



Ministry for the
Environment
Manatū Mō Te Taiao

GEMS/AMIS Air Quality Monitoring Programme

Annual Report 2008

Prepared for the Ministry for the Environment
by Watercare Services Limited

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1 Summary

This report contains the 2008 annual ambient air quality data set, measured from one site in Auckland and Christchurch. These sites form New Zealand's contribution to the Global Environmental Monitoring System (GEMS).

The GEMS monitoring sites were established to measure key air pollutants associated with adverse effects on people's health and well-being. The GEMS sites include some of the longest running air quality monitoring sites in New Zealand. For example, total suspended particulates (TSP) and Lead (Pb) monitoring has been undertaken at the Gavin Street, Penrose site in Auckland since 1964. The GEMS sites have provided long-term continuity in monitoring data for Auckland and Christchurch, and have recorded trends in pollution levels in two of New Zealand's largest cities.

There is currently one monitoring site in Auckland which is representative of vehicle and industrial emissions (Gavin Street, Penrose). The Greers Road, Burnside site in Christchurch is located within a residential area and represents emissions from domestic properties.

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

- particulate matter (PM₁₀) – principally from domestic heating, vehicle emissions and industrial processes (as well as natural processes such as soil erosion and sea spray)
- nitrogen oxides (NO and NO₂) – mostly from motor vehicle emissions
- sulfur dioxide (SO₂) – produced from the burning of fossil fuels, particularly coal and oil
- carbon monoxide (CO) – a product of incomplete combustion of carbon containing fuels, especially from motor vehicles
- total suspended particulates (TSP) – particles sufficiently small enough to be inhaled but due to its size are readily filtered out in the nasal cavity
- volatile organic compounds (VOCs) – organic chemicals, such as hydrocarbons, that are closely tied to vehicle emissions and many industrial processes
- lead (Pb) – was a petrol additive but since the significant reduction of lead in petrol from 1996, levels have declined in New Zealand.

Ambient air quality standards for CO, NO₂, SO₂, PM₁₀ 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 Guideline levels for pollutants (and averaging periods) not covered by the standards still apply.

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 all the 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 11 exceedences of the 24-hour standard for PM₁₀, mainly during the colder months from May to August 2008. These exceedences were most likely due to home heating emissions. The NES for air quality allows for one exceedence of the PM₁₀ 24-hour threshold per year before the standard is breached.

2 Introduction

This report presents the 2008 ambient air quality data set for Auckland and Christchurch, New Zealand. The monitoring is conducted by Watercare Services Ltd, on behalf of the Ministry for the Environment.

The Ministry for the Environment has a Memorandum of Understanding with the Ministry of Health to collect and supply air quality monitoring data to the World Health Organization (WHO) from two sites – one in Auckland and one in Christchurch.

This data has historically formed New Zealand's contribution to WHO's 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.

As a result, monitoring from the AMIS programme is used by the Ministry for the Environment to support and enhance ambient air quality monitoring and management in Auckland and Christchurch. The GEMS/AMIS ambient air quality sites are the longest running sites in New Zealand, and as such have provided long-term trends of air pollution for 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). Previously, there was a monitoring site 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.

Between 1989 and 2002 monitoring was undertaken in Christchurch 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.

Environment Canterbury provided sampling services for gravimetric and passive monitoring methods at the Christchurch sites (Coles Place, St Albans and Greers Road Burnside).

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.

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 in most urban areas are vehicle exhaust emissions and home heating.³ As such, elevated concentrations are mainly found in areas of significant traffic congestion, particularly at busy intersections on inner-city streets.

Carbon monoxide acts on humans by inhibiting 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 species that exist in the atmosphere, which are collectively referred to as NO_x. The two main oxides are nitrogen dioxide (NO₂), which is of concern due to its potential to cause health effects, and nitric oxide (NO), which is less toxic but may oxidise to NO₂ 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

The main health effects of the oxides of nitrogen are due to NO₂, which is a respiratory irritant. Nitric oxide is believed to be quite harmless at the levels normally encountered in urban air.

NO_x is also an important air pollutant because of its role in photochemical smog. NO₂ is a reddish brown gas, and has synergistic health effects with other pollutants such as SO₂ and particulate matter.

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.

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, NO_x, 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>

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 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 volatile organic compounds (VOC) benzene and 1,3-butadiene and provides ambient air quality guidelines for these contaminants⁵.

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 fuel combustion such as those associated with road vehicles, power generation, industrial processes and domestic heating appliances
- particulates formed 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 dusts from road vehicles, construction works, mineral extraction processes, wind-blown dusts and soils, sea salt, and biological particulates such as pollen.

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.

⁵ Ministry for the Environment. 2002. *Ambient Air Quality Guidelines*. Wellington: Ministry for the Environment.

A variety of measurements can be used to determine the different health and environmental effects of particulate matter. As part of the GEMS/AMIS programme two particle size fractions are monitored:

- particulate matter less than 10 µm (PM₁₀)
- total suspended particulates (TSP).

3.5.1 Particulate matter as PM₁₀

The main effect of PM₁₀ is on human health as PM₁₀ can be inhaled into the respiratory system. The coarser fractions of airborne particles are deposited in the trachea bronchial region, where asthma attacks are triggered.

3.5.2 Total suspended particulate (TSP)

TSP consists of all particles which range in size up to 50 µm in diameter. TSP is sufficiently small enough to be inhaled; however, the larger particles (10–50 µm) are readily filtered out in the nasal cavity. TSP has an effect on both the aesthetic and health quality of the 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 and to reflect this, in October 2000 monitoring of lead was reduced from monthly samples to samples taken over a three-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 and some New Zealand guidelines are described in table 1 below.

The criteria used for TSP, $60 \mu\text{g}/\text{m}^3$ (seven-day average), was previously used by the Ministry of Health. 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 guidelines⁶

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

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 the Ministry for the Environment (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 Services 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.			
Pollutants monitored	CO N	NO₂ Y	SO₂ Y
	PM₁₀ Y	TSP Y	Lead Y
Meteorological parameters monitored	Wind speed Y	Wind direction Y	Relative humidity Y
	Temperature (6 m) Y	Temperature (10 m) N	Temperature (2 m) 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 Services 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 m 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 north-west 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.				
Pollutants monitored	CO	NO₂	SO₂	VOCs
	Y	Y	Y	Y
Meteorological parameters monitored	PM₁₀	TSP	Lead	
	Y	N	N	
Meteorological parameters monitored	Wind speed	Wind direction	Relative humidity	
	Y	Y	Y	
	Temperature (6 m)	Temperature (10 m)	Temperature (1.5 m)	
	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 sub-urban area of St Albans which lies to the north of Christchurch city centre.				
Pollutants monitored	CO N	NO₂ N	SO₂ N	VOCs Y
	PM₁₀ N	TSP Y	Lead Y	
Meteorological parameters monitored	Wind speed N	Wind direction N	Relative humidity N	
	Temperature (6 m) N	Temperature (10 m) N	Temperature (2 m) N	
Location map		Photograph		

5.2 Air pollutants monitored at GEMS/AMIS sites

An overview of the air pollutants monitored at each site during 2008, as part of the GEMS/AMIS programme, is given in Table 2 below.

Table 2: Air pollutants monitored at GEMS/AMIS sites, 2008

Site	CO	NO ₂	SO ₂	VOC	PM ₁₀	TSP	Lead*
Transpower, Gavin Street, Penrose, Auckland AKL009		✓	✓	✓	✓	✓	✓
Greens 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 Services Ltd in accordance with the Ministry for the Environment's *Good Practice Guide for Air Quality Monitoring and Data Management* and wherever applicable the appropriate Australian/New Zealand and US EPA monitoring methods.

Watercare Laboratory Services 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) – PM₁₀ High Volume Sampling'
- US EPA Equivalent Method EQPM-1102-150 'Thermo Anderson Series FH62-C14 Continuous PM₁₀ Monitor Automated Equivalent Method'
- 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 Laboratory Services 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 bar).

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 PM₁₀

Measurements are made in accordance with the US EPA Equivalent Method for measuring PM₁₀ EQPM-1102-150 using a Thermo Andersen Series FH62-C14 Continuous PM₁₀ Ambient Particulate Beta Attenuation Monitor (BAM). This method was designated as an Equivalent Method by the US EPA in accordance with 40 CFR Part 53 on 11 December 2002.

The Thermo Andersen FH62-C14 is fitted with a size-selective PM₁₀ head and measures the mass as it accumulates during sampling. As a result, the instrument is able to generate real-time measurements of PM₁₀ data which allows measurements to be reported over a variety of average periods, including 10 minutes, 24 hours and one year. The inlet temperature of all units operated by the Ministry for the Environment is 40°C.

6.2.6 Total suspended particulate matter (TSP)

Measurements of TSP are made in accordance with Watercare's Air Quality Group Test Method T101. The TSP analysis is performed in accordance with Watercare Laboratory Services Method GE08 (for TSP filters). It is a gravimetric method of measuring particulates and is modelled on the High Volume sampler method. These techniques have been used to provide TSP data at existing GEMS/AMIS sites since 1964.

The equipment used to measure TSP is quite basic and involves ambient air being pulled through a glass fibre filter by a pump with a gas meter being used to measure the air volume drawn through the filter. The filter is weighed before and after sampling. The TSP concentration is determined from the weight of particulates collected and the air volume sampled.

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.

All sampling performed at all sites was as planned during 2008. The 2000 *Good Practice Guide for Air Quality Monitoring and Data Management* suggests that it is difficult to reach anything close to 100 per cent valid data for long-term monitoring. Site performance has therefore been evaluated against a target of 95 per cent.

The performance of continuously monitored pollutant instruments during 2008 was generally very good, all sites had annual valid data and data capture rates greater than 95 per cent with the exception of TSP at St Albans.

Table 3: Percentage valid and capture data, 2008

Analyte	Site	Percentage valid data (V) and Percentage data capture (C)																									
		January		February		March		April		May		June		July		August		September		October		November		December		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		
CO	Burnside	97.2	99.3	98.4	100	98.5	100	98.5	100	98.3	100	98.1	100	98.0	100	98.3	99.8	98.4	99.9	98.5	100	98.5	100	98.3	99.8	98.2	99.9
NO ₂	Penrose	97.3	99.3	93.2 ^d	95.0	96.7	99.8	98.3	99.9	97.7	99.6	98.2	99.9	98.4	99.9	97.9	99.7	98.3	99.9	98.3	99.7	97.9	99.9	97.9	99.7	97.5	99.4
NO ₂	Burnside	94.3 ^a	99.3	98.5	100	98.3	100	98.4	100	98.2	99.9	98.3	100	97.7	100	98.3	99.8	97.2	99.1	97.6	99.8	97.7	99.8	97.4	99.8	97.7	99.8
SO ₂	Penrose	88.6 ^b	92.3 ^b	91.5 ^d	94.9	94.9 ^e	99.0	94.2 ^f	99.7	97.1	99.6	97.0	99.9	97.1	99.9	97.3	99.7	96.9	99.9	96.9	99.6	97.4	99.9	97.0	99.7	95.5	98.6
SO ₂	Burnside	97.0	99.3	97.7	100	97.9	100	97.8	100	97.2	100	97.6	100	96.5	100	97.3	99.8	97.7	99.9	97.6	100	97.8	100	97.6	99.8	97.5	99.9
PM ₁₀	Burnside	98.0	98.9	98.8	99.5	97.9	98.6	97.8	98.4	98.0	98.7	98.5	99.2	91.5 ^h	92.6 ^h	83.3 ⁱ	84.4 ⁱ	97.6	98.4	99.1	99.9	97.8	98.5	96.6	97.4	96.2	97.0
PM ₁₀	Penrose	96.8	98.5	93.6 ^d	94.9	98.2	98.9	98.4	99.8	97.9	99.3	98.7	99.7	98.8	99.8	98.9	99.6	99.0	99.7	98.9	99.6	99.2	99.9	97.9	98.6	98.0	99.0
VOC	St Albans	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-
VOC	Penrose	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	-
TSP	St Albans	60 ^c	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	60 ^c	-	92.5	-
TSP	Penrose	100	-	100	-	100	-	100	-	50 ^g	-	100	-	100	-	100	-	100	-	100	-	100	-	100	-	96.2	-
Lead	St Albans	-	-	-	-	-	-	-	-	-	-	100	-	100	-	100	-	-	-	-	-	-	-	-	-	100	-
Lead	Penrose	-	-	-	-	-	-	-	-	-	-	100	-	100	-	100	-	-	-	-	-	-	-	-	-	100	-

Notes:

- a NO₂ – Annual maintenance analyser swapped
- b SO₂ – Datalogger jammed and analyser swapped
- c TSP – Sampling error
- d Power cut
- e SO₂ – Cooler failed analyser swapped
- f SO₂ – UV lamp problem analyser swapped
- g TSP – No power and filter cassette broke
- h PM₁₀ – Pump exchanged by ECAN
- i PM₁₀ – data invalid due to a temperature sensor fault

7.2 Carbon monoxide (CO) 2008

CO was monitored at Greers Road, Burnside. One hour and 8-hour 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	8.7 (4 June 22:00)	6.9	6.1 (21 August 03:00)	5.2

Carbon monoxide results are shown in figures 7 to 11.

At Greers Road, Burnside during the 12 month period there were no exceedences of the ambient air quality 1-hour guideline (30 mg/m³) or 8-hour National Environmental Standard (10 mg/m³).

7.3 Nitrogen oxides (NO₂ and NO) 2008

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 NO₂ 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	110.4 (10 June 09:00)	79.9	57.5 (8 July)	54.2
Greers Road, Burnside	79.7 (20 August 20:00)	61.0	36.0 (20 August)	34.0

Nitrogen dioxide results are shown in figures 12 to 21 (Penrose), and 22 to 31 (Burnside).

There were no exceedences of the NO₂ ambient air quality 1-hour standard (200 µg/m³) or the 24-hour guideline (100 µg/m³) during 2008 at any site in Auckland or Christchurch.

7.4 Sulfur dioxide (SO₂) 2008

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 SO₂ and their dates for each site are described below.

Site	Maximum 1-hour average ($\mu\text{g}/\text{m}^3$)	99.9 percentile 1-hour average ($\mu\text{g}/\text{m}^3$)	Maximum 24-hour average ($\mu\text{g}/\text{m}^3$)	99.5 percentile 24-hour average ($\mu\text{g}/\text{m}^3$)
Gavin Street, Penrose	31.1 (6 May 11:00)	23.9	11.8 (9 July)	10.1
Greers Road, Burnside	70.9 (7 February 06:00)	45.7	23.9 (7 February)	16.4

Results for Gavin Street, Penrose are shown in figures 32 to 36 and Greers Road, Burnside is shown in figures 37 to 41. There were no exceedences of the SO_2 ambient air quality 1-hour standard ($350 \mu\text{g}/\text{m}^3$) or the 24-hour guideline ($120 \mu\text{g}/\text{m}^3$) during 2008 at any site.

7.5 Volatile organic compounds (VOC) January–December 2008

Monitoring of VOCs was conducted at three sites, Gavin Street, Penrose, Greers Road, Burnside, and Coles Place, Christchurch. VOC monitoring utilises passive sampling badges, exposed over a three-month period. A set of results for each 2008 quarter are shown in tables 4 to 7.

The benzene guideline is $10 \mu\text{g}/\text{m}^3$ as an annual average, with an average value of $3.6 \mu\text{g}/\text{m}^3$ to be achieved by 2010. The 2008 six-month and 12-month averages are described below. The benzene annual averages from all the sites are less than the AAQG 2002 guideline and are graphed in figure 1.

