



Ministry for the  
**Environment**  
*Manatū Mō Te Taiao*

# **GEMS/AMIS Air Quality Monitoring Programme Annual Report 2009**

Prepared for the Ministry for the Environment  
by

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*services limited*

**Laboratory Services**  
Air Quality Department

New Zealand Government

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# 1 Summary

This report contains the 2009 annual ambient air quality data set, measured from Auckland and Christchurch. In the past, this data set formed 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 well-being. 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 pollutants arise from a number of different sources. The pollutants monitored at the GEMS sites include:

- particulate matter (PM<sub>10</sub>) – principally from domestic heating, vehicle emissions and industrial processes (as well as natural processes)
- nitrogen oxides (NO and NO<sub>2</sub>) – mostly from motor vehicle emissions
- sulphur dioxide (SO<sub>2</sub>) – 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<sub>2</sub>, SO<sub>2</sub>, PM<sub>10</sub> 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.<sup>1</sup> 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.

At Gavin Street, Penrose there were two exceedences of the national environmental standards (NES) for air quality. There was one exceedence of the 1-hour NO<sub>2</sub> standard due to local construction work and one exceedence of the 24-hour PM<sub>10</sub> standard caused by an Australian dust storm.

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<sup>1</sup> 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.

The Greers Road, Burnside site exceeded the 24-hour standard for PM<sub>10</sub> on nine occasions. Of these nine exceedences, one exceedence was caused by Australian dust in September 2009 and eight exceedences occurred during the colder months from June to July 2009, most likely due to home heating emissions.

The NES for air quality allows for one exceedence of the PM<sub>10</sub> 24-hour threshold per year before the standard is breached, meaning the Greers Road, Burnside site breached the PM<sub>10</sub> standard on eight occasions. All other air pollutants monitored at both sites were below the NES as well as the ambient air quality guidelines (AAQG) for all averaging periods.

## 2 Introduction

This report presents the 2009 ambient air quality data set from the GEMS monitoring programme for Auckland and Christchurch, New Zealand. The monitoring is conducted by Watercare Services Ltd, 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.<sup>2</sup>

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 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). 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.

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.

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<sup>2</sup> 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.<sup>3</sup> 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<sub>x</sub>. The two main oxides are nitrogen dioxide (NO<sub>2</sub>) and nitric oxide (NO). NO is less toxic than NO<sub>2</sub> but may oxidise to NO<sub>2</sub> 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<sub>x</sub> in most parts of the country, although power stations and other large combustion units may be significant localised sources as well.<sup>4</sup>

NO<sub>x</sub> is also an important air pollutant because of its role in photochemical smog. NO<sub>2</sub> is a reddish brown gas, and has synergistic health effects with other pollutants such as SO<sub>2</sub> and particulate matter.

The main health effects of the oxides of nitrogen are due to NO<sub>2</sub>, 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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<sup>3</sup> Ministry for the Environment. 2007. *Environment New Zealand 2007*. Wellington: Ministry for the Environment.

<sup>4</sup> Ministry for the Environment. 2003. *Emission Inventories for CO, NO<sub>x</sub>, SO<sub>2</sub>, 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 Sulphur dioxide

Sulphur 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 sulphur dioxide can cause stimulation of the nerves in the air passages, resulting in a reflex cough, irritation and chest tightness.

In addition, sulphur 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.<sup>5</sup> 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 sulphates 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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<sup>5</sup> 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<sub>10</sub>)
- total suspended particulates (TSP).

### **3.5.1 Particulate matter as PM<sub>10</sub>**

The main effect of PM<sub>10</sub> is on human health as PM<sub>10</sub> can be inhaled into the respiratory system. PM<sub>10</sub> can become deposited in the trachea bronchial region, where asthma attacks are triggered.

### **3.5.2 Total suspended particulate**

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 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 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 total suspended particulate (TSP),  $60 \mu\text{g}/\text{m}^3$  (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<sup>6</sup>**

| 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   | $10 \text{ mg}/\text{m}^3$                                   | $10 \text{ mg}/\text{m}^3$   | One 8-hour period in a 12-month period                         |
|                                       | 1-hour average   |  | $30 \text{ mg}/\text{m}^3$   |  |
| Nitrogen dioxide                      | 24-hour average  | $200 \mu\text{g}/\text{m}^3$                                 | $100 \mu\text{g}/\text{m}^3$   | 9 hours in a 12-month period                                   |
|                                       | 1-hour average   |  | $200 \mu\text{g}/\text{m}^3$   |  |
| Sulphur dioxide                       | 24-hour average  | $350 \mu\text{g}/\text{m}^3$<br>$570 \mu\text{g}/\text{m}^3$ | $120 \mu\text{g}/\text{m}^3$   | 9 hours in a 12-month period<br>Not to be exceeded at any time |
|                                       | 1-hour average   |  | $350 \mu\text{g}/\text{m}^3$   |  |
|                                       | 1-hour average   |  |  |  |
| Benzene<br>– Year 2002<br>– Year 2010 | Annual average   |  | $10 \mu\text{g}/\text{m}^3$  |  |
|                                       | Annual average   |  | $3.6 \mu\text{g}/\text{m}^3$   |  |
| 1,3-Butadiene                         | Annual average   |  | $2.4 \mu\text{g}/\text{m}^3$   |  |
| Fine particulate (PM <sub>10</sub> )  | Annual average   | $50 \mu\text{g}/\text{m}^3$                                  | $20 \mu\text{g}/\text{m}^3$  | One 24-hour period in a 12-month period                        |
|                                       | 24-hour average  |  | $50 \mu\text{g}/\text{m}^3$  |  |
| Total suspended particulate (TSP)     | 7-day average    |  | $60 \mu\text{g}/\text{m}^3$ (MoH)  |  |
| Lead                                  | 3-month average  |  | $0.2 \mu\text{g}/\text{m}^3$   |  |

