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Environment
Manatū Mō Te Taiao

GEMS/AMIS Air Quality Monitoring Programme Annual Report 2010

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by

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1 Summary

This report contains the 2010 annual ambient air quality data set, measured from Auckland and Christchurch. The parameters form New Zealand's contribution to the Global Environmental Monitoring System (GEMS) run by the World Health Organization (WHO). The WHO stopped aggregating international air quality information from GEMS in 2006.

The GEMS monitoring sites were established to measure key air pollutants associated with adverse effects on people's health and wellbeing. The GEMS sites have provided monitoring data for Auckland and Christchurch, and have recorded trends in pollution levels in two of New Zealand's largest cities.

The Gavin Street, Penrose site in Auckland is representative of primarily vehicle and industrial emissions. The Greers Road, Burnside site in Christchurch is located within a residential area and represents emissions primarily from domestic properties. Air quality monitoring conducted by MfE under the GEMS programme is scheduled to end in June 2011 for the Auckland site and December 2010 for the Christchurch sites.

Air pollutants arise from a number of different sources. The pollutants monitored at the GEMS sites include:

- particulate matter (PM_{10}) – principally from domestic heating, vehicle emissions and industrial processes (as well as natural processes)
- nitrogen oxides (NO and NO_2) – mostly from motor vehicle emissions
- sulfur dioxide (SO_2) – from the burning of fossil fuels, particularly coal and oil
- carbon monoxide (CO) – from incomplete combustion of carbon containing fuels, especially from motor vehicles
- total suspended particulates (TSP) – from various chemical and physical processes including all particulates less than 100 µm in aerodynamic diameter
- volatile organic compounds (VOCs) – organic chemicals, such as hydrocarbons, that are closely tied to vehicle emissions and many industrial processes
- lead (Pb) – historically from petrol but since the removal of lead in petrol from 1996, levels have declined in New Zealand.

Ambient air quality standards for CO, NO_2, SO_2, PM_{10} and ozone were promulgated in October 2004. The purpose of these standards is to provide a guaranteed level of protection for the health of all New Zealanders.[1] These standards are based largely on the ambient air quality guidelines (AAQG) developed in 1994 and revised in 2002. Guideline levels for pollutants (and averaging periods) not covered by the standards still apply.

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[1] Ministry for the Environment. 2005. *Updated Users Guide to Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) Regulations 2004*. Wellington: Ministry for the Environment.

All air pollutants monitored at the MfE sites (with the exception of Greers Road, Burnside) were below the National Environmental Standards (NES) for Air Quality as well as the ambient air quality guidelines (AAQG) for all averaging periods. The Greers Road, Burnside site had eight exceedences of the 24-hour standard for PM_{10}, mainly during the colder months from June to July 2010. These exceedences were most likely due to home heating emissions. The NES for air quality allows for one exceedence of the PM_{10} 24-hour threshold per year before the standard is breached, meaning the Greers Road, Burnside site breached the PM_{10} standard on seven occasions.

2 Introduction

This report presents the 2010 ambient air quality data set from the GEMS monitoring programme for Auckland and Christchurch, New Zealand. The monitoring is conducted by Watercare Services Limited (Watercare), on behalf of the Ministry for the Environment (MfE).

This data has historically formed New Zealand's contribution to the World Health Organization's (WHO) Global Environmental Monitoring System / Air Pollution Programme (GEMS/AIR) which began in 1973.[2]

In 1996, WHO developed the Air Management Information System (AMIS) the successor to GEMS/AIR. The objective of AMIS is to transfer information on air pollutant concentrations and air quality management between countries. The WHO ceased aggregating international air quality information in 2006. The monitoring from the AMIS programme is used by MfE to support air quality monitoring and management in Auckland and Christchurch.

The Auckland site is located in the industrial area of Penrose to the south-east of the city centre. Air quality monitoring has been conducted in Penrose since 1964 (TSP and Pb) and MfE's monitoring at this site is scheduled to be decommissioned in July 2011. Previously, there were monitoring sites in Mt Eden and Kingsland, both of which are older residential areas just south of the city centre. Monitoring at Mt Eden was conducted between 1982 and 2004. In October 2004 the Mt Eden site was decommissioned pending redevelopment of the land and replaced by the Kingsland site at Kowhai Intermediate. In September 2007, the Kowhai, Kingsland site was decommissioned due to the construction of a swimming pool complex.

Christchurch monitoring from 1989 to 2002 monitoring was undertaken at a site located in the older residential area of St Albans which is just north of the city centre. The monitoring station was relocated in November 2002 due to impending redevelopment of the site. The current site is in Burnside / Bishopdale which is a newer residential area to the north-west of the city centre. This Burnside air quality monitoring site was decommissioned in January 2011.

Environment Canterbury provided sampling services for MfE for gravimetric and passive monitoring methods at the Christchurch sites (Coles Place, St Albans and Greers Road Burnside). This type of monitoring also ceased in January 2011.

This report includes graphical and statistical presentations of the data as well as any data collection issues that may have arisen during the monitoring period.

All data in this report has been validated. Quality assurance checks have been carried out to ensure that invalid and calibration data is not reported.

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[2] Schwela DH. 1999. Public Health and the air management information system (AMIS). *Epidemiology*, 10(5), 647-655.

3 Air Pollutants Monitored

3.1 Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless, toxic gas formed as a product of incomplete combustion in the burning of fossil fuels. The main sources of carbon monoxide in most urban areas are vehicle exhaust emissions and home heating.[3] Elevated concentrations are mainly found in areas of significant traffic congestion, particularly at busy intersections on inner-city streets.

Carbon monoxide inhibits oxygen uptake in the blood. Prolonged exposure at moderate levels can lead to symptoms such as headaches and dizziness, while at high levels it can lead to loss of consciousness and even death.

3.2 Nitrogen oxides

Nitrogen oxides incorporate several substances that exist in the atmosphere, which are collectively referred to as NO_x. The two main oxides are nitrogen dioxide (NO_2) and nitric oxide (NO). NO is less toxic than NO_2 but may oxidise to NO_2 in the atmosphere.

Nitrogen oxides are formed in most combustion processes by oxidation of the nitrogen present in the atmosphere. Nitric oxide is the predominant primary product but, as indicated, this can then be oxidised to nitrogen dioxide in ambient air. Emissions from motor vehicles are the major source of NO_x in most parts of the country, although power stations and other large combustion units may be significant localised sources as well.[4]

NO_x is also an important air pollutant because of its role in photochemical smog. NO_2 is a reddish brown gas, and has synergistic health effects with other pollutants such as SO_2 and particulate matter.

The main health effects of the oxides of nitrogen are due to NO_2, which is a respiratory irritant. Nitric oxide is believed to be quite harmless at the levels normally encountered in urban air.

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[3] Ministry for the Environment. 2007. *Environment New Zealand 2007*. Wellington: Ministry for the Environment.

[4] Ministry for the Environment. 2003. *Emission Inventories for CO, NOx, SO2, ozone, benzene and benzo(a)pyrene in New Zealand*. http://www.mfe.govt.nz/publications/air/air-quality-tech-report-44-nov03/index.html

3.3 Sulfur dioxide

Sulfur dioxide is an acidic gas with a pungent odour which is mainly produced by the burning of fossil fuels. The gas is quite corrosive and can cause damage to buildings and other materials.

It can also have significant effects on the human respiratory system. Inhalation of high ambient concentrations of sulfur dioxide can cause stimulation of the nerves in the air passages, resulting in a reflex cough, irritation and chest tightness.

In addition, sulfur dioxide can also cause narrowing of the air passages, particularly in people suffering from asthma and chronic lung disease. These people frequently have narrowed airways and any further restriction will have a more significant effect compared to people with uncompromised respiratory systems.

3.4 Volatile organic compounds

Volatile organic compounds (VOCs) are chemicals that easily evaporate at room temperature. The term ‘organic’ indicates that the compounds contain carbon. VOCs include a wide range of carbon-based molecules, such as some aldehydes, ketones and hydrocarbons.

The Ministry for the Environment has compiled a list of priority contaminants, based on a review of international literature. The priority list includes the VOCs benzene and 1,3-butadiene and provides ambient air quality guidelines for these contaminants.[5] VOCs can produce neurological impairment, and benzene is well established as a carcinogen.

3.5 Particulate matter

Particulate matter (PM) can be a significant air pollutant that is associated with a variety of health and environmental effects.

Sources of particulates vary widely from location to location reflecting the wide range of emission sources that contribute to particulate concentrations in New Zealand. Typical sources of various particulate sizes can include:

- Fine particulates (less than 2.5 µm) emitted as a result of incomplete fuel combustion from road vehicles, power generation, industrial processes and domestic heating appliances. Fine particulates also form by chemical reactions in the atmosphere. These comprise largely of sulfates and nitrates.
- Coarse particulates (between 2.5 and 10 µm) that arise from a wide range of sources, including re-suspended dust from road vehicles, construction works, mineral extraction processes, wind-blown dust and soils, sea salt and biological particulates such as pollen and fungal spores.

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[5] Ministry for the Environment. 2002. *Ambient Air Quality guidelines – 2002 Update.* Wellington: Ministry for the Environment.

Particulate matter refers to numerous substances that exist in the atmosphere. It is a somewhat complex pollutant, encompassing a wide range of chemically and physically diverse substances. Particulate matter includes all solid and liquid aerosols that exist in ambient conditions.

As part of the GEMS/AMIS programme two particle size fractions are monitored:

- particulate matter less than 10 µm (PM_{10})
- total suspended particulates (TSP).

3.5.1 Particulate matter as PM_{10}

The main effect of PM_{10} is on human health as PM_{10} can be inhaled into the respiratory system. PM_{10} can become deposited in the trachea bronchial region, where asthma attacks are triggered.

3.5.2 Total suspended particulate

TSP consists of all particles which range in size up to 100 µm in diameter. TSP is sufficiently small enough to be inhaled; however, the larger particles (10–100 µm) are readily filtered out in the nasal cavity. TSP has an effect on both the aesthetic and health qualities of ambient air.

3.6 Lead

Lead is a toxic metal present in the atmosphere in its elemental form and one of the principal sources has been motor vehicle emissions. Historically, lead was included in petrol as a catalyst for combustion, but has been removed from fuel supplies since 1996.

As a result, atmospheric concentrations of lead have dropped markedly since this time. To reflect this, from October 2000 monitoring of lead was reduced from monthly samples to samples taken over a 3-month period during winter (June–August) only.

Health effects of lead in air are caused when the small particulates are inhaled or swallowed. It can harm the central nervous system, kidneys, and blood cells. Growing children and foetuses are more at risk resulting in possible physical and mental problems.

4 Ambient Air Quality Guidelines and Standards

In October 2004, the Ministry for the Environment introduced the National Environmental Standards (NES) for Air Quality. The NES includes five standards for ambient (outdoor) air quality. Four of these standards and some New Zealand guidelines are described in Table 1 below. The fifth standard is not included as it relates to ozone, which is not measured at the sites discussed in this report.

The criteria used for TSP, 60 $\mu g/m^3$ (seven-day average), was previously used by the Ministry of Health (MoH). This has been superseded by the ambient air quality guidelines but is still useful for analysing the results of the monitoring data.

Table 1: National environmental standards and guidelines[6]

Air pollutant	Averaging period	National Environmental Standards 2004	Ministry for the Environment Ambient Air Quality Guidelines 2002 and other	National Environmental Standards permissible excess
Carbon monoxide	8-hour average	10 mg/m^3	10 mg/m^3	One 8-hour period in a 12-month period
	1-hour average		30 mg/m^3	
Nitrogen dioxide	24-hour average		100 $\mu g/m^3$	
	1-hour average	200 $\mu g/m^3$	200 $\mu g/m^3$	9 hours in a 12-month period
Sulfur dioxide	24-hour average		120 $\mu g/m^3$	
	1-hour average	350 $\mu g/m^3$	350 $\mu g/m^3$	9 hours in a 12-month period
	1-hour average	570 $\mu g/m^3$		Not to be exceeded at any time
Benzene				
– Year 2002	Annual average		10 $\mu g/m^3$	
– Year 2010	Annual average		3.6 $\mu g/m^3$	
1,3-Butadiene	Annual average		2.4 $\mu g/m^3$	
Fine particulate (PM_{10})	Annual average		20 $\mu g/m^3$	
	24-hour average	50 $\mu g/m^3$	50 $\mu g/m^3$	One 24-hour period in a 12-month period
Total suspended particulate (TSP)	7-day average		60 $\mu g/m^3$ (MoH)	
Lead	3-month average		0.2 $\mu g/m^3$	

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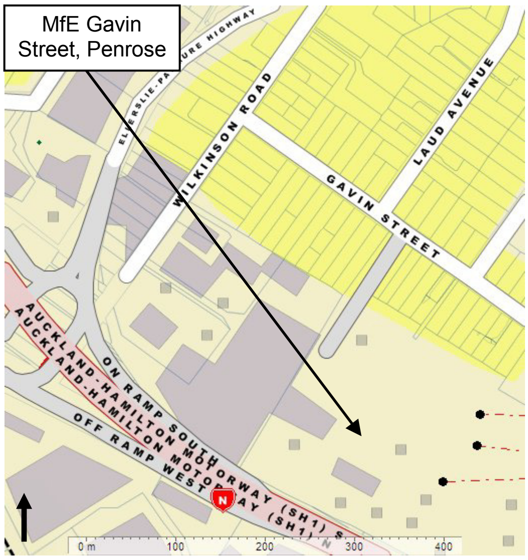
[6] Source: http://www.mfe.govt.nz/laws/standards/air-quality-standards.html.

5 Monitoring Sites

5.1 Site descriptions

A brief description of all the monitoring sites in the GEMS/AMIS air quality monitoring programme is given below. This includes one Auckland site at Gavin Street in Penrose and two sites in Christchurch at Greers Road in Burnside and Coles Place in St Albans. (Note at Coles Place, only TSP, Lead and VOCs are monitored by MfE).

5.1.1 MfE Gavin Street, Penrose, Auckland – Site AKL009

Site name	MfE Gavin Street, Penrose	**Site ID**	AKL009	
Address	Transpower, Gavin Street, Penrose, Auckland	**Site class**	Industrial – dense Traffic – peak	
Description This site is operated by Watercare and is located within the grounds of the Transpower NZ Ltd electrical substation on Gavin Street, Penrose. It is representative of road, vehicle and industrial emissions in the Penrose area which lies to the southeast of Auckland City and is also approximately 120 metres northeast of the Southern Motorway. There are residential properties immediately to the northeast of the site. During 2003, parallel monitoring was undertaken between this site and the neighbouring ACI site on Great South Road, in Penrose with a view to consolidating all monitoring at the Gavin Street site early in 2004. Other pollutants measured at this site by Auckland Council will continue to be measured.				
Pollutants monitored by MfE	**CO** N	**NO$_2$** Y	**SO$_2$** Y	**VOCs** Y
	PM$_{10}$ Y	**TSP** Y	**Lead** Y	
Meteorological parameters monitored	**Wind speed** Y	**Wind direction** Y	**Relative humidity** Y	
	Temperature (6m) Y	**Temperature (10m)** N	**Temperature (1.5m)** N	
Location map  	**Photograph** 			

5.1.2 MfE Greers Road, Burnside, Christchurch – Site CAN002

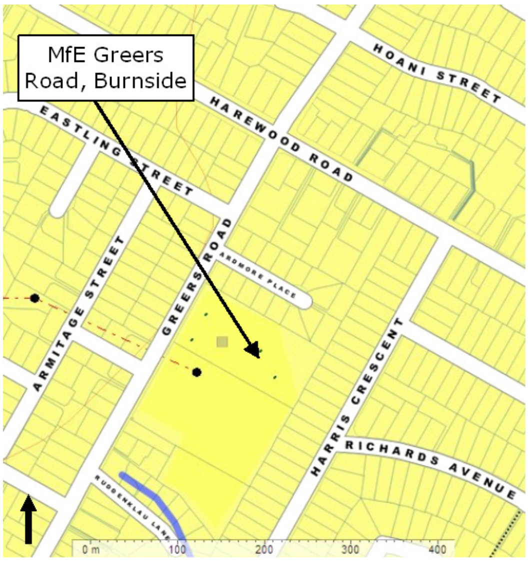
Site name	MfE Greers Road, Burnside	**Site ID**	CAN002
Address	Transpower, Greers Road, Burnside, Christchurch	**Site class**	Residential – neighbourhood

Description

This site is operated by Watercare and is located in a paddock to the rear of the Transpower NZ Ltd electrical substation on Greers Road, and is surrounded by residential properties on four sides. Greers Road is approximately 100 metres to the north west of the site. It is representative of emissions arising from domestic properties in the newer suburban areas of Burnside and Bishopdale which lie to the northwest of Christchurch city centre. The site was commissioned in November 2002 and replaces the former GEMS/AMIS site which was located off Madras Street, St Albans. The site was decommissioned in January 2011.

Pollutants monitored by MfE	**CO**	**NO$_2$**	**SO$_2$**	**VOCs**
	Y	Y	Y	Y
	PM$_{10}$	**TSP**	**Lead**	
	Y	N	N	
Meteorological parameters monitored	**Wind speed**	**Wind direction**	**Relative humidity**	
	Y	Y	Y	
	Temperature (6m)	**Temperature (10m)**	**Temperature (1.5m)**	
	N	Y	Y	

Location map



Photograph

5.1.3 MfE Coles Place, St Albans, Christchurch – Site CAN003

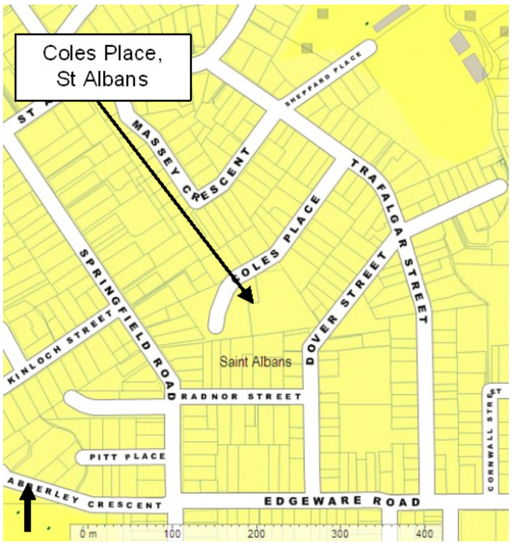
Site name	MfE Coles Place, St Albans	**Site ID**	CAN003
Address	Coles Place, St Albans, Christchurch	**Site class**	Residential – neighbourhood

Description

This site is operated by Environment Canterbury and is located on an area of public open space at the end of Coles Place. It is surrounded by residential properties on four sides. It is representative of emissions arising from domestic properties in the older suburban area of St Albans which lies to the north of Christchurch city centre. As of January 2011 the MfE ceased VOC, TSP and lead monitoring. Other pollutants are continued to be monitored at this site by Environment Canterbury.

