figure 4-8: Summary wind speed and temperature data from 2006 to 2015 in Tokoroa.

Daily variations in meteorological conditions and hourly average PM_{10} concentrations on the 10 days when the 24-hour average PM_{10} concentrations exceeded 50 µg/m^3 during 2015 are shown in Figure 4.9. Hourly average $PM_{2.5}$ concentrations are also included for days after 15 July when monitoring commenced.

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

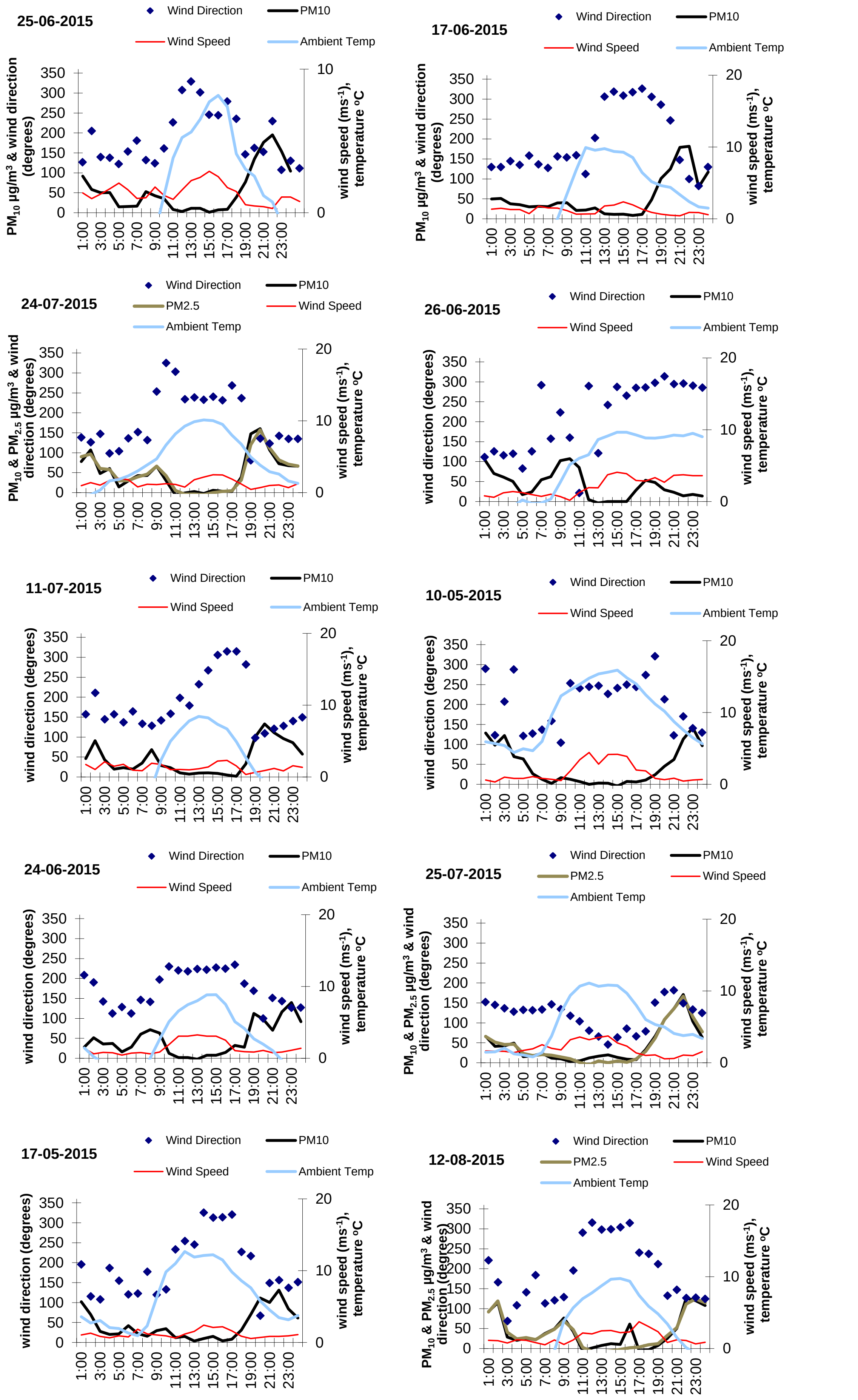

Figure 4-9: Hourly average PM_{10}, $PM_{2.5}$, wind speed, wind direction and temperature on days when PM_{10} concentrations exceeded the NES in Tokoroa.

4.4 Trend Analysis

Analysis of trends in PM_{10} concentrations requires an assessment of the variability from year to year occurring as a result of meteorological conditions. 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 therefore needed to confirm or exclude the possibility of any underlying trend.

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) can be used 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 (Caldwell 2015). This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is real or a result of chance. 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.

While the Seasonal Mann Kendall test results (MK-Stat of -1.4 and a p-value of 0.18) do not provide conclusive evidence that PM_{10} concentrations in Tokoroa have been improving over the period 2006 to 2015, the MK-stat has been increasing in negativity and the p-value decreasing towards $p = 0.05$ for the past three years. For example, the 2006 to 2014 MK stat was -1.2 and p-value 0.23). While this is indicative of a decreasing trend, the p-value suggests some probability (18%) that the results are due to chance.

Additional analysis has also been undertaken using methodologies 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 wind speeds 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.

In summary, if these criteria are met then these are the days you would expect the majority of exceedances to occur. Figure 4.10 provides a summary of the year-to-year variation of the proportion of high pollution potential days which resulted in exceedances in Tokoroa. Figure 4.11 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. Between 2006 and 2012 breaches occurred on 39-70% of days when meteorological conditions conducive to elevated PM_{10} occurred. From 2013-2015 the proportion ranges from 20-30% and is likely indicative of a reduction in upper end PM_{10} concentrations.

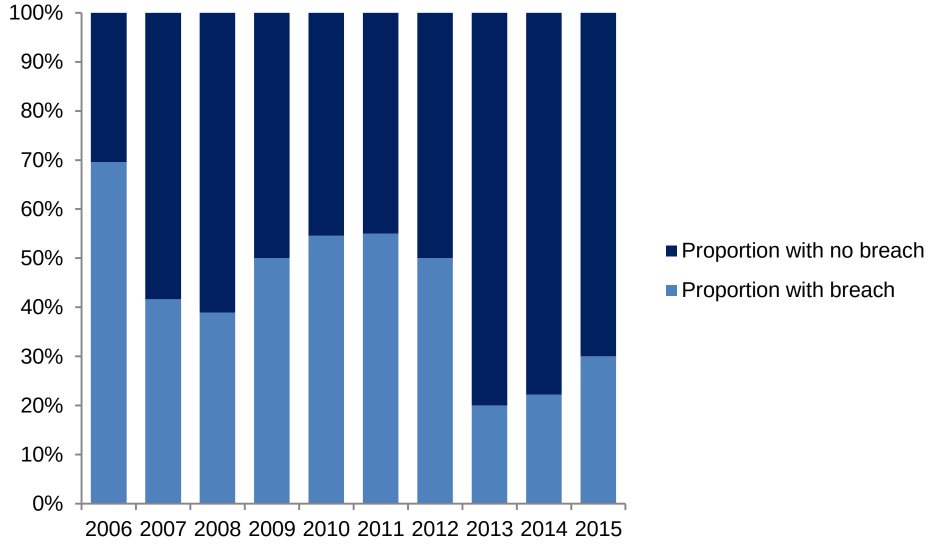

Figure 4-10: Year-to-year variation of the proportion of high pollution potential days which resulted in exceedances.

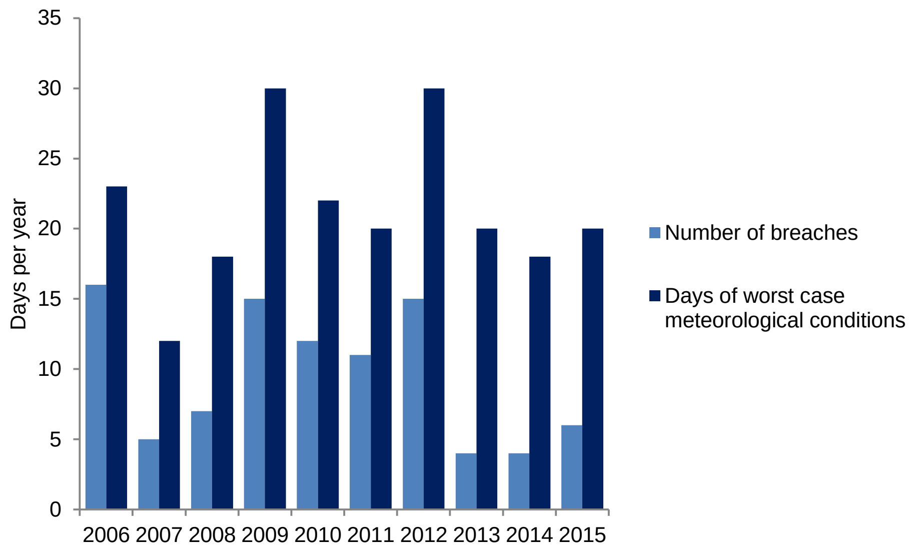

Figure 4-11: Year-to-year variation of the absolute number of high pollution potential days compared with the total number of exceedance days.

Wilton (2013) outlines a method for adjusting PM_{10} concentrations for some of the impact of meteorological conditions. Figure 4.12 shows the normalised PM_{10} concentrations for Tokoroa using that method to minimise the impact of meteorology. No clear trend is evident from these data.

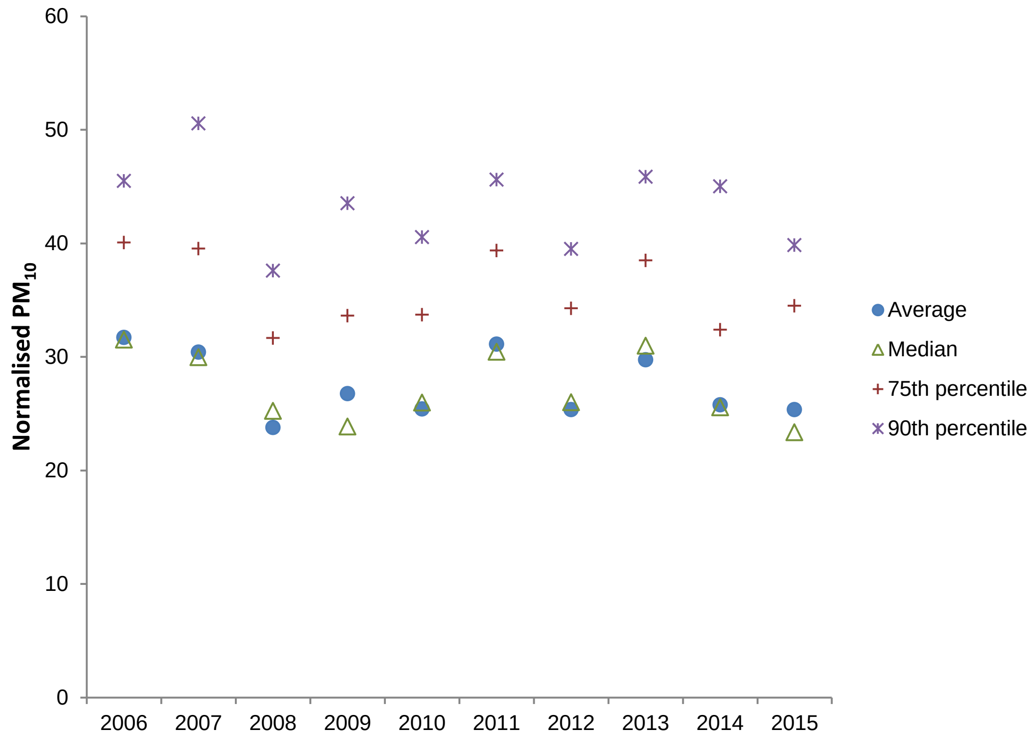

Figure 4-12: **Average, 75th percentile, 90th percentile and median PM_{10} concentrations for the days when the impacts of meteorological variability have been minimised.**

Another way of comparing changes in air quality over time is to compare the 5 year exceedance average from year to year (Figure 4.13). The use of a five year average removes some of the impact of the year to year variability in meteorological conditions whilst targeting the indicator of most concern, the number of exceedences of 50 µg/m^3. Figure 4.13 provides some indication of a reduction in exceedences at Tokoroa with a consistent decrease in the five year rolling average exceedences from 2008-2012 (15.0 µg/m^3) to 2011-2015 (11.8 µg/m^3).

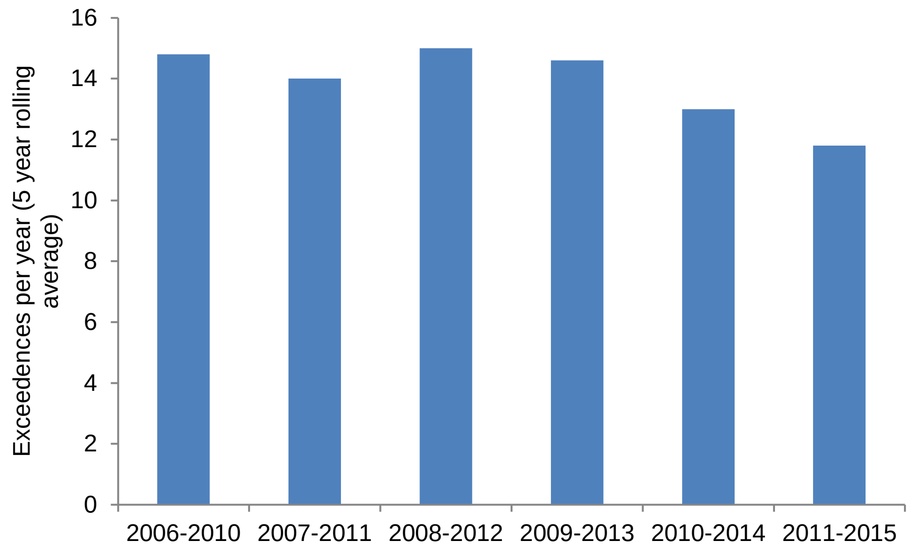

Figure 4-13: **Comparison of the five year exceedance averages for the period 2006 to 2015.**

Notwithstanding this, the interim NES target of no more than three exceedances by September 2016 will not be met and significant intervention would be required to meet the September

2020 target of no more than one exceedence per year. It has been estimated that an emission reduction of around 24% of 2007 emission levels is required to meet the 2016 target and around 43% to meet the 2020 target (Wilton, 2011).

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} gravimetric 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.