<sup>6</sup> 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

|   |   |                               |                                     |                  |
|---|---|-------------------------------|-------------------------------------|------------------|
| <b>Site name</b>  | MfE Gavin Street, Penrose                   | <b>Site ID</b>                | AKL009                              |                  |
| <b>Address</b>  | Transpower, Gavin Street, Penrose, Auckland | <b>Site class</b>             | Industrial – dense / Traffic – peak |                  |
| <b>Description</b>  |   |                               |                                     |                  |
| This site is operated by Watercare Services and is located within the grounds of the Transpower NZ Ltd electrical sub-station 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. |   |                               |                                     |                  |
| <b>Pollutants monitored</b>   | <b>CO</b><br>N                              | <b>NO<sub>2</sub></b><br>Y    | <b>SO<sub>2</sub></b><br>Y          | <b>VOCs</b><br>Y |
|   | <b>PM<sub>10</sub></b><br>Y                 | <b>TSP</b><br>Y               | <b>Lead</b><br>Y                    |                  |
| <b>Meteorological parameters monitored</b>  | <b>Wind speed</b><br>Y                      | <b>Wind direction</b><br>Y    | <b>Relative humidity</b><br>Y       |                  |
|   | <b>Temperature (6m)</b><br>Y                | <b>Temperature (10m)</b><br>N | <b>Temperature (1.5m)</b><br>N      |                  |
| <b>Location map</b>   |   | <b>Photograph</b>             |                                     |                  |
|   |   |                               |                                     |                  |

### 5.1.3 MfE Greers Road, Burnside, Christchurch – Site CAN002

|   |   |                               |                                |                  |
|---|---|-------------------------------|--------------------------------|------------------|
| <b>Site name</b>  | MfE Greers Road, Burnside                       | <b>Site ID</b>                | CAN002                         |                  |
| <b>Address</b>  | Transpower, Greers Road, Burnside, Christchurch | <b>Site class</b>             | Residential – neighbourhood    |                  |
| <b>Description</b>  |   |                               |                                |                  |
| 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 metres to the northwest 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. |   |                               |                                |                  |
| <b>Pollutants monitored</b>   | <b>CO</b><br>Y                                  | <b>NO<sub>2</sub></b><br>Y    | <b>SO<sub>2</sub></b><br>Y     | <b>VOCs</b><br>Y |
|   | <b>PM<sub>10</sub></b><br>Y                     | <b>TSP</b><br>N               | <b>Lead</b><br>N               |                  |
| <b>Meteorological parameters monitored</b>  | <b>Wind speed</b><br>Y                          | <b>Wind direction</b><br>Y    | <b>Relative humidity</b><br>Y  |                  |
|   | <b>Temperature (6m)</b><br>N                    | <b>Temperature (10m)</b><br>Y | <b>Temperature (1.5m)</b><br>Y |                  |
| <b>Location map</b>   |   | <b>Photograph</b>             |                                |                  |
|   |   |                               |                                |                  |

### 5.1.4 MfE Coles Place, St Albans, Christchurch – Site CAN003

|  |                                      |                          |                           |                             |
|--|--------------------------------------|--------------------------|---------------------------|-----------------------------|
| <b>Site name</b>   | MfE Coles Place, St Albans           |                          | <b>Site ID</b>            | CAN003                      |
| <b>Address</b>   | Coles Place, St Albans, Christchurch |                          | <b>Site class</b>         | Residential – neighbourhood |
| <b>Description</b>   |                                      |                          |                           |                             |
| 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. |                                      |                          |                           |                             |
| <b>Pollutants monitored</b>  | <b>CO</b>                            | <b>NO<sub>2</sub></b>    | <b>SO<sub>2</sub></b>     | <b>VOCs</b>                 |
|  | N                                    | N                        | N                         | Y                           |
| <b>Meteorological parameters monitored</b>   | <b>PM<sub>10</sub></b>               | <b>TSP</b>               | <b>Lead</b>               |                             |
|  | N                                    | Y                        | Y                         |                             |
| <b>Meteorological parameters monitored</b>   | <b>Wind speed</b>                    | <b>Wind direction</b>    | <b>Relative humidity</b>  |                             |
|  | N                                    | N                        | N                         |                             |
| <b>Meteorological parameters monitored</b>   | <b>Temperature (6m)</b>              | <b>Temperature (10m)</b> | <b>Temperature (1.5m)</b> |                             |
|  | N                                    | N                        | N                         |                             |
| <b>Location map</b>  |                                      | <b>Photograph</b>        |                           |                             |
|  |                                      |                          |                           |                             |

## 5.2 Air pollutants monitored at GEMS/AMIS sites

An overview of the air pollutants monitored at each site during 2009, as part of the GEMS/AMIS programme, is given in table 2 below.

**Table 2: Air pollutants monitored at GEMS/AMIS sites, 2009**

| Site   | CO | NO <sub>2</sub> | SO <sub>2</sub> | VOC | PM <sub>10</sub> | 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 sulphur 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<sub>10</sub> high volume sampling'
- AS 3580.9.11 – 2008 'Method 9.11: Determination of suspended particulate matter – PM<sub>10</sub> 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 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 Sulphur dioxide**

Measurements are made in accordance with AS 3580.4.1-2008 'Determination of Sulphur 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 sulphur 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 PM<sub>10</sub>

Measurements are made in accordance with AS 3580.9.11-2008 'Determination of suspended particulate matter – PM<sub>10</sub> beta attenuation monitors' (BAM). The instrument is fitted with a size-selective PM<sub>10</sub> 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<sub>10</sub> 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<sup>3</sup>) drawn through the filter. The filter is held in a cassette and is covered with a rain shelter at 3.5 m above ground. Pre-weighed filters are collected and sampled on a weekly or seven-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 2009*. 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 three-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 Ministry for the Environment *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. As such, site performance has been evaluated against a target of 95 per cent for capture data and 75 per cent for valid data.

The performance of continuously monitored pollutant instruments during 2009 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, 2009**