Pollutants monitored by MfE	**CO**	**NO_2**	**SO_2**	**VOCs**
	N	N	N	Y
	PM_{10}	**TSP**	**Lead**	
	N	Y	Y	
Meteorological parameters monitored	**Wind speed**	**Wind direction**	**Relative humidity**	
	N	N	N	
	Temperature (6m)	**Temperature (10m)**	**Temperature (1.5m)**	
	N	N	N	

Location map



Photograph

5.2 Air pollutants monitored under the GEMS/AMIS programme

An overview of the air pollutants monitored at each site during 2010, as part of the GEMS/AMIS programme, is given in Table 2 below.

Table 2: Air pollutants monitored under the GEMS/AMIS programme 2010

Site	CO	NO_2	SO_2	VOC	PM_{10}	TSP	Lead*
Transpower, Gavin Street, Penrose, Auckland AKL009		✓	✓	✓	✓	✓	✓
Greers Road, Burnside, Christchurch CAN002	✓	✓	✓	✓	✓		
Coles Place, St Albans, Christchurch CAN003				✓		✓	✓

Note:

* Lead is measured from the TSP filters collected during the months of June, July and August only.

6 Methods

6.1 Quality assurance

All monitoring services are undertaken by Watercare accordance with the MfE 'Good Practice Guide for Air Quality Monitoring and Data Management' (or GPG) and wherever applicable the appropriate Australian/New Zealand and US EPA monitoring methods.

Watercare is accredited by International Accreditation New Zealand (IANZ) for the following methods:

- AS 3580.7.1-1992 'Method 7.1: Determination of carbon monoxide – direct-reading instrumental method'
- AS 3580.5.1-1993 'Method 5.1: Determination of oxides of nitrogen – chemiluminescence method'
- AS 3580.4.1-2008 'Method 4.1: Determination of sulfur dioxide – direct reading instrumental method'
- AS/NZS 3580.9.3-2003 'Method 9.3: Determination of ambient particulates (gravimetric method) – TSP high volume sampling'
- AS/NZS 3580.9.6-2003 'Method 9.6: Determination of ambient particulates (gravimetric method) – PM_{10} high volume sampling'
- AS 3580.9.11 – 2008 'Method 9.11: Determination of suspended particulate matter – PM_{10} beta attenuation monitors'
- APHA Method 3030 for the lead digest
- US EPA Method 200.8 (modified) for lead analysis by ICPMS.

As part of the GEMS/AMIS programme, Watercare provides the following monitoring services:

- instrument operation, calibration and maintenance. This includes the use of automatic daily calibration systems for all continuous ambient gas monitors ensuring that the requirements of the relevant Australian Standards for weekly calibration of continuous analysers are met
- site maintenance as well as commissioning new sites and decommissioning old sites, when necessary
- data logging, polling, checking, re-scaling, validation, ratification and reporting. This encompasses the entire data quality assurance process ensuring that the final data set reported is fit for the purpose of the GEMS/AMIS programme.

6.2 Analytical methods

6.2.1 Carbon monoxide

Measurements are made in accordance with AS 3580.7.1-1992 ‘Determination of Carbon Monoxide – Direct Reading Instrumental Method’. The performance of the instrument is checked using an automatic calibration system ensuring compliance with the method which requires instrumentation to be calibrated on a weekly basis.

The instrument itself is an infrared absorption gas analyser which continuously measures carbon monoxide. This allows data to be analysed and reported over a variety of average periods, including 10 minute, 24 hour and one year.

6.2.2 Nitrogen oxides

Measurements are made in accordance with AS 3580.5.1-1993 ‘Determination of Oxides of Nitrogen – Chemiluminescence Method’. The performance of the instrument is checked using an automatic calibration system ensuring compliance with the method which requires instrumentation to be calibrated on a weekly basis.

The instruments themselves are chemiluminescence gas analysers which continuously measure nitrogen oxides. This allows data to be analysed and reported over a variety of average periods, including 10 minute, 24 hour and one year.

6.2.3 Sulfur dioxide

Measurements are made in accordance with AS 3580.4.1-2008 ‘Determination of Sulfur Dioxide – Direct Reading Instrumental Method’. The performance of the instrument is checked using an automatic calibration system ensuring compliance with the method which requires instrumentation to be calibrated on a weekly basis.

The instruments themselves are UV fluorescence gas analysers which continuously measure sulfur dioxide. This allows data to be analysed and reported over a variety of average periods, including 10 minute, 24 hour and one year.

6.2.4 Volatile organic compounds (VOCs)

VOCs are measured using passive 3M organic vapour monitor badges, which are exposed for three-month periods (January–March, April–June, July–September and October–December). The VOCs diffuse on to the badges, which are coated with activated carbon. Following exposure, the samples are forwarded to AsureQuality who extract the VOCs using carbon disulfide and analyse them using gas chromatography-mass spectrometry (GC-MS). AsureQuality is IANZ accredited for VOCs by GC-MS using National Institute for Occupational Safety and Health (NIOSH) Method 1500.

The subsequent results are calculated in accordance with the manufacturer's instructions (3M Technical Data Bulletin 1028) allowing results to be converted to standard temperature (0 °C) and pressure (1 atm).

Note: Investigations have determined that samples of 1,3-butadiene are unstable when held above -4.41 °C with significant reverse desorption occurring. Due to the potential for error over a three-month exposure period, 1,3-butadiene has not been analysed and reported. Alternative methods of measuring 1,3-butadiene are OSHA Method 56 and NIOSH Method 1024. Both of these involve the use of solid sorbent coconut charcoal tubes.

6.2.5 Particulate matter as PM_{10}

Measurements are made in accordance with AS 3580.9.11–2008 'Determination of suspended particulate matter – PM_{10} beta attenuation monitors' (BAM). The instrument is fitted with a size-selective PM_{10} head with an inlet temperature of 40 °C. The BAM continuously measures the intensity of beta particles passing through a filter tape. This allows PM_{10} data to be analysed and reported over a variety of average periods, including 10 minute, 24 hour and one year.

6.2.6 Total suspended particulate matter (TSP)

TSP monitoring is in accordance with Watercare's Air Quality Group Test Method T101. The method was based on Australian Standard 2724.2 – 1987 and British Standard 1747 and was developed by the Ministry of Health (MoH). It is a gravimetric method of measuring particulates and is modelled on the system for high volume sampling as described in AS/NZS 3580.9.3-2003.

The equipment used to collect TSP involves ambient air being pulled through a 55 mm glass fibre filter by a vacuum pump. A gas meter is attached and is used to measure the air volume (m^3) drawn through the filter. The filter is held in a cassette and is covered with a rain shelter at 3.5 m above ground. Preweighed filters are collected and sampled on a weekly or 7 day cycle every Thursday.

This method is different to that recommended in the Ministry for the Environment's 'Good Practice Guide for Air Quality Monitoring and Data Management 2010'. The method has been used to measure TSP since 1964 and the results will vary when compared to more modern techniques.

6.2.7 Lead

Lead is sampled during the winter months, June–August, using the same samples acquired to measure TSP. Analysis of lead is performed by Watercare Laboratory Services according to APHA Method 3030 and US EPA Method 200.8 modified. This involves analysing each individual TSP filter exposed during the winter period using mixed acid digestion. This sample is then analysed for lead using ICP-MS. The concentration of lead is then determined from the amount of lead detected and the total volume of air sampled during that sample period. Concentrations are averaged for the 3-month monitoring period.

7 Results and Discussion

7.1 Site performance and quality assurance

Monthly and annual site performance and explanations are shown in Table 3, based on 10 minute averages for continuously monitored data. Per cent of valid data (V) is defined as the per cent of valid data following quality assurance adjustments. Per cent of captured data (C) is the per cent of valid data excluding calibration and maintenance.

The 2000 MfE *Good Practice Guide for Air Quality Monitoring and Data Management* suggests that it is difficult to reach anything close to 100% valid data for long-term monitoring. As such site performance has been evaluated against a target of 95% for capture data and 75% for valid data.

The performance of continuously monitored pollutant instruments during 2010 was generally very good. All sites had annual valid data greater than 75% and data capture rates greater than 95% with the exception of one VOC sample at Burnside.

Table 3: Percentage valid and capture data 2010

Analyte	Site	Percentage valid data (V) and percentage data capture (C)																									
		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Annual	
		V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C	V	C
CO	Burnside	98.5	100	97.2	99.1	98.5	100	98.4	100	98.1	100	98.5	100	98.2	99.9	89.9	91.8[d]	97.2	98.7	97.6	100	97.8	99.5	97.7	99.2	**97.3**	**99.0**
NO_2	Penrose	97.6	99.7	98.0	99.8	97.8	100	98.0	100	98.1	100	97.6	100	98.1	100	98.1	100	97.4	100	97.5	100	79.8	81.6[f]	97.8	100	**96.3**	**98.4**
NO_2	Burnside	98.2	100	97.8	99.8	98.0	100	97.9	100	97.9	100	98.2	100	97.4	100	89.6	91.7[d]	87.5	89.0[e]	97.1	100	81.1	83.1[g]	97.6	100	**94.9**	**97.0**
SO_2	Penrose	97.1	99.8	97.4	99.8	97.9	100	97.6	99.8	97.9	99.9	97.9	100	98.1	100	98.2	100	98.1	100	97.8	100	97.6	99.9	97.1	99.5	**97.7**	**99.9**
SO_2	Burnside	97.3	100	97.5	99.8	97.7	100	97.8	100	97.7	100	97.8	100	97.7	100	89.5	91.8[d]	96.7	99.0	97.3	100	97.6	100	97.6	100	**96.8**	**99.2**
PM_{10}	Penrose	98.5	99.0	98.6	99.3	98.9	99.6	98.8	99.8	99.2	99.9	99.3	100	83.9	85.0[c]	99.0	99.7	99.2	99.9	96.6	97.2	99.0	99.7	98.8	99.5	**97.4**	**97.6**
PM_{10}	Burnside	98.4	99.1	98.9	99.6	98.4	99.1	96.1	97.6	98.5	99.7	98.9	99.6	99.0	99.7	89.9	90.5[d]	97.1	98.0	98.2	99.4	98.6	99.3	98.6	99.3	**97.5**	**97.8**
VOC	Penrose	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	**100**	**100**
VOC	Burnside	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0[h]	0[h]	**75.0**	**75.0**
VOC	St Albans	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	**100**	**100**
TSP	Penrose	100	100	100	100	100	100	100	100	100	100	75.0	75.0[b]	100	100	100	100	100	100	100	100	100	100	100	100	**98.1**	**98.1**
TSP	St Albans	75.0	75.0[a]	100	100	100	100	100	100	100	100	100	100	100	100	100	100	75.0	75.0[a]	100	100	100	100	75.0	75.0[a]	**94.2**	**94.2**
Lead	Penrose	–	–	–	–	–	–	–	–	–	–	75.0	–	100	–	100	–	–	–	–	–	–	–	–	–	**92.3**	**–**
Lead	St Albans	–	–	–	–	–	–	–	–	–	–	100	–	100	–	100	–	–	–	–	–	–	–	–	–	**100**	**–**

a TSP – Sampling error
b TSP – No power
c PM_{10} – Pump faulty
d CO, NO_2, SO_2, and PM_{10} – Power connection failure
e NO_2 – Christchurch earthquake no data
f NO_2 – Moly converter faulty
g NO_2 – Ozone flow faulty
h VOC – Sample contaminated

7.2 Carbon monoxide (CO) 2010

CO was monitored at Greers Road, Burnside. One hour and 8-hour rolling averages have been calculated from 10-minute averages recorded by the instrument.

Summary statistics for CO and their dates are described below.

Site	**Maximum 1-hour average (mg/m^3)**	**99.9 percentile 1-hour average (mg/m^3)**	**Maximum 8-hour average (mg/m^3)**	**99.9 percentile 8-hour average (mg/m^3)**
Greers Road, Burnside	8.4 (21 Jun 23:00)	6.3	5.8 (22 Jun 02:00)	4.7

At Greers Road, Burnside during 2010 there were no exceedences of the ambient air quality 1-hour guideline (30 mg/m^3) or the 8-hour national environmental standard (10 mg/m^3). The 2010 CO results are shown in Figures 7 to 11.

7.3 Nitrogen oxides (NO_2 and NO) 2010

Oxides of nitrogen were monitored at Gavin Street, Penrose and Greers Road, Burnside. One hour and 24-hour averages have been calculated from 10-minute averages recorded by the instruments.

Summary statistics for NO_2 and their dates for each site are described below.

Site	**Maximum 1-hour average (µg/m^3)**	**99.9 percentile 1-hour average (µg/m^3)**	**Maximum 24-hour average (µg/m^3)**	**99.5 percentile 24-hour average (µg/m^3)**
Gavin Street, Penrose	92.9 (16 Jun 09:00)	75.5	54.5 (16 Jun)	52.6
Greers Road, Burnside	58.1 (14 Jun 11:00)	53.3	30.7 (14 May)	28.3

There were no exceedences of the NO_2 ambient air quality 1-hour standard (200 µg/m^3) or the 24-hour guideline (100 µg/m^3) during 2010 at either site.

The 2010 NO_x results for Penrose are shown in Figures 12 to 21 and results for Burnside are shown in Figures 22 to 31.

7.4 Sulfur dioxide (SO_2) 2010

Sulfur dioxide was monitored at Gavin Street, Penrose and Greers Road, Burnside. One hour and 24-hour averages have been calculated from 10-minute averages recorded by the instruments.

Summary statistics for SO_2 and their dates for each site are described below.

Site	**Maximum 1-hour average (μg/m^3)**	**99.9 percentile 1-hour average (μg/m^3)**	**Maximum 24-hour average (μg/m^3)**	**99.5 percentile 24-hour average (μg/m^3)**
Gavin Street, Penrose	59.4 (13 Oct 05:00)	38.5	27.7 (13 Oct)	16.2
Greers Road, Burnside	22.4 (28 Jul 23:00)	18.4	8.7 (24 Jun)	7.4

There were no exceedences of the SO_2 national environmental 1-hour standard (350 μg/m^3) or the 24-hour guideline (120 μg/m^3) during 2010 at either site.

The 2010 SO_2 results for Penrose are shown in Figures 32 to 36 and results for Burnside are shown in Figures 37 to 41.

7.5 Volatile organic compounds (VOC) January–December 2010

Monitoring of VOCs was conducted at three sites; Gavin Street, Penrose; Greers Road, Burnside; and Coles Place, St Albans. VOC monitoring utilises passive sampling badges exposed over a 3-month period. Results for each 2010 quarter are shown in Tables 4 to 7.

The benzene guideline 2002 was 10 μg/m^3 as an annual average, with an average value of 3.6 μg/m^3 to be achieved by 2010. The 2010 6-month and 12-month averages are described below. The benzene annual averages from all the sites are less than the annual average guideline (3.6 μg/m^3) and are graphed in Figure 1.

Site	**Six-month average (January–June 2010) benzene (μg/m^3)**	**Six-month average (July–December 2010) benzene (μg/m^3)**	**2010 annual average benzene (μg/m^3)**
Gavin Street, Penrose	0.9	0.7	0.8
Greers Road, Burnside	1.0	1.0	1.0
Coles Place, St Albans	1.1	1.0	1.0

Table 4: VOC results (January–March 2010)

Jan–Feb–Mar 2010	**Limit of detection**	**Results (µg/m³)**		
Analyte	**(µg/m³)**	**Coles Place**	**Burnside**	**Penrose**
Target VOCs				
ethanol	ND			
isopropyl alcohol	ND			
acetone	ND			
pentane	2.6	ND	ND	3.2
dichloromethane	ND			
butan-2-one	ND			
hexane	ND			
ethyl acetate	ND			
trichloromethane	ND			
1,1,1-trichloroethane	ND			
n-butanol	ND			
benzene	**0.3**	**0.4**	**0.4**	**0.5**
2-methylhexane	ND			
2,3-dimethylpentane	ND			
3-methylhexane	ND			
heptane	ND			
trichloroethene	ND			
propyl acetate	ND			
methylcyclohexane	ND			
4-methylpentan-2-one	ND			
toluene	0.3	2.2	1.8	4.0
octane	ND			
tetrachloroethene	ND			
butyl acetate	ND			
ethylbenzene	0.3	ND	ND	0.6
m+p-xylene	0.3	1.1	0.9	2.0
styrene	ND			
o-xylene	0.3	0.4	ND	0.7
nonane	ND			
alpha pinene	ND			
propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
beta pinene	ND			
decane	ND			
1,2,4-trimethylbenzene	0.7	ND	ND	0.7
limonene	ND			
undecane	ND			
dodecane	ND			
tetradecane	ND			

ND = Not detected.

Table 5: VOC results (April–June 2010)

Apr–May–Jun 2010	**Limit of detection**	**Results (µg/m³)**		
Analyte	**(µg/m³)**	**Coles Place**	**Burnside**	**Penrose**
Target VOCs				
ethanol	ND			
isopropyl alcohol	ND			
acetone	ND			
pentane	ND			
dichloromethane	ND			
butan-2-one	ND			
hexane	0.5	1.1	0.8	1.3
ethyl acetate	ND			
trichloromethane	ND			
1,1,1-trichloroethane	ND			
n-butanol	ND			
benzene	**0.2**	**1.9**	**1.6**	**1.4**
2-methylhexane	0.5	0.6	ND	ND
2,3-dimethylpentane	ND			
3-methylhexane	0.5	0.7	ND	0.6
heptane	0.5	0.7	ND	0.5
trichloroethene	ND			
propyl acetate	ND			
methylcyclohexane	ND			
4-methylpentan-2-one	ND			
toluene	0.3	8.0	5.8	8.3
octane	ND			
tetrachloroethene	ND			
butyl acetate	ND			
ethylbenzene	0.3	1.2	0.9	1.3
m+p-xylene	0.3	3.9	2.9	4.6
styrene	ND			
o-xylene	0.3	1.4	1.1	1.6
nonane	ND			
alpha pinene	ND			
propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
beta pinene	0.7	ND	0.9	ND
decane	ND			
1,2,4-trimethylbenzene	0.6	1.8	1.4	1.7
limonene	ND			
undecane	ND			
dodecane	ND			
tetradecane	ND			

ND = Not detected.