Site	Six-month average (January–June 2008) benzene ($\mu\text{g}/\text{m}^3$)	Six-month average (July–December 2008) benzene ($\mu\text{g}/\text{m}^3$)	2008 annual average benzene ($\mu\text{g}/\text{m}^3$)
Coles Place, St Albans	1.7	1.1	1.4
Greers Road, Burnside	1.5	1.1	1.3
Gavin Street, Penrose	1.1	0.8	0.9

Table 4: VOC results (January–March 2008)

January–February–March 2008 Analyte	Limit of detection (µg/m ³)	Results (µg/m ³)		
		Coles Place	Burnside	Penrose
Target VOCs				
Ethanol	ND			
Isopropyl alcohol	ND			
Acetone	ND			
Pentane	2.4			2.8
Dichloromethane	ND			
Butan-2-one	ND			
Hexane	0.5	0.5	1.3	0.8
Ethyl acetate	0.5			0.5
Trichloromethane	ND			
1,1,1-trichloroethane	ND			
N-butanol	ND			
Benzene	0.2	0.6	0.6	0.7
2-methylhexane	ND			
2,3-dimethylpentane	ND			
3-methylhexane	ND			
Heptane	0.6		0.9	
Trichloroethene	ND			
Propyl acetate	ND			
Methylcyclohexane	ND			
4-methylpentan-2-one	ND			
Toluene	0.3	3.6	3.8	5.3
Octane	ND			
Tetrachloroethene	ND			
Butyl acetate	ND			
Ethylbenzene	0.3	0.5	0.5	0.7
M+p-xylene	0.3	1.9	1.7	2.8
Styrene	ND			
O-xylene	0.3	0.7	0.7	1.0
Nonane	ND			
Alpha pinene	ND			
Propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
Beta pinene	ND			
Decane	ND			
1,2,4-trimethylbenzene	0.6	0.7		1.1
Limonene	ND			
Undecane	ND			
Dodecane	ND			
Tetradecane	ND			

ND = Not detected.

Table 5: VOC results (April–June 2008)

April–May–June 2008 Analyte	Limit of detection ($\mu\text{g}/\text{m}^3$)	Results ($\mu\text{g}/\text{m}^3$)		
		Coles Place	Burnside	Penrose
Target VOCs				
Ethanol	ND			
Isopropyl alcohol	ND			
Acetone	ND			
Pentane	2.4	2.7		
Dichloromethane	ND			
Butan-2-one	ND			
Hexane	0.5	1.9	1.7	1.3
Ethyl acetate	0.5			0.5
Trichloromethane	ND			
1,1,1-trichloroethane	ND			
N-butanol	ND			
Benzene	0.2	2.8	2.5	1.5
2-methylhexane	0.6	0.9	0.7	
2,3-dimethylpentane	ND			
3-methylhexane	0.6	1.1	0.9	0.6
Heptane	0.6	0.9	0.9	
Trichloroethene	0.5			
Propyl acetate	ND			
Methylcyclohexane	0.6	1.7	0.9	
4-methylpentan-2-one	ND			
Toluene	0.3	10.7	8.1	9.1
Octane	ND			
Tetrachloroethene	ND			
Butyl acetate	0.5			0.6
Ethylbenzene	0.3	1.7	1.3	1.4
M+p-xylene	0.3	5.2	3.9	4.8
Styrene	ND			
O-xylene	0.3	2.1	1.6	1.7
Nonane	0.6			
Alpha pinene	0.8		0.8	
Propylbenzene	ND			
1,3,5-trimethylbenzene	0.6	0.7		0.6
Beta pinene	0.8		1.0	
Decane	0.7			
1,2,4-trimethylbenzene	0.7	2.4	1.7	2.0
Limonene	ND			
Undecane	ND			
Dodecane	ND			
Tetradecane	ND			
Ethanol	ND			

ND = Not detected.

Table 6: VOC results (July–September 2008)

July–August–September 2008 Analyte	Limit of detection (µg/m ³)	Results (µg/m ³)		
		Coles Place	Burnside	Penrose
Target VOCs				
Ethanol	ND			
Isopropyl alcohol	ND			
Acetone	ND			
Pentane	3.0			3.6
Dichloromethane	ND			
Butan-2-one	ND			
Hexane	0.6	1.0	1.3	0.9
Ethyl acetate	ND			
Trichloromethane	ND			
1,1,1-trichloroethane	ND			
N-butanol	ND			
Benzene	0.3	1.8	1.7	1.0
2-methylhexane	ND			
2,3-dimethylpentane	ND			
3-methylhexane	0.7	0.5	0.6	
Heptane	0.7	0.6	0.8	
Trichloroethene	ND			
Propyl acetate	ND			
Methylcyclohexane	ND			
4-methylpentan-2-one	ND			
Toluene	0.3	5.8	4.9	6.1
Octane	ND			
Tetrachloroethene	ND			
Butyl acetate	0.6			0.5
Ethylbenzene	0.4	1.0	0.9	0.9
M+p-xylene	0.4	3.3	2.7	3.5
Styrene	ND			
O-xylene	0.4	1.2	1.0	1.2
Nonane	ND			
Alpha pinene	ND			
Propylbenzene	ND			
1,3,5-trimethylbenzene	0.8	1.2		
Beta pinene	1.0		0.7	
Decane	0.9			0.7
1,2,4-trimethylbenzene	0.8	2.2	1.0	1.7
Limonene	ND			
Undecane	0.9			2.4
Dodecane	0.9	0.9	0.7	1.5
Tetradecane	0.9	0.8	0.9	

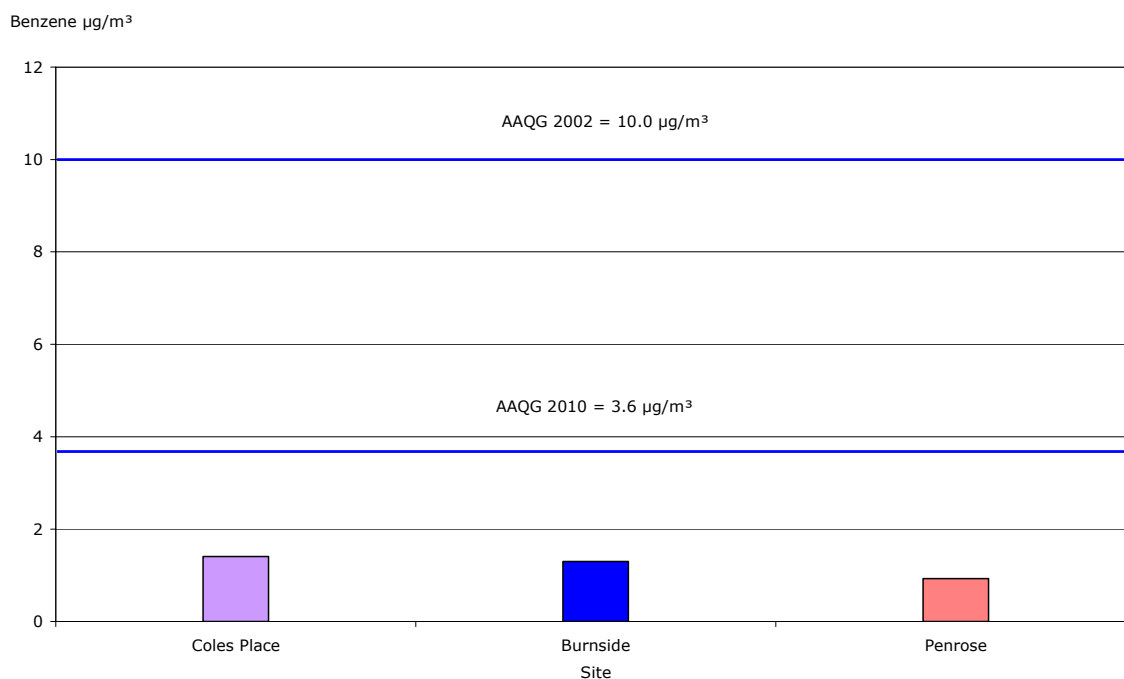
ND = Not detected.

Table 7: VOC results (October–December 2008)

October–November–December 2008 Analyte	Limit of detection ($\mu\text{g}/\text{m}^3$)	Results ($\mu\text{g}/\text{m}^3$)		
		Coles Place	Burnside	Penrose
Target VOCs				
Ethanol	ND			
Isopropyl alcohol	ND			
Acetone	ND			
Pentane	ND			
Dichloromethane	ND			
Butan-2-one	ND			
Hexane	0.6	0.5	1.0	0.6
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	0.6		0.6	
Trichloroethene	ND			
Propyl acetate	ND			
Methylcyclohexane	ND			
4-methylpentan-2-one	ND			
Toluene	0.3	2.5	2.5	3.3
Octane	ND			
Tetrachloroethene	ND			
Butyl acetate	ND			
Ethylbenzene	0.4	0.4	0.4	0.5
M+p-xylene	0.4	1.3	1.1	1.8
Styrene	ND			
O-xylene	0.4	0.4	0.4	0.6
Nonane	ND			
Alpha pinene	ND			
Propylbenzene	ND			
1,3,5-trimethylbenzene	ND			
Beta pinene	ND			
Decane	0.8			0.6
1,2,4-trimethylbenzene	0.8			0.8
Limonene	ND			
Undecane	0.8			1.2
Dodecane	ND			
Tetradecane	ND			

ND = Not detected.

Figure 1: MfE benzene annual average 2008



7.6 Particulate matter (PM₁₀) 2008

PM₁₀ is monitored at Gavin Street, Penrose and Greers Road, Burnside, using Thermo FH62-C14 BAM. Twenty-four hour averages have been calculated from 10-minute averages recorded by the instruments. All PM₁₀ concentrations are reported at standard temperature and pressure (0°C and 101.3 kPa).

Summary statistics for PM₁₀ 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	41 (29 February)	38
Greers Road, Burnside	68 (30 May)	64

There were no exceedences of the ambient air quality standard (50 µg/m³) in Auckland during the 12 month period. PM₁₀ for 2008 for Penrose are shown in Figures 42 to 44.

At Greers Road, Burnside, there were 11 exceedences of the 24-hour standard. Each exceedence and the date are listed in table 8 below. PM₁₀ for 2008 for Burnside are shown in figures 45 to 47. As there were exceedences at the Christchurch site, more data analysis was carried out in section 7.9. All exceedences occurred over the winter period, 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. All 12 exceedences occurred in cooler months between mid May and August 2008.

Table 8: Greers Road, Burnside PM₁₀ exceedences of the daily NES 2008

Date	Burnside PM ₁₀ (µg/m ³)
15/05/2008	64
28/05/2008	60
29/05/2008	64
30/05/2008	68
04/06/2008	54
10/06/2008	53
20/06/2008	51
21/06/2008	52
25/06/2008	52
16/08/2008	51
20/08/2008	65

Note: National Environmental Standard for PM₁₀ = 50 µg/m³.

7.7 Total suspended particulates (TSP) 2008

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

Site	Maximum seven-day average (µg/m ³)
Gavin Street, Penrose	27 (19 March)
Coles Place, St Albans	26 (21 August)

There were no exceedences of the Ministry of Health (MoH) guideline of 60 µg/m³ at any 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 seven-day average 2008