| 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  | 97.5  | 100             | 98.4 | 99.9              | 98.4 | 100               | 98.4 | 99.9 | 98.3            | 100             | 98.5 | 100  | 98.5 | 100  | 98.4            | 100             | 98.4           | 100            | 97.6           | 99.7           | 98.4 | 100  | 98.5 | 100               | 98.3   | 99.9 |     |
| NO <sub>2</sub>  | Penrose   | 98.4  | 99.9            | 97.9 | 99.7              | 97.6 | 99.7              | 97.8 | 99.4 | 97.3            | 99.8            | 97.6 | 99.7 | 97.5 | 100  | 98.1            | 99.9            | 97.4           | 99.6           | 97.8           | 99.7           | 98.1 | 100  | 92.8 | 95.0 <sup>f</sup> | 97.4   | 99.4 |     |
| NO <sub>2</sub>  | Burnside  | 97.5  | 99.6            | 98.4 | 100               | 98.3 | 100               | 97.9 | 99.9 | 98.4            | 100             | 98.5 | 100  | 98.5 | 100  | 98.2            | 100             | 98.4           | 100            | 97.2           | 99.7           | 98.2 | 100  | 98.1 | 100               | 98.1   | 99.9 |     |
| SO <sub>2</sub>  | Penrose   | 96.8  | 99.6            | 96.9 | 99.4              | 96.6 | 99.4              | 96.4 | 99.4 | 97.6            | 99.8            | 97.6 | 99.7 | 98.1 | 100  | 97.8            | 99.9            | 97.8           | 99.6           | 97.8           | 99.7           | 97.9 | 100  | 95.7 | 99.5              | 97.2   | 99.7 |     |
| SO <sub>2</sub>  | Burnside  | 97.6  | 100             | 97.3 | 100               | 97.6 | 100               | 97.1 | 99.9 | 97.8            | 100             | 97.8 | 100  | 97.8 | 100  | 97.8            | 100             | 97.7           | 100            | 97.4           | 99.7           | 97.6 | 100  | 97.8 | 100               | 97.6   | 100  |     |
| PM <sub>10</sub> | Penrose   | 97.8  | 98.9            | 95.2 | 96.2              | 94.3 | 95.1              | 93.6 | 95.4 | 99.2            | 99.2            | 99   | 99   | 98.2 | 98.5 | 96.8            | 97.2            | 99.6           | 99.6           | 99.2           | 99.5           | 99.8 | 99.8 | 99.6 | 99.6              | 97.7   | 98.2 |     |
| PM <sub>10</sub> | Burnside  | 95.3  | 96.2            | 93.5 | 94.9 <sup>b</sup> | 93.4 | 94.5 <sup>c</sup> | 96.3 | 97.7 | 98.6            | 99.3            | 98.6 | 99.3 | 98.9 | 99.7 | 98.6            | 99.3            | 99             | 99.7           | 98.4           | 99.4           | 98.9 | 99.6 | 98.9 | 99.6              | 97.4   | 98.3 |     |
| 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  | 100  | 100               | 100    | 100  |     |
| 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             | 100  | 100  | 100  | 100  | 100             | 100             | 100            | 100            | 100            | 100            | 100  | 100  | 100  | 100               | 100    | 100  |     |
| TSP              | St Albans | 75  | 75 <sup>a</sup> | 100  | 100               | 100  | 100               | 100  | 100  | 50 <sup>d</sup> | 50 <sup>d</sup> | 100  | 100  | 100  | 100  | 40 <sup>e</sup> | 40 <sup>e</sup> | 0 <sup>e</sup> | 0 <sup>e</sup> | 0 <sup>e</sup> | 0 <sup>e</sup> | 100  | 100  | 75   | 75 <sup>a</sup>   | 71.2   | 71.2 |     |
| Lead             | Penrose   | -   | -               | -    | -                 | -    | -                 | -    | -    | 100             | -               | 100  | -    | 100  | -    | -               | -               | -              | -              | -              | -              | -    | -    | -    | -                 | -      | 100  | 100 |
| Lead             | St Albans | -   | -               | -    | -                 | -    | -                 | -    | -    | 100             | -               | 100  | -    | 20   | -    | -               | -               | -              | -              | -              | -              | -    | -    | -    | -                 | -      | 100  | 100 |

a TSP – Sampling error

b PM10 – Negative results six-monthly maintenance performed

c PM10 – Negative results six-monthly maintenance performed and unit swapped

d TSP – One sample ran for two weeks

e TSP – Pump faulty

f NOx – Pump faulty and datalogger communication error

## 7.2 Carbon monoxide (CO), 2009

CO was monitored at Greers Road, Burnside. One-hour and eight-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 <sup>3</sup> ) | 99.9 percentile 1-hour average (mg/m <sup>3</sup> ) | Maximum 8-hour average (mg/m <sup>3</sup> ) | 99.9 percentile 8-hour average (mg/m <sup>3</sup> ) |
|-----------------------|---|---|---|---|
| Greers Road, Burnside | 11.5<br>(26 June 22:00)                     | 7.7   | 7.6<br>(27 June 01:00)                      | 6.6   |

At Greers Road, Burnside during 2009 there were no exceedences of the ambient air quality one-hour guideline (30 mg/m<sup>3</sup>) or the eight-hour national environmental standard (10 mg/m<sup>3</sup>). Carbon monoxide results are shown in figures 7 to 11.

## 7.3 Nitrogen oxides (NO<sub>2</sub> and NO), 2009

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<sub>2</sub> and their dates for each site are described below.

| Site                  | Maximum 1-hour average (µg/m <sup>3</sup> ) | 99.9 percentile 1-hour average (µg/m <sup>3</sup> ) | Maximum 24-hour average (µg/m <sup>3</sup> ) | 99.5 percentile 24-hour average (µg/m <sup>3</sup> ) |
|-----------------------|---|---|--|--|
| Gavin Street, Penrose | 221.3<br>(5 April 13:00)                    | 137.0   | 54.1<br>(5 April)                            | 53.2   |
| Greers Road, Burnside | 67.4<br>(5 June 11:00)                      | 57.6  | 34.5<br>(9 September)                        | 31.8   |

At Gavin Street, Penrose, there was one exceedence of the NO<sub>2</sub> one-hour national environmental standard (200 µg/m<sup>3</sup>) and no exceedences of the NO<sub>2</sub> 24-hour guideline (100 µg/m<sup>3</sup>). The 2009 NO<sub>x</sub> results for Penrose are shown in figures 12 to 21.

The 1-hour NO<sub>2</sub> national environmental standard exceedence of 221.3µg/m<sup>3</sup> was on 5 April 2009 at 13:00. The source of this exceedence was most likely from construction work. A crane was being used to move transformers 5–10 m from the Penrose monitoring site operating from 1 April to 6 April 2009. Elevated levels of NO<sub>2</sub> occurred throughout this period due to the construction work.

There were no exceedences of the NO<sub>2</sub> one-hour national environmental standard (200 µg/m<sup>3</sup>) or the NO<sub>2</sub> 24-hour guideline (100 µg/m<sup>3</sup>) in Christchurch during the 12-month period. The 2009 NO<sub>x</sub> results for Burnside are shown in figures 22 to 31.