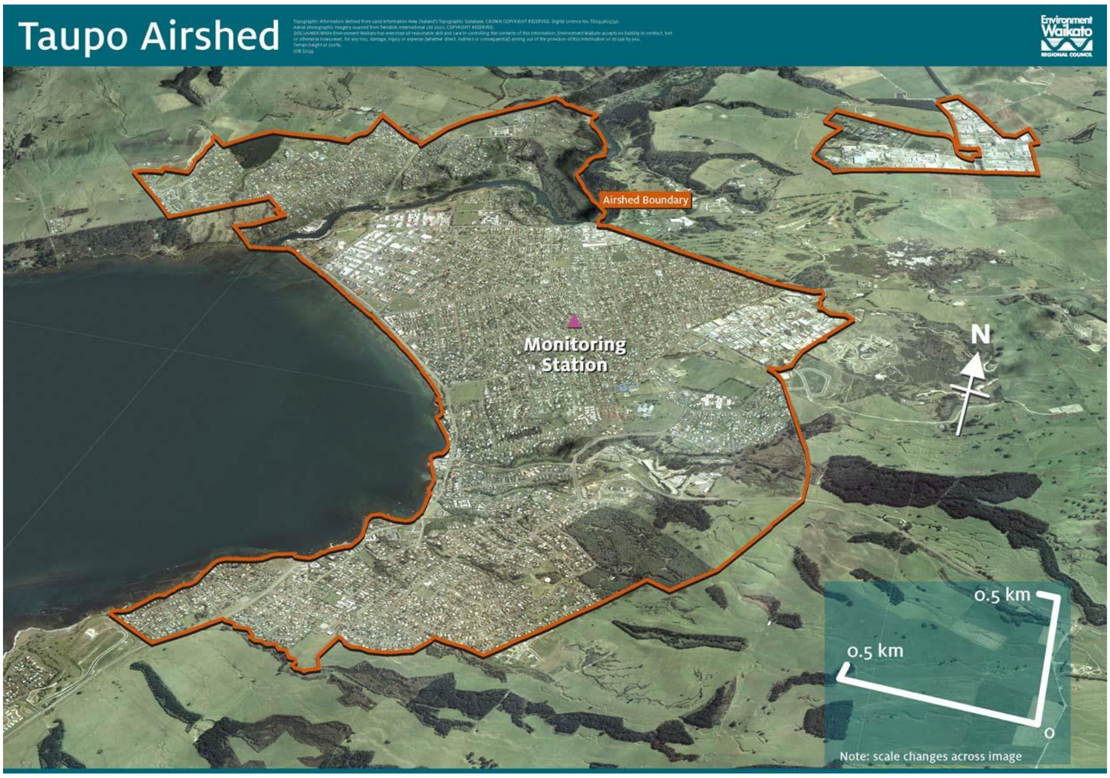

Figure 5-1: Taupo Airshed and air quality monitoring site.

5.2 PM_{10} concentrations in Taupo

During 2015 concentrations of PM_{10} were below the NES value of 50 µg/m³ (Figure 5.2). The maximum 24 hour average concentration was 44 µg/m³ and was measured on 31 May. This is a similar result to 2014. The last year when exceedences were recorded at this site was 2013 when two exceedances (65 µg/m³ and 62 µg/m³) were measured and resulted in a breach of the NES. The years 2011 and 2012 were both compliant with the NES with only one exceedance occurring each year.

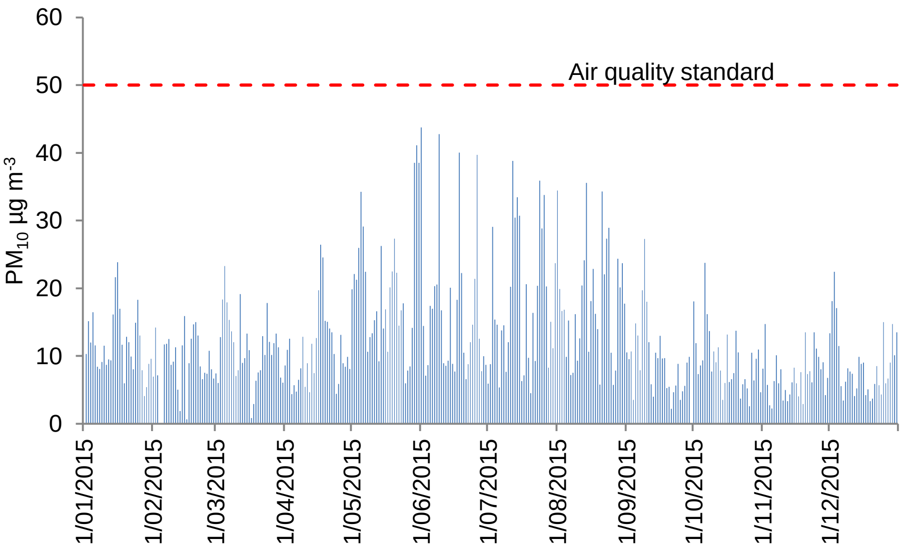

Figure 5-2: Daily average PM_{10} concentrations measured at Taupo during 2015.

Figure 5.3 shows the changes in PM_{10} concentrations relative to air quality indicator categories at the Taupo site from 2006 to 2015. Data are adjusted for gravimetric equivalency only since 2007 so comparison of trends with pre 2006 data are limited[5]. There has been a gradual increase in the proportion of PM_{10} concentrations in the 'good' category since 2007. Figure 5.4 shows the seasonal variations in the distribution of PM_{10} concentrations for 2015.

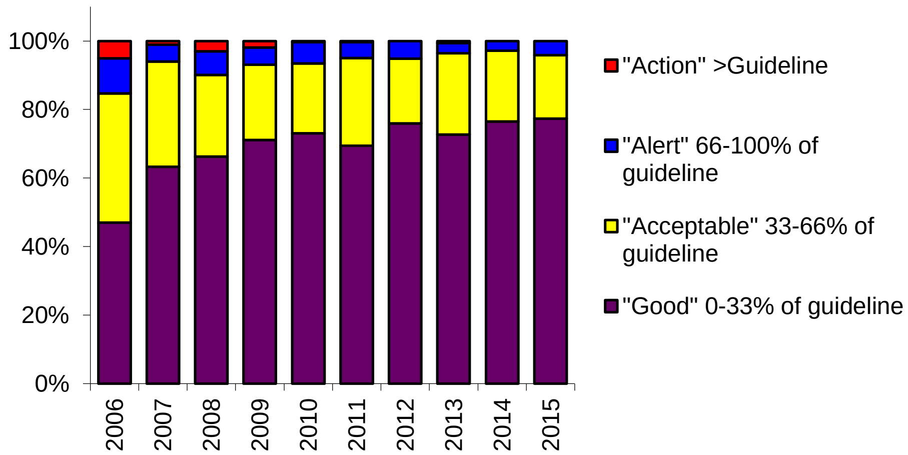

Figure 5-3: **Comparison of PM_{10} concentrations measured at the Taupo site from 2006 to 2015 to air quality indicator categories.**

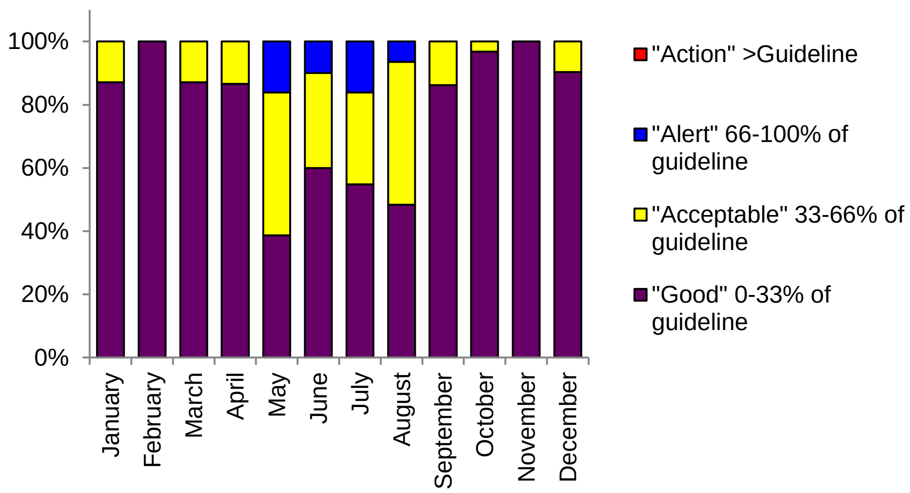

Figure 5-4: **Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.**

Figure 5.5 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 2nd highest concentration for 2006 to 2015. Data suggests improvements in PM_{10} concentrations particularly between the years 2006 and 2011. Data suggests high likelihood of compliance with the NES by 2016 if meteorological conditions similar to 2014 and 2015 occur. Further discussion of trends and compliance with the NES is presented in Section 5.4 of this report.

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

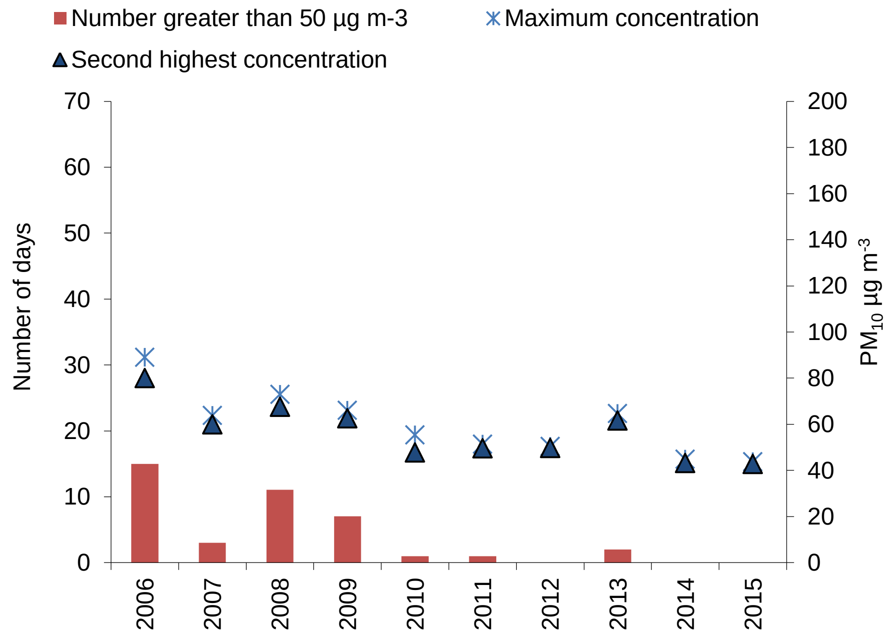

Figure 5-5: **Number of days (left axis) when 50 µg/m^3 was exceeded compared with the maximum concentration and the 2nd highest concentration (right axis) measured from 2006 to 2015.**

The annual average PM_{10} concentration for Taupo for 2015 was 12.6 µg/m^3. Figure 5.6 shows annual average PM_{10} concentrations at Taupo have decreased since 2006. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002).

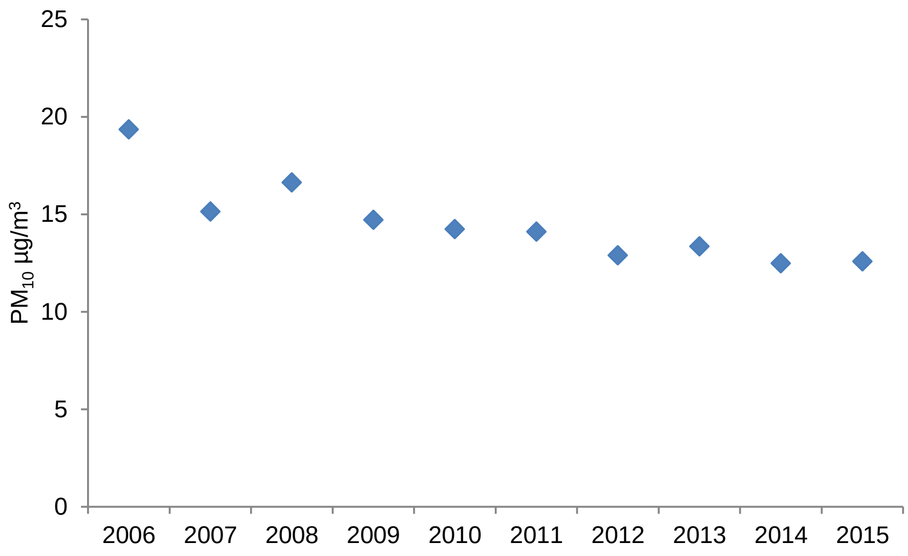

Figure 5-6: **Comparison of annual averages measured at the Taupo site from 2006 to 2015.**

Summary statistics for PM_{10} monitoring results for the period 2001 to 2015 are shown in Table 5.1.

Table 5-1: Summary of PM_{10} concentrations measured at the Taupo monitoring site from 2001 to 2015[1].

Indicator	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
"Good" 0-33% of guideline	43%	59%	52%	55%	56%	47%	65%	66%	71%	73%	69%	76%	73%	77%	77%
"Acceptable" 33-66% of guideline	36%	33%	32%	30%	36%	38%	29%	24%	22%	20%	26%	19%	24%	21%	19%
"Alert" 66-100% of guideline	18%	7%	12%	12%	7%	10%	5%	7%	5%	6%	5%	5%	3%	3%	4%
"Action" >Guideline	2%	1%	4%	2%	1%	5%	1%	3%	2%	0%	0%	0%	1%	0%	0%
Percentage of valid data	12%	21%	29%	29%	30%	27%	83%	99%	99%	100%	99%	99%	99%	98%	99%
Annual average[2] ($\mu g/m^3$)	19.7	15.9	18.5	17.8	15.8	20.4	15.4	16.7	14.7	14.0	14.2	12.9	13.4	12.4	12.6
Measured exceedances[3]	1 (7)	1 (6)	4 (12)	2 (6)	1 (3)	5 (15)	3	10	7	1	1	1	2	0	0
99.7 %ile PM_{10} conc. ($\mu g/m^3$)	55	51	62	62	50	86	60	67	62	47	49	50	60	43	43
Annual maximum ($\mu g/m^3$)	57	54	62	65	52	89	64	73	66	55	51	51	65	45	44
Number of records	44	76	106	105	111	98	303	362	363	364	361	362	363	358	362
2nd Highest						80	60	68	66	48	50	50	62	43	43

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).
3. For the years 2001 to 2006 both measured and reported exceedences are shown (in brackets). Reported exceedences are a statistical extrapolation of measured exceedences after accounting for non sample days.

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

Figure 5.7 shows variations in PM_{10} concentrations and meteorological data on 31 May when the maximum 24-hour average PM_{10} of 44 µg/m^3 was measured at Taupo. This shows relatively low PM_{10} concentrations during the daytime. Concentrations increase at 5pm as would be expected for a typical urban winter PM_{10} profile for New Zealand. However, concentrations peak relatively early (6-7pm) and decrease to around 50 µg/m^3 at 10pm. While the evening and early morning concentrations are reasonably typical of a typical urban winter PM_{10} profile it is also common to have a second smaller peak in concentrations between 8 and 10am.