Table 6: VOC results (July–September 2010)

Jul–Aug–Sept 2010	**Limit of detection**	**Results (µg/m^3)**		
Analyte	**(µg/m^3)**	**Coles Place**	**Burnside**	**Penrose**
Target VOCs				
ethanol	ND			
isopropyl alcohol	ND			
acetone	ND			
pentane	2.3	3.6	4.6	7.6
dichloromethane	ND			
butan-2-one	ND			
hexane	0.5	1.0	1.5	0.9
ethyl acetate	ND			
trichloromethane	ND			
1,1,1-trichloroethane	ND			
n-butanol	ND			
benzene	**0.2**	**2.0**	**2.0**	**1.2**
2-methylhexane	ND			
2,3-dimethylpentane	ND			
3-methylhexane	0.5	0.6	0.6	ND
heptane	0.5	ND	0.7	ND
trichloroethene	ND			
propyl acetate	ND			
methylcyclohexane	ND			
4-methylpentan-2-one	ND			
toluene	0.3	6.5	6.0	5.8
octane	ND			
tetrachloroethene	ND			
butyl acetate	ND			
ethylbenzene	0.3	0.9	0.8	1.0
m+p-xylene	0.3	2.7	2.4	3.3
styrene	ND			
o-xylene	0.3	1.0	0.9	1.1
nonane	ND			
alpha pinene	ND			
propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
beta pinene	0.7	ND	0.8	ND
decane	ND			
1,2,4-trimethylbenzene	0.6	1.5	1.3	1.1
limonene	ND			
undecane	ND			
dodecane	ND			
tetradecane	ND			

ND = Not detected.

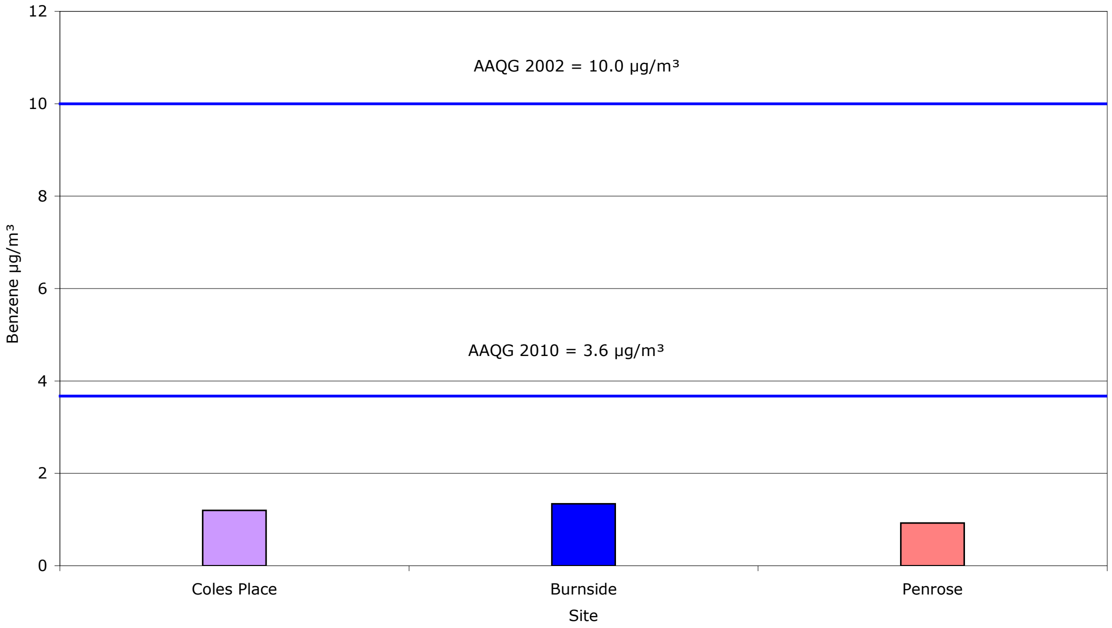
Table 7: VOC results (October–December 2010)

Oct–Nov–Dec 2010	**Limit of detection**	**Results (µg/m³)**		
Analyte	**(µg/m³)**	**Coles Place**	**Burnside[1]**	**Penrose**
Target VOCs				
ethanol	ND			
isopropyl alcohol	ND			
acetone	ND			
pentane	2.1	ND		2.8
dichloromethane	ND			
butan-2-one	ND			
hexane	0.4	ND		0.5
ethyl acetate	ND			
trichloromethane	ND			
1,1,1-trichloroethane	ND			
n-butanol	ND			
benzene	**0.2**	**0.4**		**0.5**
2-methylhexane	ND			
2,3-dimethylpentane	ND			
3-methylhexane	ND			
heptane	ND			
trichloroethene	ND			
propyl acetate	ND			
methylcyclohexane	ND			
4-methylpentan-2-one	ND			
toluene	0.2	2.4		3.8
octane	ND			
tetrachloroethene	ND			
butyl acetate	ND			
ethylbenzene	0.3	ND		0.5
m+p-xylene	0.3	0.6		1.6
styrene	ND			
o-xylene	0.3	ND		0.5
nonane	ND			
alpha pinene	ND			
propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
beta pinene	ND			
decane	ND			
1,2,4-trimethylbenzene	ND			
limonene	ND			
undecane	ND			
dodecane	ND			
tetradecane	ND			

1 Sample contaminated

ND = Not detected.

Figure 1: MfE Benzene annual average 2010



7.6 Particulate matter (PM_{10}) 2010

PM_{10} was monitored at Gavin Street, Penrose and Greers Road, Burnside. Twenty-four-hour averages have been calculated from 10-minute averages recorded by the instruments.

Summary statistics for PM_{10} and their dates for each site are described below.

Site	Maximum 24-hour average (µg/m^3)	99.5 percentile 24-hour average (µg/m^3)
Gavin Street, Penrose	43 (22 Nov)	36
Greers Road, Burnside	70 (28 Jul)	61

There were no exceedences of the 24-hour national environmental standard (50 µg/m^3) at the Auckland site during 2010. The 2010 PM_{10} results for Penrose are shown in Figures 42 to 44.

At Greers Road, Burnside, there were eight exceedences of the 24-hour standard. Each exceedence and the date of the exceedence are listed in Table 8 below. As there were multiple exceedences at the Christchurch site, more data analysis was carried out and reported in Section 7.9. The 2010 PM_{10} results for Burnside are shown in Figures 45 to 47.

All exceedences occurred over the winter period (June to August), a time when wood burning is widely used for domestic heating. Cold winter conditions strongly influence air pollution in the region especially in calm conditions.

Table 8: Greers Road, Burnside PM_{10} exceedences of the daily NES 2010

Date	Burnside PM_{10} (µg/m^3)
21-Jun-10	61
1-Jul-10	59
3-Jul-10	50
11-Jul-10	58
13-Jul-10	56
27-Jul-10	61
28-Jul-10	70
29-Jul-10	56

Note: National environmental standard for PM_{10} = 50 µg/m³

7.7 Total suspended particulates (TSP) 2010

TSP is measured as a 7-day average at Gavin Street, Penrose and Coles Place, St Albans. Maximum results and their dates (7-day ending period) for each site are described below.

Site	Maximum 7-day average (µg/m^3)
Gavin Street, Penrose	26 (10 Mar)
Coles Place, St Albans	44 (08 Jul)

There were no exceedences of the MoH guideline of 60 µg/m^3 at either site. The TSP concentrations in Auckland are shown in Figures 2 and 3 while Christchurch TSP concentrations are shown in Figures 4 and 5.

Figure 2: Auckland TSP 7-day average January–December 2010

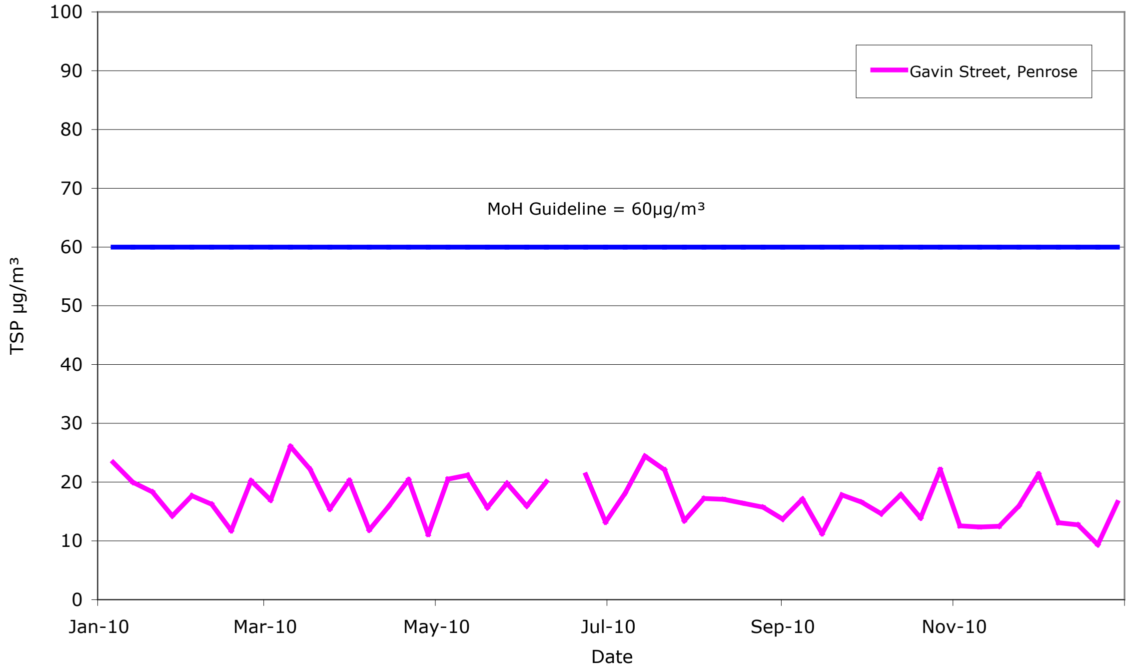


Figure 3: Auckland TSP 7-day average 1994–2010

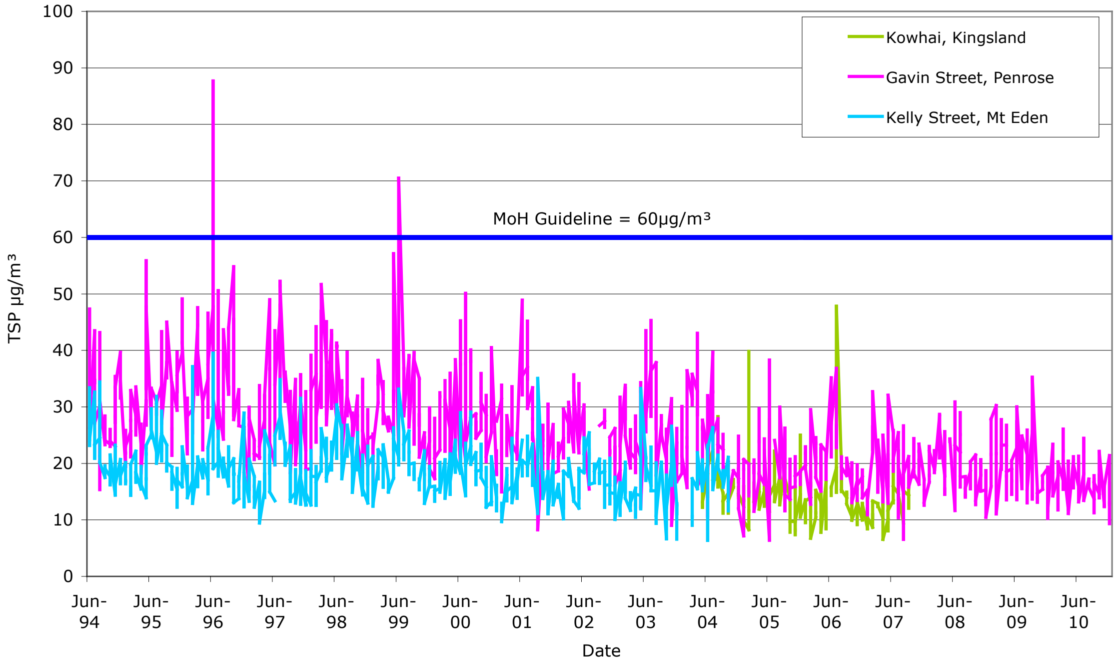


Figure 4: Christchurch TSP 7-day average January–December 2010

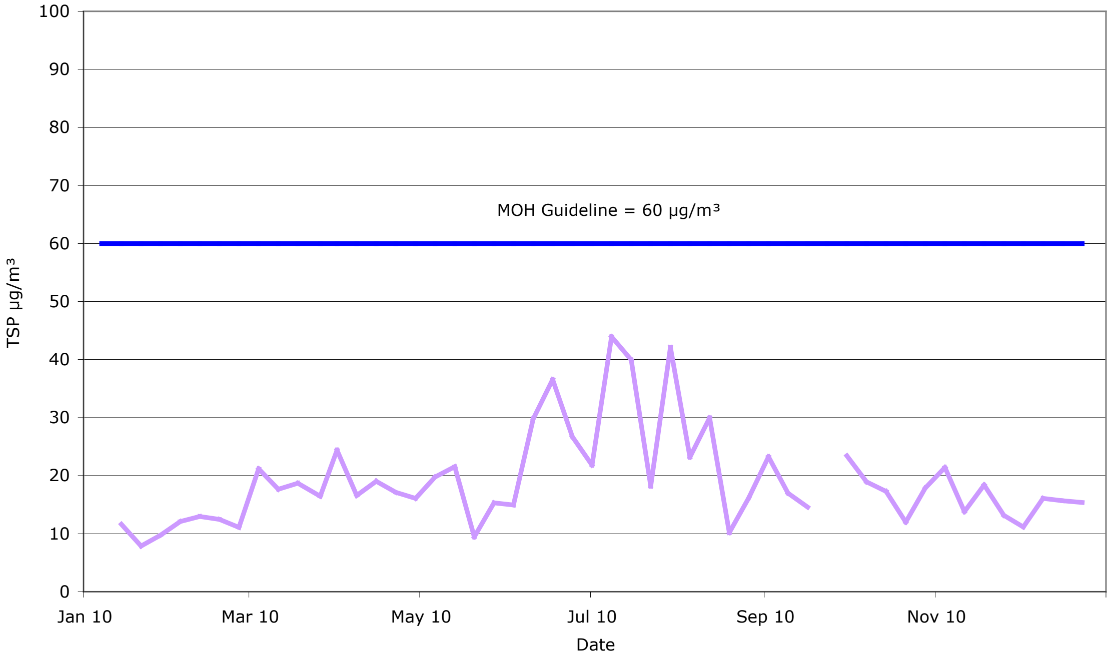
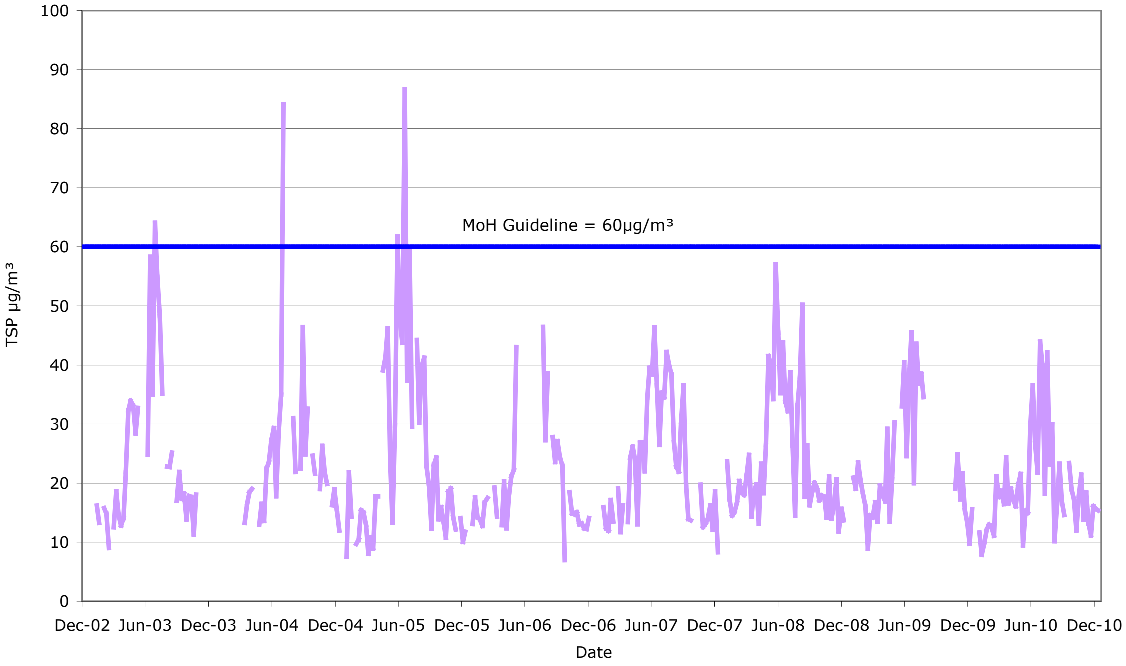


Figure 5: Christchurch TSP 7-day average 2002–2010



7.8 Lead (Pb) June–August 2010

Lead is measured from seven-day averaged TSP samples to derive a 3-month average at Gavin Street, Penrose and Coles Place, St Albans. The results are described in the table below. Figure 6 provides moving 3-month averaged lead data between January 1996 and September 2000 when lead monitoring was performed on a monthly basis. From this point lead was monitored over a 3-month period (June to August) annually.

Site	June 2010 average (µg/m^3)	July 2010 average (µg/m^3)	August 2010 average (µg/m^3)	Winter 2010 average (µg/m^3)
Gavin Street, Penrose	0.008	0.008	0.005	0.007
Coles Place, St Albans	0.023	0.029	0.011	0.021

No site exceeded the 3-month average guideline for lead (0.2 µg/m^3).