## 7.4 Sulphur dioxide (SO<sub>2</sub>), 2009

Sulphur 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<sub>2</sub> and their dates for each site are described below.

| Site                  | Maximum 1-hour average (µg/m <sup>3</sup> ) | 99.9 percentile 1-hour average (µg/m <sup>3</sup> ) | Maximum 24-hour average (µg/m <sup>3</sup> ) | 99.5 percentile 24-hour average (µg/m <sup>3</sup> ) |
|-----------------------|---|---|--|--|
| Gavin Street, Penrose | 51.6<br>(13 July 08:00)                     | 27.3  | 13.0<br>(12 July)                            | 11.4   |
| Greers Road, Burnside | 111.8<br>(20 March 01:00)                   | 49.3  | 22.9<br>(16 March)                           | 19.1   |

There were no exceedences of the SO<sub>2</sub> national environmental 1-hour standard (350 µg/m<sup>3</sup>) or the 24-hour guideline (120 µg/m<sup>3</sup>) during 2009 at any site. The 2009 SO<sub>2</sub> results for Gavin Street, Penrose are shown in figures 32 to 36 and Greers Road, Burnside are shown in figures 37 to 41.

## 7.5 Volatile organic compounds (VOC), January–December 2009

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. Results for each 2009 quarter are shown in tables 4 to 7.

The benzene guideline is 10 µg/m<sup>3</sup> as an annual average, with an average value of 3.6 µg/m<sup>3</sup> to be achieved by 2010. The 2009 six-month and 12-month averages are described below. The benzene annual averages from all the sites are less than the annual average guideline (10 µg/m<sup>3</sup>) and are graphed in figure 1.

| Site                   | Six-month average (January–June 2009) benzene (µg/m <sup>3</sup> ) | Six-month average (July–December 2009) benzene (µg/m <sup>3</sup> ) | 2009 annual average benzene (µg/m <sup>3</sup> ) |
|------------------------|--|---|--|
| 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 2009)**

| January–February–March 2009<br>Analyte | Limit of detection<br>( $\mu\text{g}/\text{m}^3$ ) | 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                                 | 0.5  | 0.7                                  | 1.1        | 0.9        |
| ethyl acetate                          | ND   |                                      |            |            |
| trichloromethane                       | ND   |                                      |            |            |
| 1,1,1-trichloroethane                  | ND   |                                      |            |            |
| n-butanol                              | ND   |                                      |            |            |
| <b>benzene</b>                         | <b>0.3</b>   | <b>0.6</b>                           | <b>0.5</b> | <b>0.8</b> |
| 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  | 3.3                                  | 3.3        | 5.4        |
| octane                                 | ND   |                                      |            |            |
| tetrachloroethene                      | ND   |                                      |            |            |
| butyl acetate                          | ND   |                                      |            |            |
| ethylbenzene                           | 0.3  | 0.6                                  | 0.5        | 0.9        |
| m+p-xylene                             | 0.3  | 1.3                                  | 1.2        | 2.7        |
| styrene                                | ND   |                                      |            |            |
| o-xylene                               | 0.3  | 0.5                                  | 0.5        | 0.9        |
| nonane                                 | ND   |                                      |            |            |
| alpha pinene                           | ND   |                                      |            |            |
| propylbenzene                          | ND   |                                      |            |            |
| 1,3,5-trimethylbenzene                 | ND   |                                      |            |            |
| beta pinene                            | ND   |                                      |            |            |
| decane                                 | ND   |                                      |            |            |
| 1,2,4-trimethylbenzene                 | 0.7  | 0.7                                  |            | 1.1        |
| limonene                               | ND   |                                      |            |            |
| undecane                               | ND   |                                      |            |            |
| dodecane                               | ND   |                                      |            |            |
| tetradecane                            | ND   |                                      |            |            |

ND = Not detected.

**Table 5: VOC results (April–June 2009)**

| April–May–June 2009<br>Analyte | Limit of detection<br>( $\mu\text{g}/\text{m}^3$ ) | Results ( $\mu\text{g}/\text{m}^3$ ) |            |            |
|--------------------------------|--|--------------------------------------|------------|------------|
|                                |  | Coles Place                          | Burnside   | Penrose    |
| Target VOCs                    |  |                                      |            |            |
| ethanol                        | ND   |                                      |            |            |
| isopropyl alcohol              | ND   |                                      |            |            |
| acetone                        | ND   |                                      |            |            |
| pentane                        | 2.3  | 4.5                                  | 3.8        | 11.3       |
| dichloromethane                | ND   |                                      |            |            |
| butan-2-one                    | ND   |                                      |            |            |
| hexane                         | 0.5  | 0.8                                  | 0.9        | 1.1        |
| ethyl acetate                  | ND   |                                      |            |            |
| trichloromethane               | ND   |                                      |            |            |
| 1,1,1-trichloroethane          | ND   |                                      |            |            |
| n-butanol                      | ND   |                                      |            |            |
| <b>benzene</b>                 | <b>0.2</b>   | <b>1.6</b>                           | <b>1.5</b> | <b>1.0</b> |
| 2-methylhexane                 | ND   |                                      |            |            |
| 2,3-dimethylpentane            | ND   |                                      |            |            |
| 3-methylhexane                 | 0.5  |                                      |            | 0.6        |
| heptane                        | ND   |                                      |            |            |
| trichloroethene                | ND   |                                      |            |            |
| propyl acetate                 | ND   |                                      |            |            |
| methylcyclohexane              | ND   |                                      |            |            |
| 4-methylpentan-2-one           | ND   |                                      |            |            |
| toluene                        | 0.3  | 4.1                                  | 3.6        | 5.8        |
| octane                         | ND   |                                      |            |            |
| tetrachloroethene              | ND   |                                      |            |            |
| butyl acetate                  | ND   |                                      |            |            |
| ethylbenzene                   | 0.3  | 0.6                                  | 0.5        | 0.8        |
| m+p-xylene                     | 0.3  | 1.9                                  | 1.6        | 3.0        |
| styrene                        | ND   |                                      |            |            |
| o-xylene                       | 0.3  | 0.7                                  | 0.6        | 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  | 1.0                                  | 0.8        | 0.8        |
| limonene                       | ND   |                                      |            |            |
| undecane                       | ND   |                                      |            |            |
| dodecane                       | ND   |                                      |            |            |
| tetradecane                    | ND   |                                      |            |            |

ND = Not detected.