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). Meteorological conditions on 31 May were reasonably consistent with these conditions. The daytime shift to westerly appears only for a short duration and it is possible that winds may have shifted to westerly late evening.

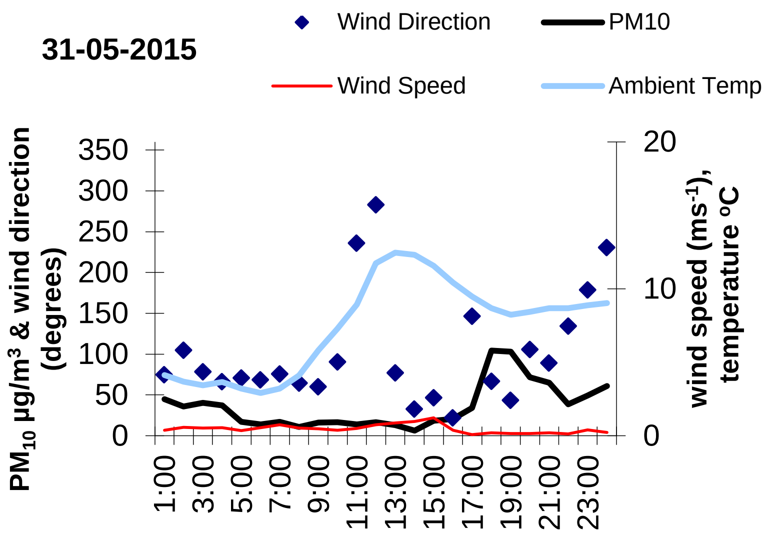

Figure 5-7: Hourly average PM_{10}, wind speed, wind direction and temperature on the 31 May when the highest 24-hour average PM_{10} concentration of 43 µg/m^3 was recorded at Taupo.

5.4 Trend analysis

Seasonal Mann-Kendall test for monotonic trends (consistently increasing or decreasing trends) can be used 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 (Caldwell 2015). This method generates probability (p) values that are used to assess the likelihood that the apparent relationship is real or a result of chance. 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 -2.3 and p-value of 0.01) provides evidence that PM_{10} concentrations in Taupo have been decreasing over the period 2006 to 2015.

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 (Wilton 2013), 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. This suggests a decrease in the proportion of high pollution potential days that resulted in exceedences of 50 µg/m^3, with around 20% of high pollution potential days having exceedences between 2007 and 2009 compared with 0% in 2014 and 2015.

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. This shows that during 2014 and 2015 there were fewer days of high pollution potential than for the years 2008-2013. This is likely to have been a contributing factor in the lack of exceedences of 50 µg/m^3 for PM_{10} during these years.

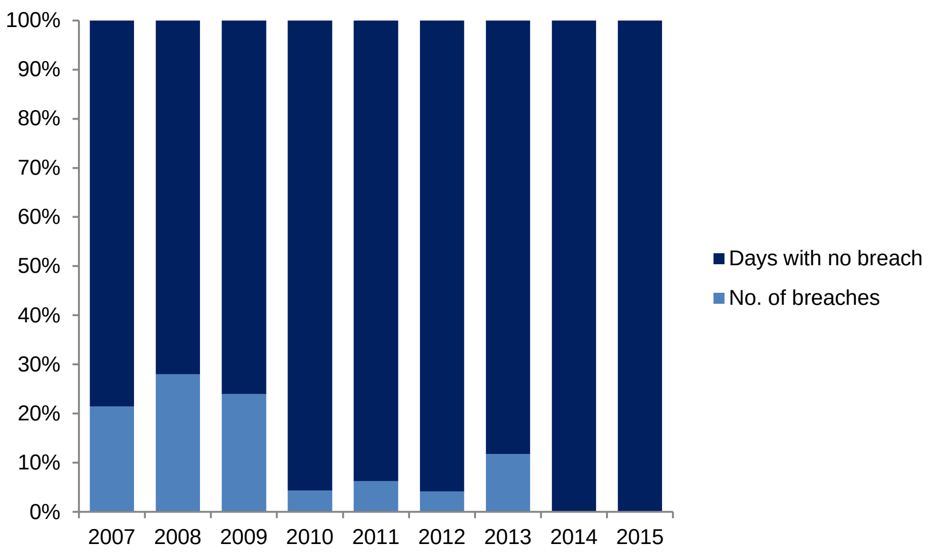

Figure 5-8: Year-to-year variation in the proportion of high potential pollution days which resulted in exceedances.

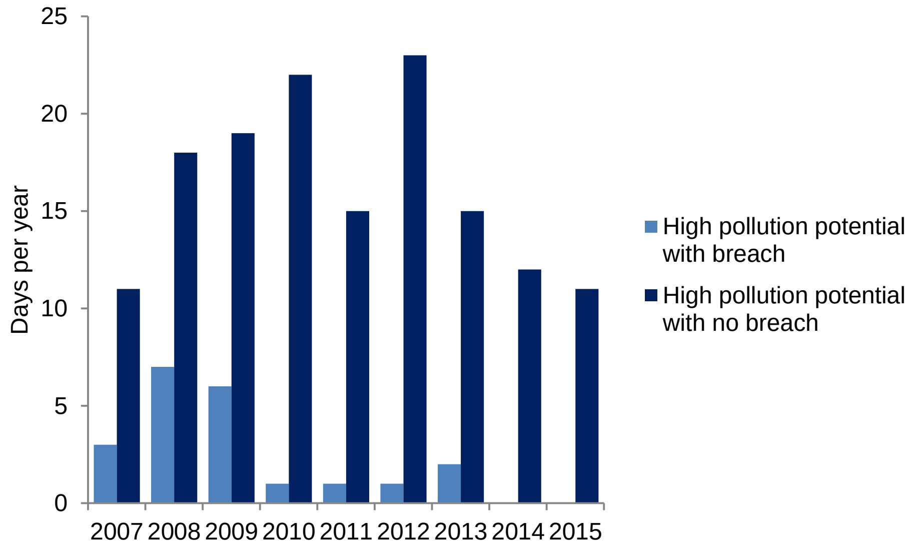

Figure 5-9: **Year-to-year variation in the absolute number of high pollution potential days compared with the total number of exceedance days.**

Wilton (2013) outlines a method for adjusting PM_{10} concentrations for some of the impact of meteorological conditions. Figure 5.10 shows the normalised PM_{10} concentrations for Taupo using that method to minimise the impact of meteorology. There are some indications of a downward trend in PM_{10} concentrations from these data.

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

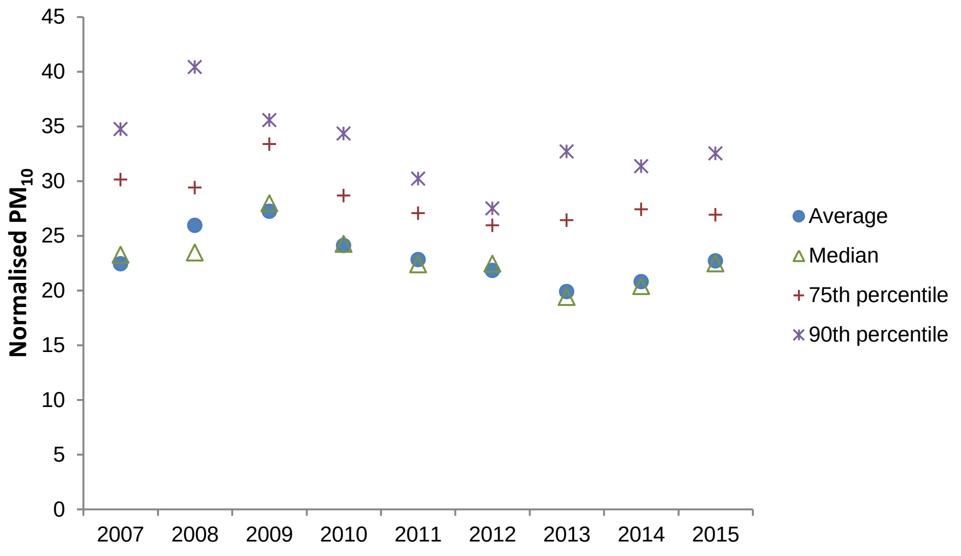

Figure 5-10: **Average, 75th percentile, 90th percentile and median PM_{10} concentrations for the days when the impacts of meteorological variability have been minimised.**

Figure 5.11 shows the 5 year average of exceedances per year from 2006 to 2015. Comparing averages over a number of years is another way of reducing some of the impact of year to year variability in meteorological conditions. There has been a consistent downwards trend in the 5 year exceedance average over the period 2006 to 2015.

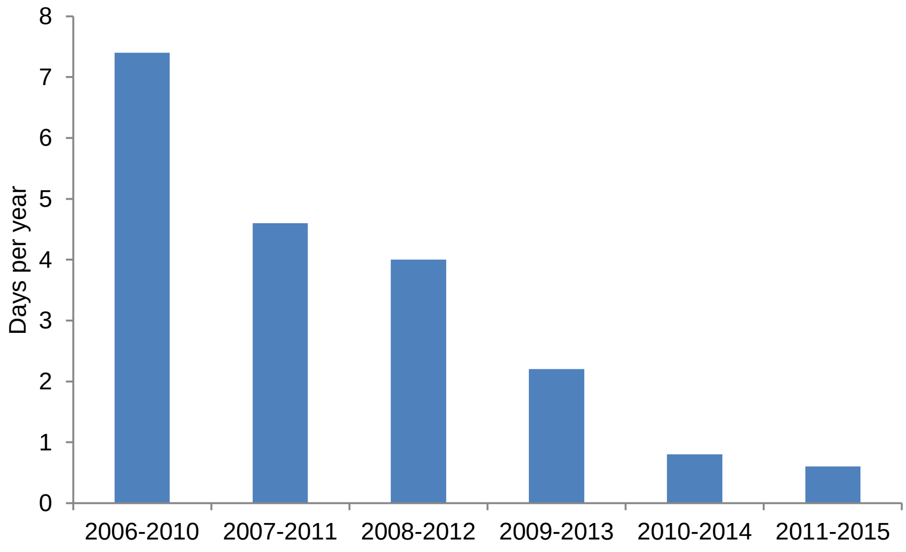

Figure 5-11: Comparison of the five year exceedance averages for the period 2006 to 2015.

Based on these analyses and the current previous five year exceedance average of less than 1, it is likely that Taupo will meet the NES 2016 target of no more than one exceedance per 12 month period. But this will still 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 Waitomo District 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.

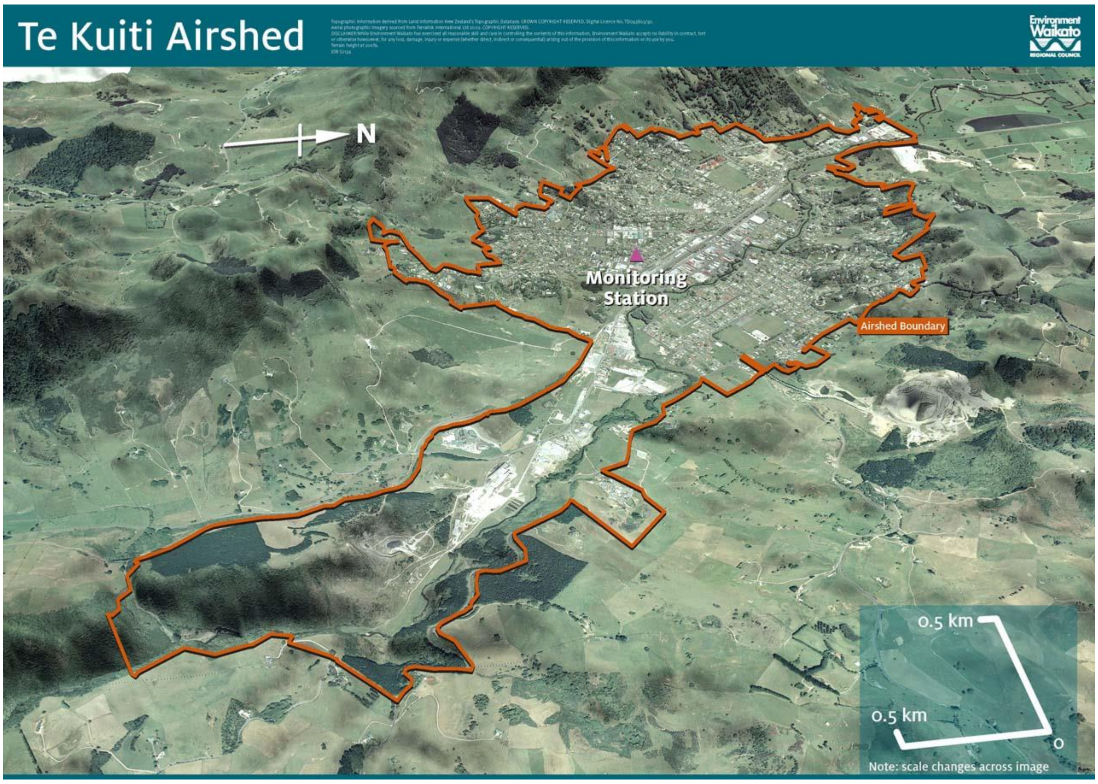

Figure 6-1: Te Kuiti Airshed and air quality monitoring site.

6.2 PM_{10} concentrations in Te Kuiti

Daily average PM_{10} concentrations measured in Te Kuiti during 2015 are shown in Figure 6.2. There were no PM_{10} exceedances of 50 µg/m^3 (24-hour average) and the maximum concentration in Te Kuiti was 49 µg/m^3 (24-hour average). No exceedances have been recorded at the site since 2012 when one exceedance of 50 µg/m^3 (61 µg/m^3) occurred. As the 2012 exceedence occurred less than 12 months before after the 2012 exceedence the site remains a "polluted" airshed under the NES.

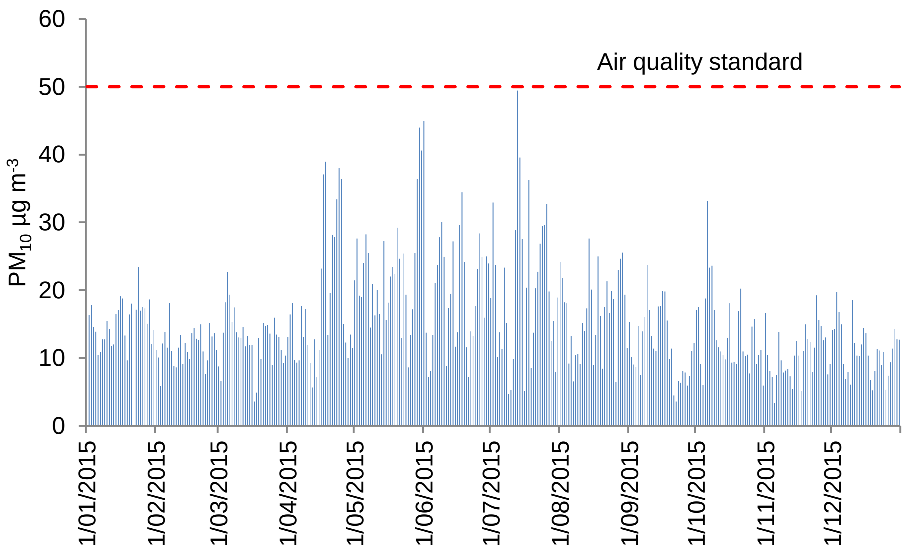

Figure 6-2: Daily average PM_{10} concentrations measured at the Te Kuiti site during 2015.