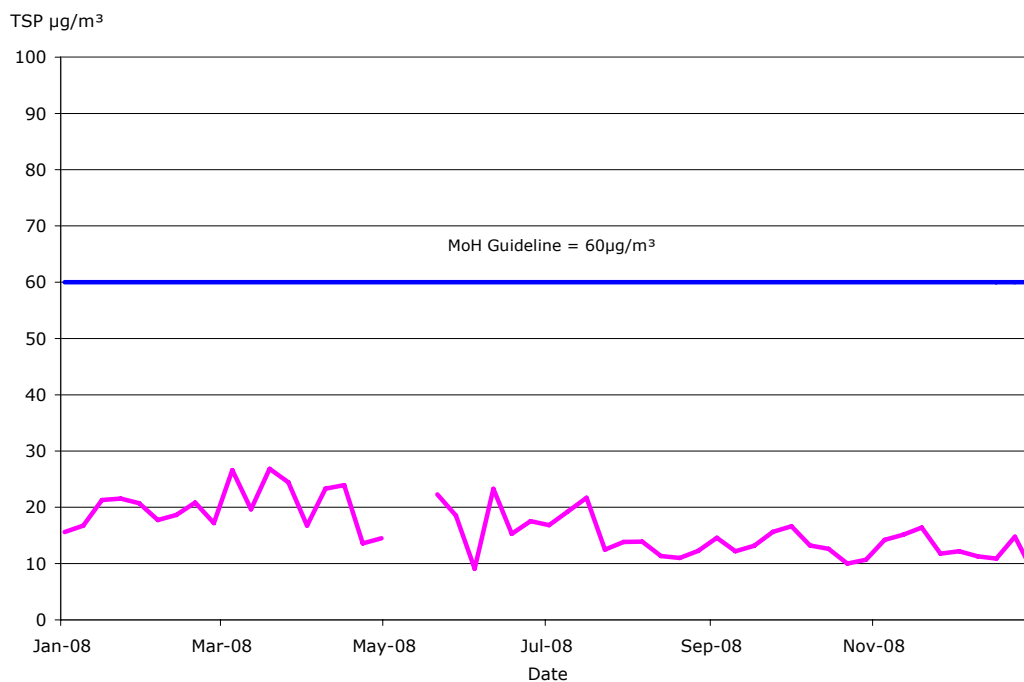


Figure 3: Auckland TSP seven-day average 1994–2008

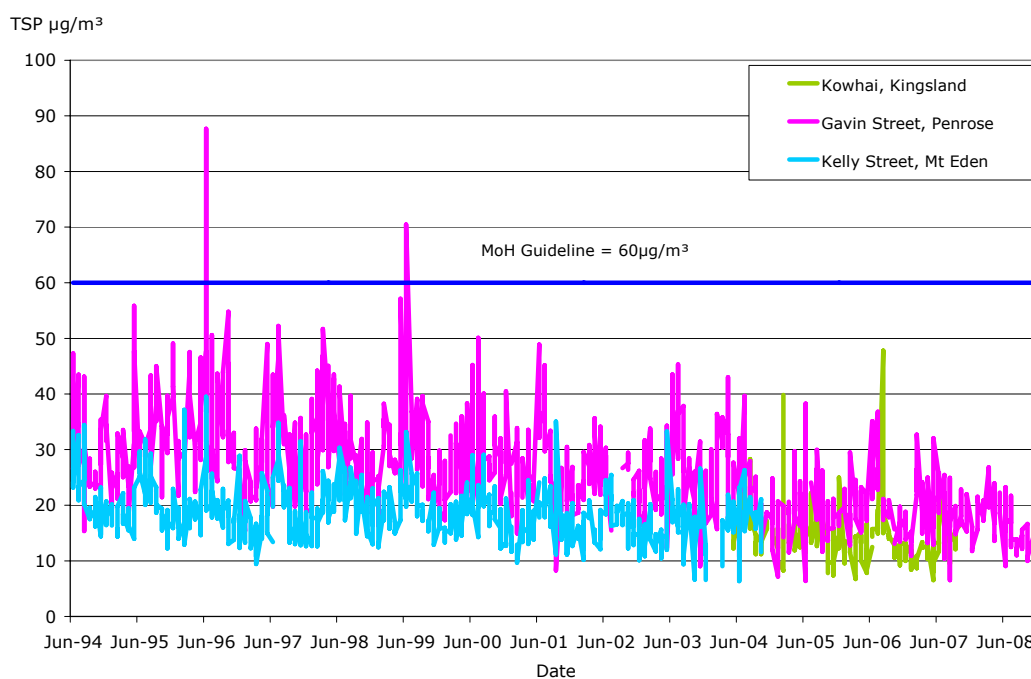


Figure 4: Christchurch TSP seven-day average 2008

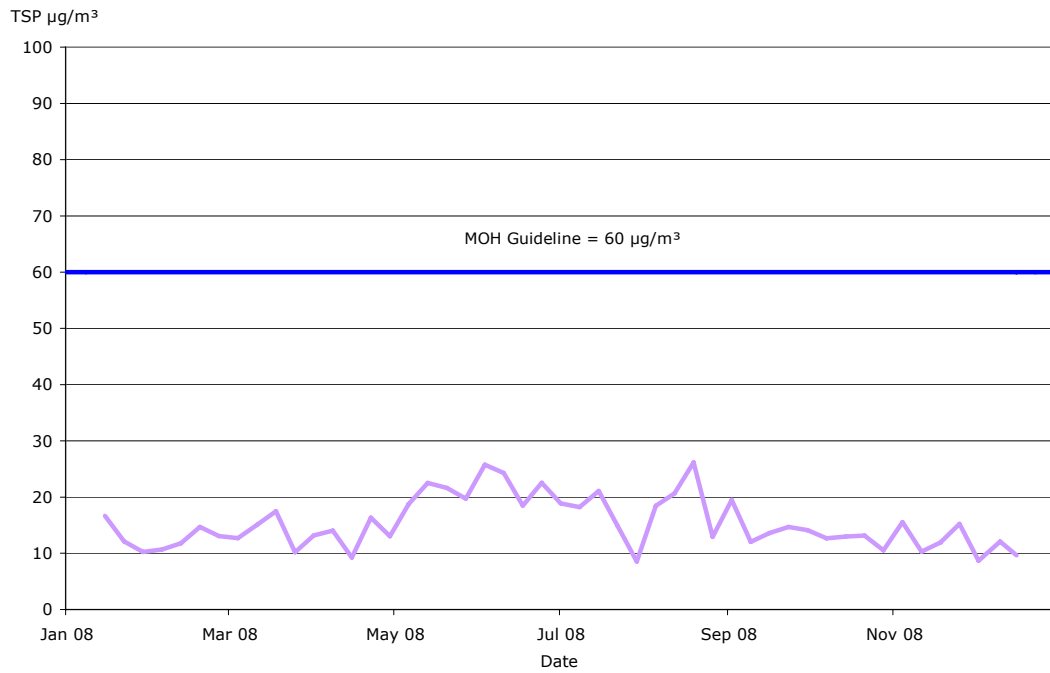
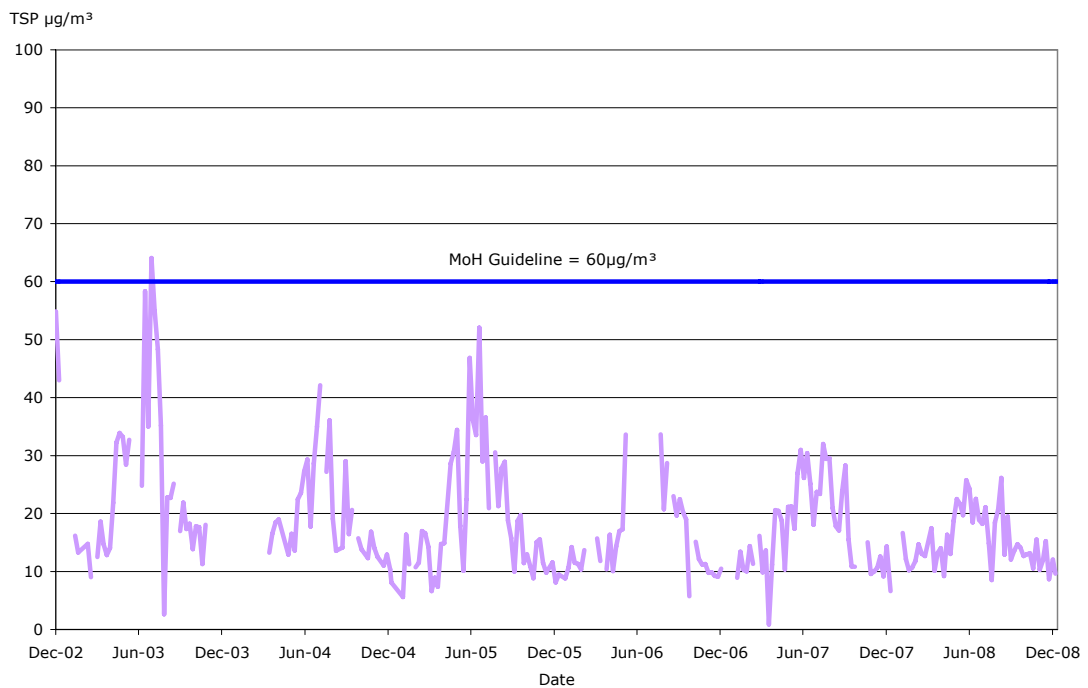


Figure 5: Christchurch TSP seven-day average 2002–2008



7.8 Lead (Pb) June–August 2008

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

Site	June 2008 average ($\mu\text{g}/\text{m}^3$)	July 2008 average ($\mu\text{g}/\text{m}^3$)	August 2008 average ($\mu\text{g}/\text{m}^3$)	Winter 2008 average ($\mu\text{g}/\text{m}^3$)
Gavin Street, Penrose	0.007	0.009	0.003	0.007
Coles Place, St Albans	0.025	0.016	0.016	0.019

No site exceeded the three-month average guideline for lead ($0.2 \mu\text{g}/\text{m}^3$).