Figure 6: MfE lead 3-month average results 1996–2010

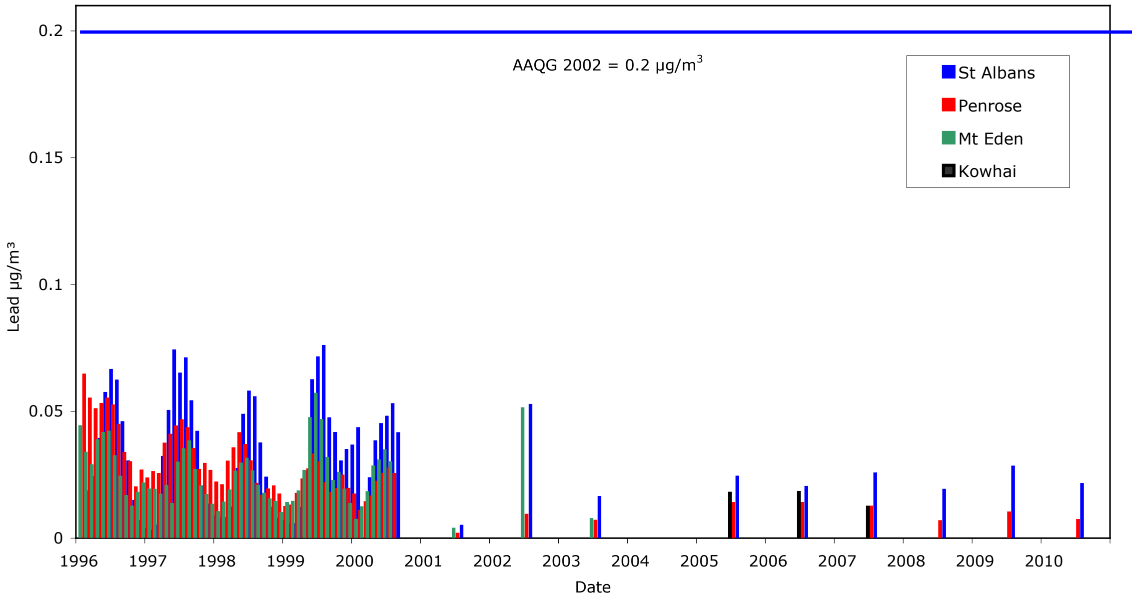


Figure 7: MfE Burnside CO 1-hour fixed average January–December 2010

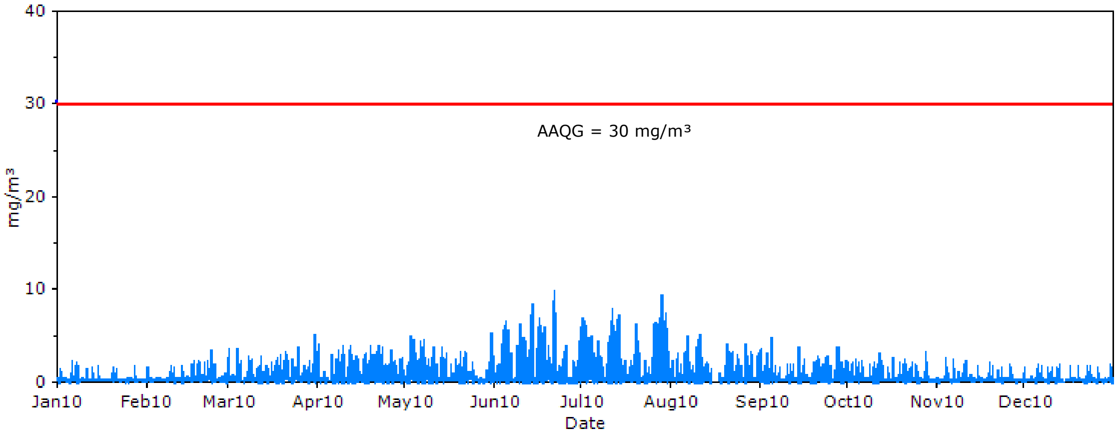


Figure 8: MfE Burnside CO 1-hour fixed average 2003–2010

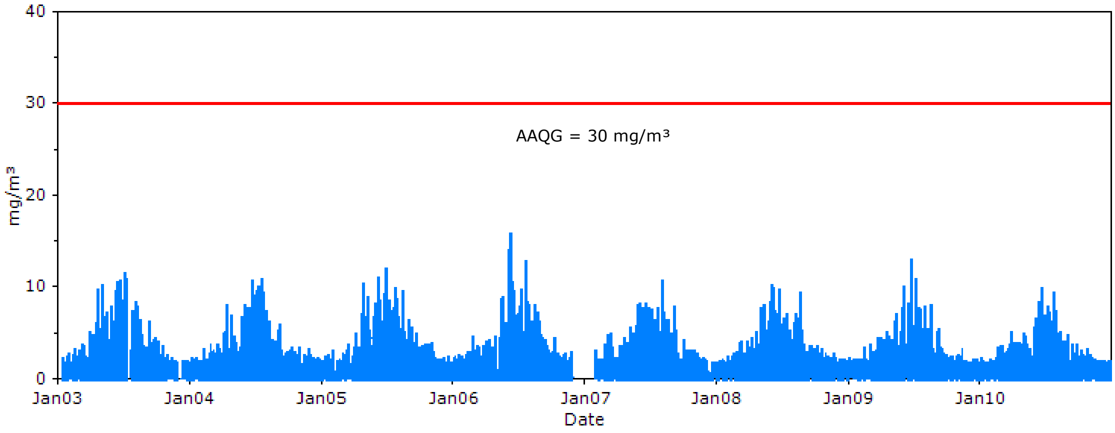


Figure 9: MfE Burnside CO 8-hour rolling average January–December 2010

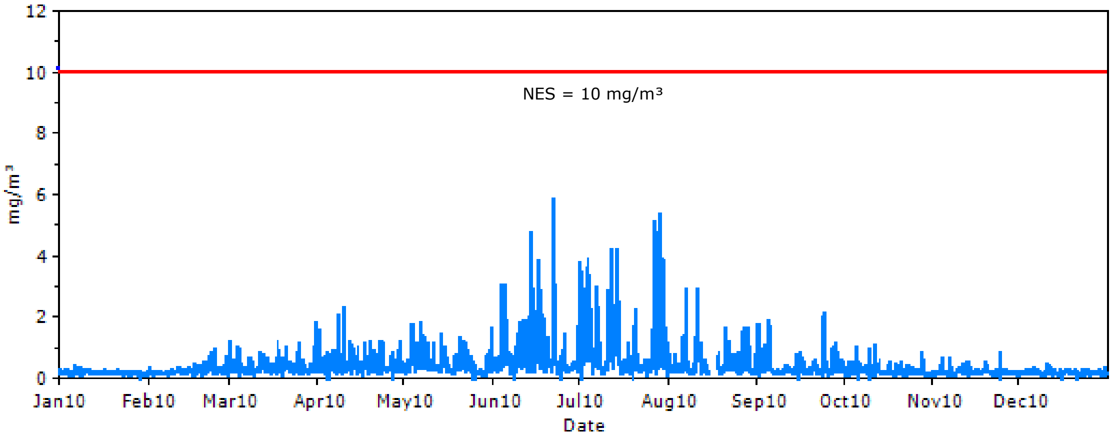


Figure 10: MfE Burnside CO 8-hour rolling average 2003–2010

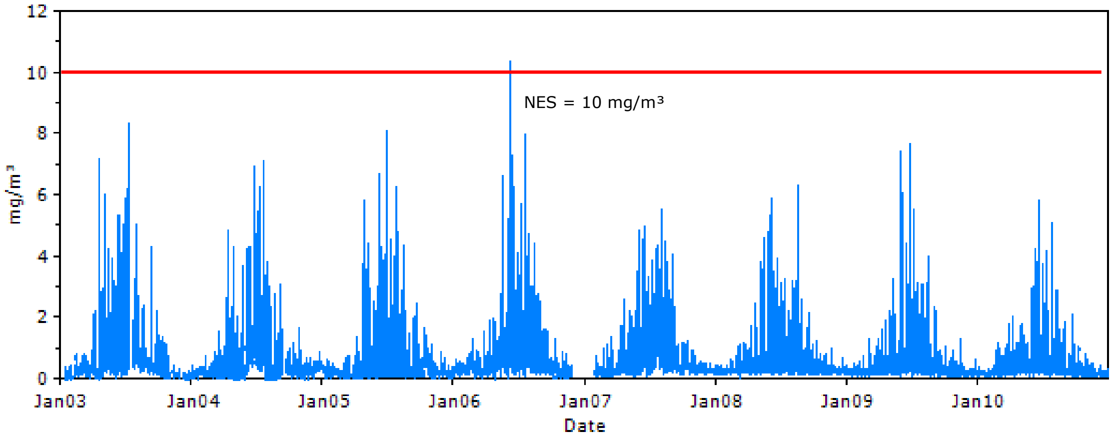


Figure 11: MfE Burnside CO annual average 2003–2010

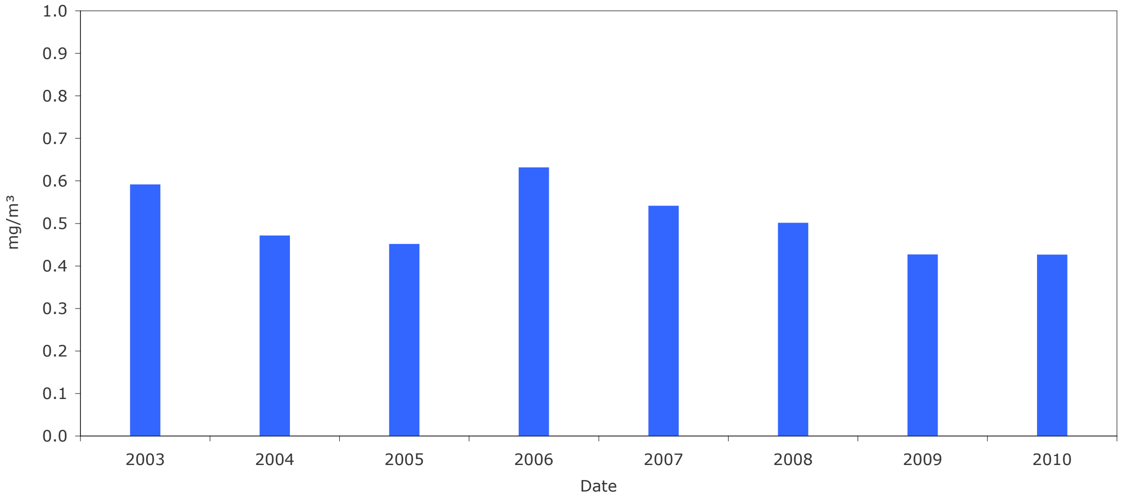


Figure 12: MfE Penrose NO_2 1-hour fixed average January–December 2010

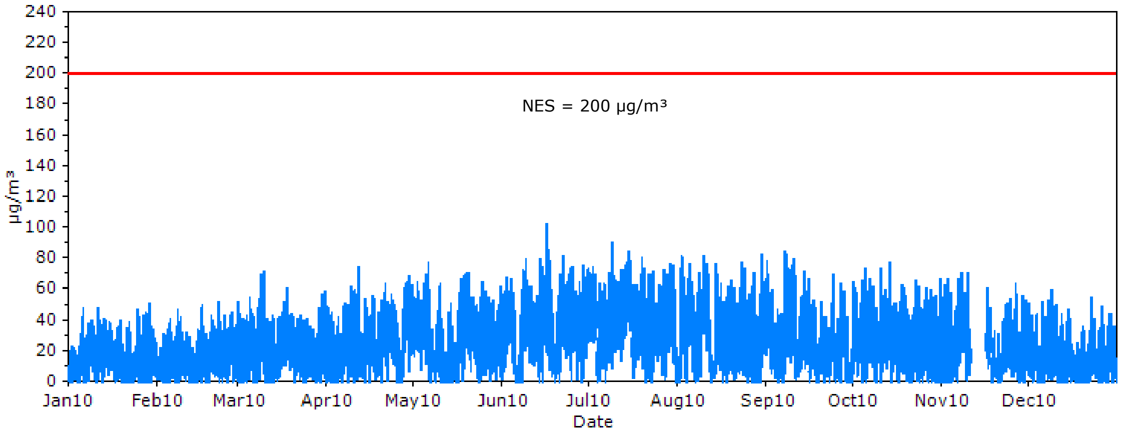


Figure 13: MfE Penrose NO_2 1-hour fixed average 1997–2010

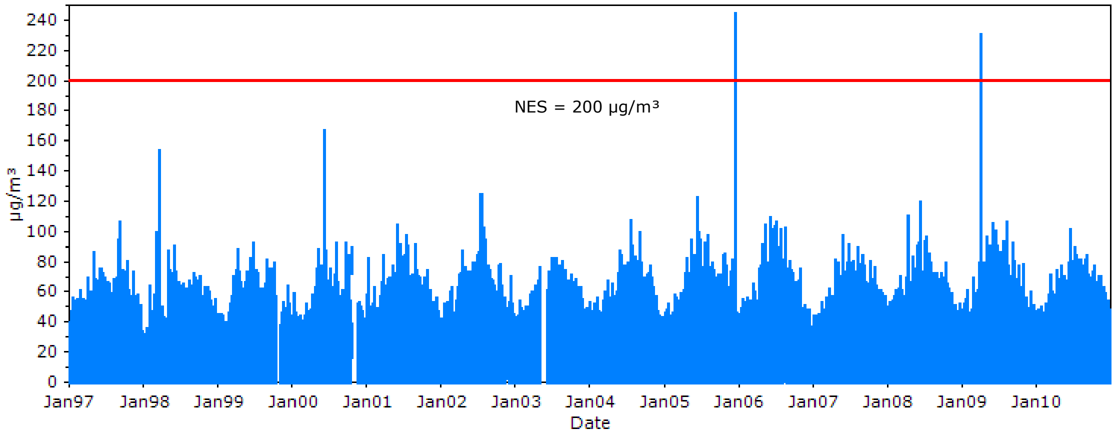


Figure 14: MfE Penrose NO_2 24-hour fixed average January–December 2010

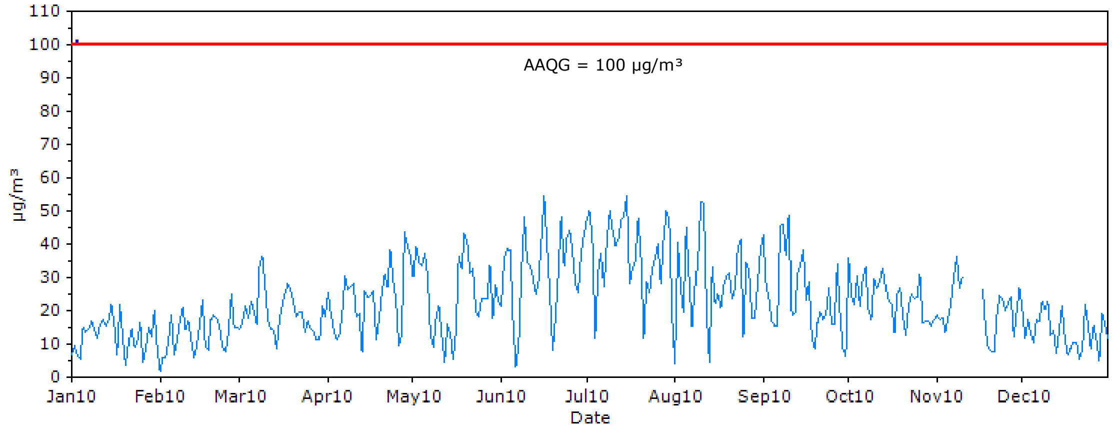


Figure 15: MfE Penrose NO_2 24-hour fixed average 1 January 1997–2010

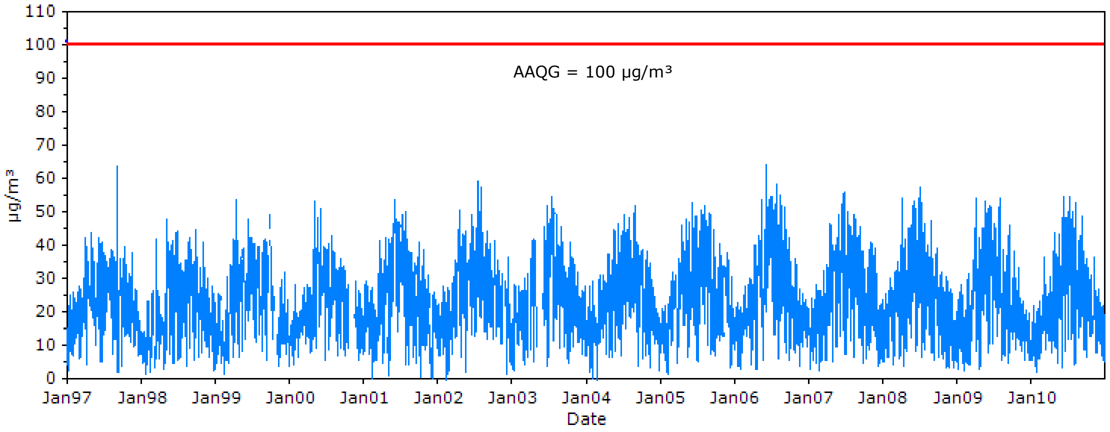


Figure 16: MfE Penrose NO_2 annual average 1997–2010

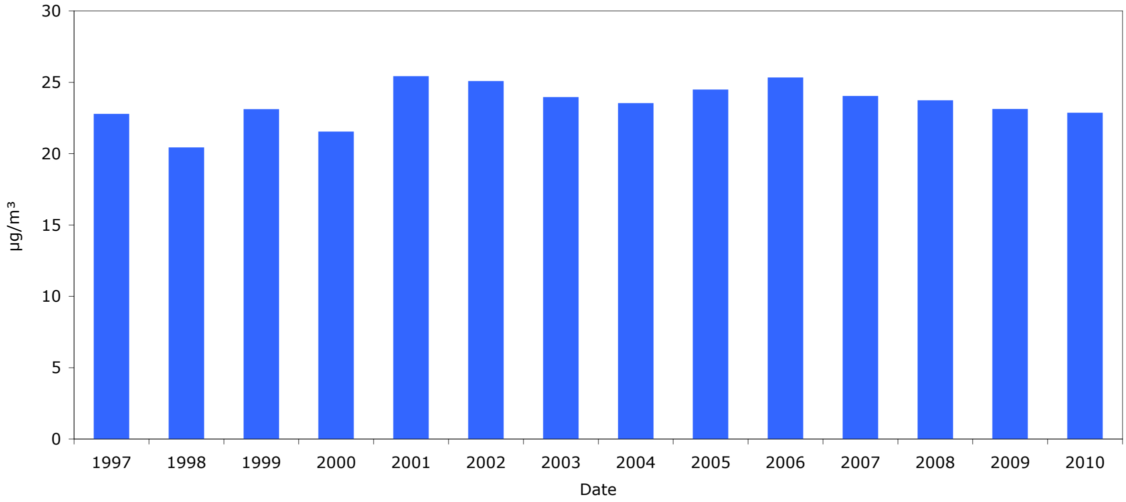


Figure 17: MfE Penrose NO_2 and NO 1-hour fixed average January–December 2010

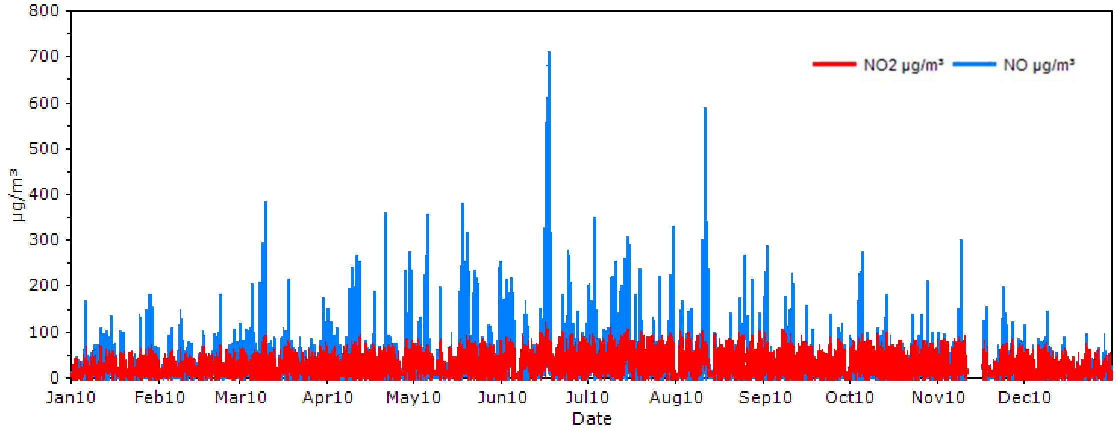


Figure 18: MfE Penrose NO_2 and NO 24-hour fixed average January–December 2010

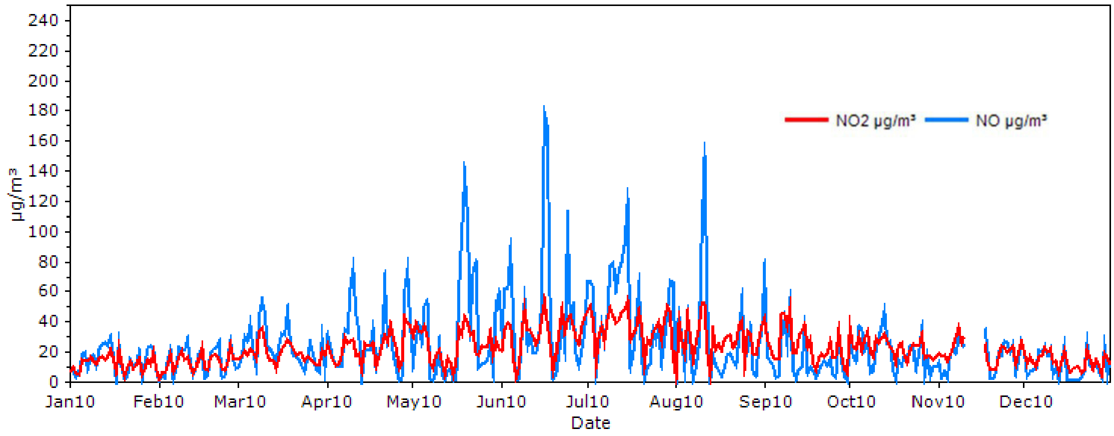