Variations in PM_{10} concentrations relative to air quality indicator categories at the Te Kuiti site from 2003 to 2015 are shown in Figure 6.3. Improvements in particulate concentrations at the site are illustrated by a gradual increase in the proportion of PM_{10} concentrations in the 'good' category and decreases in the proportion of concentrations in the "action" and "alert" categories. Figure 6.4 shows the seasonal variations in the distribution of PM_{10} concentrations for 2015.

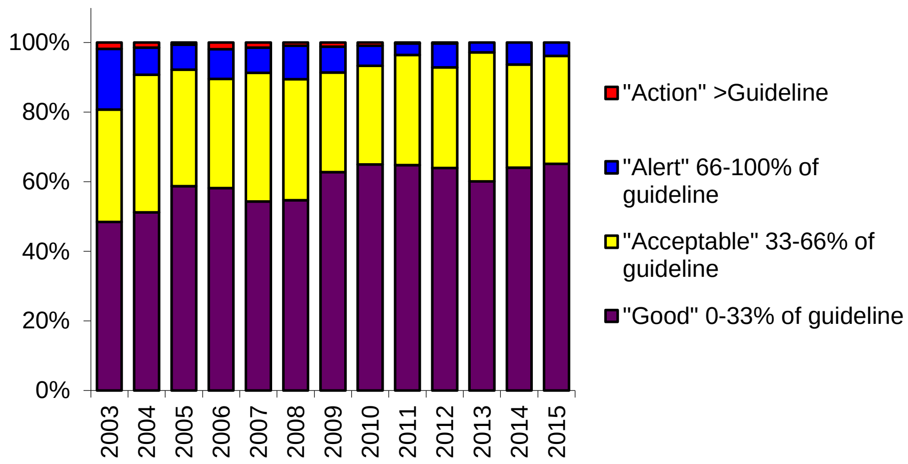

Figure 6-3: **Comparison of PM_{10} concentrations measured at the Te Kuiti site from 2003 to 2015 to air quality indicator categories.**

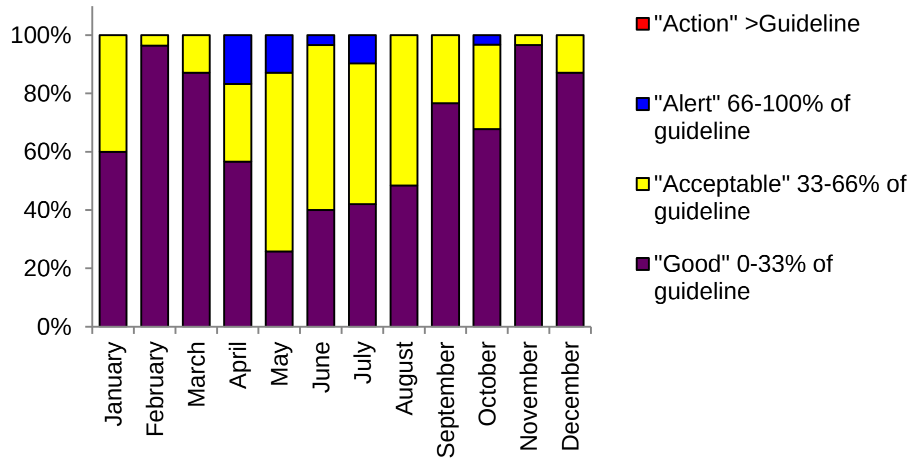

Figure 6-4: **Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.**

Figure 6.5 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 2nd highest concentration from 2003 to 2015. Data is indicative of improvements in PM_{10} concentrations since 2003. A trend analysis is presented in Section 6.4 of this report.

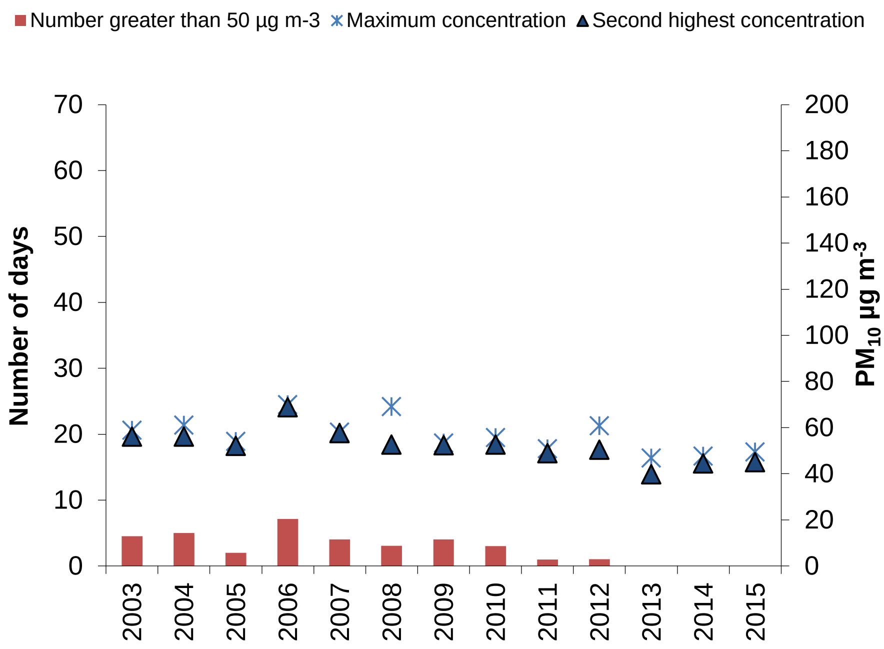

Figure 6-5: **Number of days (left axis) when 50 µg/m^3 was exceeded compared with the maximum concentration and the 2nd Highest concentration (right axis) measured from 2003 to 2015.**

Summary statistics for PM_{10} monitoring data from the Te Kuiti site from 2003 to 2015 are shown in Table 6.1. The annual average PM_{10} concentration for 2015 was 15.4 µg/m^3. This is consistent with the last four to five years and lower than the typical average of approximately 18 µg/m^3 prior to 2009. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m^3 (MfE, 2002).

Table 6-1: Summary of PM$_{10}$ concentrations measured at the Te Kuiti monitoring site from 2003 to 2015.

Indicator	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Good 0-33% of Guideline	48%	51%	59%	58%	54%	55%	63%	65%	65%	64%	60%	64%	65%
Acceptable 33-66% of guideline	32%	40%	34%	31%	38%	35%	29%	28%	32%	29%	37%	30%	31%
Alert 66-100% of guideline	17%	8%	7%	9%	7%	9%	8%	6%	3%	7%	3%	6%	4%
Action >Guideline	2%	1%	1%	2%	1%	1%	1%	1%	0%	0%	0%	0%	0%
Percentage of valid data	63%	95%	92%	100%	99%	99%	99%	99%	100%	99%	98%	100%	100%
Annual average (μg/m^3)	18.0	18.0	17.0	17.7	17.8	18.2	16.8	16.1	15.1	16.4	16.3	15.9	15.4
Number exceedances	4	5	2	7	4	3	4	3	1	1	0	0	0
99.7 %ile concentration (μg/m^3)	56	56	52	67	55	52	52	53	41	50	40	44	45
Annual maximum (μg/m^3)	59	61	54	69	58	74	53	56	51	61	47	48	49
Number records	229	346	337	363	360	362	360	360	363	363	358	364	364
2nd Highest concentration (μg/m^3)	56	56	52	67	58	53	52	53	41	50	40	44	45

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 12 July when the 24-hour average PM_{10} concentration reached a maximum of 49 µg/m^3. The hourly PM_{10} profile is fairly typical of an urban PM_{10} pollution event with an elevated broad peak extending from the previous night and slowly reducing over the early hours of the morning followed by a peak in concentrations around 9 to 10 am, a drop off to around zero during the middle of the day and then a gradual increase again from about 5 pm. The main difference with the 12 July distribution in PM_{10} concentrations is the magnitude of the morning peak which well exceeds that of the evening peak. Morning temperatures of around negative two degrees were experienced indicating strong temperature inversions and likely increasing the proportion of households relighting fires for the morning period. The wind speed was low throughout the day and temperatures peaked at just over 10 degrees in the early afternoon.

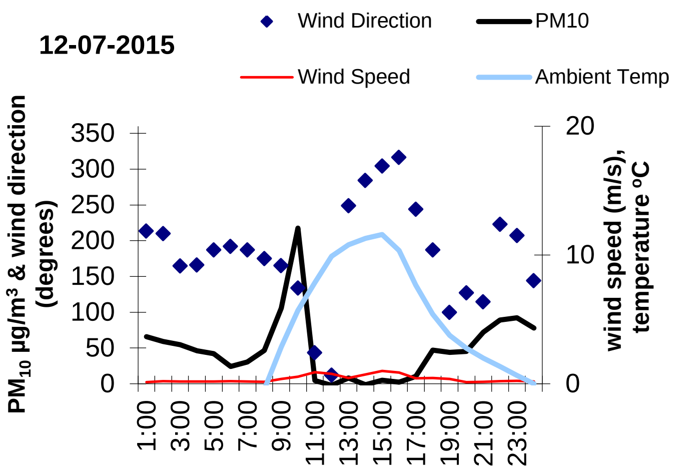

Figure 6-6: **Hourly average PM_{10}, wind speed, wind direction, and temperature on 12 July when the highest 24-hour average PM_{10} concentration of 49 µg/m^3 was recorded at Te Kuiti.**

6.4 Trend analysis

Seasonal Mann Kendall test results (MK-Stat of -2.8 and p-value of 0.005) provides strong evidence that PM_{10} concentrations in Te Kuiti have been decreasing over the period 2005 to 2015.

Another indicator of trends over time is the 5 year exceedance average (Figure 6.7) as averaging over a longer time period will remove some of the variation that occurs from year to year. A consistent downwards trend in the 5 year exceedance average over the period 2006 to 2015 is apparent.

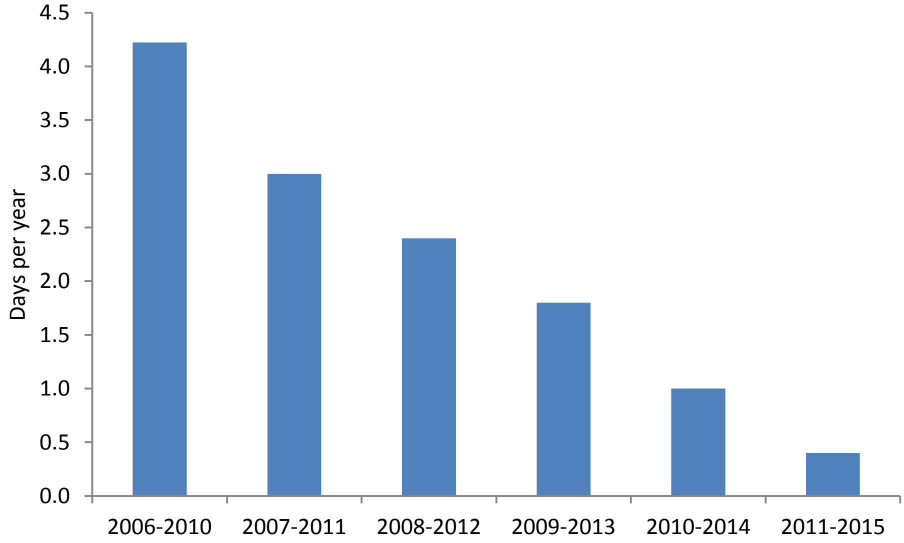

Figure 6-7: Comparison of the five year exceedance averages for the period 2006 to 2015.

On a calendar year basis, Te Kuiti has had no more than one exceedance per year since 2011. However, two exceedances occurred in Te Kuiti over a 12 month period that straddled the period 2011 to 2012. The first exceedance of the breach occurred on 9 December 2011 and the second exceedance occurred on 2 July 2012.

An airshed ceases to be polluted when the PM_{10} standard has not been breached in the airshed for five years. That is only one exceedance of the 24-hour average within any 12-month period during that five years. Therefore, the compliance period for Te Kuiti starts from 10 December 2011, the day after the first exceedance of the breach that occurred between 2011 and 2012. On this basis, the Te Kuiti airshed could potentially be re-classified as non-polluted by 10 December 2016 subject to there being no more than one exceedance prior to this date.

An air emission inventory undertaken in Te Kuiti in 2015 indicates that there has been a 14% reduction in PM_{10} emissions since 2007 as a result of reductions in both domestic heating and industrial emissions (Wilton 2015). While it appears emissions have reduced sufficient that further breaches may seem unlikely, it is possible that the NES for PM_{10} could still be breached in the airshed if particularly conducive meteorological conditions were experienced.

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 midway 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.