Figure 6: MfE lead three-month average results 1996–2008

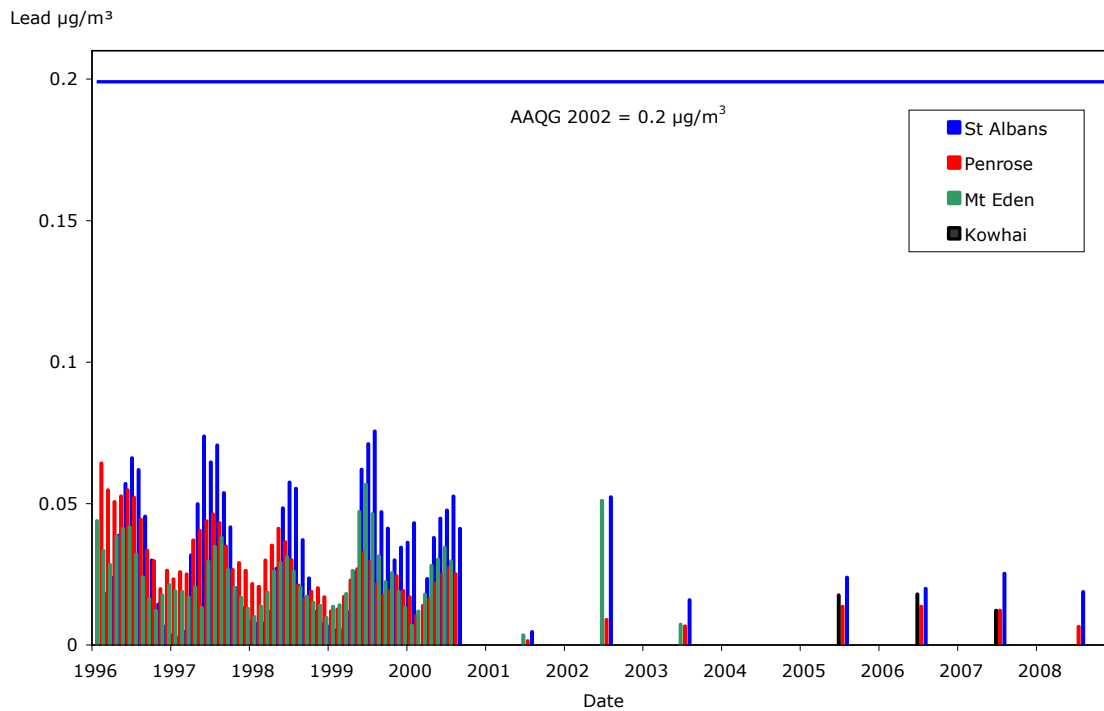


Figure 7: MfE Burnside CO 1-hour fixed average January–December 2008

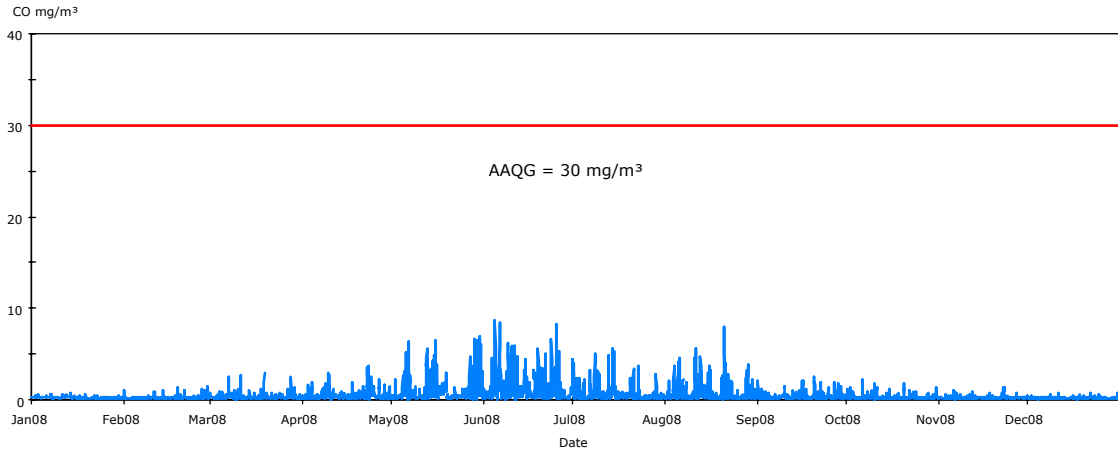


Figure 8: MfE Burnside CO 1-hour fixed average 2003–2008

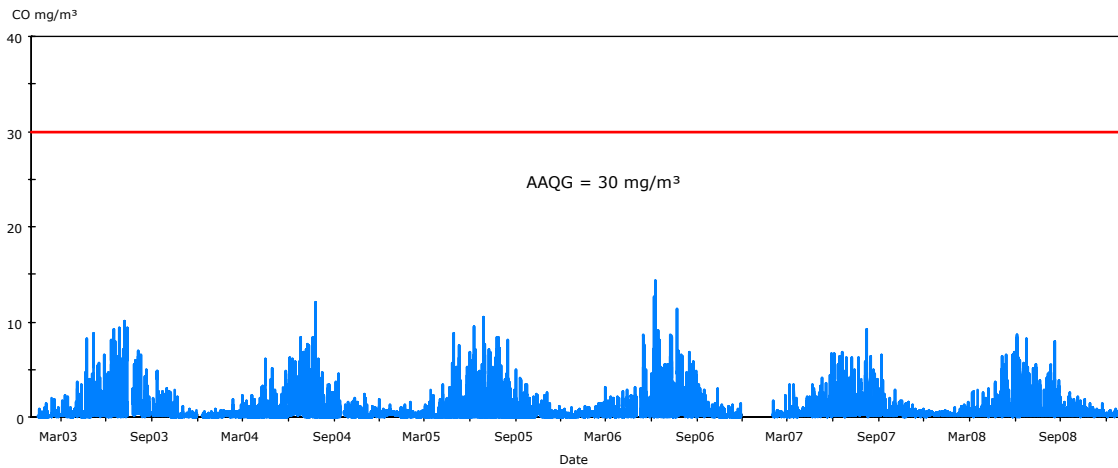


Figure 9: MfE Burnside CO 8-hour rolling average January–December 2008

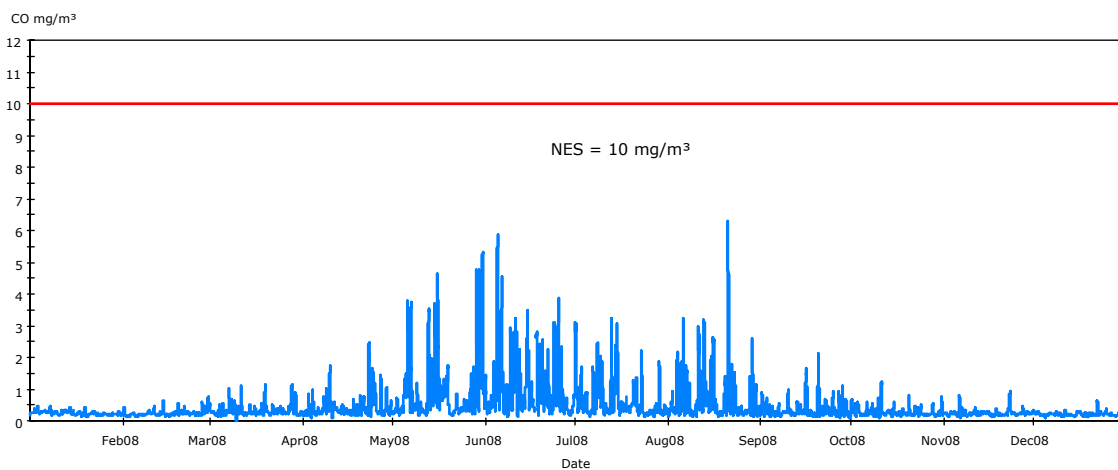


Figure 10: MfE Burnside CO 8-hour rolling average 2003–2008

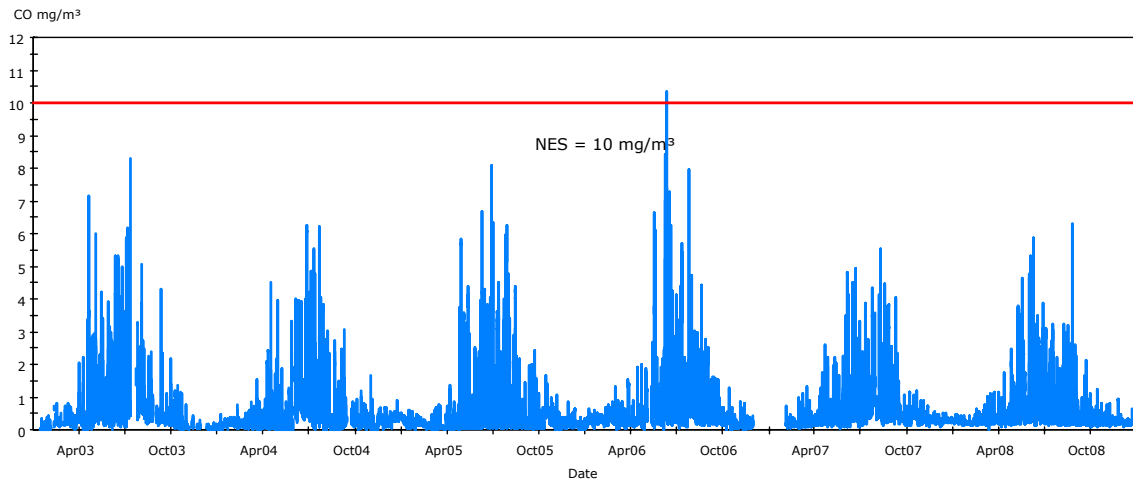


Figure 11: MfE Burnside CO annual average 2003–2008

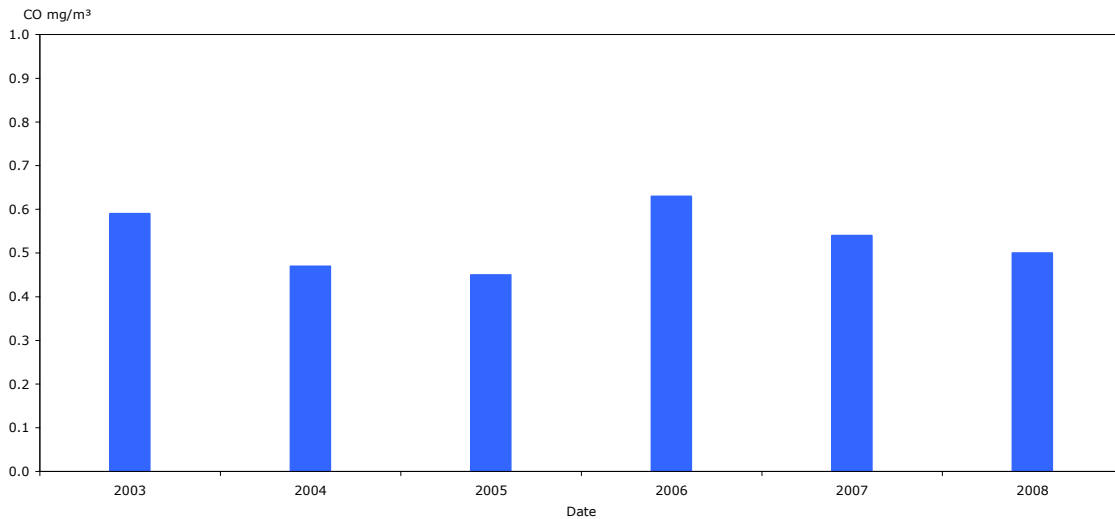


Figure 12: MfE Penrose NO₂ 1-hour fixed average January–December 2008

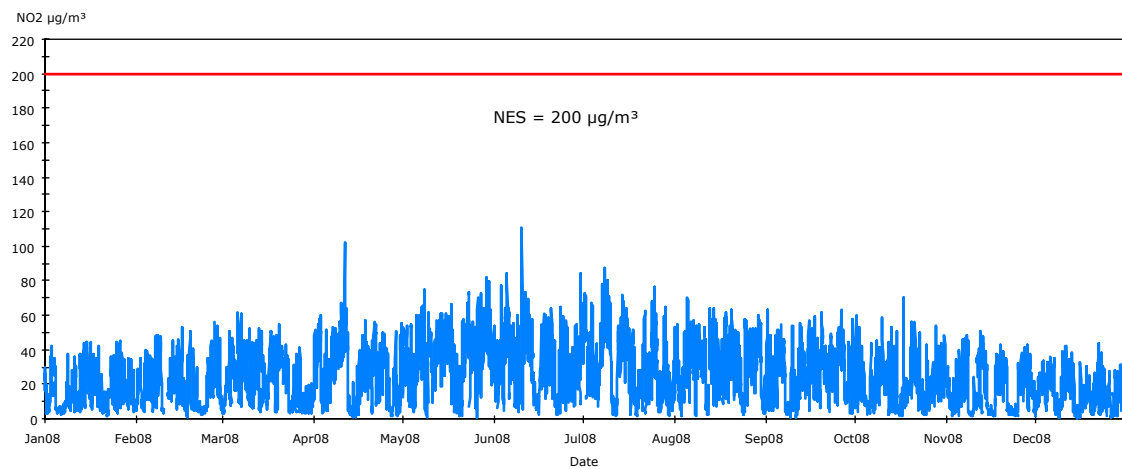


Figure 13: MfE Penrose NO₂ 1-hour fixed average 1997–2008

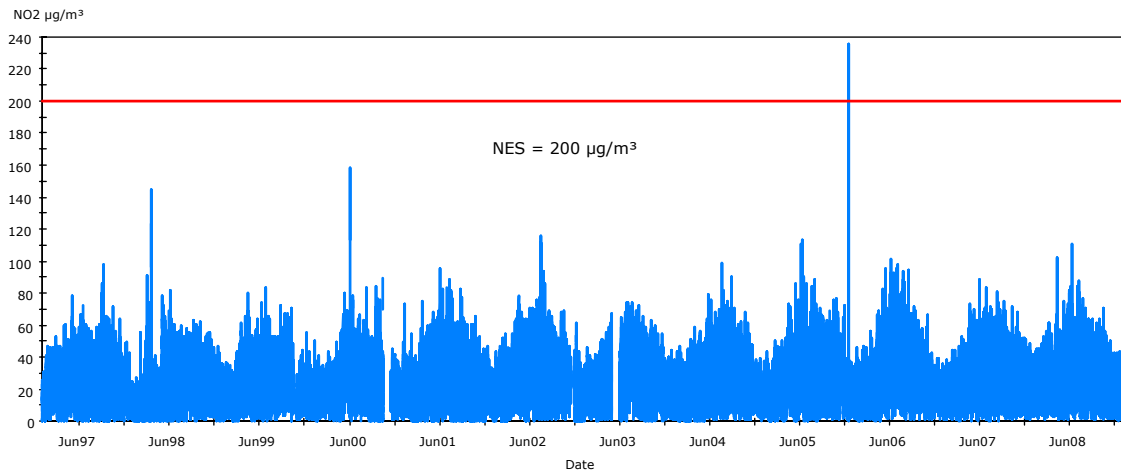


Figure 14: MfE Penrose NO₂ 24-hour fixed average January–December 2008

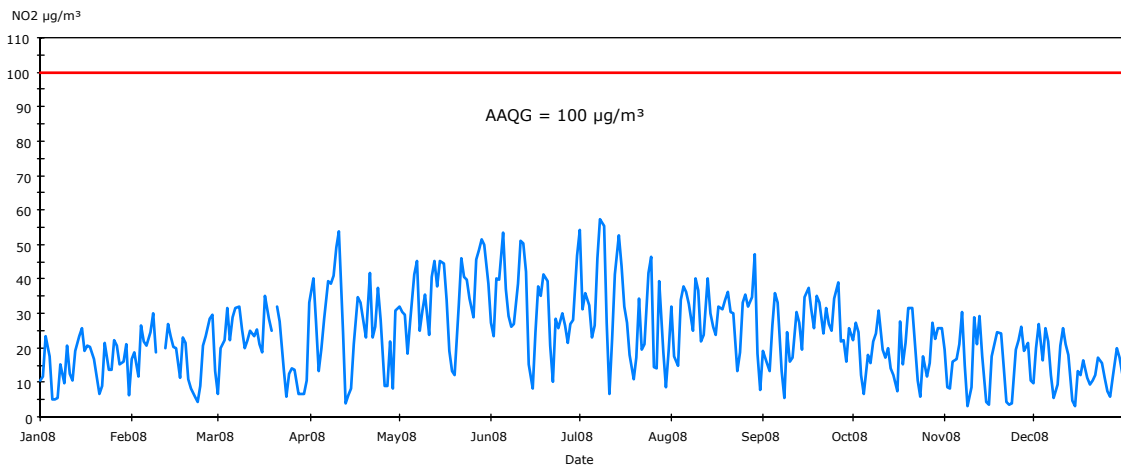


Figure 15: MfE Penrose NO₂ 24-hour fixed average 1 January 1997–2008

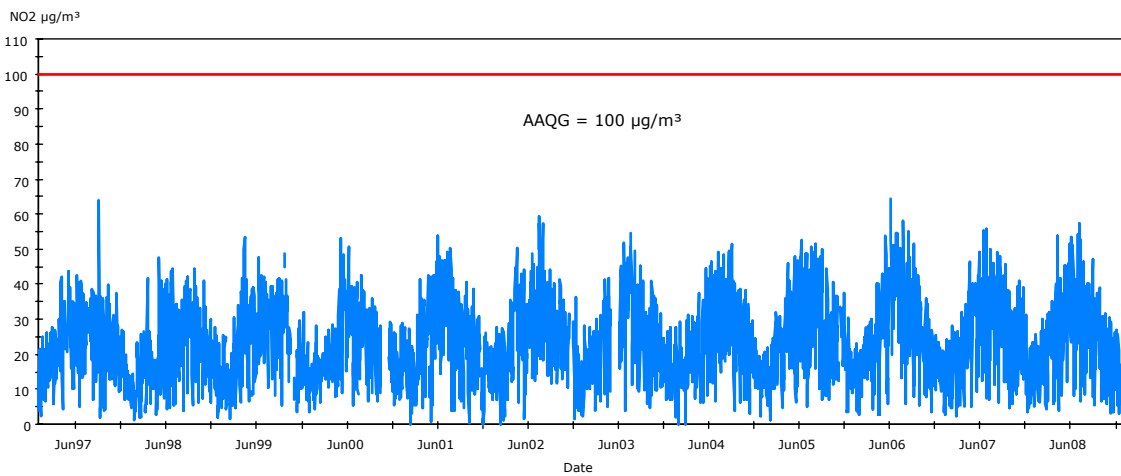


Figure 16: MfE Penrose NO₂ annual average 1997–2008

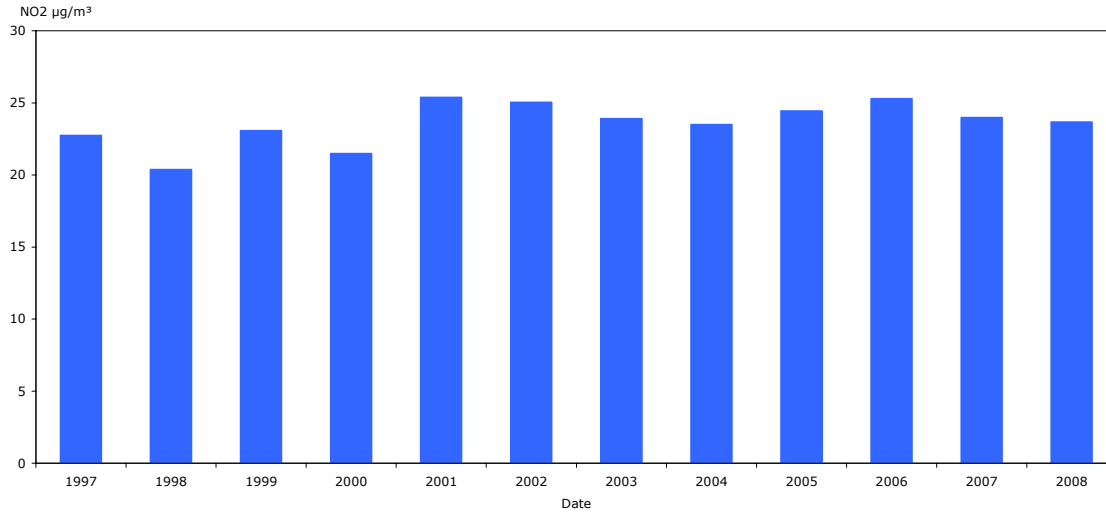


Figure 17: MfE Penrose NO₂ and NO 1-hour fixed average January–December 2008