Figure 19: MfE Penrose NO 1-hour fixed average 1997–2010

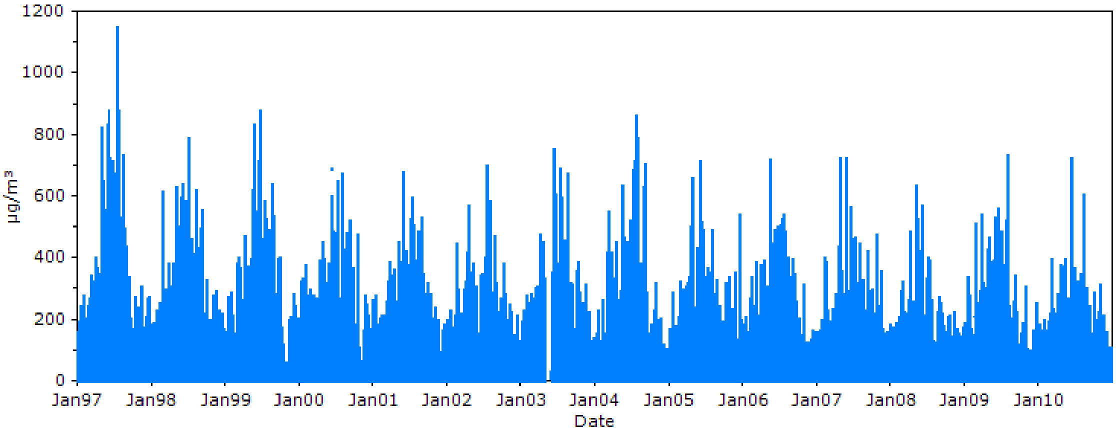


Figure 20: MfE Penrose NO 24-hour fixed average 1997–2010

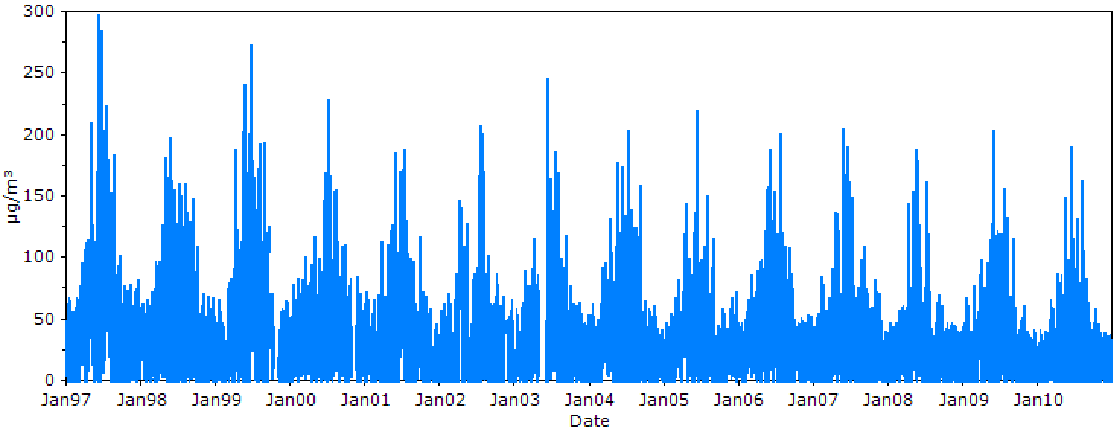


Figure 21: MfE Penrose NO annual average 1997–2010

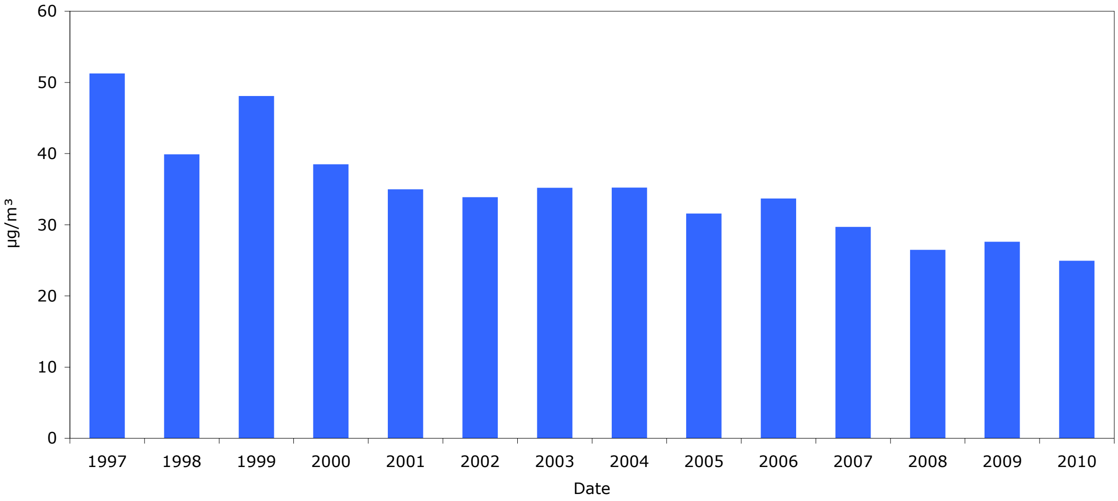


Figure 22: MfE Burnside NO_2 1-hour fixed average January–December 2010

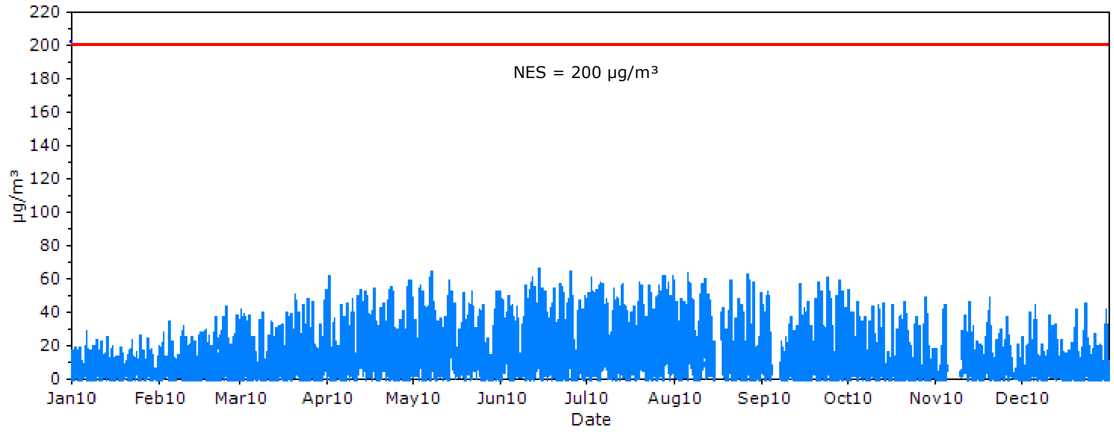


Figure 23: MfE Burnside NO_2 1-hour fixed average 2003–2010

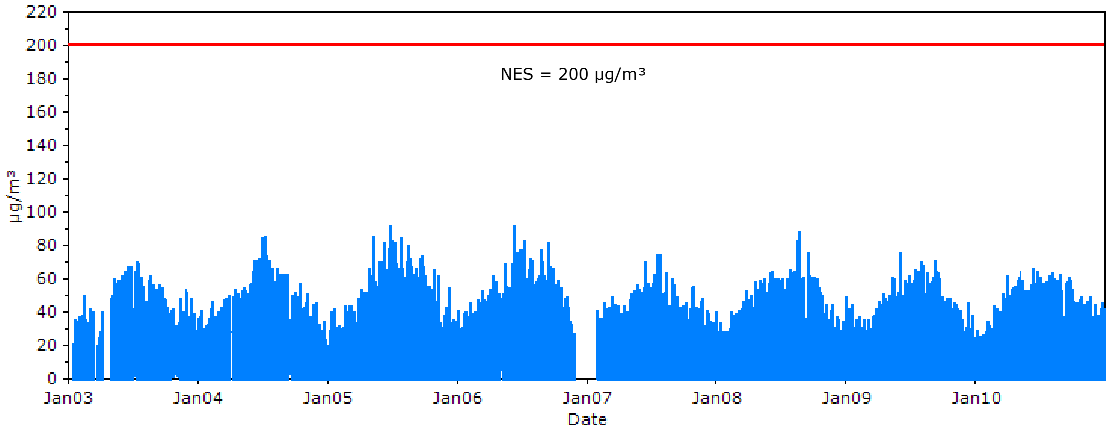


Figure 24: MfE Burnside NO_2 24-hour fixed average January–December 2010

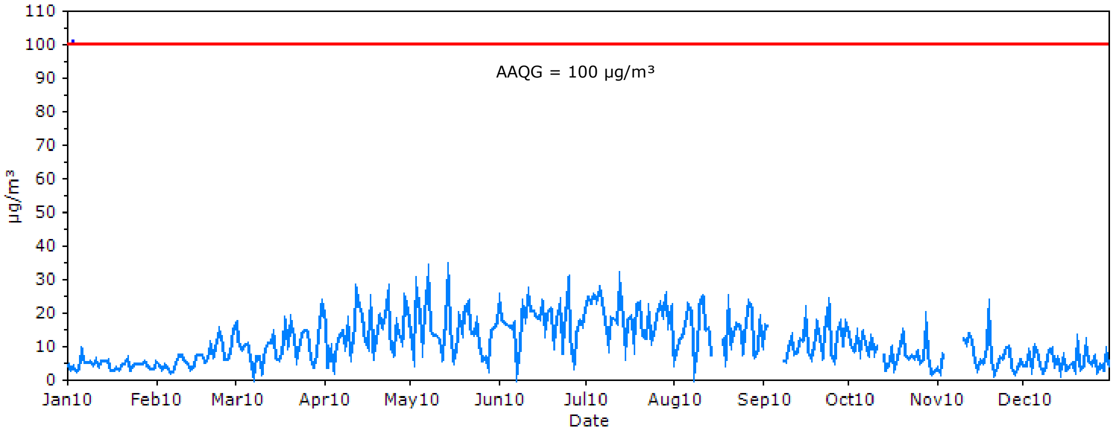


Figure 25: MfE Burnside NO_2 24-hour fixed average 2003–2010

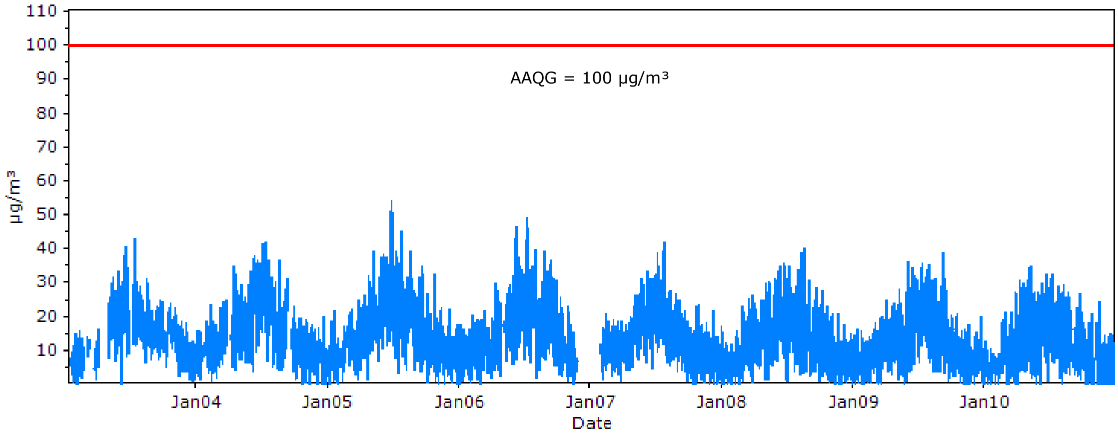


Figure 26: MfE Burnside NO_2 annual average 2003–2010

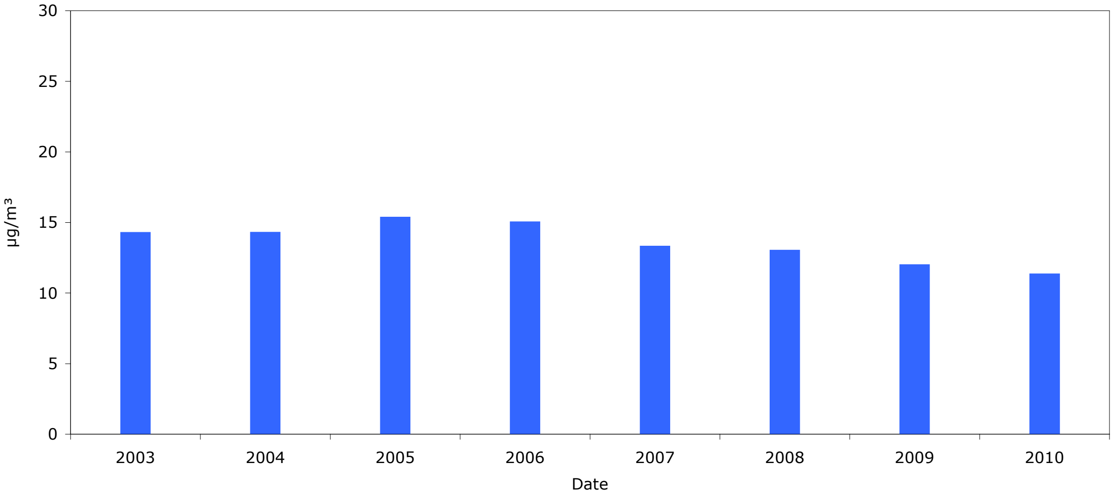


Figure 27: MfE Burnside NO_2 and NO 1-hour fixed average January–December 2010

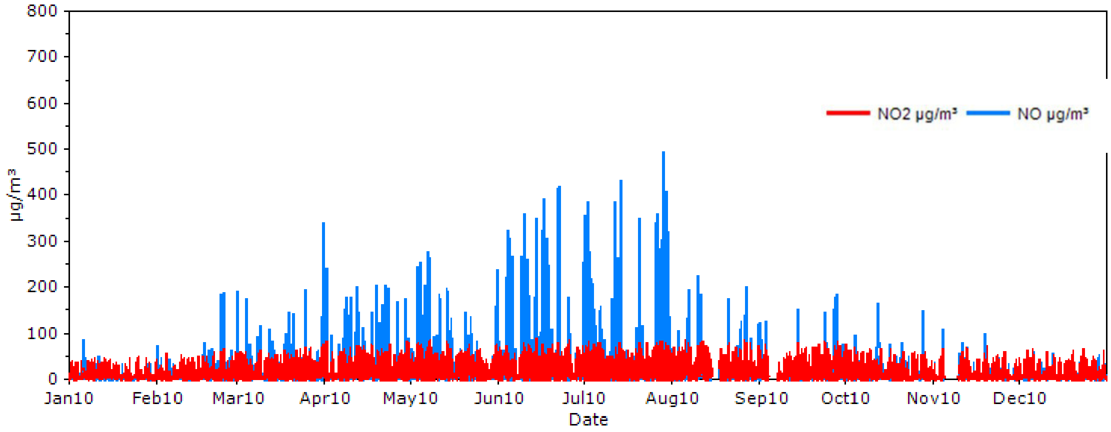


Figure 28: MfE Burnside NO_2 and NO 24-hour fixed average January–December 2010

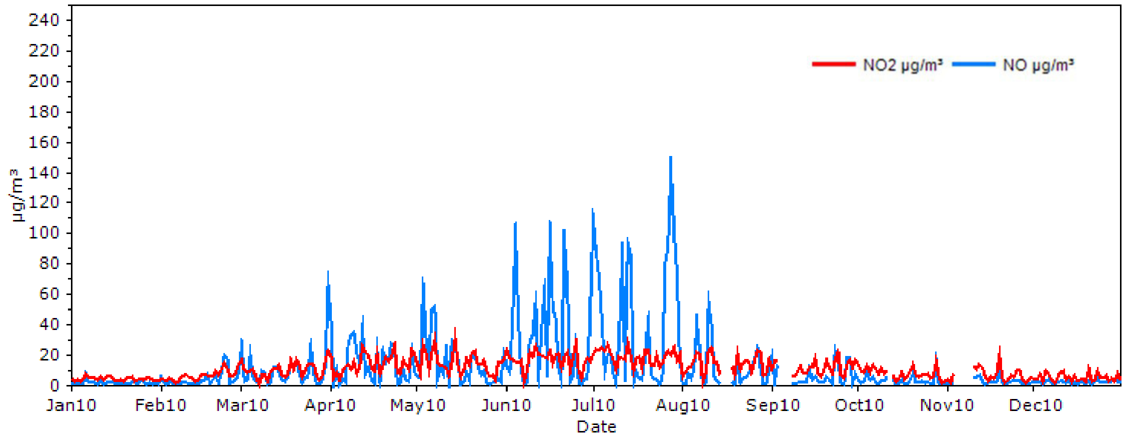


Figure 29: MfE Burnside NO 1-hour fixed average 2003–2010

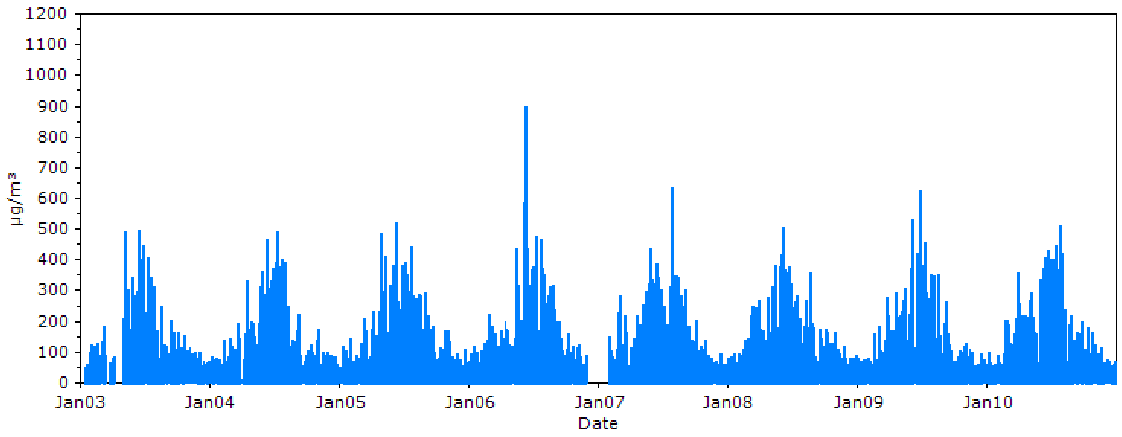


Figure 30: MfE Burnside NO 24-hour fixed average 2003–2010

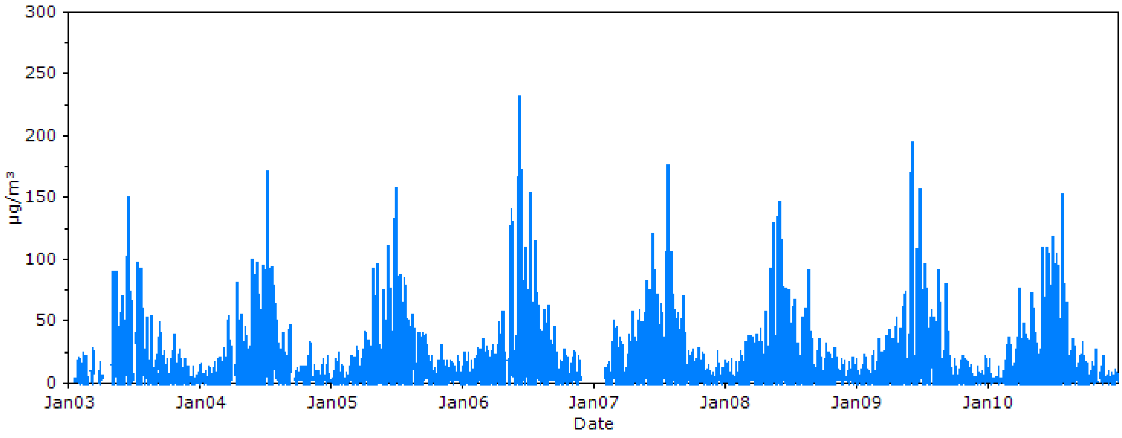


Figure 31: MfE Burnside NO annual average 2003–2010

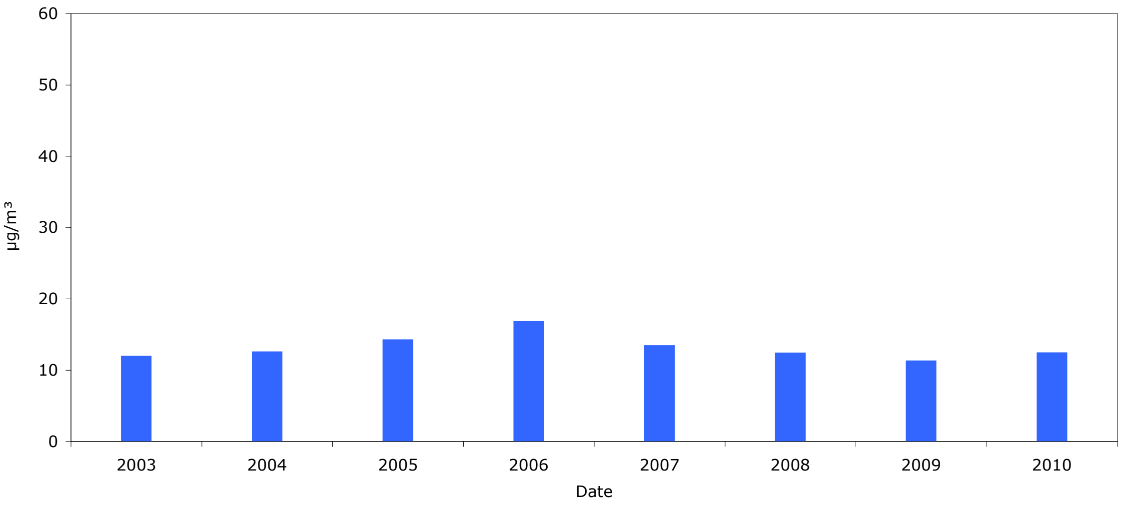