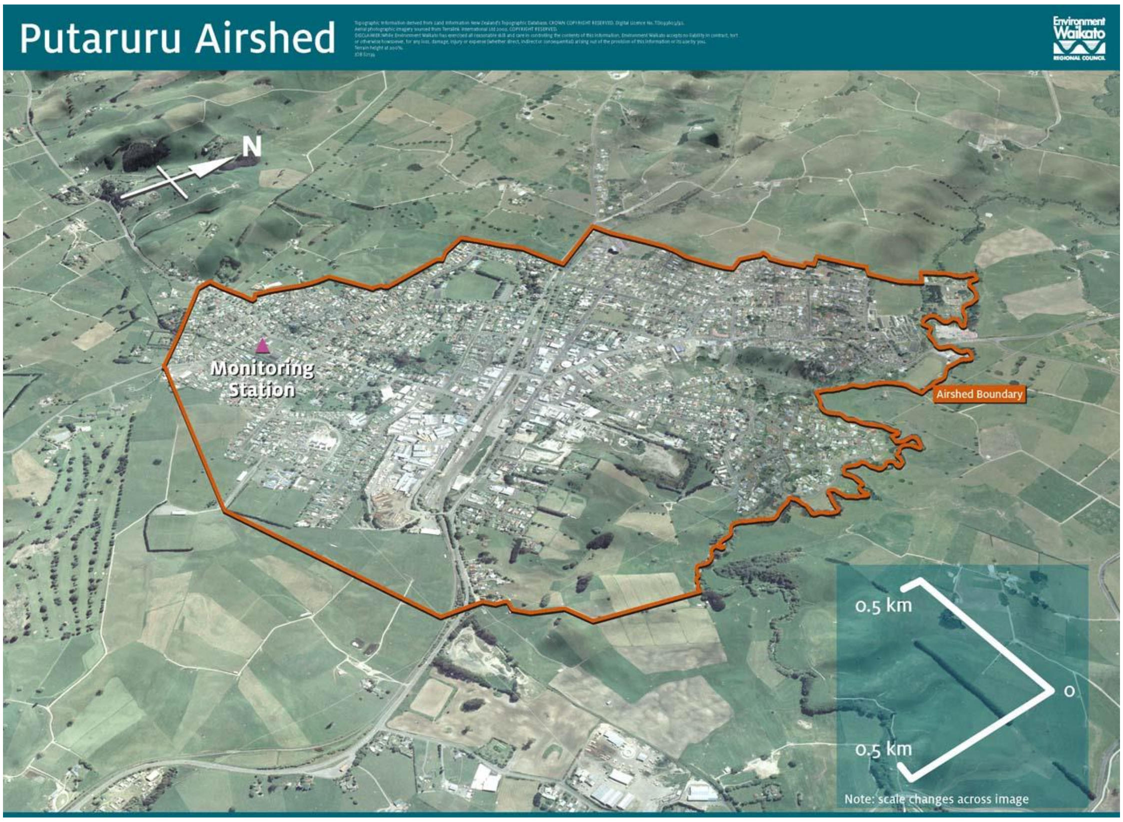

Figure 7-1: Putaruru Airshed and air quality monitoring site.

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

Figure 7-2: **Putaruru air quality monitor.**

7.2 PM_{10} concentrations in Putaruru

Figure 7.3 shows daily average PM_{10} concentrations measured at Putaruru during 2015. The maximum PM_{10} concentration measured during 2015 on 22 July was 50.1 µg/m^3. This is not considered an exceedance as the threshold for exceeding the NES limit value is 50.5 µg/m^3.

During 2014 two exceedances of 50 µg/m^3 (24-hour average) were recorded but occurred outside of the typical wintertime season (March/ early April) and had hourly profiles inconsistent with the typical diurnal pattern indicative of a home heating source. Prior to 2014 the previous NES breach occurred in 2009 when three exceedences of 50 occurred.

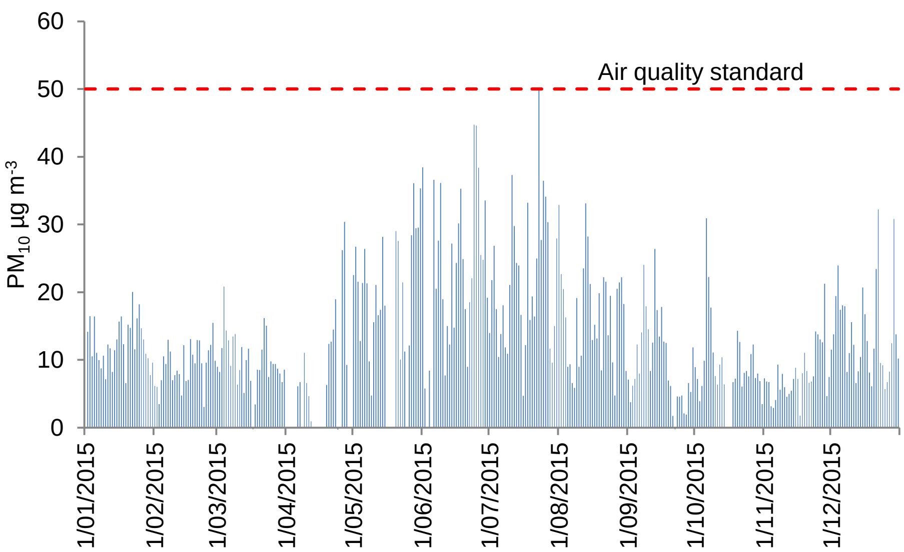

Figure 7-3: **Daily average PM_{10} concentrations measured at the Putaruru site during 2015.**

Figure 7.4 compares PM_{10} concentrations measured at Putaruru from 2006 to 2015 to the MfE (2000) air quality indicator categories.

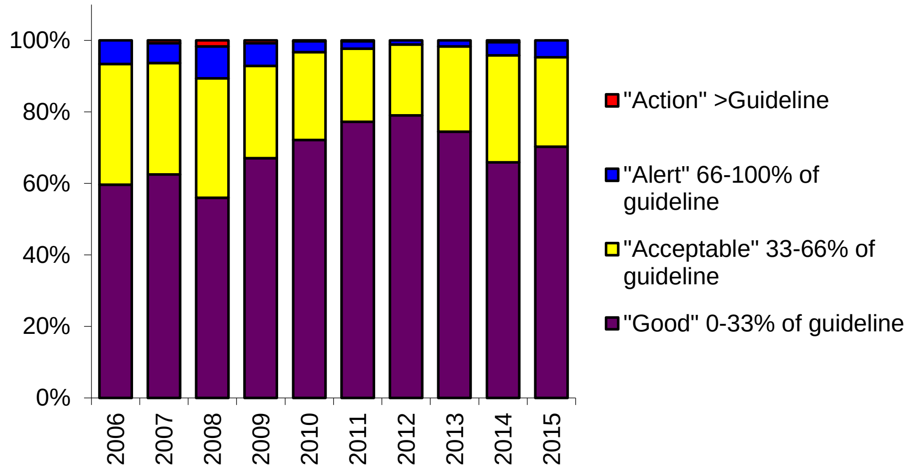

Figure 7-4: **Comparison of PM_{10} concentrations measured at the Putaruru site from 2006 to 2015 to air quality indicator categories.**

Figure 7.5 shows seasonal variations in the distribution of PM_{10} concentrations for 2015. During the winter months only a small proportion of the PM_{10} concentrations are within the "good" air quality indicator category.

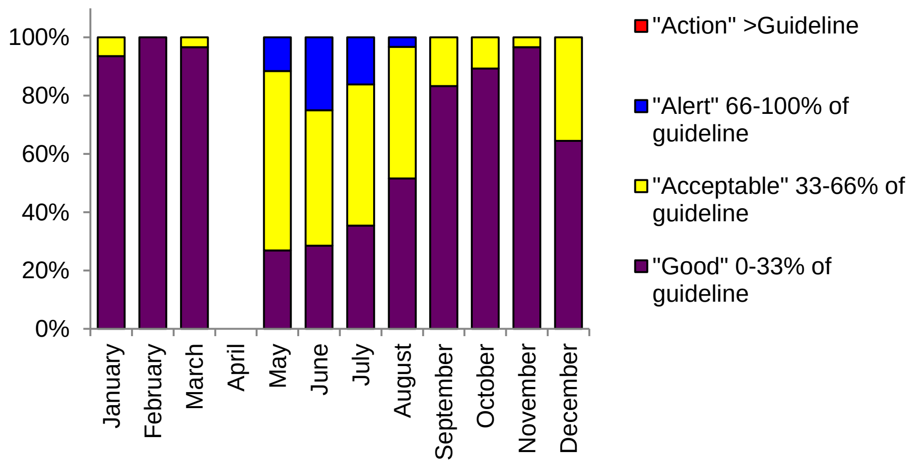

Figure 7-5: **Comparison of daily PM_{10} concentrations for 2015 to air quality indicator categories.**

Figure 7.6 shows the number of days when 50 µg/m^3 was exceeded, the maximum concentration and the 2nd highest concentration from 2007 to 2015. The 2006 data has been excluded from the comparison as monitoring only began half way through the winter season. 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. The two exceedances that occurred during 2014 are also atypical and occurring out of season.

Data indicates no breaches of the NES for PM_{10} that occur as a result of typical winter air pollution since 2009. This suggests that in the absence of the atypical sources, the sites would be in compliance with the NES. However, because the atypical sources have not been identified it is possible that they could result in future breaches at the site. An evaluation of trends in PM_{10} concentrations at Putaruru is presented in Section 7.3 of this report.

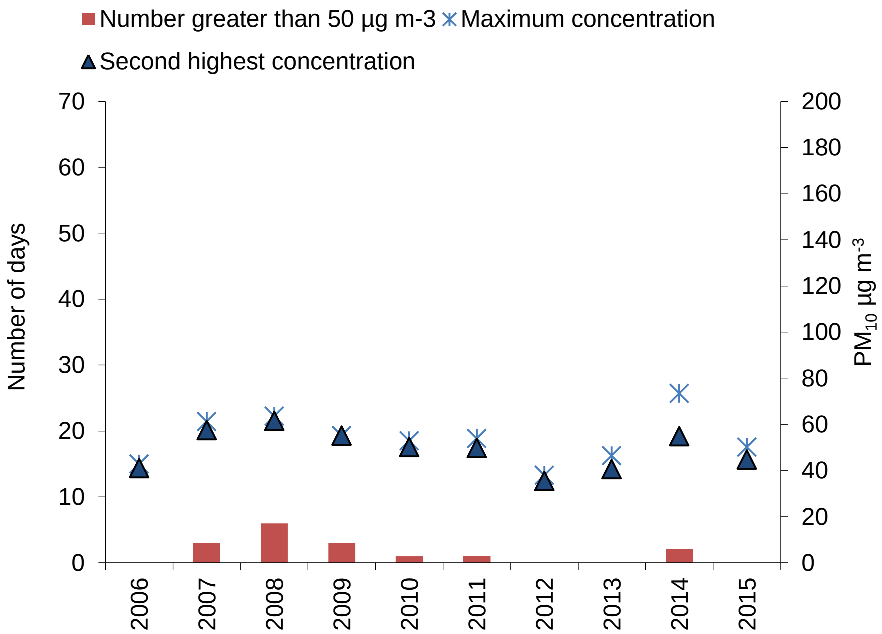

Figure 7-6: Number of days when 50 µg/m³ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2007 to 2015.

The annual average PM_{10} concentration for Putaruru for 2015 was 14 µg/m³. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m³ (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 2015.**

Indicator	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Good 0-33% of Guideline	65%	67%	61%	71%	72%	78%	79%	74%	66%	70%
Acceptable 33-66% of guideline	30%	27%	31%	23%	25%	20%	20%	24%	30%	25%
Alert 66-100% of guideline	5%	5%	7%	6%	3%	2%	1%	2%	4%	5%
Action > Guideline	0%	1%	1%	1%	0.3%	0.3%	0%	0%	1%	0%
Percentage of valid data	46%	100%	100%	100%	100%	95%	99%	99%	98%	93%
Annual average (µg/m^3)	n/a	15.1	17.2	13.6	14.2	12.5	11.8	13.2	15.3	14.0
Number exceedances	0	3	4	3	1	1	0	0	2	0
99.7 %ile (µg/m^3)	41	56	59	53	50	50	35	41	54	45
Annual maximum (µg/m^3)	42	60	78	54	53	54	38	46	73	50
Number records	166	365	364	364	363	346	361	360	359	340
2nd Highest (µg/m^3)	40	56	60	54	50	50	35	41	55	45

7.3 Trend analysis

As with other long term monitoring sites trend analysis using a seasonal Mann-Kendall test has been carried out.

Seasonal Mann Kendall test results for Putaruru (MK-Stat of -1.7 and p-value of 0.09) do not provide evidence that PM_{10} concentrations have been getting either better or worse over the period 2007 to 2015 and is a similar result to the 2014 analysis (Caldwell 2015). Interestingly the assessment for the period 2007 to 2013 (Caldwell 2015) did provide evidence of an improving trend (MK-Stat of -1.98 and p-value of 0.048) which is consistent with the visual observation in Figure 7.4 of an improvement in PM_{10} in the “good” and “acceptable” air quality indicator categories over the period 2008 - 2012. It is unclear whether the reversal of this trend occurs as a result of a couple of years of worst case meteorological conditions or an increase in PM_{10} emissions.

A comparison of winter PM_{10} averages (May to August) are illustrated in Figure 7.7. While a decrease in the winter averages was evident around 2011 and 2012, the winter averages have begun increasing again but still remain below the winter averages recorded prior to 2010. A comparison of annual averages as illustrated in Figure 7.8 shows a similar pattern with the lowest annual averages recorded in 2011 and 2012.

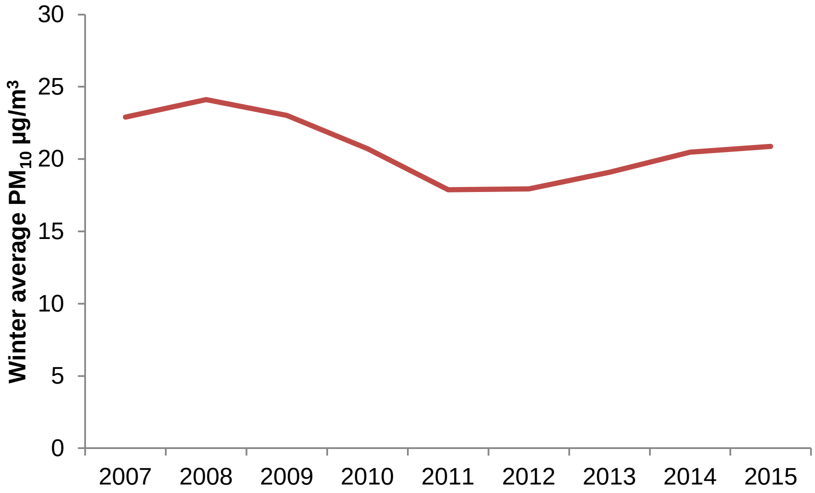

Figure 7-7: Comparison of the monthly averages (May to August) for the period 2007 to 2015.

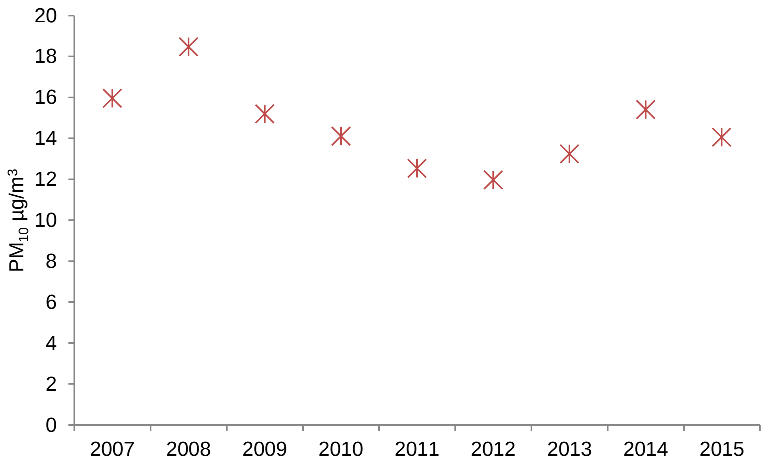

Figure 7-8: Comparison of the annual averages for the period 2007 to 2015.