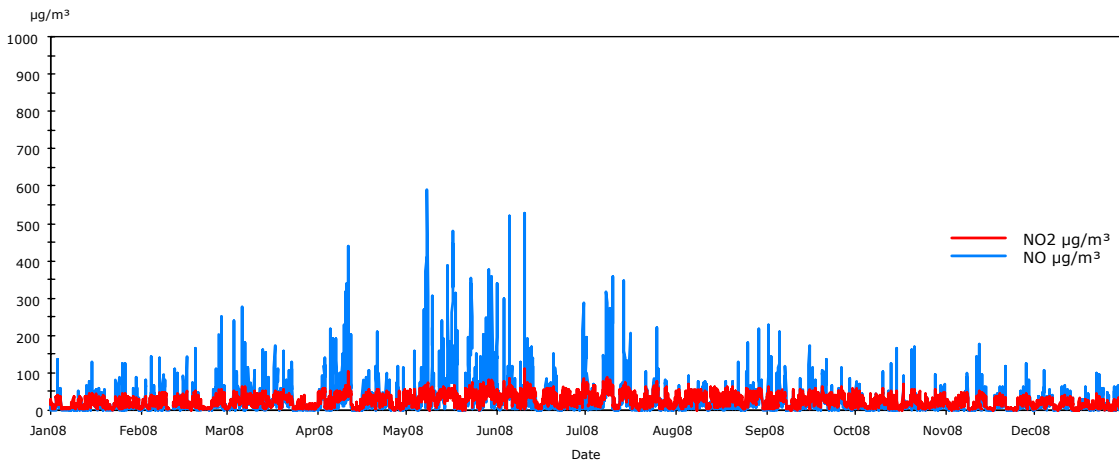


Figure 18: MfE Penrose NO₂ and NO 24-hour fixed average January–December 2008

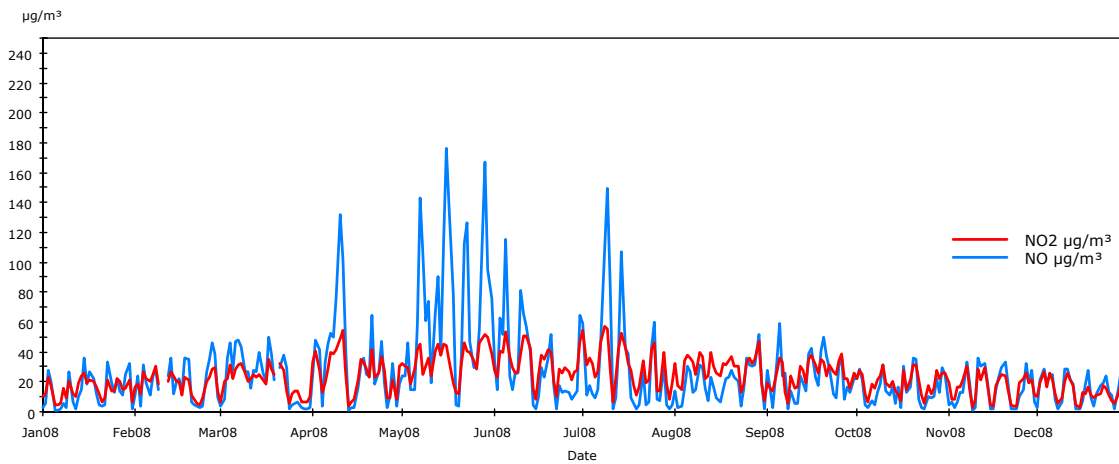


Figure 19: MfE Penrose NO 1-hour fixed average 1997–2008

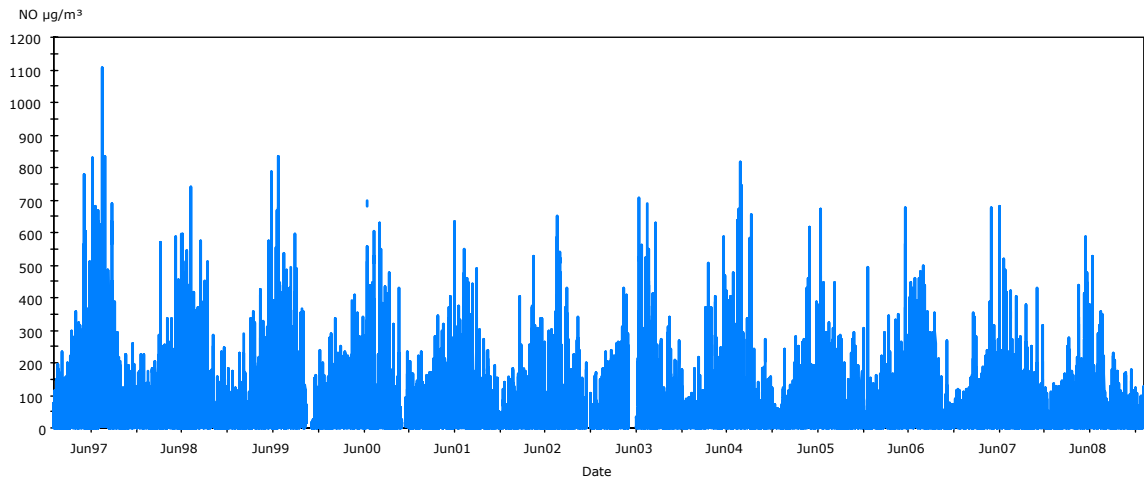


Figure 20: MfE Penrose NO 24-hour fixed average 1997–2008

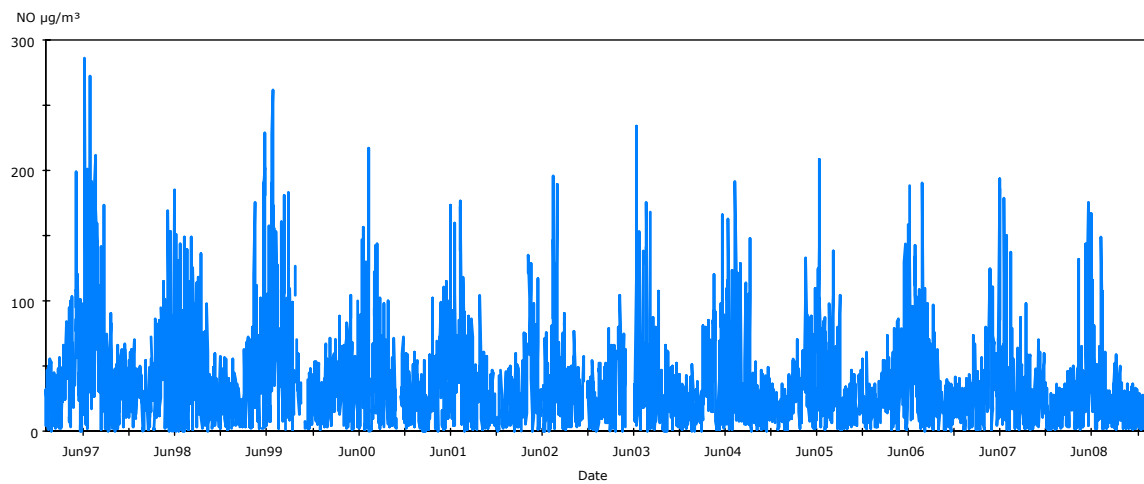


Figure 21: MfE Penrose NO annual average 1997–2008

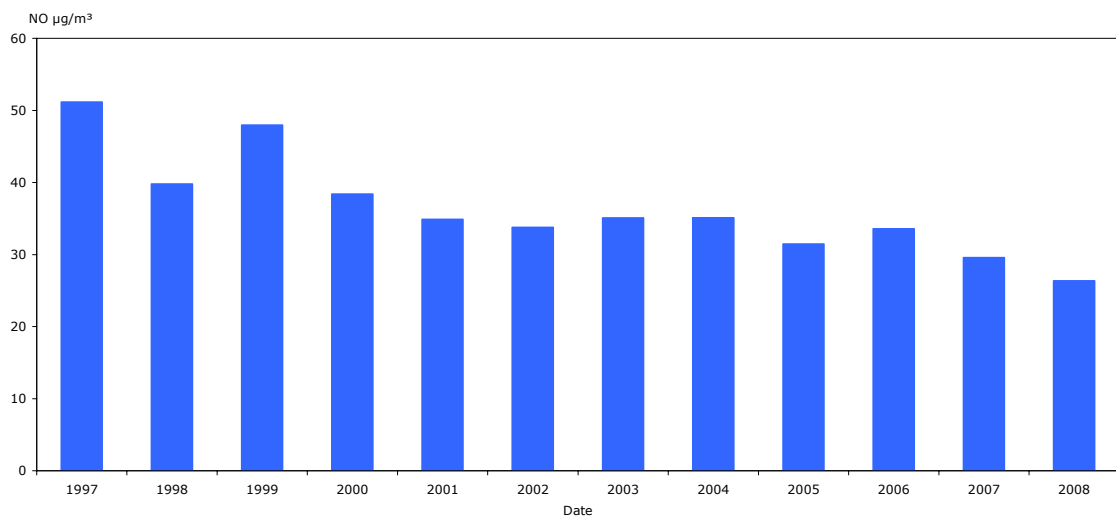


Figure 22: MfE Burnside NO₂ 1-hour fixed average January–December 2008

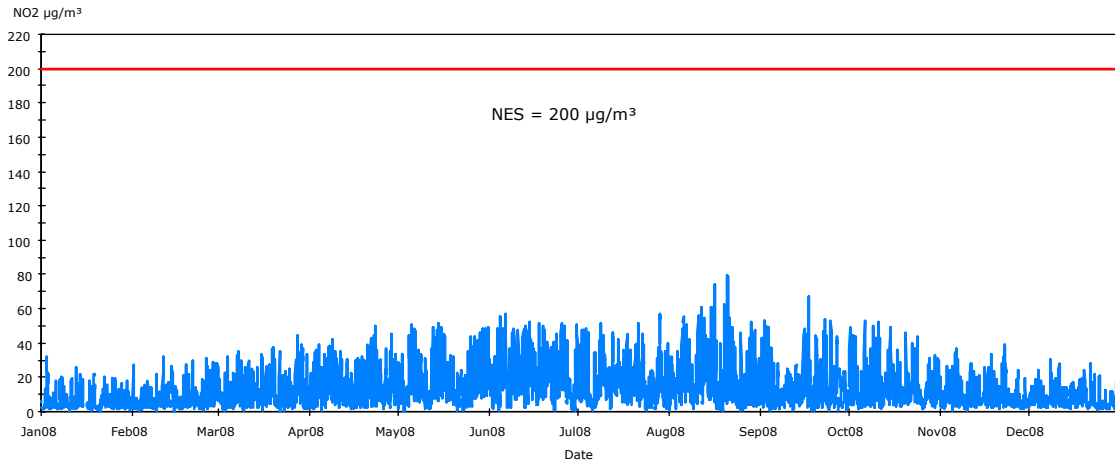


Figure 23: MfE Burnside NO₂ 1-hour fixed average 2003–2008

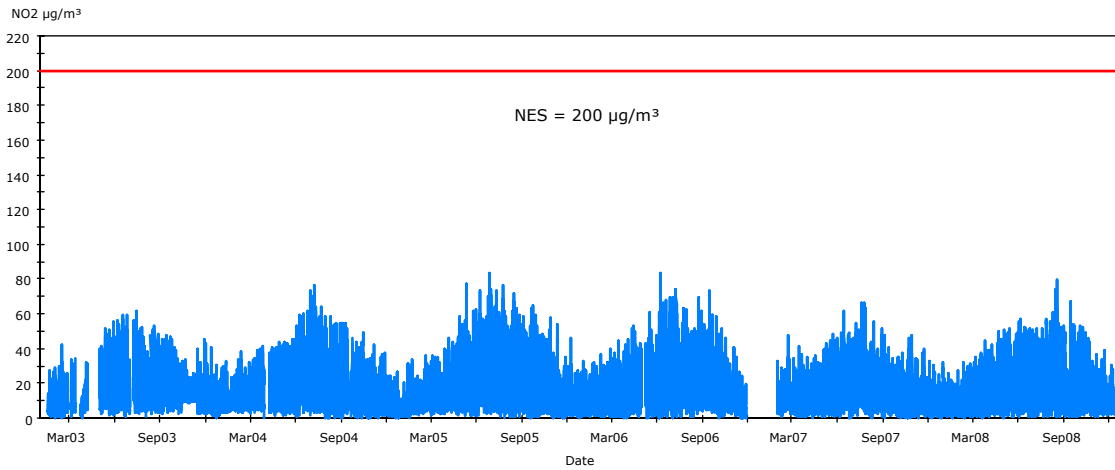


Figure 24: MfE Burnside NO₂ 24-hour fixed average January–December 2008

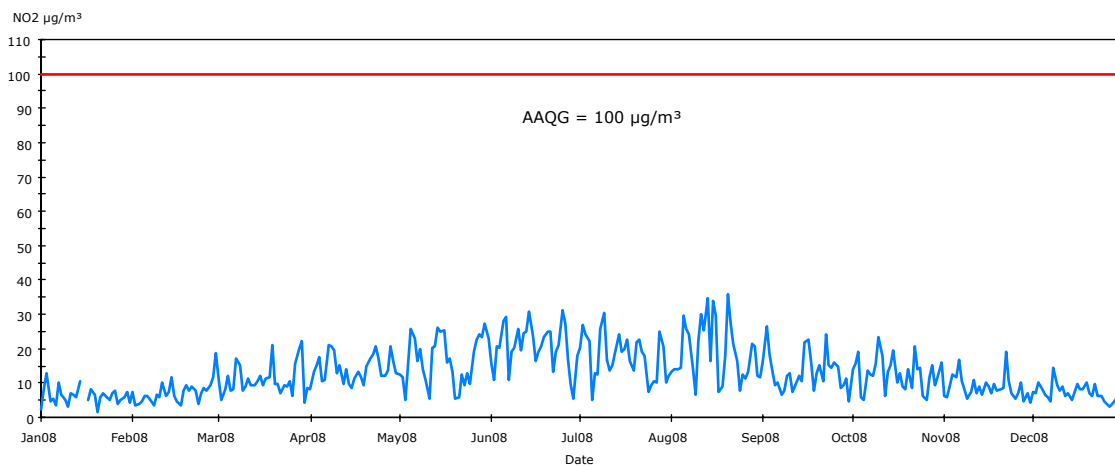


Figure 25: MfE Burnside NO₂ 24-hour fixed average 2003–2008

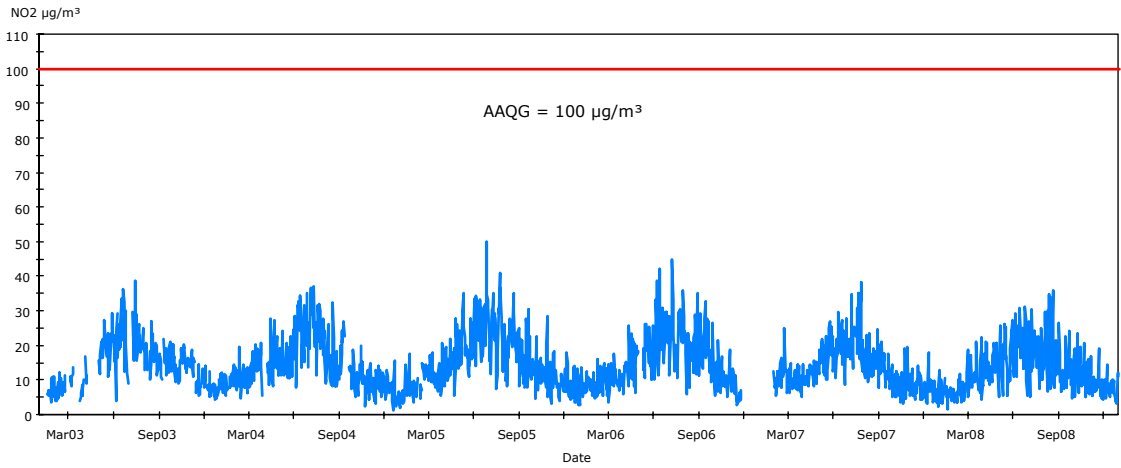


Figure 26: MfE Burnside NO₂ annual average 2003–2008

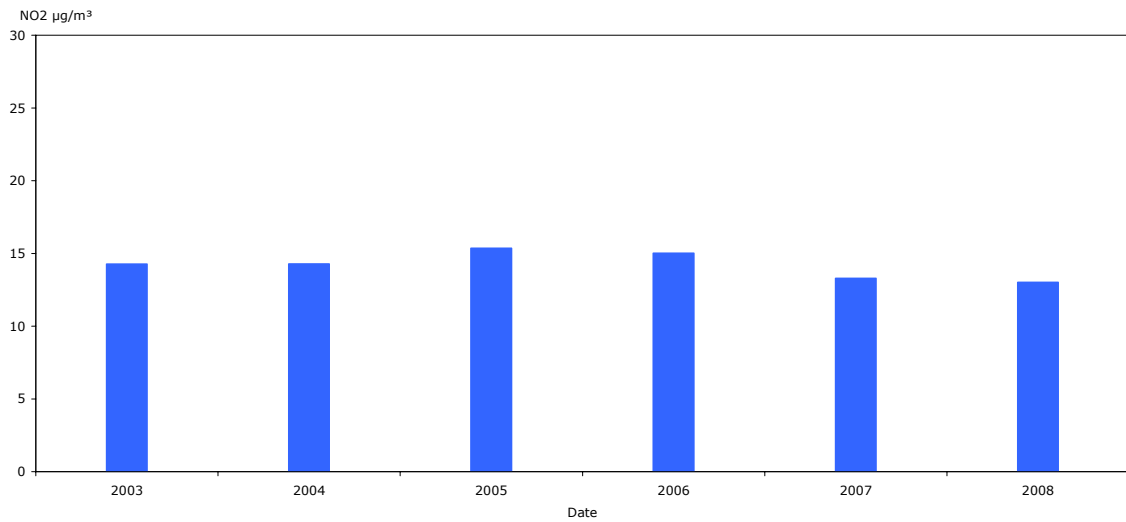


Figure 27: MfE Burnside NO₂ and NO 1-hour fixed average January–December 2008

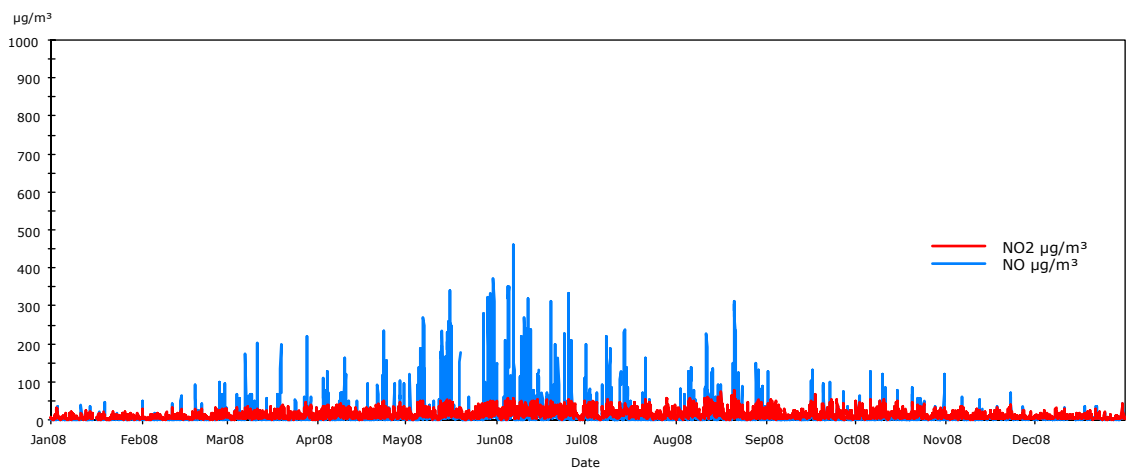


Figure 28: MfE Burnside NO₂ and NO 24-hour fixed average January–December 2008

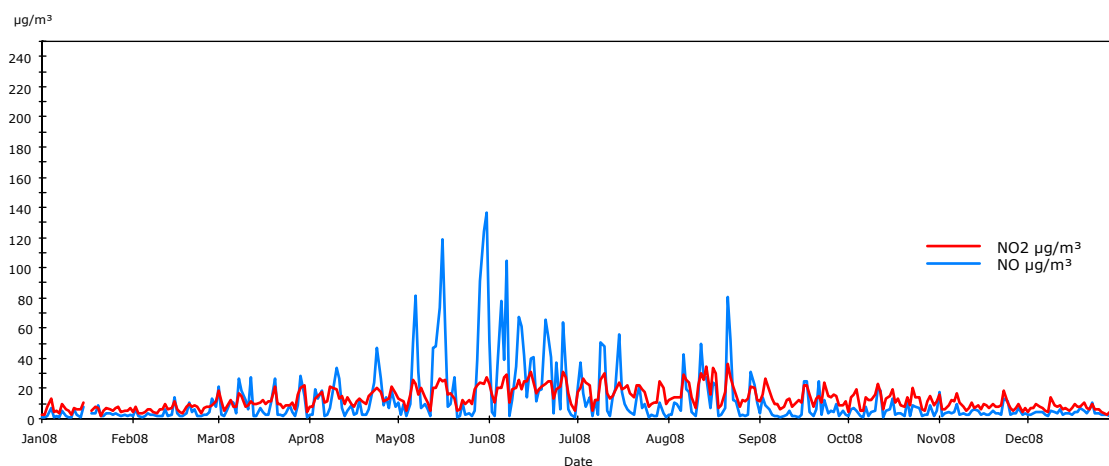


Figure 29: MfE Burnside NO 1-hour fixed average 2003–2008