**Table 6: VOC results (July–September 2009)**

| July–August–September 2009<br>Analyte | Limit of detection<br>( $\mu\text{g}/\text{m}^3$ ) | Results ( $\mu\text{g}/\text{m}^3$ ) |            |            |
|---------------------------------------|--|--------------------------------------|------------|------------|
|                                       |  | Coles Place                          | Burnside   | Penrose    |
| Target VOCs                           |  |                                      |            |            |
| ethanol                               | ND   |                                      |            |            |
| isopropyl alcohol                     | ND   |                                      |            |            |
| acetone                               | ND   |                                      |            |            |
| pentane                               | 2.3  | 3.4                                  | 3.4        | 7.5        |
| dichloromethane                       | ND   |                                      |            |            |
| butan-2-one                           | ND   |                                      |            |            |
| hexane                                | 0.5  | 1.0                                  | 1.3        | 0.9        |
| ethyl acetate                         | ND   |                                      |            |            |
| trichloromethane                      | ND   |                                      |            |            |
| 1,1,1-trichloroethane                 | ND   |                                      |            |            |
| n-butanol                             | ND   |                                      |            |            |
| <b>benzene</b>                        | <b>0.2</b>   | <b>1.5</b>                           | <b>1.5</b> | <b>0.9</b> |
| 2-methylhexane                        | ND   |                                      |            |            |
| 2,3-dimethylpentane                   | ND   |                                      |            |            |
| 3-methylhexane                        | 0.5  | 0.6                                  |            |            |
| heptane                               | 0.5  | 0.7                                  | 0.5        |            |
| trichloroethene                       | ND   |                                      |            |            |
| propyl acetate                        | ND   |                                      |            |            |
| methylcyclohexane                     | ND   |                                      |            |            |
| 4-methylpentan-2-one                  | ND   |                                      |            |            |
| toluene                               | 0.3  | 4.8                                  | 4.0        | 4.7        |
| octane                                | ND   |                                      |            |            |
| tetrachloroethene                     | ND   |                                      |            |            |
| butyl acetate                         | ND   |                                      |            |            |
| ethylbenzene                          | 0.3  | 0.7                                  | 0.6        | 0.6        |
| m+p-xylene                            | 0.3  | 2.2                                  | 1.8        | 2.2        |
| styrene                               | ND   |                                      |            |            |
| o-xylene                              | 0.3  | 0.7                                  | 0.6        | 0.7        |
| nonane                                | ND   |                                      |            |            |
| alpha pinene                          | ND   |                                      |            |            |
| propylbenzene                         | ND   |                                      |            |            |
| 1,3,5-trimethylbenzene                | ND   |                                      |            |            |
| beta pinene                           | ND   |                                      |            |            |
| decane                                | ND   |                                      |            |            |
| 1,2,4-trimethylbenzene                | 0.6  | 0.8                                  | 0.6        | 0.7        |
| limonene                              | ND   |                                      |            |            |
| undecane                              | ND   |                                      |            |            |
| dodecane                              | ND   |                                      |            |            |
| tetradecane                           | ND   |                                      |            |            |

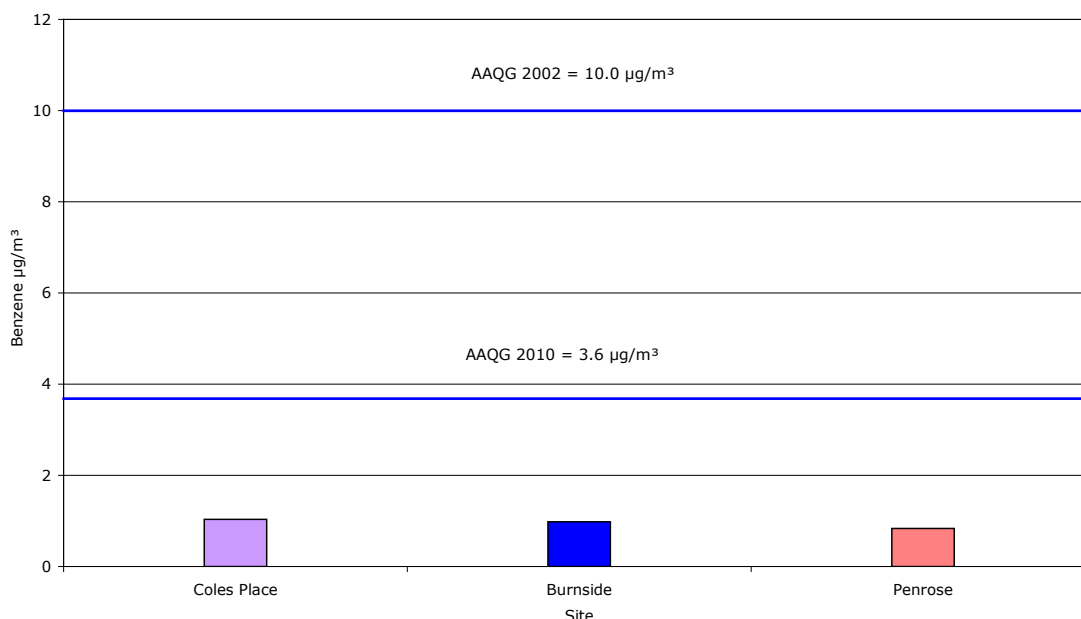
ND = Not detected.