The key area of interest in terms of trends is the worst case concentrations which can result in exceedences during the winter months. Figure 7.9 shows a consistent downward trend in the rolling average exceedences per year from 2006 to 2015.

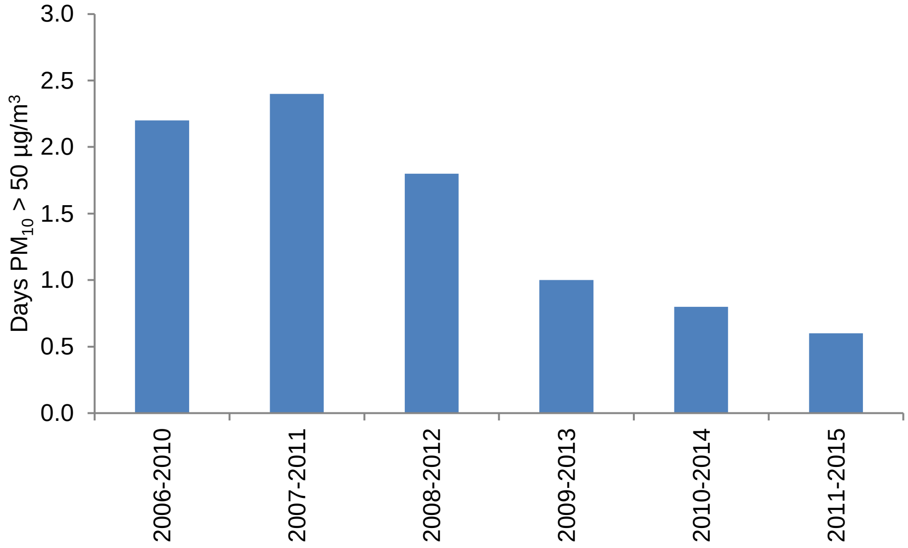

Figure 7-9: Comparison of the five year exceedance averages for the period 2006 to 2015.

The overall indication for Putaruru is that exceedance numbers are tracking downwards. However, non-winter exceedances in 2014 indicate the presence of an unidentified localised source of PM_{10} that could result in further exceedances in future.

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 (Figure 8.1) on 11 March 2009. Daily and hourly average PM_{10} concentrations are measured at the site using a FH 62 BAM.

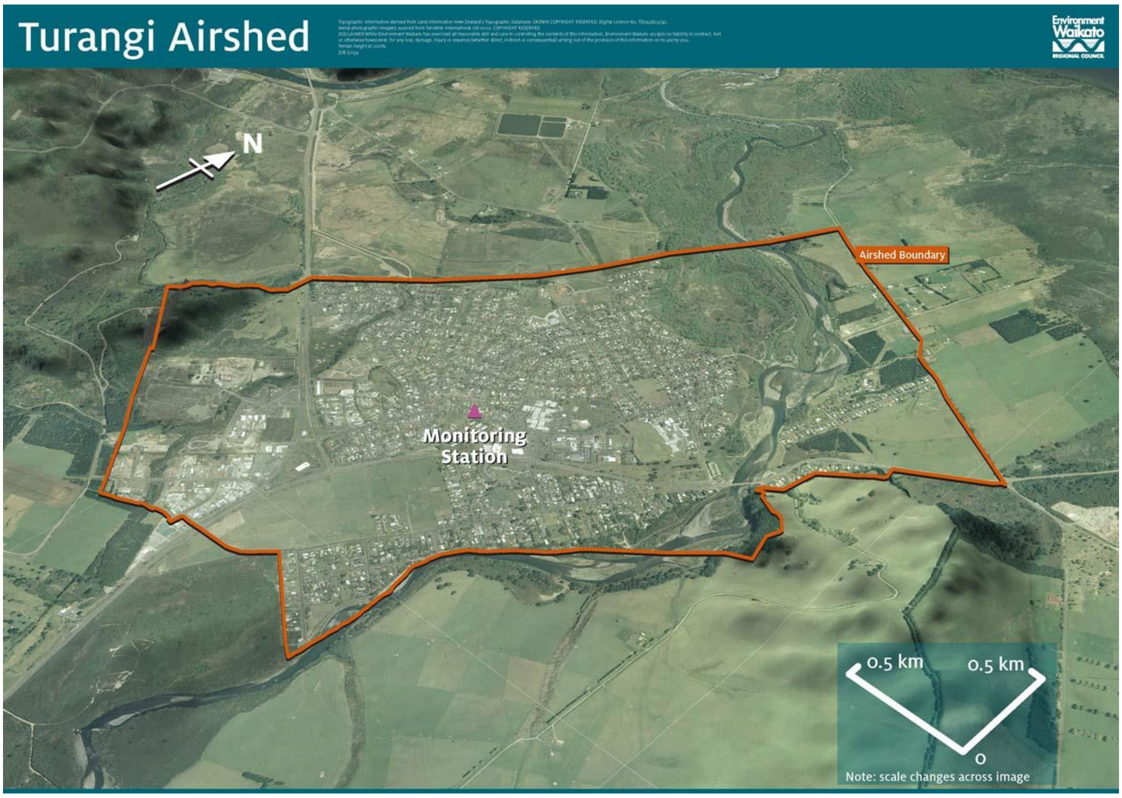

Figure 8-1: **Turangi Airshed and air quality monitoring site.**

8.2 PM_{10} concentrations in Turangi

The maximum PM_{10} concentration in Turangi during 2015 was 41 µg m^{-3} (24-hour average) and was recorded on 17 June. This is slightly higher than previous winter maximum of 33 µg/m^3. Daily average PM_{10} concentrations measured at the Turangi site during 2015 are shown in Figure 8.2.

In 2014 the maximum 24-hour average concentration at Turangi occurred during February. Figure 8.2 shows that during 2015, the second highest concentration was measured during October. Like the February 2014 high concentration this event is unlikely to have occurred as a result of domestic home heating.

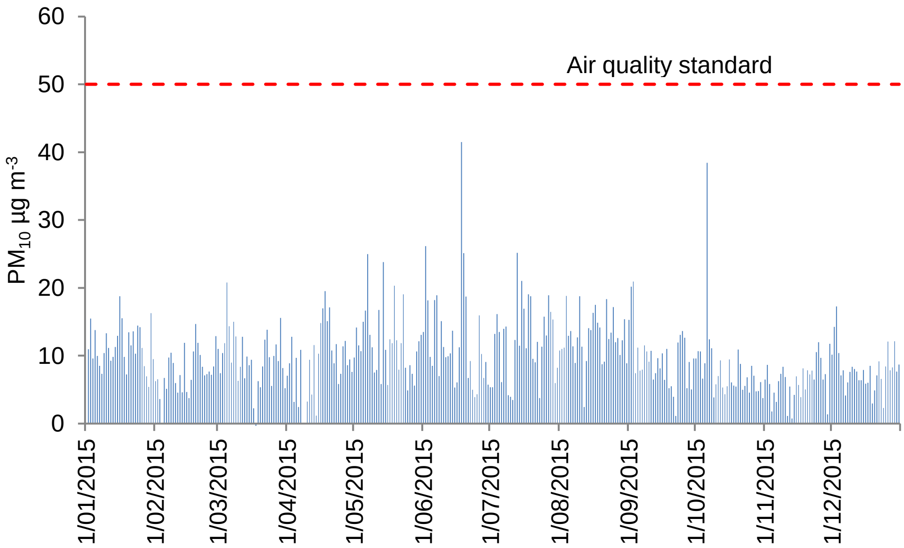

Figure 8-2: **Daily average PM_{10} concentrations measured at the Turangi site for 2015.**

Figure 8.3 shows concentrations of PM_{10} relative to air quality indicator categories at Turangi from 2009 to 2015. In 2015, 89% of days experienced PM_{10} concentrations within the 'good' category. On all other days PM_{10} was within the "acceptable" category apart from 0.6% of days falling within the "alert" category.

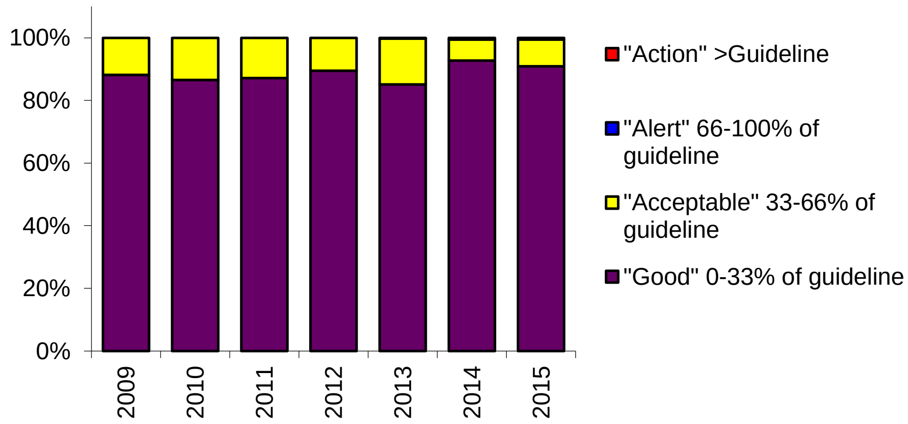

Figure 8-3: Comparison of PM_{10} concentrations measured at the Turangi site from 2009 to 2015 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations for 2015 are shown in Figure 8.4.

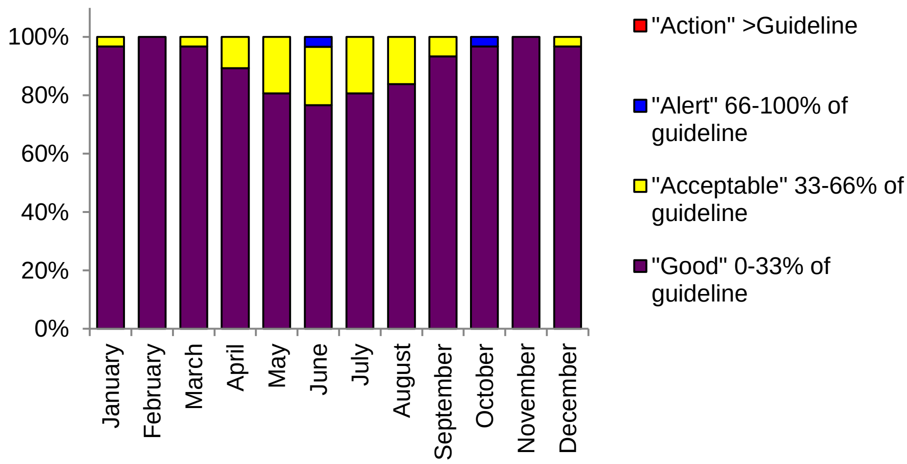

Figure 8-4: Comparison of daily PM_{10} concentrations each month for 2015 to air quality indicator categories.

Figure 8.5 shows that there have been no exceedances of 50 µg/m^3 over the monitoring period 2009 to 2015. While the maximum PM_{10} concentrations measured at the site of 40 and 41 µg/m^3 have occurred recently in 2014 and 2015, analysis of the data (e.g., Figure 8.3) is not indicative of a worsening trend. It is likely that the higher maximum concentrations during 2014 and 2015 occurred as a result of meteorological conditions more conducive to elevated concentrations.

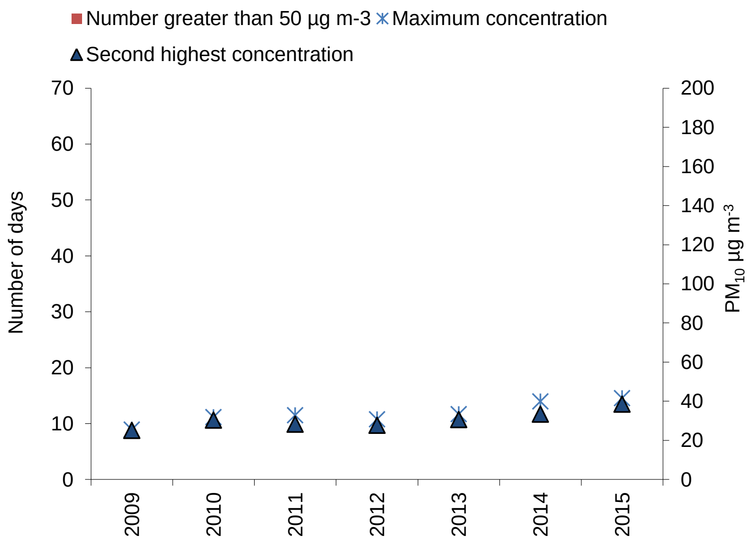

Figure 8-5: Number of days when 50 µg/m³ was exceeded compared with the maximum concentration and the 2nd highest concentration measured from 2009 to 2015.

The annual average PM_{10} concentration for Turangi for 2015 is 10 µg/m³ and is consistent with previous years. The Ministry for the Environment specifies an annual average guideline for PM_{10} of 20 µg/m³ (MfE, 2002). Table 8.1 shows summary statistics for PM_{10} monitoring results from 2009 to 2015.

Table 8-1: Summary of PM_{10} concentrations measured at the Turangi monitoring site from 2009 to 2015.

Indicator	2009	2010	2011	2012	2013	2014	2015
Good (0-33% of guideline)	88%	87%	87%	90%	85%	89%	91%
Acceptable (33-66% of guideline)	12%	13%	13%	10%	15%	7%	9%
Alert (66-100% of guideline)	0%	0%	0%	0%	0%	1%	1%
Action > guideline	0%	0%	0%	0%	0%	0%	0%
Percentage of valid data	79%	84%	85%	99%	100%	95%	99%
Annual average (µg/m3)	9.8	10.8	10.2	10.0	10.8	9.9	10.0
Measured exceedances	0	0	0	0	0	0	0
99.7 %ile concentration	25	30	28	28	31	33	37
Annual maximum (µg/m3)	25	32	33	31	33	40	41
Number of records	288	305	312	362	363	346	362
2nd highest (µg/m3)	25	30	28	28	31	33	38

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.