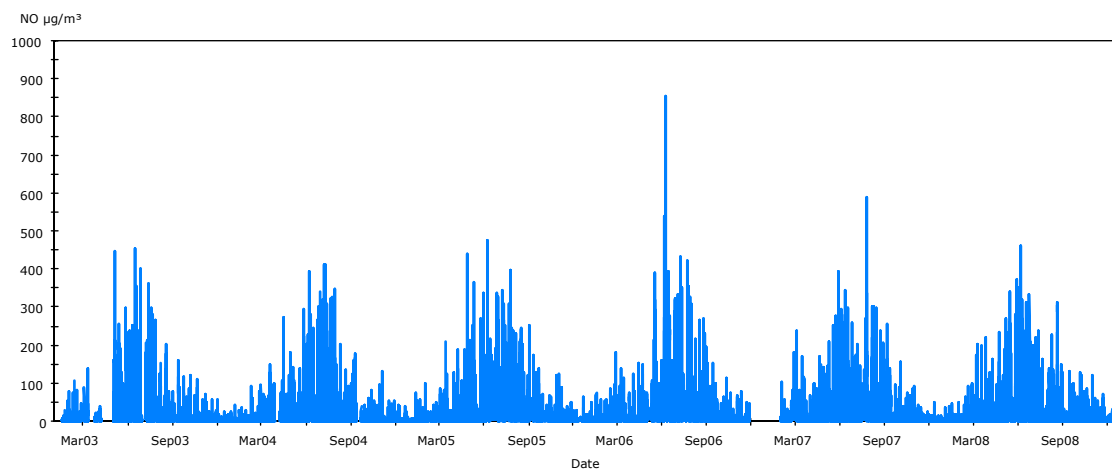


Figure 30: MfE Burnside NO 24-hour fixed average 2003–2008

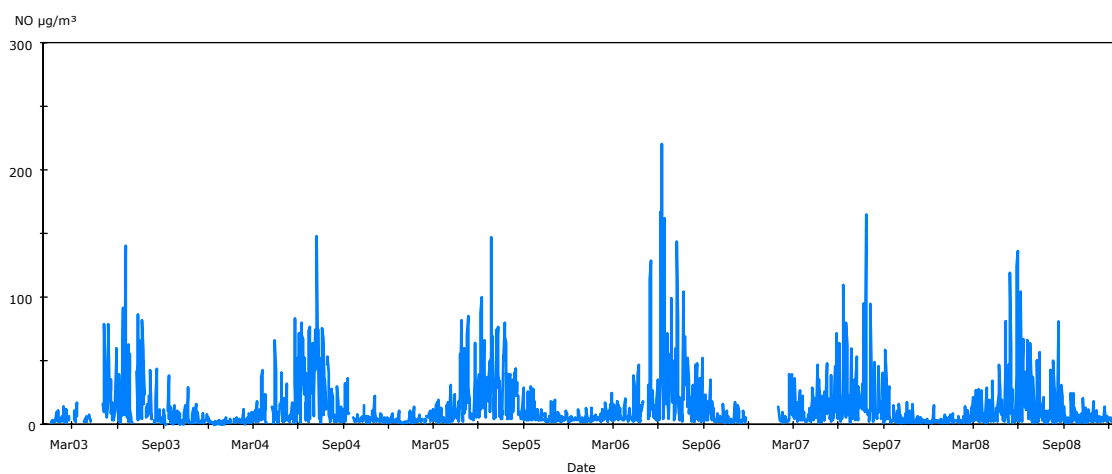


Figure 31: MfE Burnside NO annual average 2003–2008

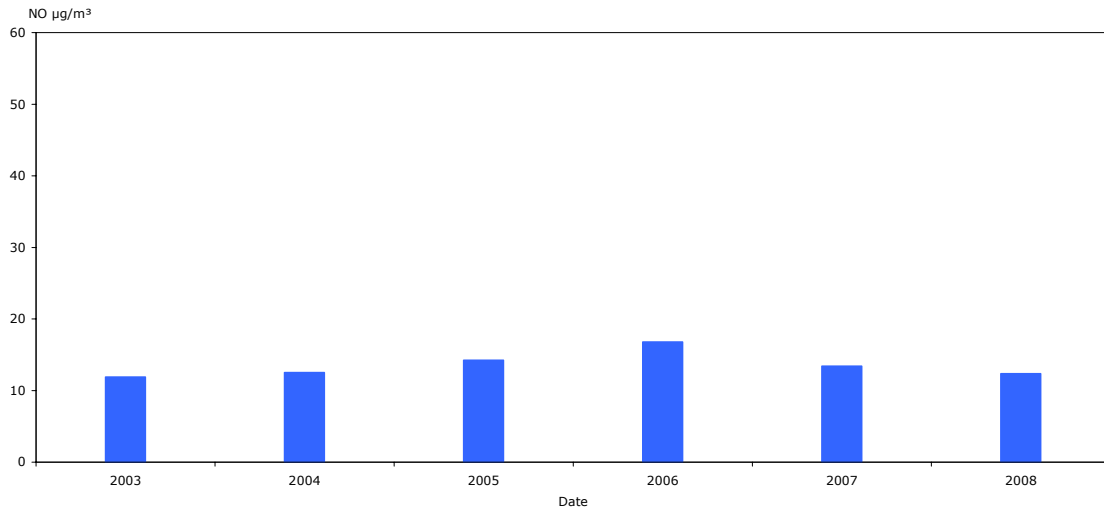


Figure 32: MfE Penrose SO₂ 1-hour fixed average January–December 2008

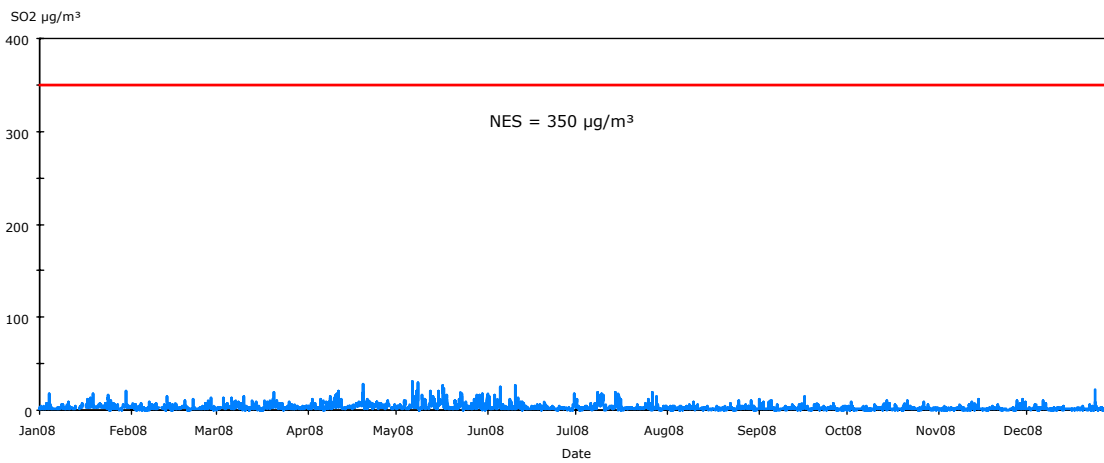


Figure 33: MfE Penrose SO₂ 1-hour fixed average 2003–2008

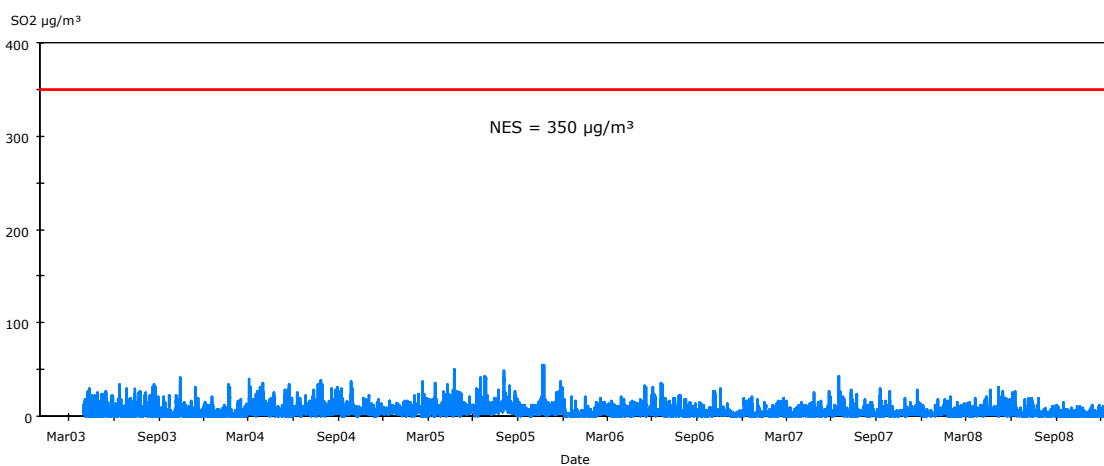


Figure 34: MfE Penrose SO₂ 24-hour fixed average January–December 2008

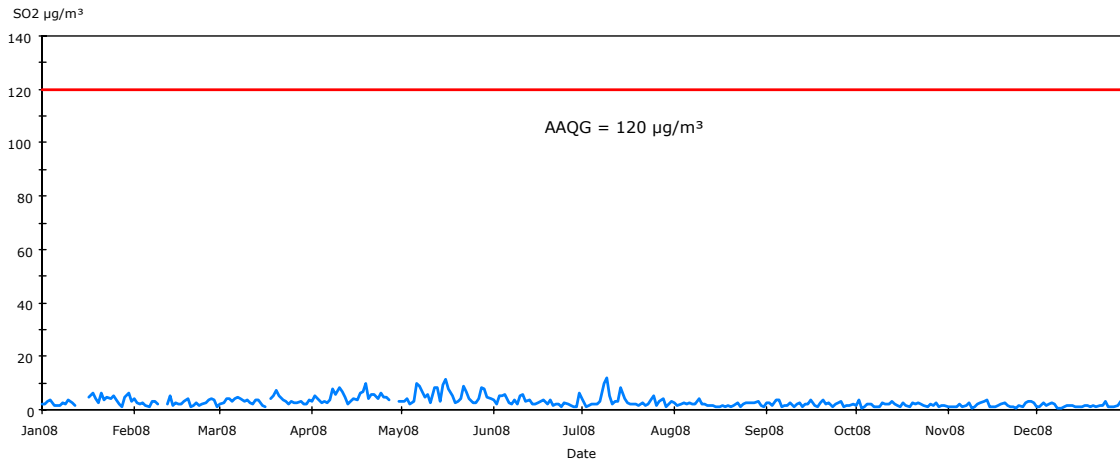


Figure 35: MfE Penrose SO₂ 24-hour fixed average 2003–2008

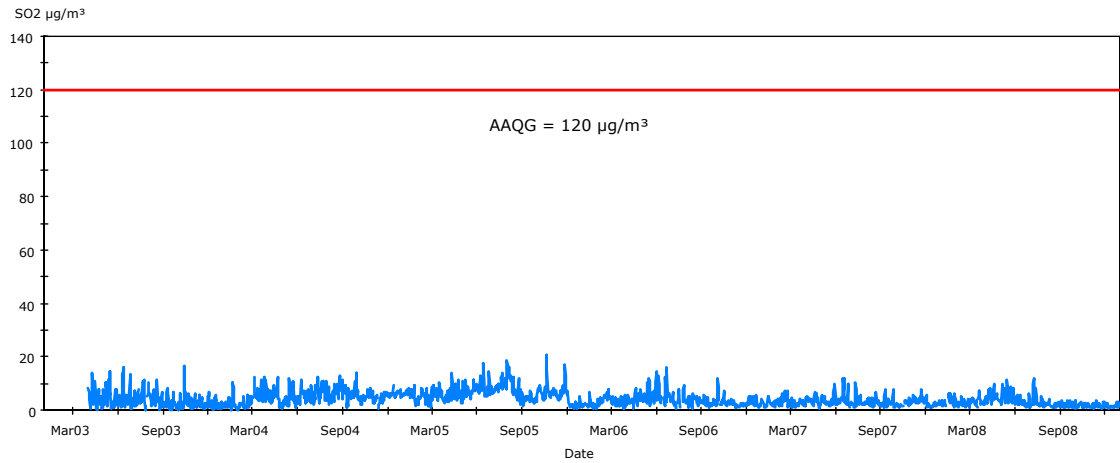


Figure 36: MfE Penrose SO₂ annual average 2003–2008

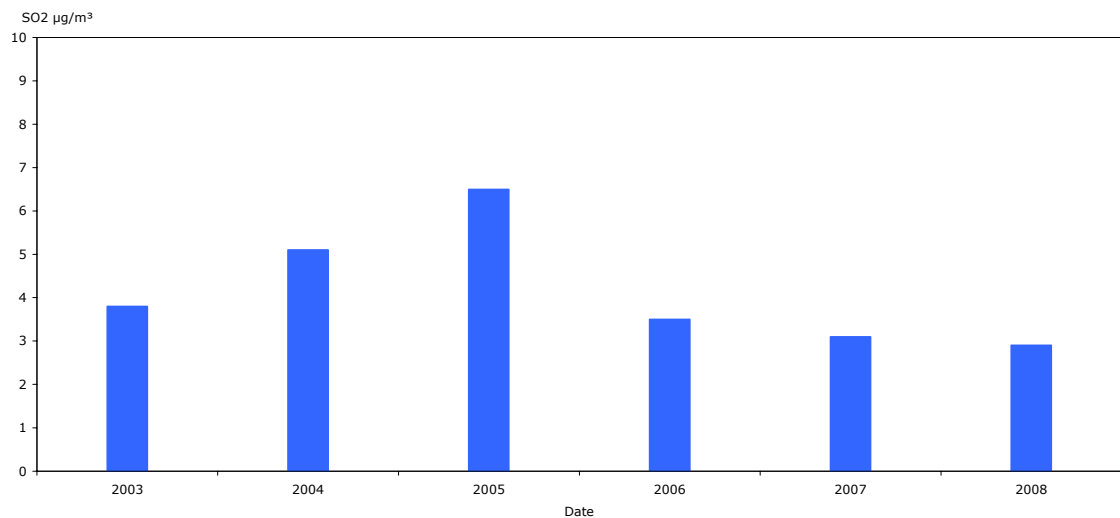


Figure 37: MfE Burnside SO₂ 1-hour fixed average January–December 2008

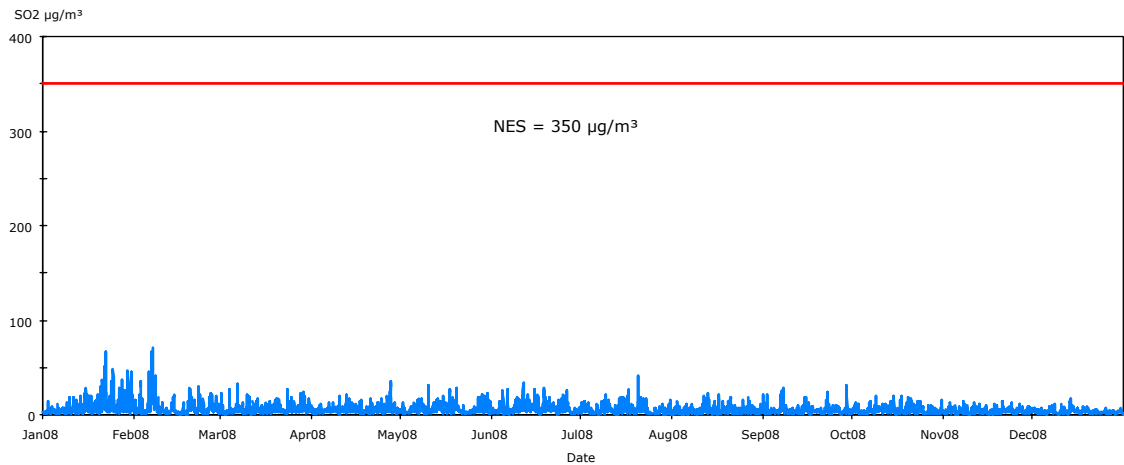


Figure 38: MfE Burnside SO₂ 1-hour fixed average 2003–2008

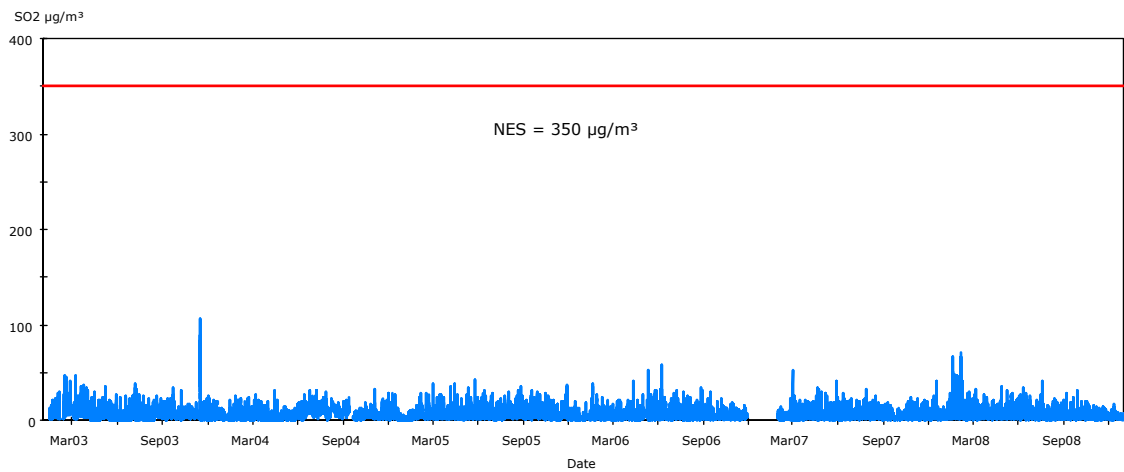


Figure 39: MfE Burnside SO₂ 24-hour fixed average January–December 2008

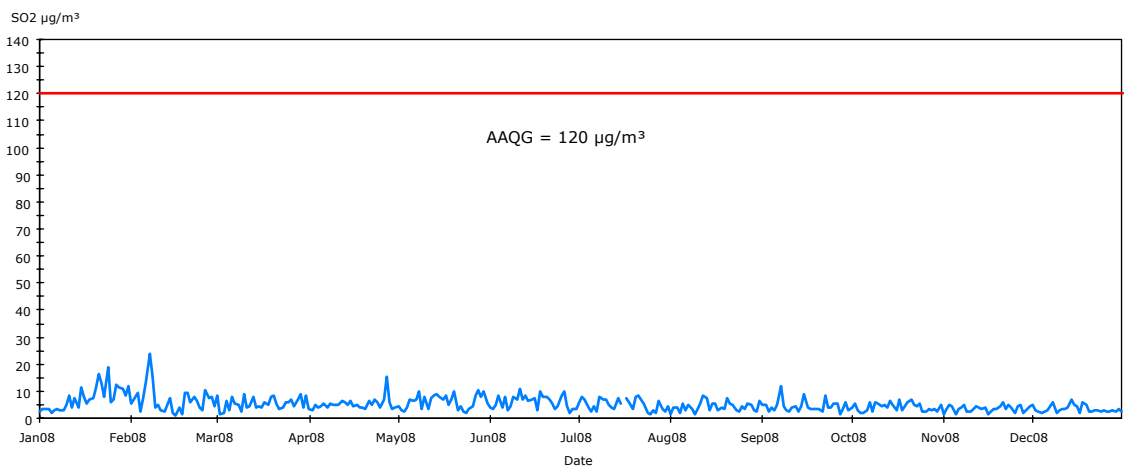


Figure 40: MfE Burnside SO₂ 24-hour fixed average 2003–2008

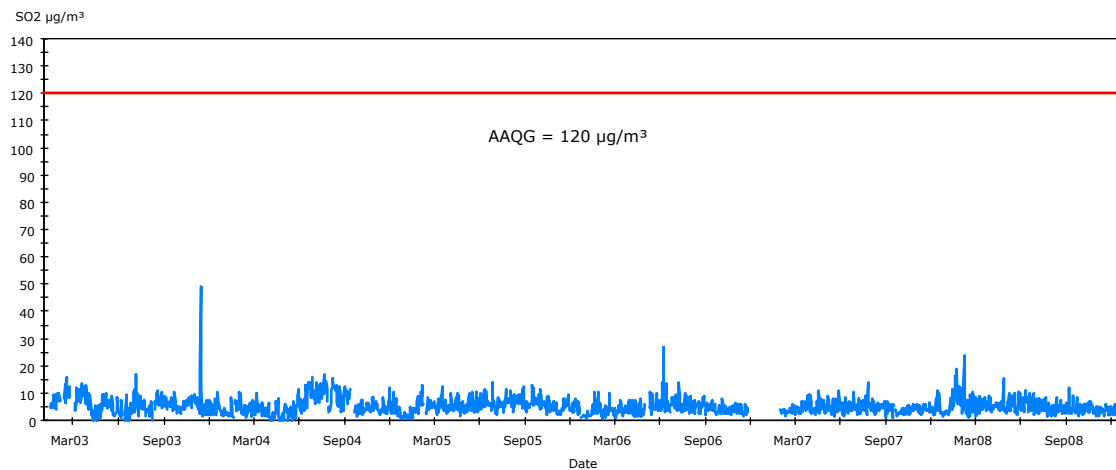


Figure 41: MfE Burnside SO₂ annual average 2003–2008