**Table 7: VOC results (October–December 2009)**

| October–November–December 2009<br>Analyte | Limit of detection<br>( $\mu\text{g}/\text{m}^3$ ) | Results ( $\mu\text{g}/\text{m}^3$ ) |            |            |
|---|--|--------------------------------------|------------|------------|
|   |  | Coles Place                          | Burnside   | Penrose    |
| Target VOCs                               |  |                                      |            |            |
| ethanol                                   | ND   |                                      |            |            |
| isopropyl alcohol                         | ND   |                                      |            |            |
| acetone                                   | ND   |                                      |            |            |
| pentane                                   | 2.1  |                                      |            | 4.7        |
| dichloromethane                           | ND   |                                      |            |            |
| butan-2-one                               | ND   |                                      |            |            |
| hexane                                    | 0.4  | 0.4                                  | 1.0        | 0.6        |
| ethyl acetate                             | ND   |                                      |            |            |
| trichloromethane                          | ND   |                                      |            |            |
| 1,1,1-trichloroethane                     | ND   |                                      |            |            |
| n-butanol                                 | ND   |                                      |            |            |
| <b>benzene</b>                            | <b>0.2</b>   | <b>0.5</b>                           | <b>0.4</b> | <b>0.6</b> |
| 2-methylhexane                            | ND   |                                      |            |            |
| 2,3-dimethylpentane                       | ND   |                                      |            |            |
| 3-methylhexane                            | 0.5  |                                      | 0.5        |            |
| heptane                                   | 0.5  |                                      | 0.7        |            |
| trichloroethene                           | ND   |                                      |            |            |
| propyl acetate                            | ND   |                                      |            |            |
| methylcyclohexane                         | ND   |                                      |            |            |
| 4-methylpentan-2-one                      | ND   |                                      |            |            |
| toluene                                   | 0.2  | 1.8                                  | 1.9        | 3.3        |
| octane                                    | ND   |                                      |            |            |
| tetrachloroethene                         | ND   |                                      |            |            |
| butyl acetate                             | ND   |                                      |            |            |
| ethylbenzene                              | 0.3  | 0.3                                  | 0.3        | 0.6        |
| m+p-xylene                                | 0.3  | 1.0                                  | 0.9        | 1.7        |
| styrene                                   | ND   |                                      |            |            |
| o-xylene                                  | 0.3  | 0.4                                  | 0.3        | 0.6        |
| nonane                                    | ND   |                                      |            |            |
| alpha pinene                              | ND   |                                      |            |            |
| propylbenzene                             | ND   |                                      |            |            |
| 1,3,5-trimethylbenzene                    | ND   |                                      |            |            |
| beta pinene                               | ND   |                                      |            |            |
| decane                                    | ND   |                                      |            |            |
| 1,2,4-trimethylbenzene                    | 0.6  |                                      | 0.6        | 0.7        |
| limonene                                  | ND   |                                      |            |            |
| undecane                                  | ND   |                                      |            |            |
| dodecane                                  | ND   |                                      |            |            |
| tetradecane                               | ND   |                                      |            |            |

ND = Not detected.

**Figure 1: MfE benzene annual average, 2009**



## 7.6 Particulate matter (PM<sub>10</sub>), 2009

PM<sub>10</sub> 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<sub>10</sub> and their dates for each site are described below.

| Site                  | Maximum 24-hour average (µg/m <sup>3</sup> ) | 99.5 percentile 24-hour average (µg/m <sup>3</sup> ) |
|-----------------------|--|--|
| Gavin Street, Penrose | 132<br>(25 September)                        | 40   |
| Greers Road, Burnside | 108<br>(4 June)                              | 70   |

There was one exceedence of the 24-hour national environmental standard (50 µg/m<sup>3</sup>) at the Auckland site during 2009. This PM<sub>10</sub> exceedence of 132 µg/m<sup>3</sup> occurred on 25 September 2009 and is the highest ever recorded at the Penrose site. Elevated levels of PM<sub>10</sub> were recorded at Penrose from 24 September at 21:10 until 25 September at 10:50. Particulate matter collected during this period was orange and originated from Australian dust storms. The 2009 PM<sub>10</sub> results for Penrose are shown in figures 42 to 44.

At Greers Road, Burnside, there were nine 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 2009 PM<sub>10</sub> results for Burnside are shown in figures 45 to 47.

Eight out of the nine 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. The PM<sub>10</sub> exceedence of 77 µg/m<sup>3</sup> on 14 September 2009 was due to PM<sub>10</sub> sources that originated from Australia. Elevated levels of PM<sub>10</sub> were recorded at Burnside from 14 September at 09:20 until 15 September at 01:50.

**Table 8: Greers Road, Burnside PM<sub>10</sub> exceedences of the daily NES, 2009**

| Date              | Burnside PM <sub>10</sub> (µg/m <sup>3</sup> ) |
|-------------------|--|
| 3 June 2009       | 57   |
| 4 June 2009       | 108  |
| 5 June 2009       | 63   |
| 26 June 2009      | 70   |
| 7 July 2009       | 51   |
| 9 July 2009       | 57   |
| 14 July 2009      | 57   |
| 26 July 2009      | 53   |
| 14 September 2009 | 77   |

Note: National environmental standard for PM<sub>10</sub> = 50 µg/m<sup>3</sup>.

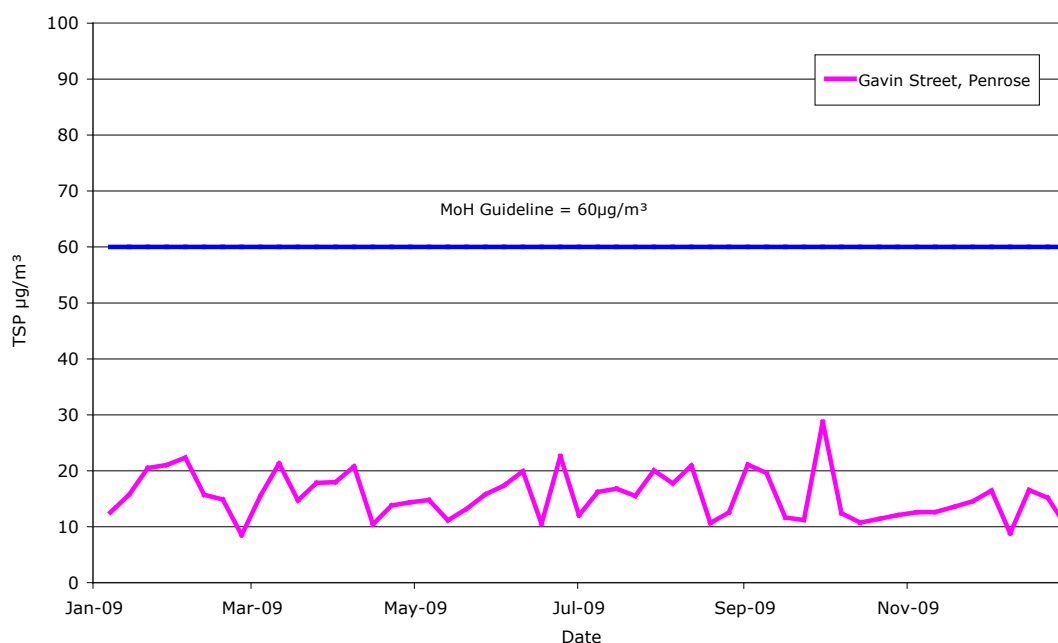
## 7.7 Total suspended particulates (TSP), 2009

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.