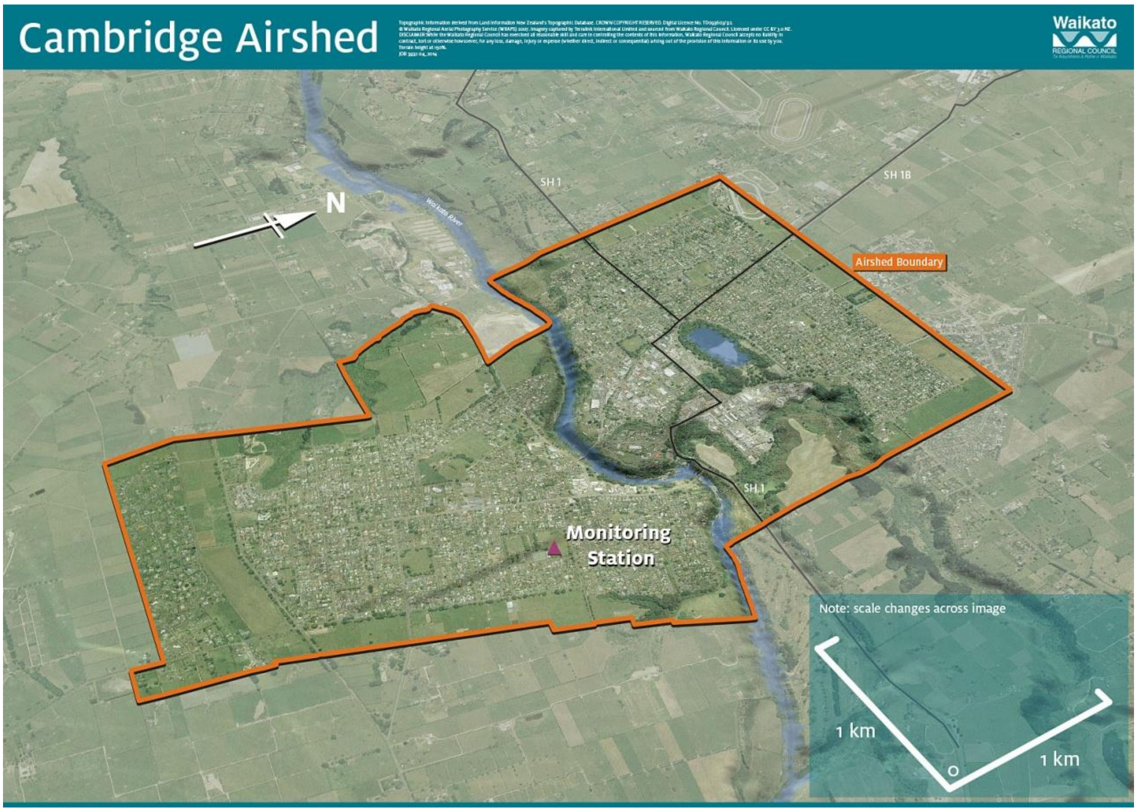

Figure 9-1: Cambridge Airshed and air quality monitoring site.

9.2 PM_{10} concentrations in Cambridge

Daily average PM_{10} concentrations measured at the Leamington Domain site during 2015 are shown in Figure 9.2. The maximum concentration in Cambridge was 31 µg/m^3 (24-hour average) and was measured in October. During 2014 the maximum concentration was 42 µg/m^3 and was recorded during March. No exceedances of 50 µg/m^3 have been recorded since monitoring commenced in 2013.

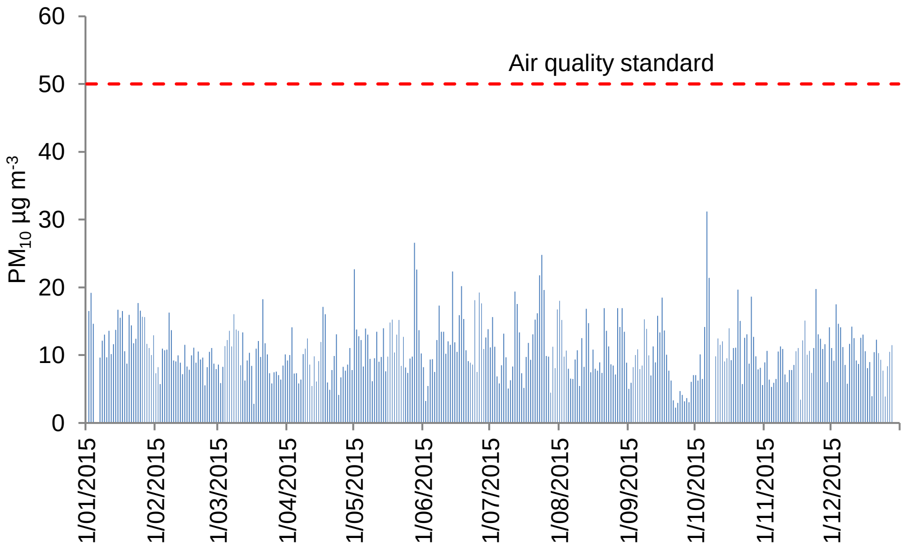

Figure 9-2: Daily average PM_{10} concentrations measured at Cambridge during 2015.

Figure 9.3 shows concentrations of PM_{10} relative to air quality indicator categories at Cambridge from 2013-2015. In 2015, 90% of days experienced PM_{10} concentrations within the 'good' category with the remaining 10% falling within the "acceptable" category.

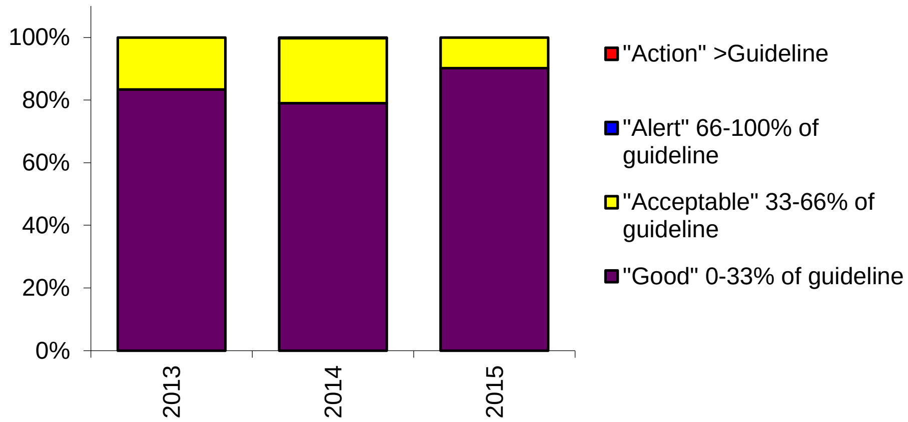

Figure 9-3: Comparison of PM_{10} concentrations measured at the Cambridge site from 2013 to 2015 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations for 2015 are shown in Figure 9.4.

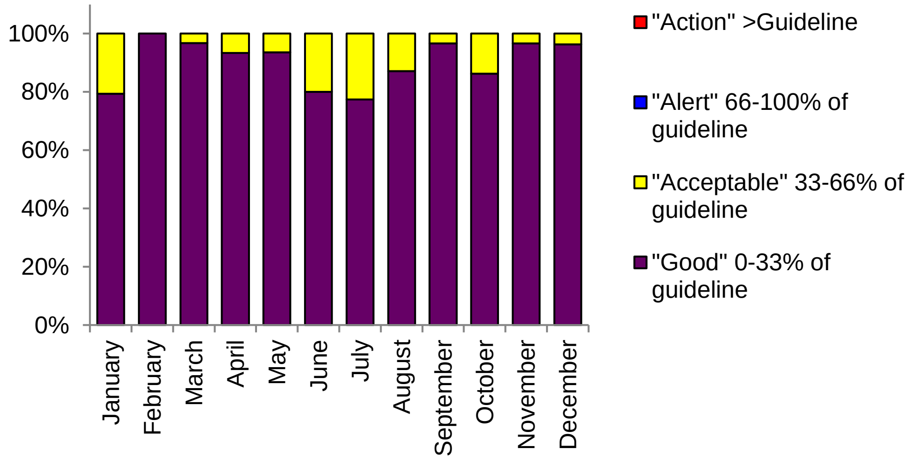

Figure 9-4: Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.

The annual average PM_{10} concentration for 2015 of 10.8 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 2015 are shown in Table 9.1.

Table 9-1: Summary of PM_{10} concentrations measured at the Cambridge monitoring site from 2013 - 2015.

Indicator	2013	2014	2015
Good (0-33% of guideline)	83%	79%	90%
Acceptable (33-66% of guideline)	17%	21%	10%
Alert (66-100% of guideline)	0%	0.3%	0%
Action (> guideline)	0%	0%	0%
Percentage of valid data	59%	99%	98%
Annual average (µg/m^3)	11.8	12.4	10.8
Measured exceedances	0	0	0
99.7 %ile PM_{10} conc. (µg/m^3)	26	30	26
Annual maximum (µg/m^3)	28	42	31
Number of records	216	361	357
2nd highest conc. (µg/m^3)	26	30	27

10 Te Awamutu-Kihikihi

10.1 Air quality monitoring in Te Awamutu-Kihikihi

Te Awamutu is located approximately 30 km south of Hamilton and has 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.

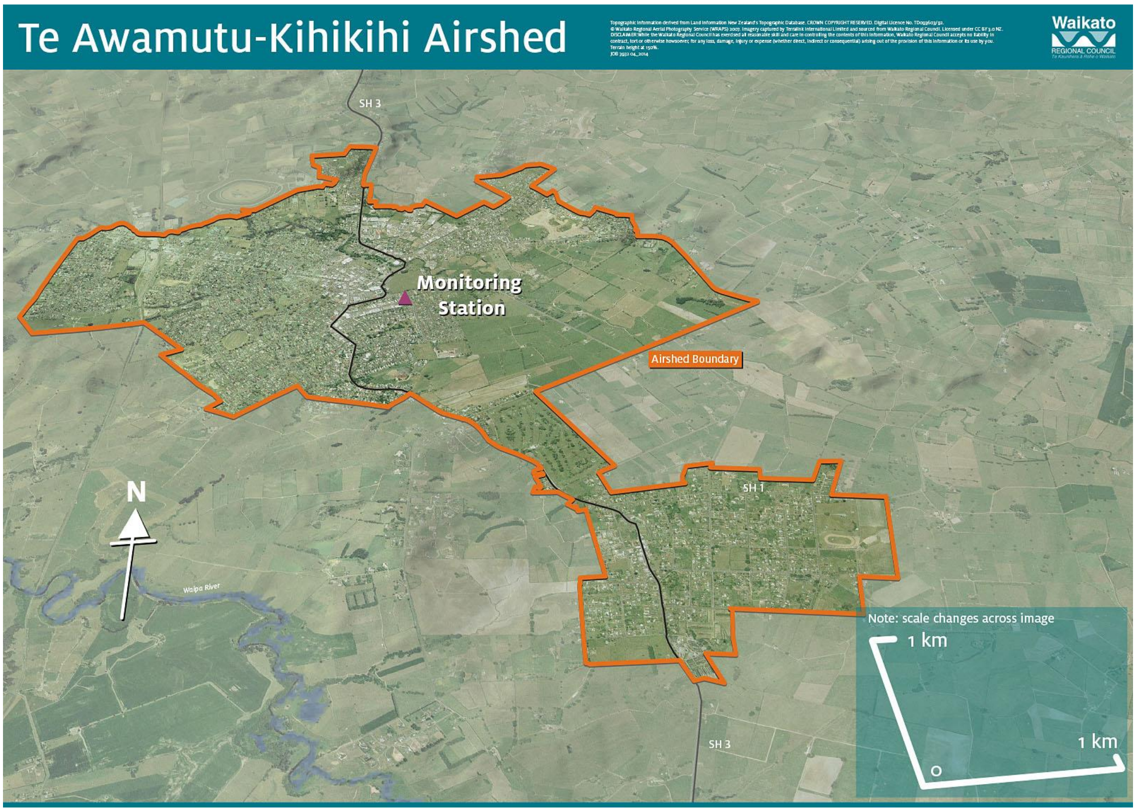

Figure 10-1:Te Awamutu-Kihikihi Airshed and air quality monitoring site.

10.2 PM_{10} concentrations in Te Awamutu-Kihikihi

Figure 10.2 shows the daily average PM_{10} concentrations measured at the Albert Park site for 2015. The maximum concentration in Te Awamutu was 34 µg/m^3 (24-hour average) and is similar to 2013 and 2014 maximums. No exceedances of 50 µg/m^3 have been recorded at the site since monitoring commenced.

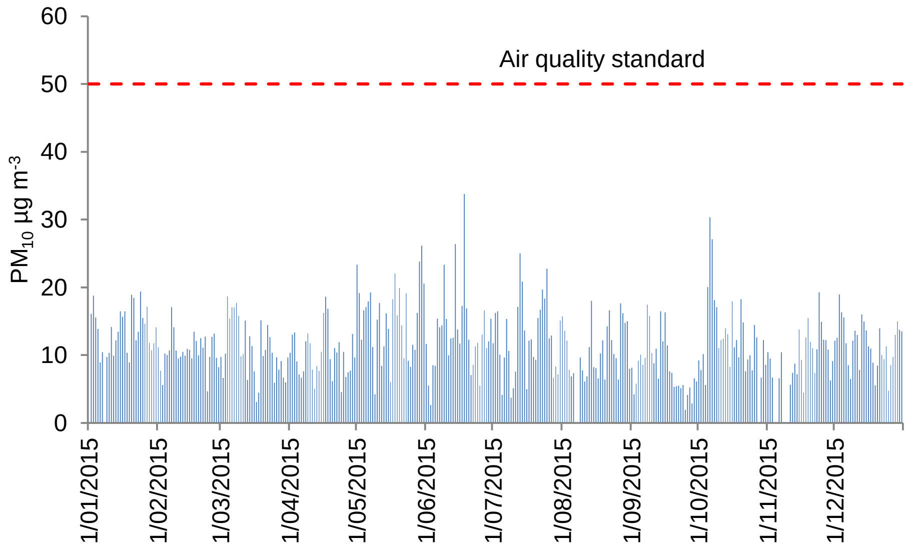

Figure 10-2: Daily average PM_{10} concentrations measured at Te Awamutu during 2015.

Figure 10.3 shows concentrations of PM_{10} relative to air quality indicator categories at Te Awamutu from 2013 to 2015. In 2015, 85% of days experienced PM_{10} concentrations within the 'good' category. On all other days, but one which fell within the "alert" category, PM_{10} was within the "acceptable" category.

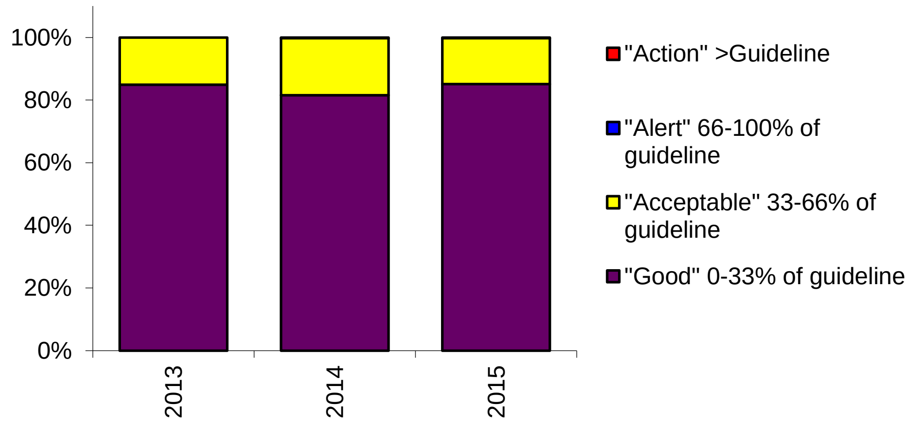

Figure 10-3: Comparison of PM_{10} concentrations measured at the Te Awamutu site from 2013 to 2015 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations for 2015 are shown in Figure 10.4.