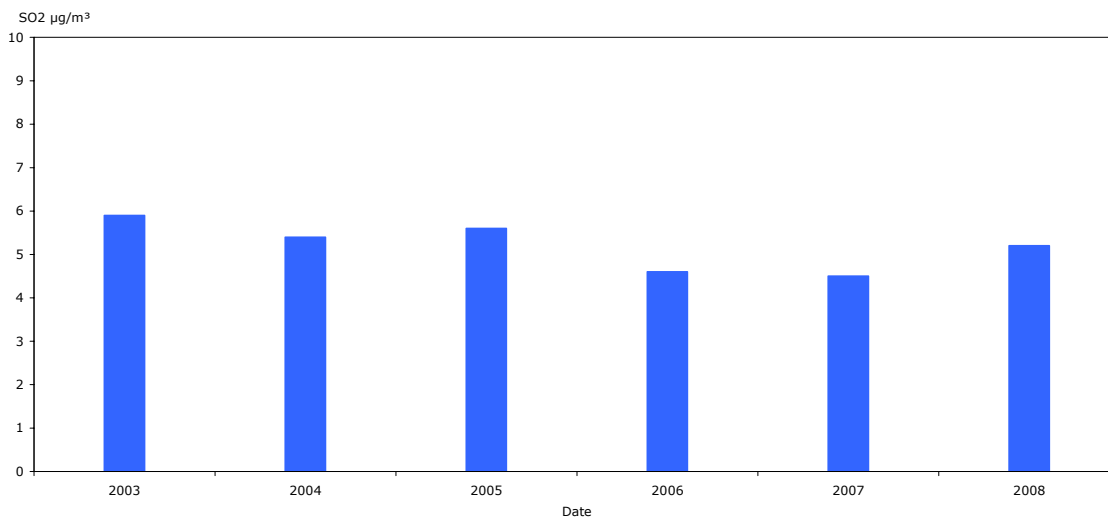


Figure 42: MfE Penrose PM₁₀ 24-hour fixed average January–December 2008

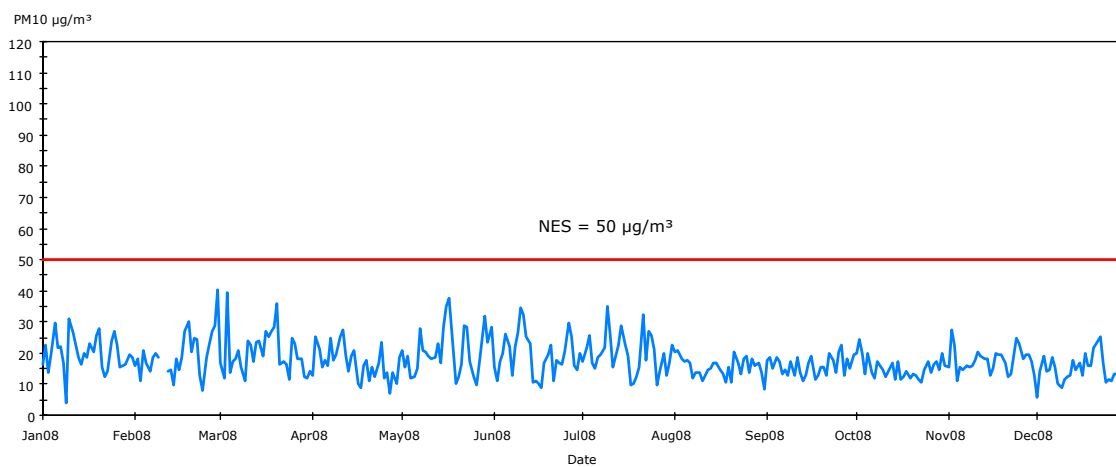


Figure 43: MfE Penrose PM₁₀ 24-hour fixed average 2003–2008

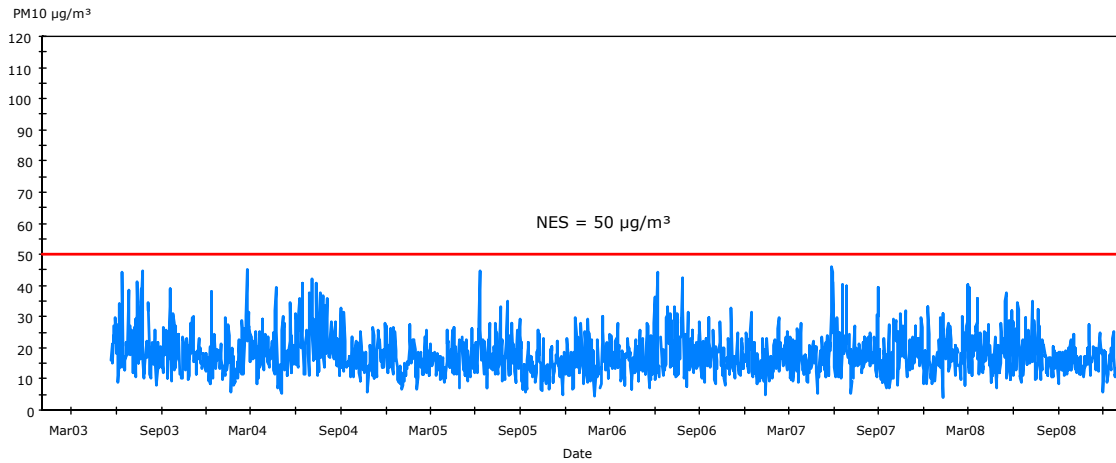


Figure 44: MfE Penrose PM₁₀ annual average 2003–2008

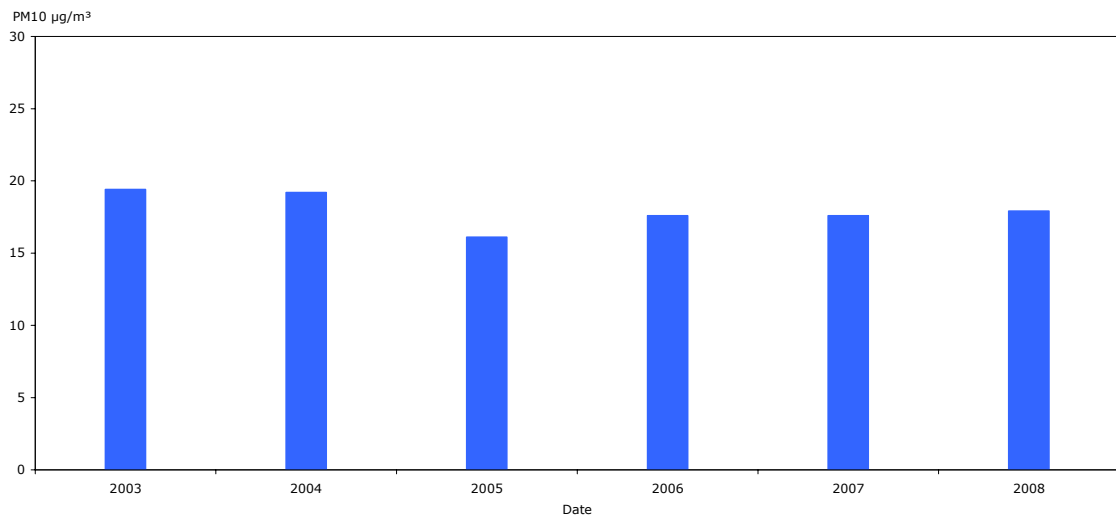


Figure 45: MfE Burnside PM₁₀ 24-hour fixed average January–December 2008

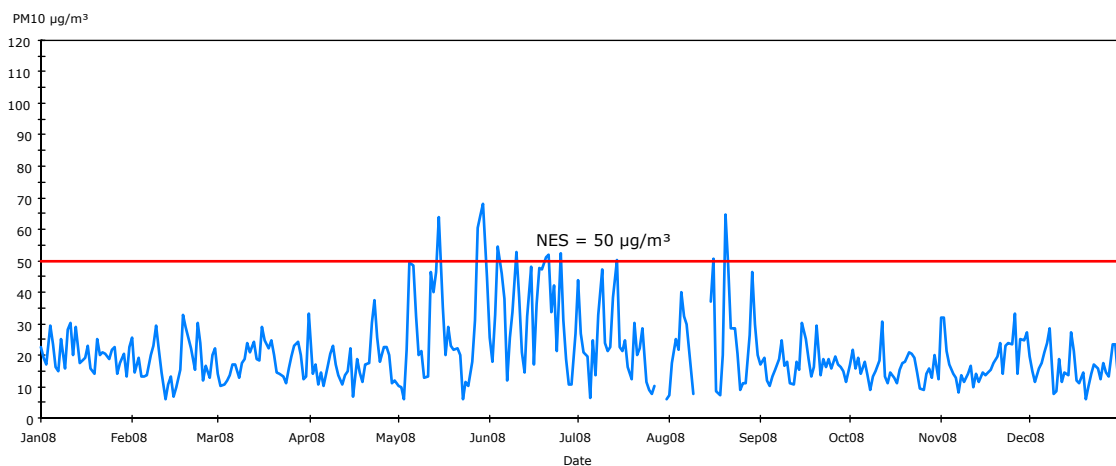


Figure 46: MfE Burnside PM₁₀ 24-hour fixed average 2003–2008

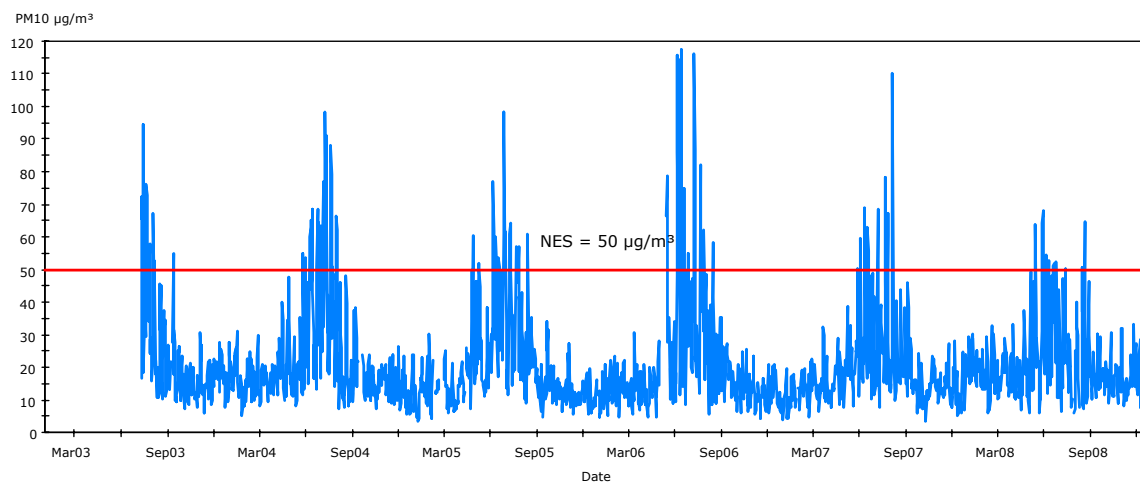
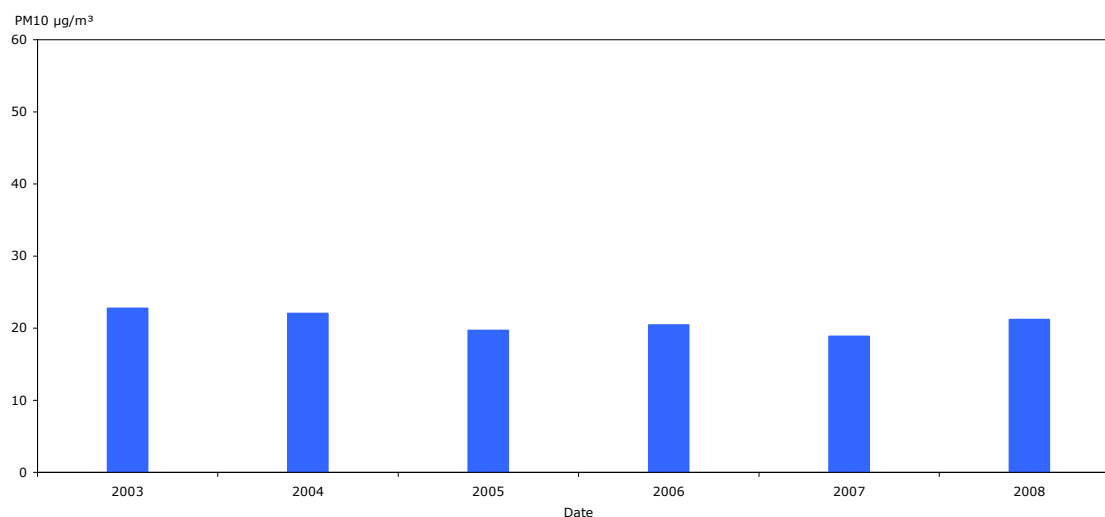


Figure 47: MfE Burnside PM₁₀ annual average 2003–2008



7.9 Analysis of exceedences

7.9.1 Exceedences at Greers Road, Burnside

The only exceedences recorded during 2008 were at Greers Road, Burnside, for PM₁₀ daily averages. All the other parameters monitored at all sites were below the national environmental standards (NES) for air quality.

Time of year

The PM₁₀ standard of 50 µg/m³ was exceeded 11 days in 2008 during the cooler months from May to August. During May there were three consecutive days that incurred exceedences (28–30 May). During June there were two consecutive days that incurred exceedences (20–21 June).