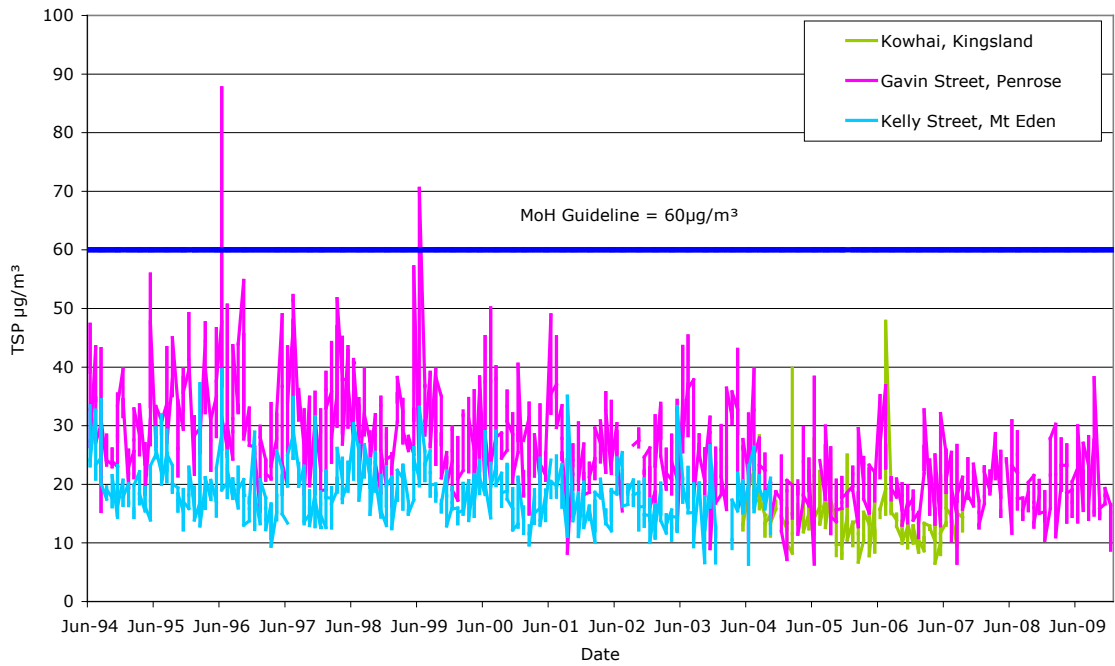
| Site                   | Maximum seven-day average (µg/m <sup>3</sup> ) |
|------------------------|--|
| Gavin Street, Penrose  | 38<br>(30 September)                           |
| Coles Place, St Albans | 36<br>(2 July)                                 |

There were no exceedences of the MoH guideline of 60 µg/m<sup>3</sup> 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.

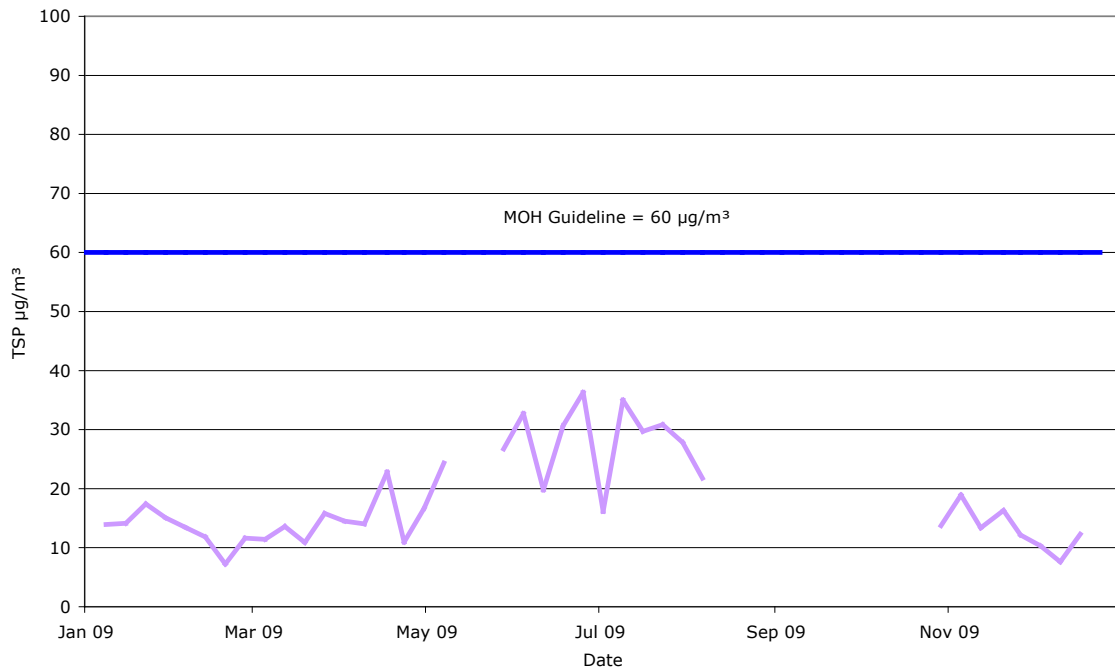
**Figure 2: Auckland TSP seven-day average January–December, 2009**