Figure 32: MfE Penrose SO_2 1-hour fixed average January–December 2010

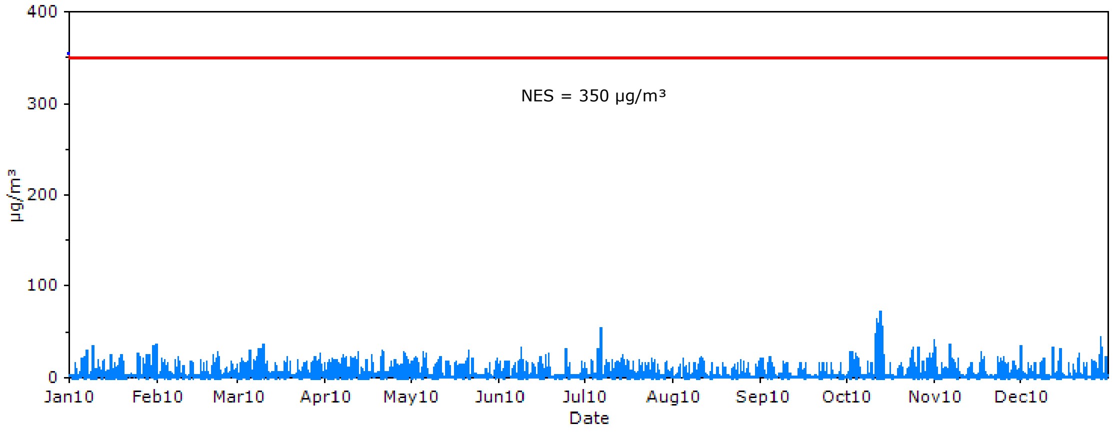


Figure 33: MfE Penrose SO_2 1-hour fixed average 2003–2010

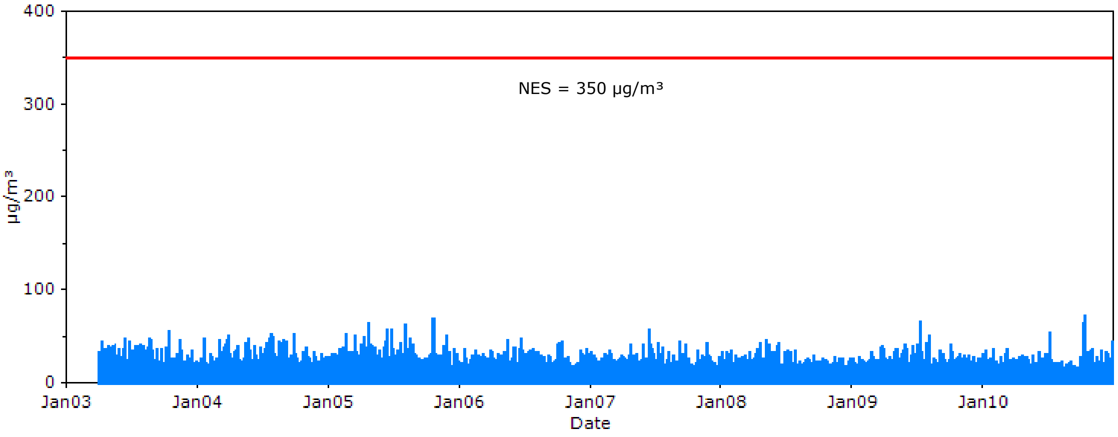


Figure 34: MfE Penrose SO_2 24-hour fixed average January–December 2010

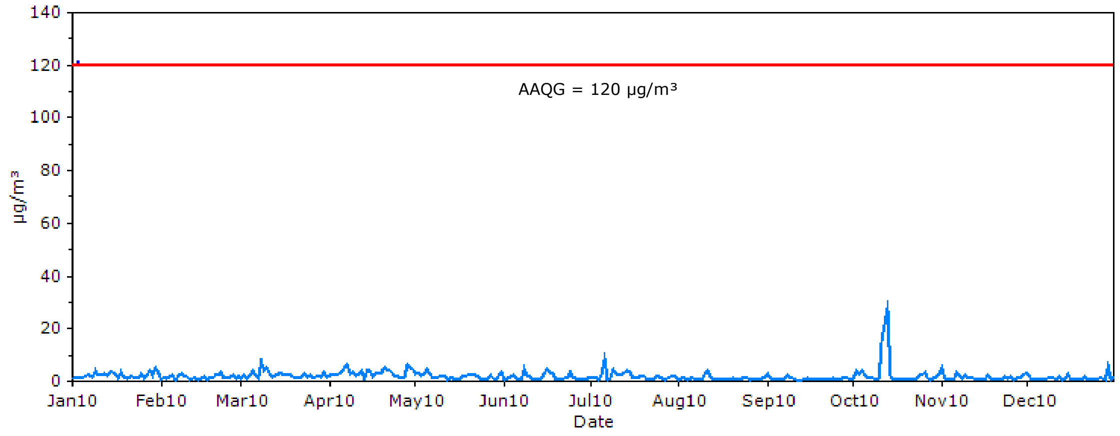


Figure 35: MfE Penrose SO_2 24-hour fixed average 2003–2010

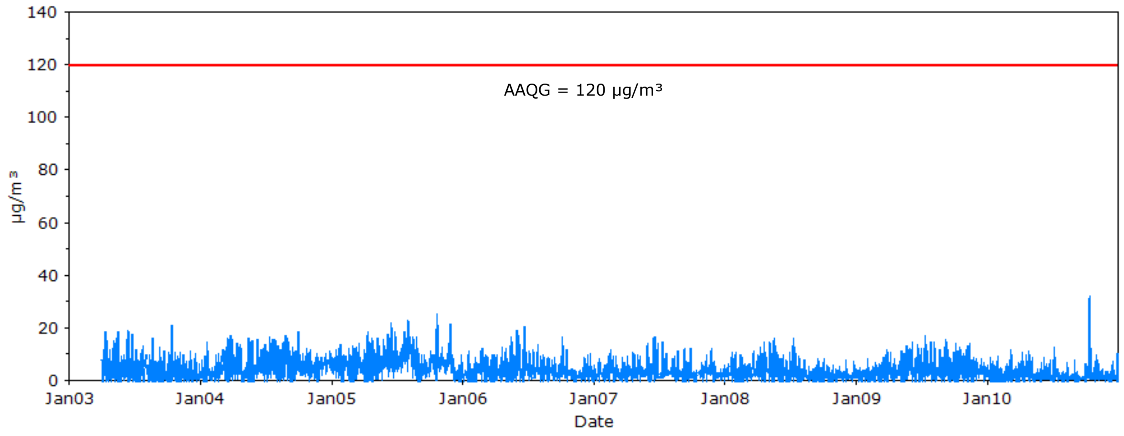


Figure 36: MfE Penrose SO_2 annual average 2003–2010

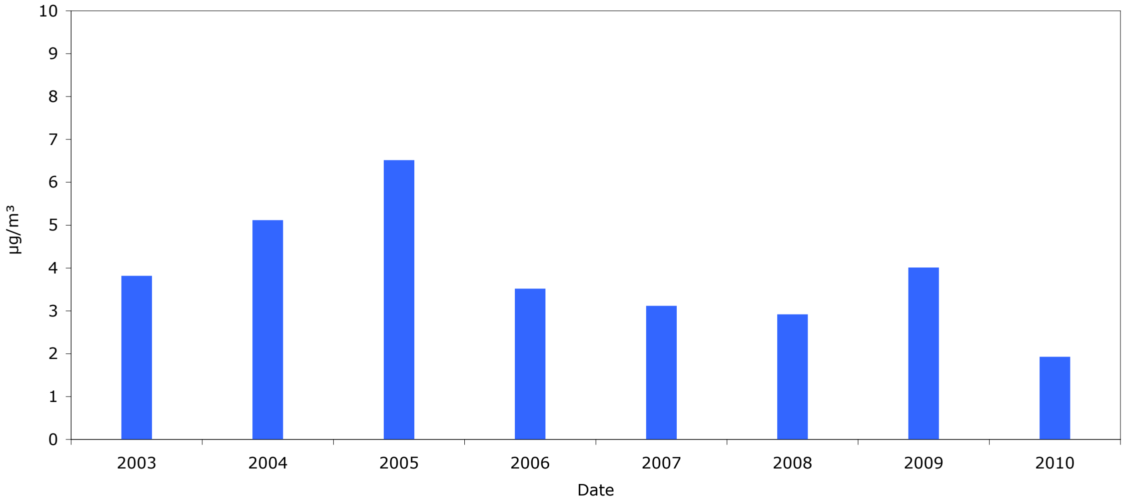


Figure 37: MfE Burnside SO_2 1-hour fixed average January–December 2010

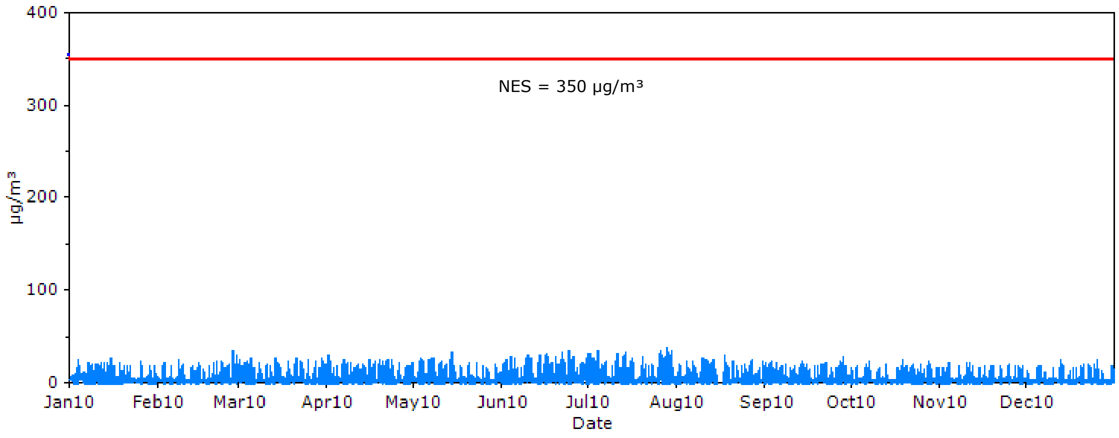


Figure 38: MfE Burnside SO_2 1-hour fixed average 2003–2010

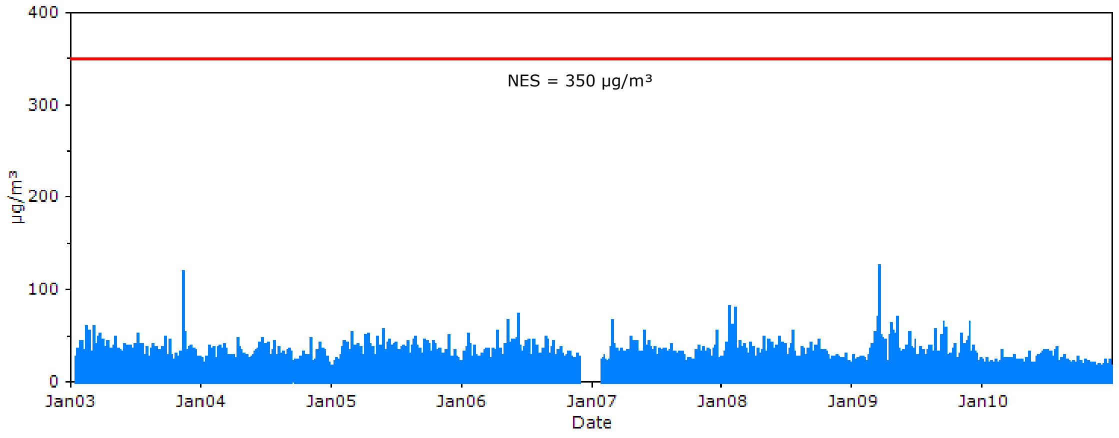


Figure 39: MfE Burnside SO_2 24-hour fixed average January–December 2010

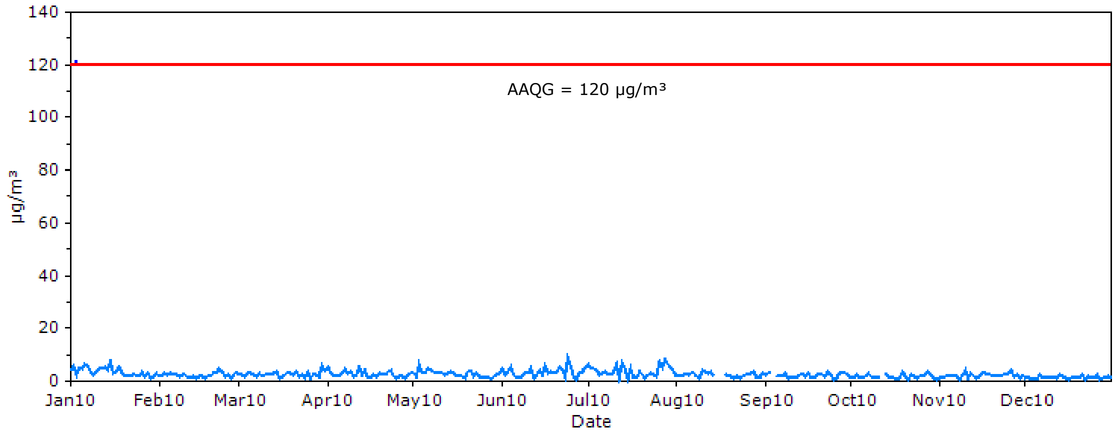


Figure 40: MfE Burnside SO_2 24-hour fixed average 2003–2010

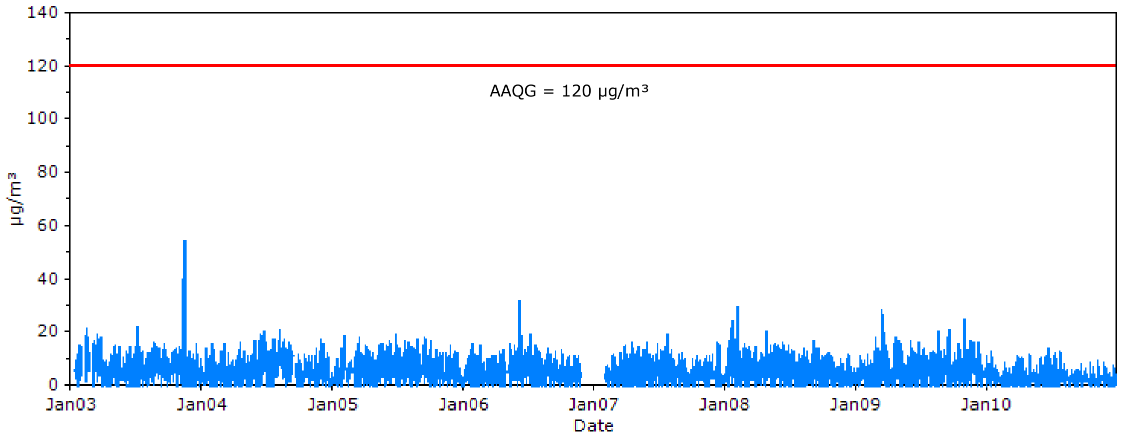


Figure 41: MfE Burnside SO_2 annual average 2003–2010

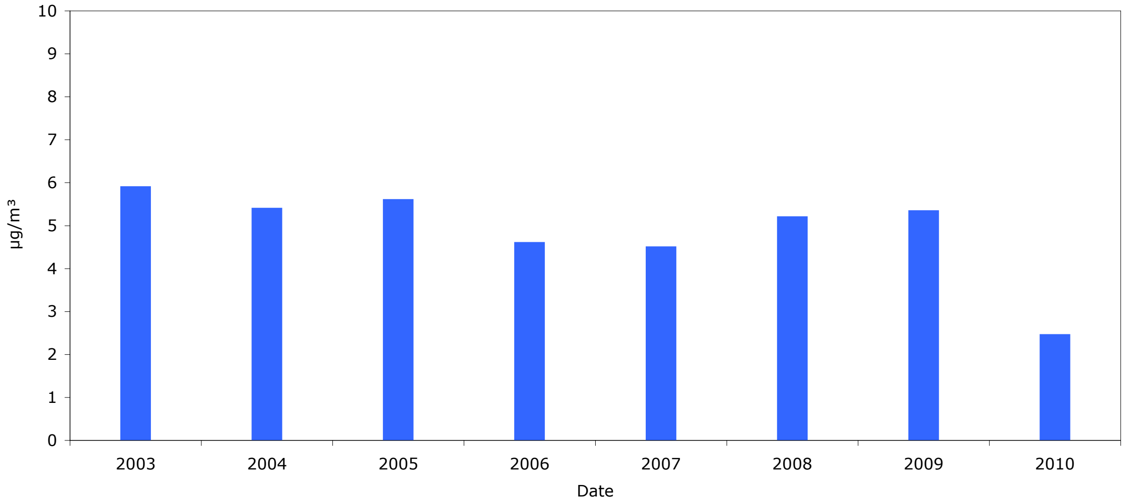


Figure 42: MfE Penrose PM_{10} 24-hour fixed average January–December 2010

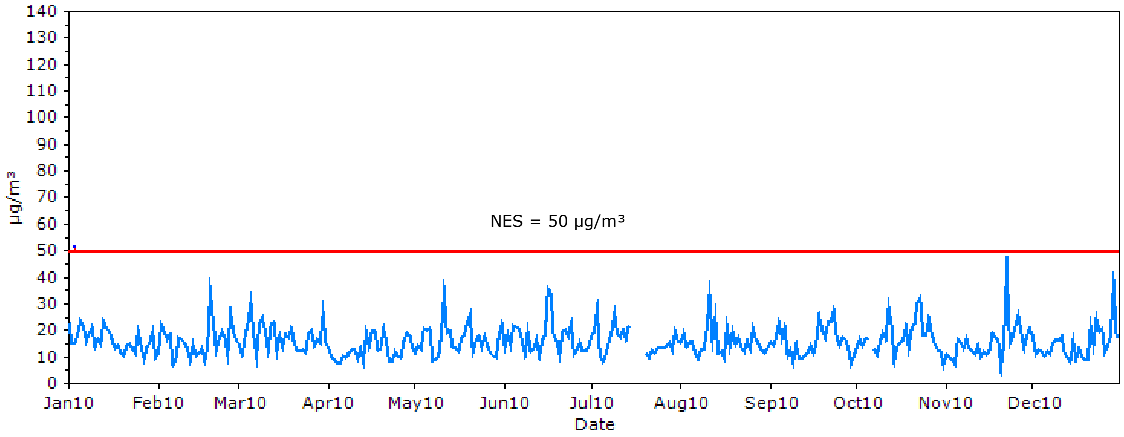


Figure 43: MfE Penrose PM_{10} 24-hour fixed average 2003–2010

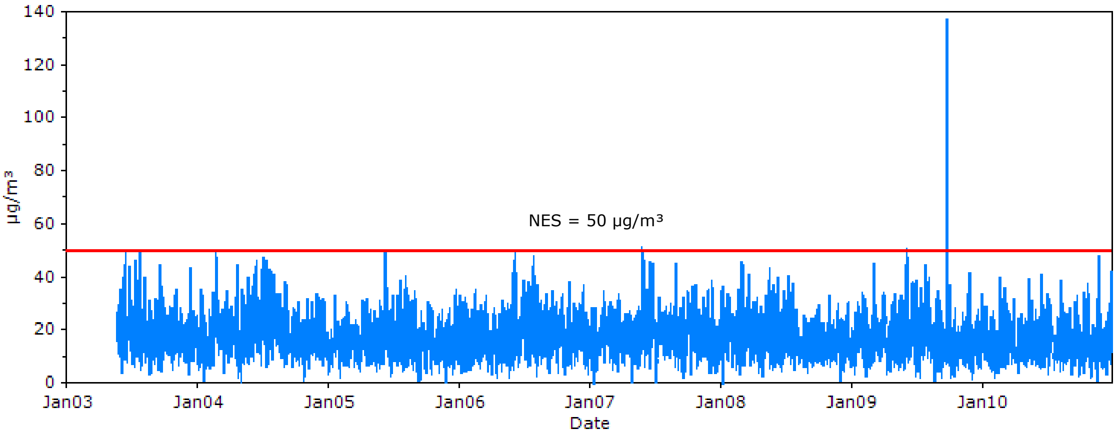


Figure 44: MfE Penrose PM_{10} annual average 2003–2010

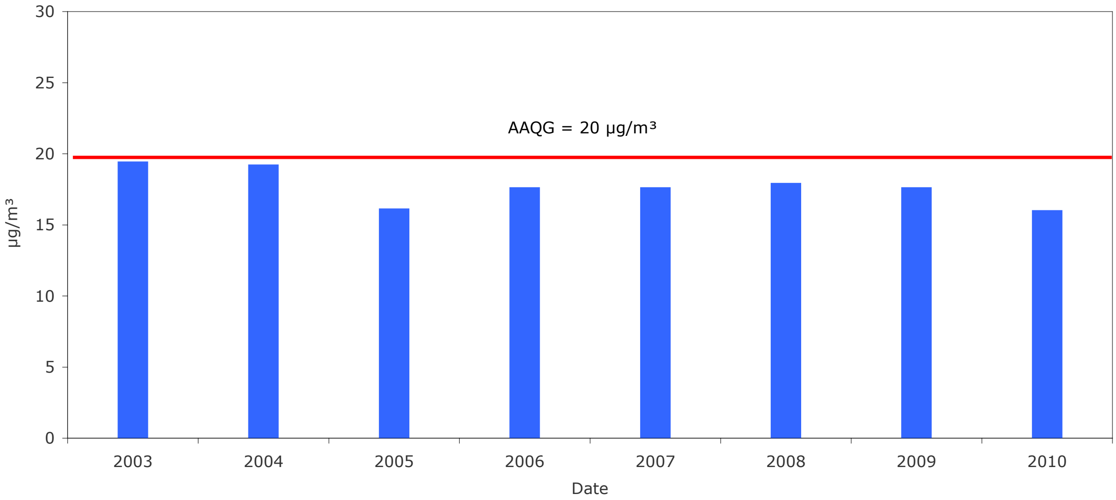