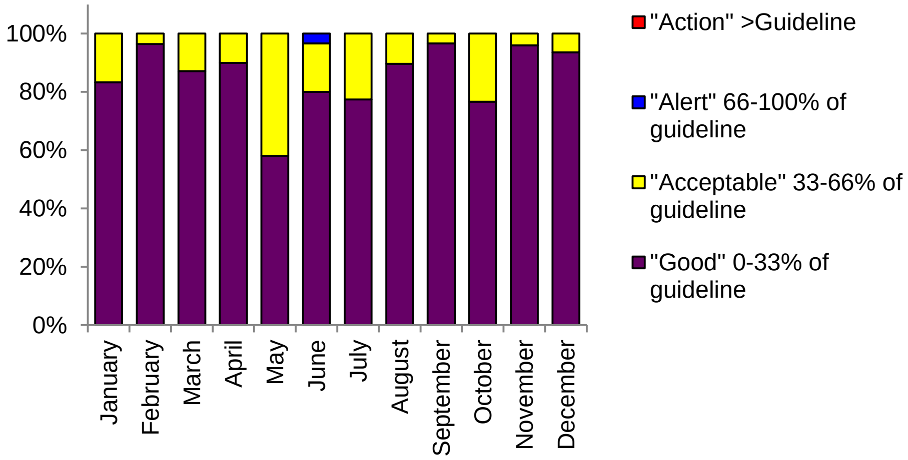

Figure 10-4: Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.

The annual average PM_{10} concentration for 2015 of 11.8 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 2015 are shown in Table 10.1.

Table 10-1: Summary of PM_{10} concentrations measured at the Te Awamutu monitoring site from 2013 - 2015.

Indicator	2013	2014	2015
Good (0-33% of guideline)	85%	82%	85%
Acceptable (33-66% of guideline)	15%	18%	15%
Alert (66-100% of guideline)	0%	0.3%	0%
Action (> guideline)	0%	0%	0%
Percentage of valid data	51%	99%	98%
Annual average (µg/m^3)	11.8	12.3	11.8
Measured exceedances	0	0	0
99.7 %ile PM_{10} conc. (µg/m^3)	28	30	30
Annual maximum (µg/m^3)	32	38	34
Number of records	186	362	356
2nd highest conc. (µg/m^3)	25	30	30

11 Morrinsville

Morrinsville is located approximately 30 km northeast of Hamilton with a population of approximately 7000. The air quality monitoring site for Morrinsville is located at Morrinsville College in the vicinity of North Street and was established in May 2015. A 5014i BAM is used to measure PM_{10} concentrations at this site.

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). Figure 11.1 shows the Morrinsville Airshed and the location of the monitoring site at Morrinsville College.

Figure 11-1: Morrinsville Airshed and air quality monitoring site.

11.1 PM_{10} concentrations in Morrinsville

Daily average PM_{10} concentrations at Morrinsville are shown in Figure 11.2. The maximum concentration was 45 µg/m^3 (24-hour average) and was measured on the 12 July 2015. No previous monitoring for PM_{10} has been carried out in Morrinsville.

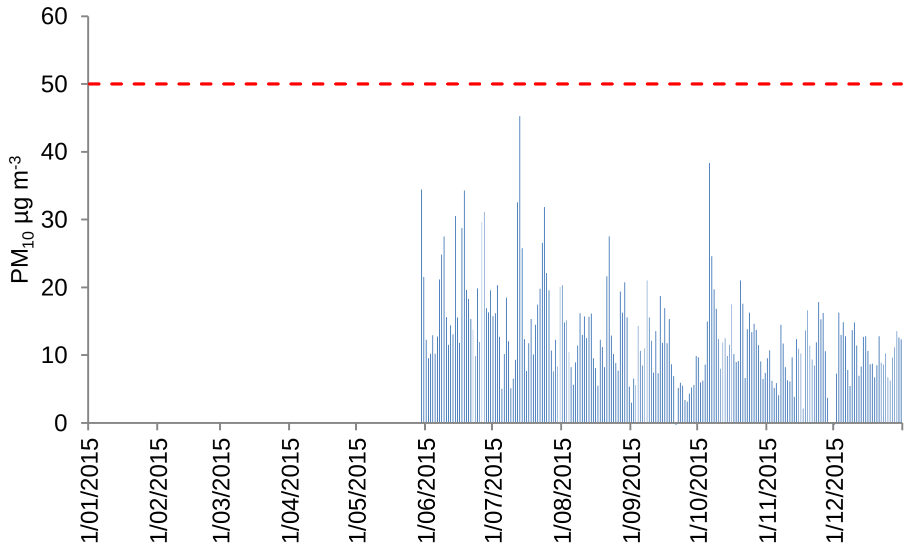

Figure 11-2: Daily average PM_{10} concentrations measured at Morrinsville during 2015.

Figure 11.3 shows concentrations of PM_{10} relative to air quality indicator categories at Morrinsville for 2015. In 2015, 80% of days experienced PM_{10} concentrations within the 'good' category, 18% within the acceptable category and 2% within the alert category.

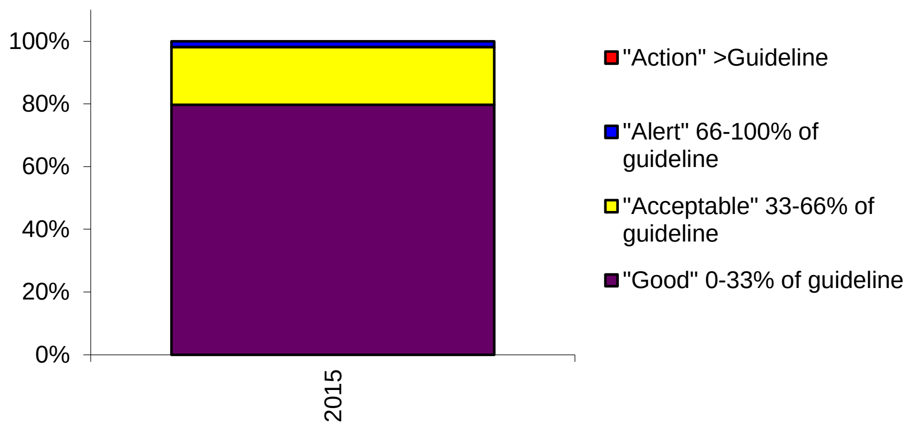

Figure 11-3: Comparison of PM_{10} concentrations measured at the Morrinsville site in 2015 to air quality indicator categories.

Seasonal variations in the distribution of PM_{10} concentrations for 2015 are shown in Figure 11.4.

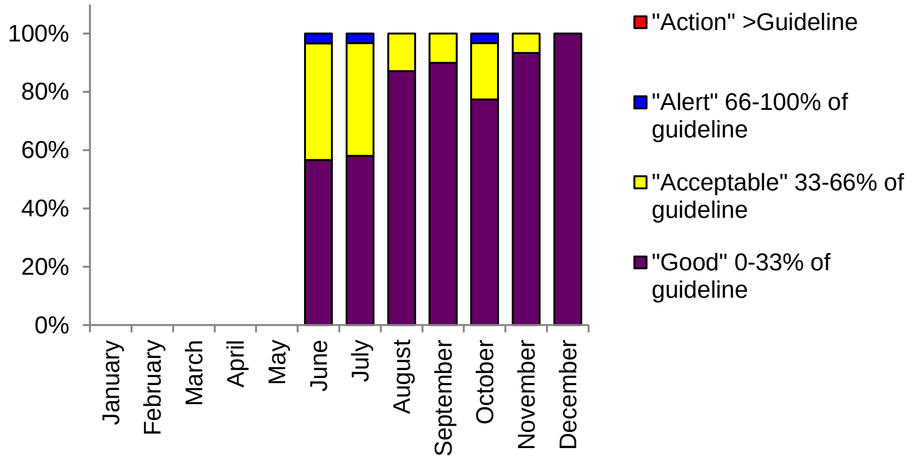

Figure 11-4: Comparison of daily PM_{10} concentrations each month during 2015 to air quality indicator categories.

The estimated annual average[6] PM_{10} concentration for 2015 for Morrinsville is 12 µg/m^3. 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 2015 are shown in Table 11.1.

Table 11-1: Summary of PM_{10} concentrations measured at the Morrinsville monitoring site for 2015.

Indicator	2015
Good (0-33% of guideline)	80%
Acceptable (33-66% of guideline)	18%
Alert (66-100% of guideline)	2%
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)	41
Annual maximum (µg/m^3)	45
Number of records	217
2nd highest concentration (µg/m^3)	38

[6] As monitoring commenced in May a seasonally adjusted average was made by multiplying the September- December average by two (assuming it is representative of January – April) and averaging with the winter average PM_{10} (ie (1 x May – August average + 2 x September – December average)/3)

12 Summary

During 2015 PM_{10} concentrations were measured at air quality monitoring sites in Hamilton, Tokoroa, Taupo, Te Kuiti, Putaruru, Turangi, Cambridge, Te Awamutu-Kihikihi and Morrinsville. Concentrations of $PM_{2.5}$, benzene, toluene, xylenes and ethylbenzene were measured in Hamilton and $PM_{2.5}$ was measured in Tokoroa.

More than one exceedance of 50 µg/m^3 as a 24-hour PM_{10} average (rolling 12-month period) constitutes a breach of the NESAQ.

In 2015 the NES for PM_{10} was breached nine times in Tokoroa. There were no breaches in any of the other airsheds. Concentrations of PM_{10} were within the annual average guideline of 20 µg/m^3 in all airsheds.

Table 12.1 summarises worst case 24-hour average PM_{10} concentrations, number of exceedances of 50 µg/m^3 and the annual average PM_{10} concentrations in all airsheds.

Table 12-1: Summary of PM_{10} monitoring results for 2015.

Site	Maximum measured concentration (µg/m^3)	Measured exceedances	Number of NES breaches	Annual Average (µg/m^3)
Hamilton (Claudelands)	35	0	0	11
Hamilton (Ohaupo Rd)	39	0	0	13
Tokoroa	69	10	9	17
Taupo	44	0	0	13
Te Kuiti	49	0	0	15
Putaruru	50	0	0	14
Turangi	41	0	0	10
Cambridge	31	0	0	11
Te Awamutu-Kihikihi	34	0	0	12
Morrinsville	45	0	0	12

Table 12.2 shows the average exceedences at Hamilton, Tokoroa, Taupo, Putaruru and Te Kuiti over a five year period and provides an indication of likely trends in PM_{10} concentrations. Based on historical monitoring, these airsheds have the greatest potential for particulate pollution.

Trend assessment using statistical analysis of seasonal PM_{10} data indicates that concentrations have decreased in Hamilton, Te Kuiti and Taupo over the previous six or more year period. No statistically significant change has been identified for Tokoroa and the previous decreasing trend identified for Putaruru is no longer significant. 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 12-2: Five year exceedance average and trend analysis for the five worst airsheds.

Airshed	Five year exceedance average (2010 to 2015)	Trend
Hamilton	0.4	Decrease[1]
Tokoroa	11.8	No change
Taupo	0.6	Decrease
Te Kuiti	0.4	Decrease
Putaruru	0.6	No change

1. Based on data collected up to 2013 from Peachgrove Rd only.

A comparison of the changes in the five year exceedance average for the four polluted airsheds and Hamilton airshed is provided in Figure 12.1 which indicates that the exceedance averages have been decreasing in all five airsheds.

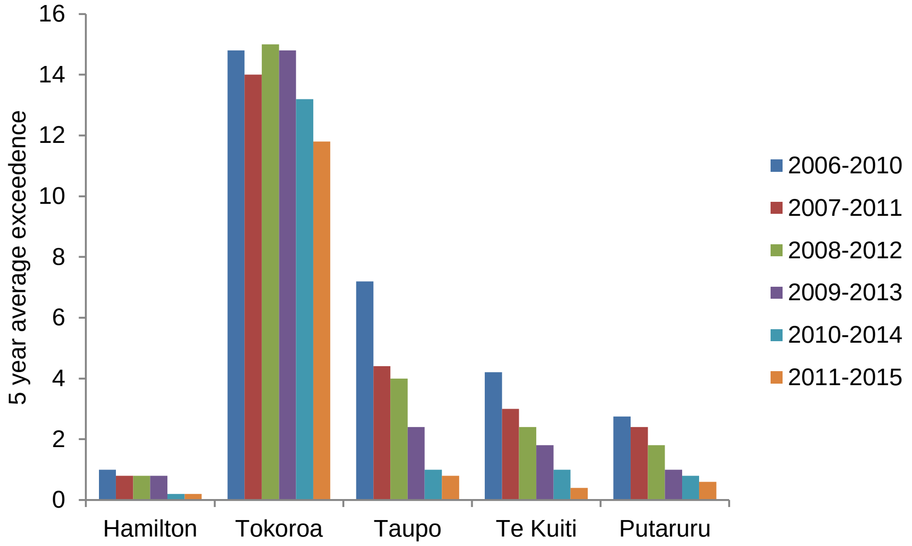

Figure 12-1: Comparison of changes in the annual exceedance averages (per 5 year period) for Hamilton, Tokoroa, Taupo, Te Kuiti and Putaruru.

Of the smaller urban areas Morrinsville appears to have the greatest potential for air quality issues with the highest maximum PM_{10} concentration for 2015 and the greatest proportion of concentrations falling outside of the "good" air quality category.

The highest annual average concentration for benzene of 2.3 µg/m^3 was measured at the Greenwood Street monitoring site in Hamilton and is lower than the Ministry for the Environment's annual guideline of 3.6 µg/m^3. 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.

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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	**WRC Document Reference Number**
Hamilton BTEX	4057485
Hamilton (Peachgrove Rd & Claudelands) PM_{10} & $PM_{2.5}$	4075275
Hamilton (Ohaupo Rd) PM_{10}	4082579
Hamilton Meteorology	4055698
Taupo PM_{10}	4076082
Taupo Normalisation	3380658
Taupo Meteorology	4278908
Tokoroa PM_{10}	4072838
Tokoroa Normalisation	3139620
Tokoroa Meteorology	4055701
Te Kuiti PM_{10}	4055700
Te Kuiti Meteorology	1026996
Cambridge PM_{10}	4215479
Te Awamutu PM_{10}	3005650
Putaruru PM_{10}	4057094
Turangi PM_{10}	4251671
Morrinsville PM_{10}	3676031