Time of day

The typical diurnal trend in PM₁₀ during winter is shown in figure 48. Here PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ are plotted against time of day. From figure 48, the biggest contributions to PM₁₀ were between the hours of 18:00 and 03:00. This would suggest contributions from wood burning for home heating.

Temperature

Figures 49, 50 and 51 plot PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average temperature measured at 1.5 m, hourly average temperature measured at 10 m, and the difference between the hourly averages of the two temperature heights. From figure 49, the biggest contributions to PM₁₀ were when temperature measured at 1.5 m was below 10°C. From figure 50, the biggest contributions to PM₁₀ were when temperature measured at 10 m was below 12°C. From figure 51, the biggest contributions to PM₁₀ were when temperature difference between 10 m 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 PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average relative humidity (RH). From figure 52, contribution to PM₁₀ began when RH was above 60 per cent and peaked at around 90 per cent, ie, high RH conditions. This is consistent with diurnal RH and temperature patterns throughout the day.

Wind direction

Figure 53 plots PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ 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 wide diffuse (as opposed to point/line) source of pollution. There were very few data points in the sector 120 degrees to 180 degrees as wind frequency from this sector is usually low.

Wind speed

Figure 54 plots PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average wind speeds. From figure 54, contributions to PM₁₀ began when wind speed was below 1.5 m/s and peaked at a wind speed of 0.5 m/s, ie, low wind speed conditions. This is consistent with reduced dispersion under low wind speed conditions.

NO

Figure 55 plots PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average NO. From figure 55, a positive linear relationship seems to exist between PM₁₀ and NO concentrations. This relationship is more defined at PM₁₀ concentrations below 60 µg/m³ and NO concentrations below 80 µg/m³. This is expected as PM₁₀ and NO is co-generated during the burning of wood and fossil fuels.

CO

Figure 56 plots PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average CO. From figure 56, a positive linear relationship seems to exist between PM₁₀ and CO concentrations. This relationship is more defined at PM₁₀ concentrations below 60 µg/m³ and CO concentrations below 2.5 mg/m³. This is expected as PM₁₀ and CO is co-generated during the burning of wood and fossil fuels. This is also expected due to meteorological conditions during winter.

SO₂

Figure 57 plots PM₁₀ hourly averages for those days where the daily PM₁₀ average exceeded 50 µg/m³ against hourly average SO₂. From figure 57, the relationship between PM₁₀ and SO₂ 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 the PM₁₀ exceedences were most likely due to home heating during the colder months, especially in the evenings, worsened by temperature inversions trapping the pollutants and low wind speed conditions preventing effective dispersion of pollutants.

Figure 48: MfE Burnside PM₁₀ vs time of day

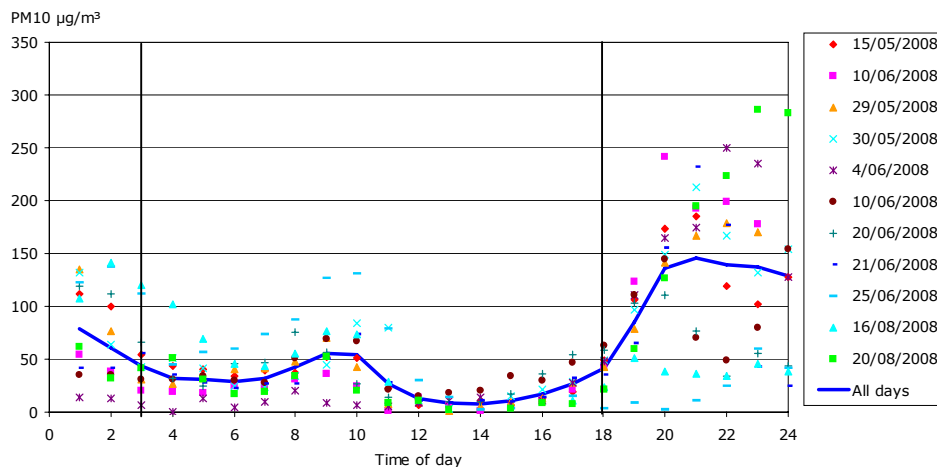


Figure 49: MfE Burnside PM₁₀ vs 1.5 m temperature

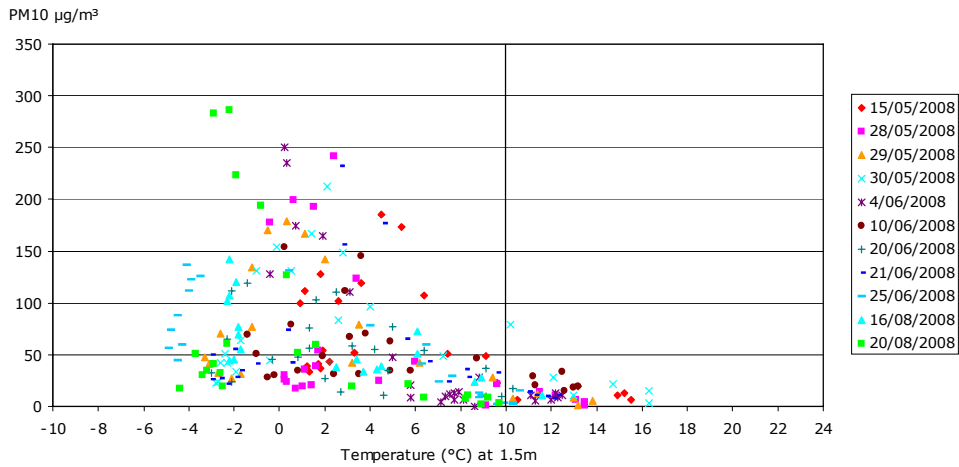


Figure 50: MfE Burnside PM₁₀ vs 10 m temperature

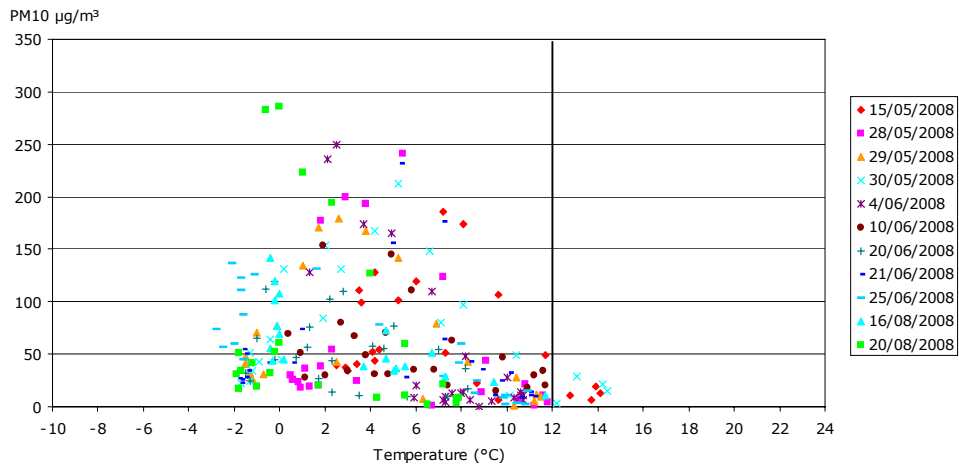


Figure 51: MfE Burnside PM₁₀ vs temperature difference 10 m–1.5 m

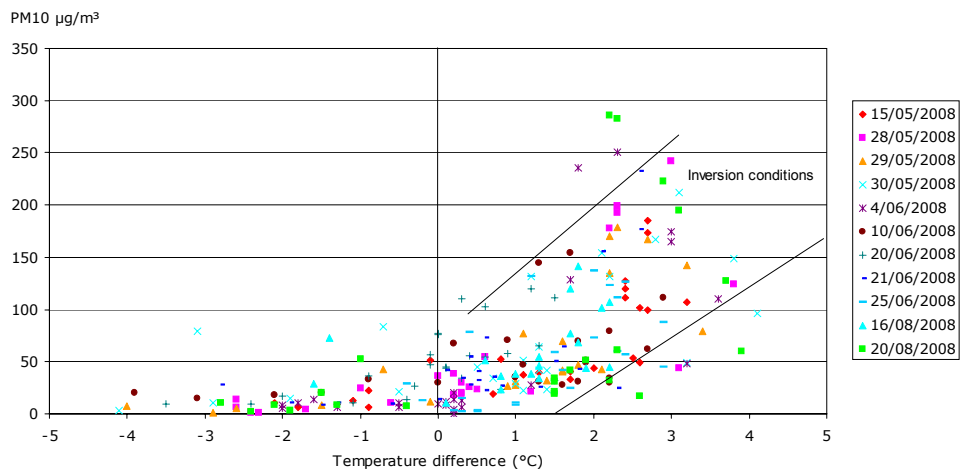


Figure 52: MfE Burnside PM₁₀ vs relative humidity

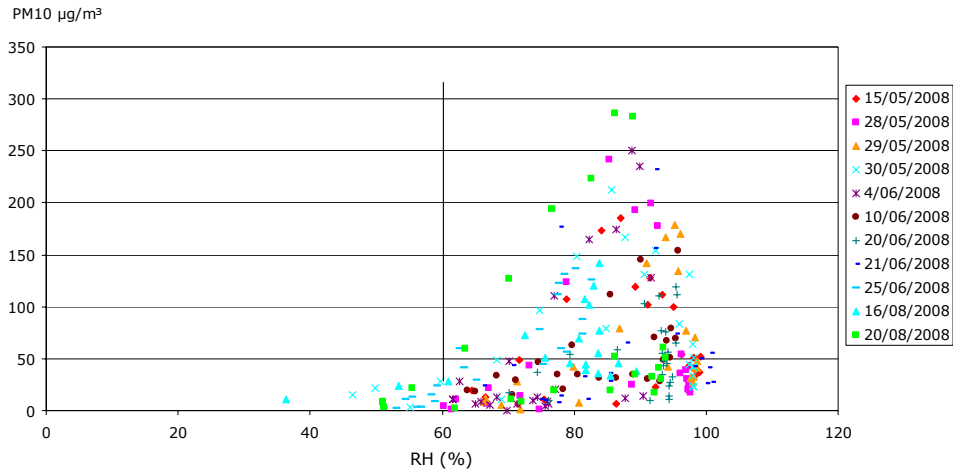


Figure 53: MfE Burnside PM₁₀ vs wind direction

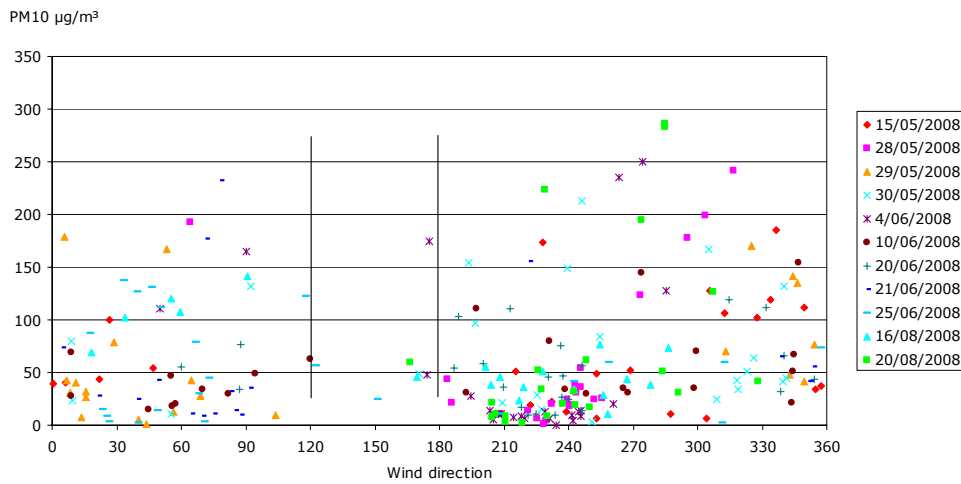


Figure 54: MfE Burnside PM₁₀ vs wind speed

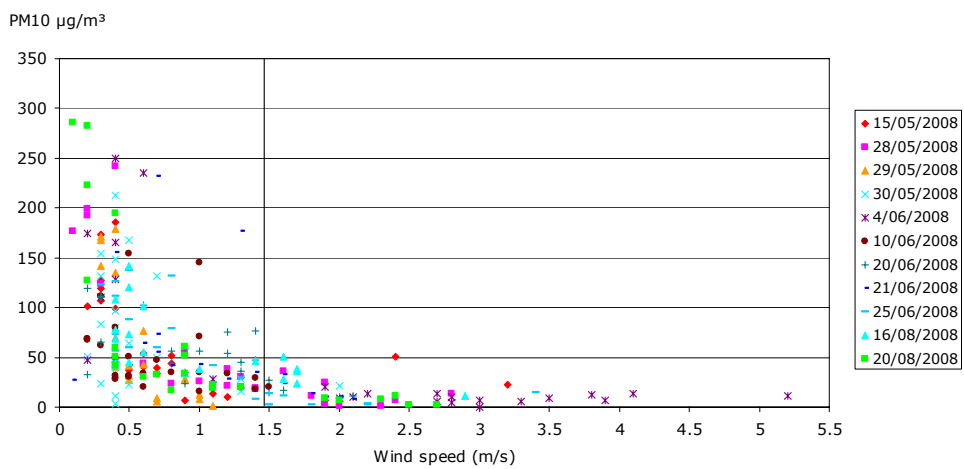


Figure 55: MfE Burnside PM₁₀ vs NO

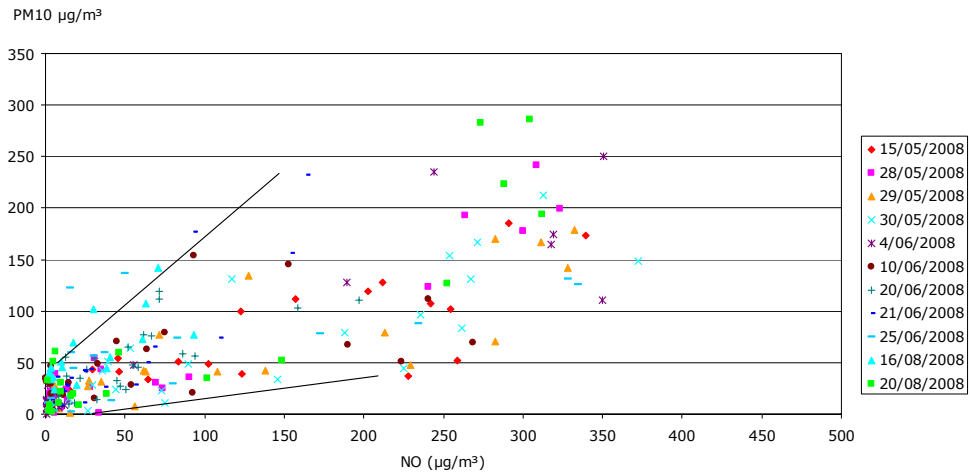


Figure 56: MfE Burnside PM₁₀ vs CO

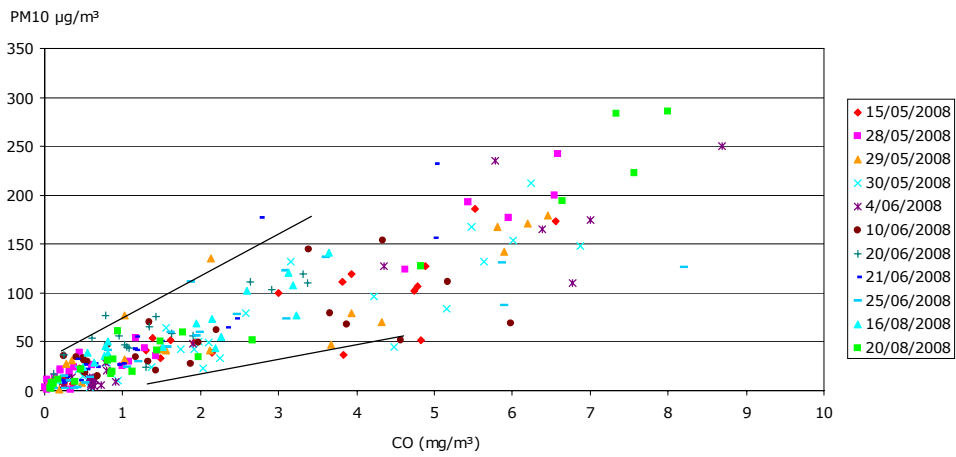


Figure 57: MfE Burnside PM₁₀ vs SO₂