Figure 45: MfE Burnside PM_{10} 24-hour fixed average January–December 2010

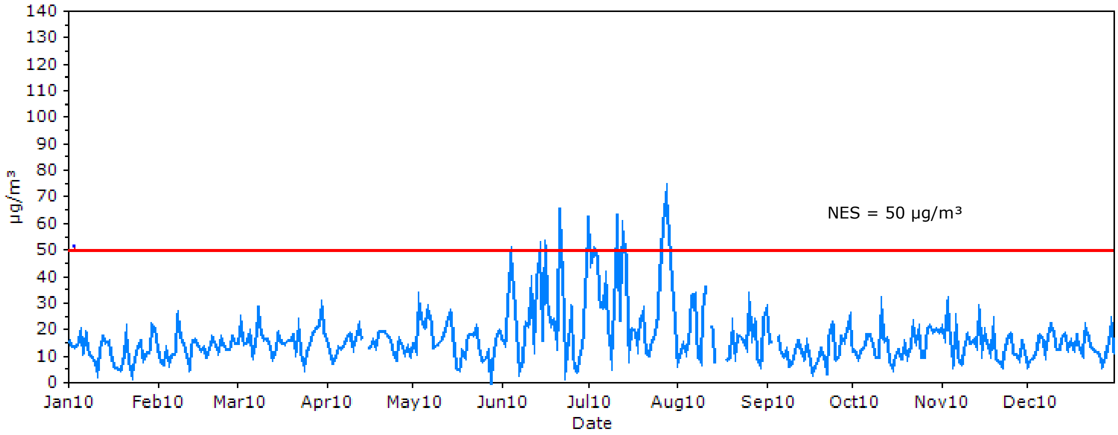


Figure 46: MfE Burnside PM_{10} 24-hour fixed average 2003–2010

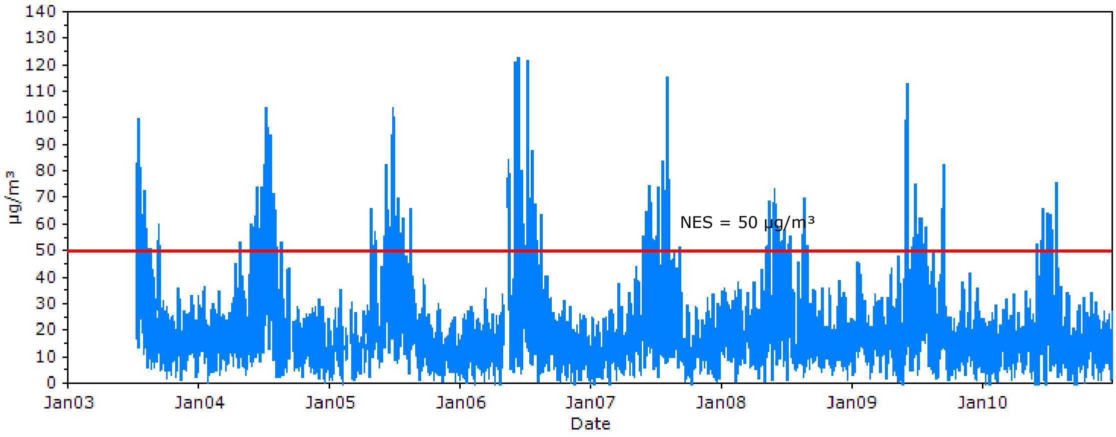
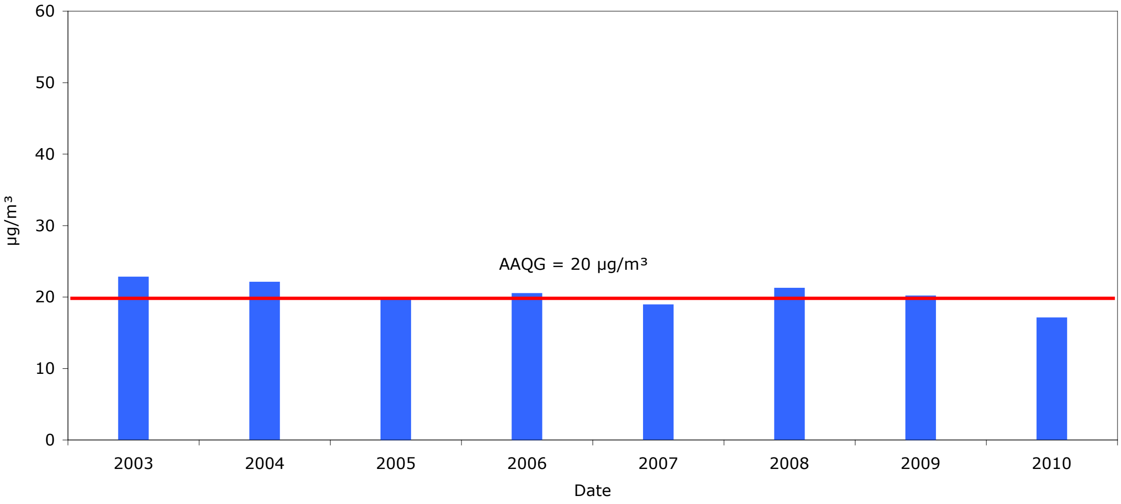


Figure 47: MfE Burnside PM_{10} annual average 2003–2010



7.9 Analysis of exceedences

The only exceedences recorded during 2010 were at Greers Road, Burnside, for PM_{10} daily averages. All the other parameters monitored at all sites were below the National Environmental Standards (NES) for Air Quality.

7.9.1 Exceedences at Greers Road, Burnside

Time of year

The PM_{10} standard of 50 $\mu g/m^3$ was exceeded on eight days in 2010 during the cooler months from June to July. During July there were three consecutive days that incurred exceedences (27–29 July).

Time of day

The typical diurnal trend in PM_{10} during winter is shown in Figure 48. Here PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 $\mu g/m^3$ are plotted against time of day. From Figure 48, the biggest contributions to PM_{10} levels were between the hours of 19:00 and 04:00. This would suggest contributions from wood burning for home heating. On 21 June, PM_{10} concentrations remained higher at night compared to the other exceedence days. On 27 to 29 July elevated PM_{10} levels occur from the early morning (01:00).

Temperature

Figures 49, 50 and 51 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 $\mu g/m^3$ against hourly average temperature measured at 1.5 m, and 10 m, and the difference between the two temperature heights. From Figure 49, the biggest contributions to PM_{10} levels were when temperature measured at 1.5 m was below 6 °C. From Figure 50, the biggest contributions to PM_{10} levels were when temperature measured at 10 m was below 7 °C. On 11 July, both temperatures were lower compared to the other exceedence days. From Figure 51, the biggest contributions to PM_{10} were when temperature difference between 10 and 1.5 m was greater than zero, ie, when temperature inversion conditions prevailed. This is consistent with the trapping of pollutants and subsequent higher concentrations expected during temperature inversion conditions.

Relative humidity

Figure 52 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 $\mu g/m^3$ against hourly average relative humidity (RH). From Figure 52, PM_{10} levels began to rise when RH was above 75 per cent and peaked at around 90 per cent. This is consistent with diurnal RH patterns throughout the day.

Wind direction

Figure 53 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 µg/m^3 against hourly average wind directions. From Figure 53, no wind direction seems to contribute significantly higher concentrations than others. This is consistent with an area with wide diffuse sources of pollution as opposed to point/line source of pollution. There were very few data points in the sector 120 to 180 degrees as wind frequency from this sector is usually low.

Wind speed

Figure 54 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 µg/m^3 against hourly average wind speeds. From Figure 54, contributions to PM_{10} began when wind speed was below 1.0 m/s and peaked at very low wind speed conditions. This is consistent with reduced dispersion under low wind speed conditions. 21 June and 27 July had higher wind speed compared to the other exceedence days. These winds increased from mid morning increasing dispersion and decreasing the PM_{10} concentrations.

NO

Figure 55 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 µg/m^3 against hourly average NO. From Figure 55, a positive linear relationship seems to exist between PM_{10} and NO concentrations. This relationship is usually more defined at PM_{10} concentrations below 60 µg/m^3 and NO concentrations below 80 µg/m^3. This is expected as PM_{10} and NO is co-generated during the burning of wood and fossil fuels.

CO

Figure 56 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 µg/m^3 against hourly average CO. From Figure 56, a positive linear relationship seems to exist between PM_{10} and CO concentrations. This relationship is usually more defined at PM_{10} concentrations below 60 µg/m^3 and CO concentrations below 2.5 mg/m^3. This is expected as PM_{10} and CO is co-generated during the burning of wood and fossil fuels.

SO_2

Figure 57 plots PM_{10} hourly averages for those days where the daily PM_{10} average exceeded 50 µg/m^3 against hourly average SO_2. From Figure 57, the relationship between PM_{10} and SO_2 concentrations seems to depend on the exceedence day. On a few days there seems to be a positive trend although this is probably due to meteorological conditions.

Conclusions

From the comparisons of available meteorological parameters and other pollutants as discussed above, it can be concluded that PM_{10} exceedences were likely due to home heating during the colder months. This is observed especially in the evenings and early mornings, when PM_{10} levels are worsened by temperature inversions trapping the pollutants and low wind speed conditions preventing effective dispersion of pollutants.

Figure 48: MfE Burnside, PM_{10} vs time of day

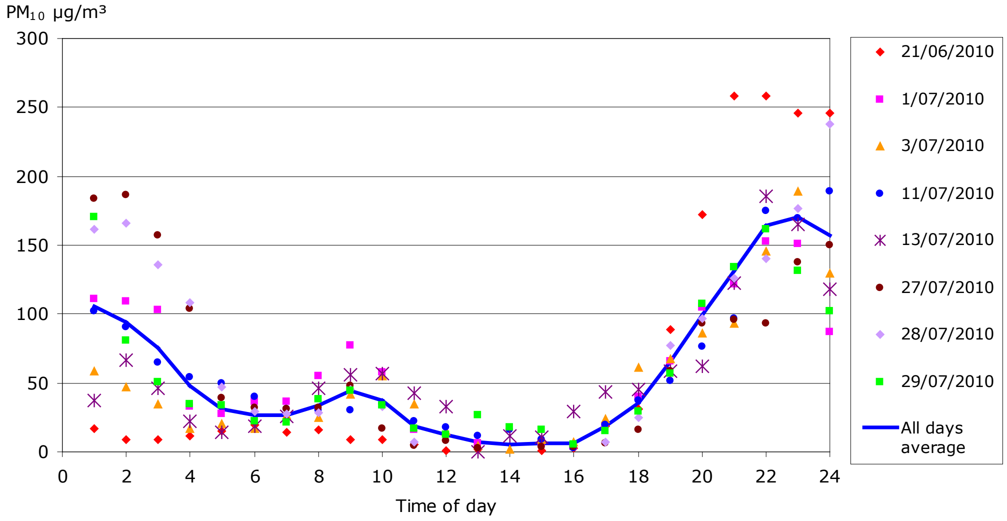


Figure 49: MfE Burnside, PM_{10} vs 1.5 m temperature

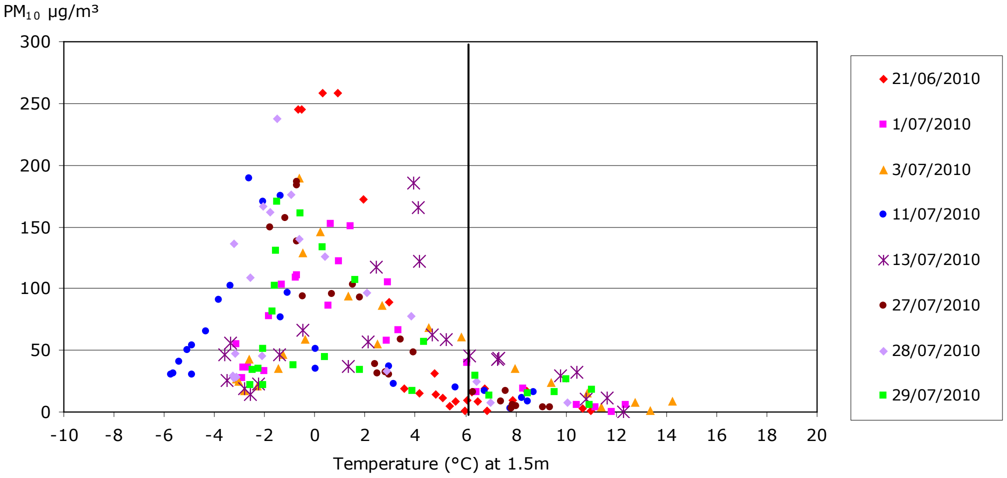


Figure 50: MfE Burnside, PM_{10} vs 10 m temperature

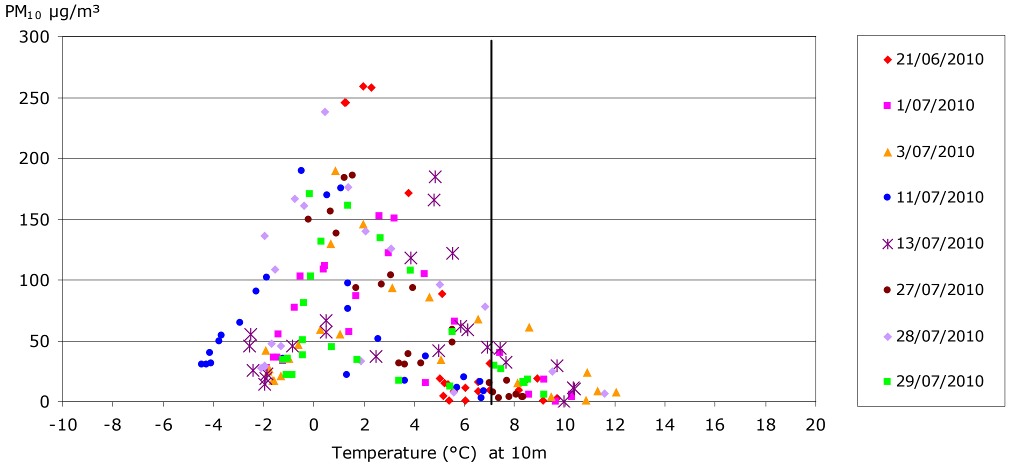


Figure 51: MfE Burnside, PM_{10} vs temperature diff 10–1.5m

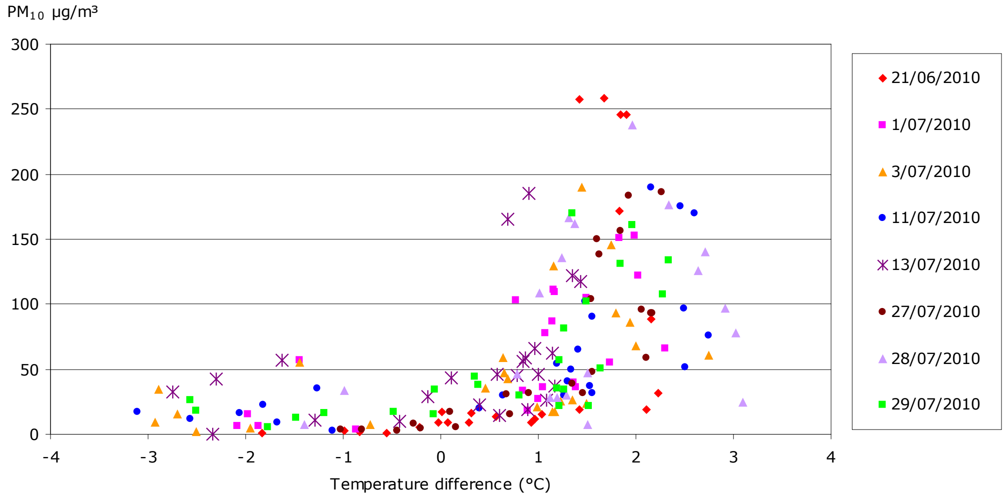


Figure 52: MfE Burnside, PM_{10} vs. relative humidity

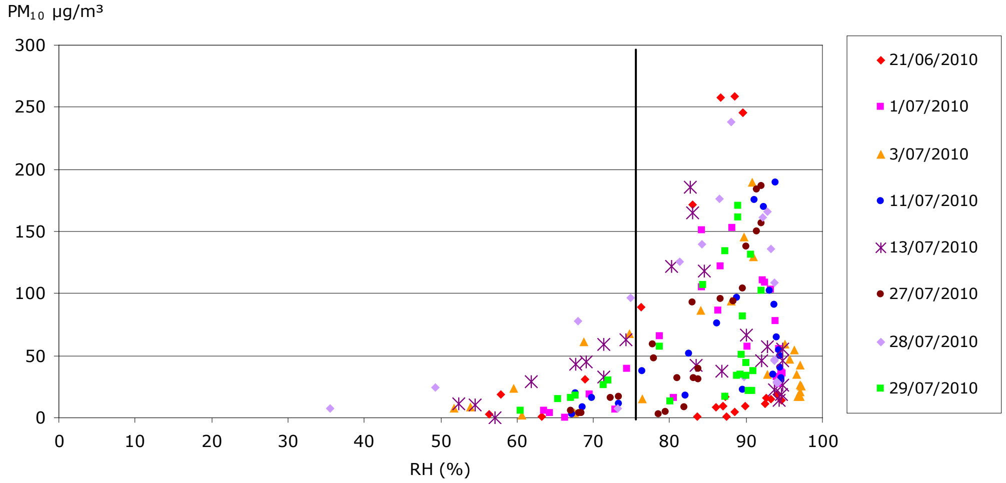


Figure 53: MfE Burnside, PM_{10} vs wind direction

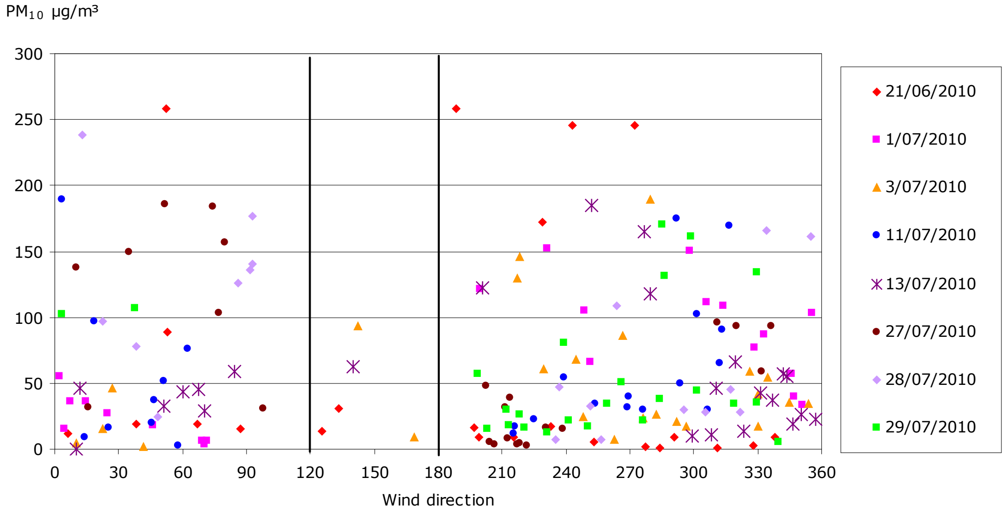


Figure 54: MfE Burnside, PM_{10} vs wind speed

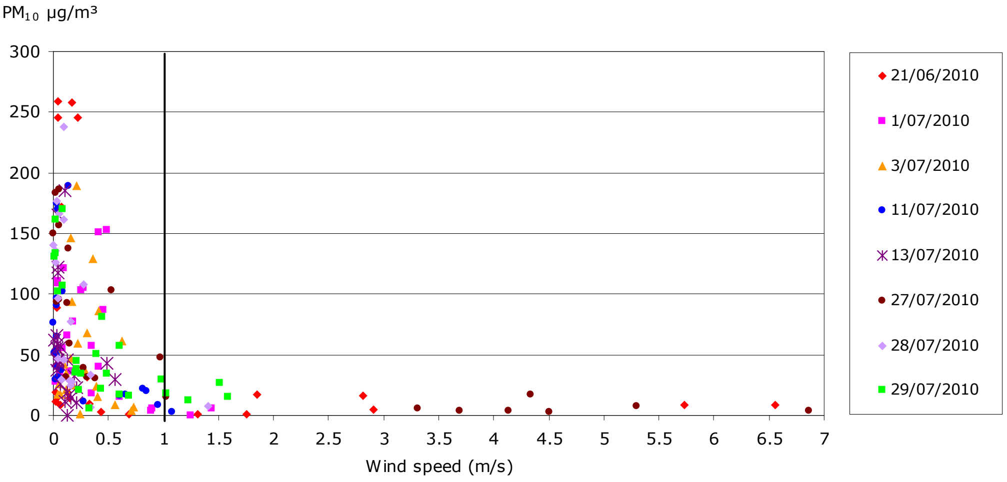


Figure 55: MfE Burnside, PM_{10} vs NO

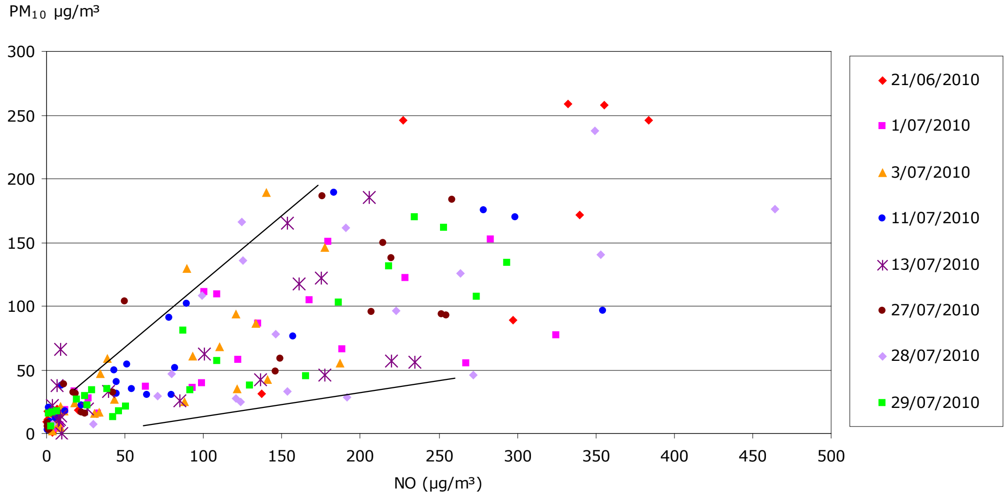


Figure 56: MfE Burnside, PM_{10} vs CO

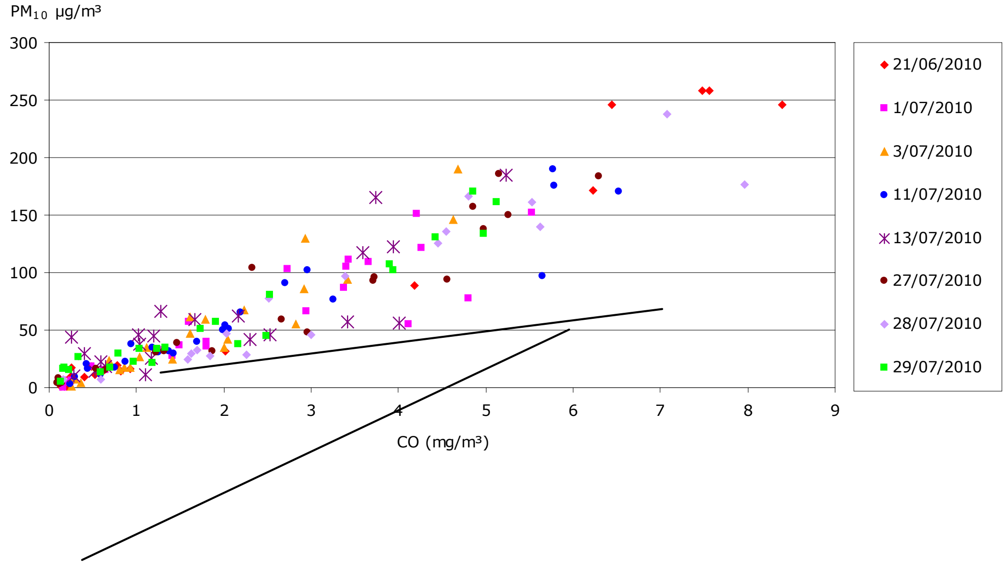


Figure 57: MfE Burnside, PM_{10} vs SO_2