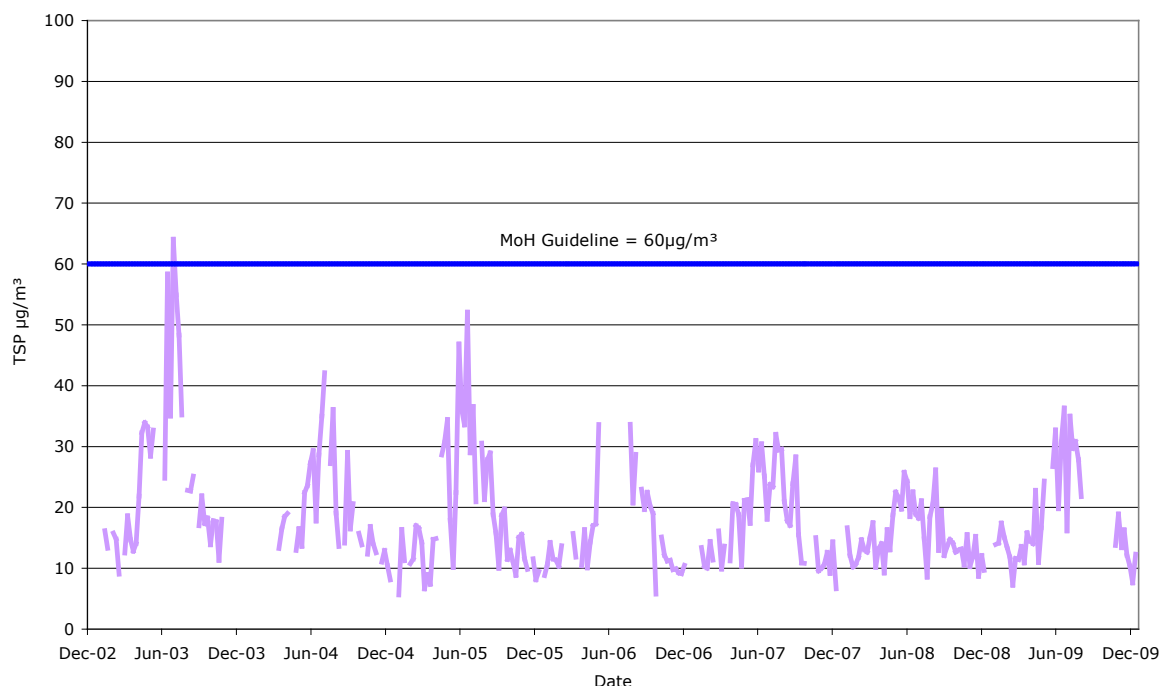
**Figure 3: Auckland TSP seven-day average, 1994–2009**



**Figure 4: Christchurch TSP seven-day average, January–December 2009**



**Figure 5: Christchurch TSP seven-day average, 2002–2009**



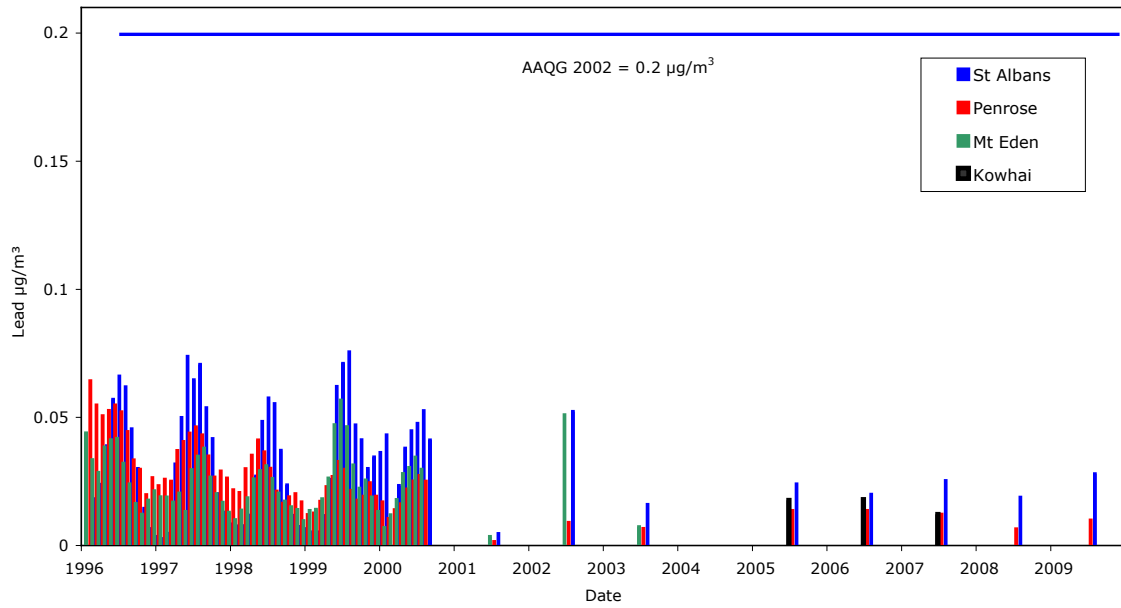
## 7.8 Lead (Pb), June–August 2009

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 was monitored over a three-month period (June to August) annually.

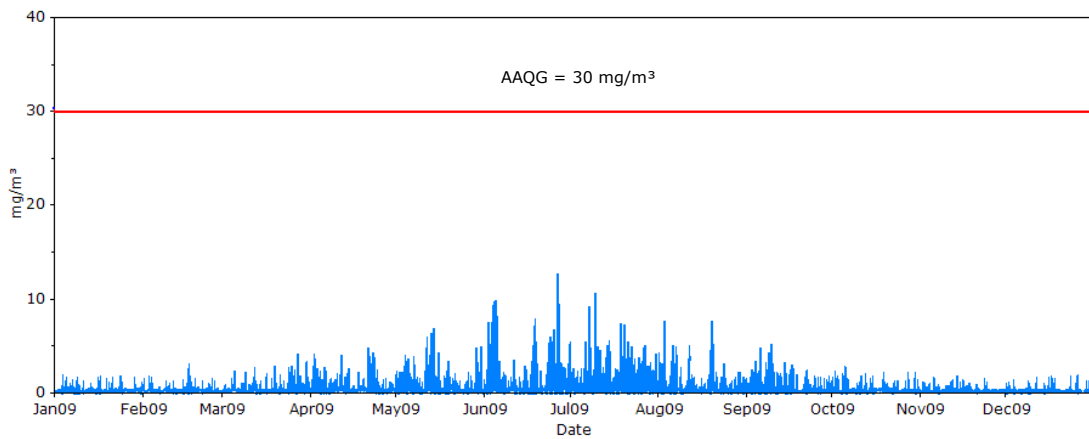
| Site                   | June 2009 average ( $\mu\text{g}/\text{m}^3$ ) | July 2009 average ( $\mu\text{g}/\text{m}^3$ ) | August 2009 average ( $\mu\text{g}/\text{m}^3$ ) | Winter 2009 average ( $\mu\text{g}/\text{m}^3$ ) |
|------------------------|--|--|--|--|
| Gavin Street, Penrose  | 0.014  | 0.012  | 0.004  | 0.010  |
| Coles Place, St Albans | 0.025  | 0.029  | 0.031  | 0.028  |

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

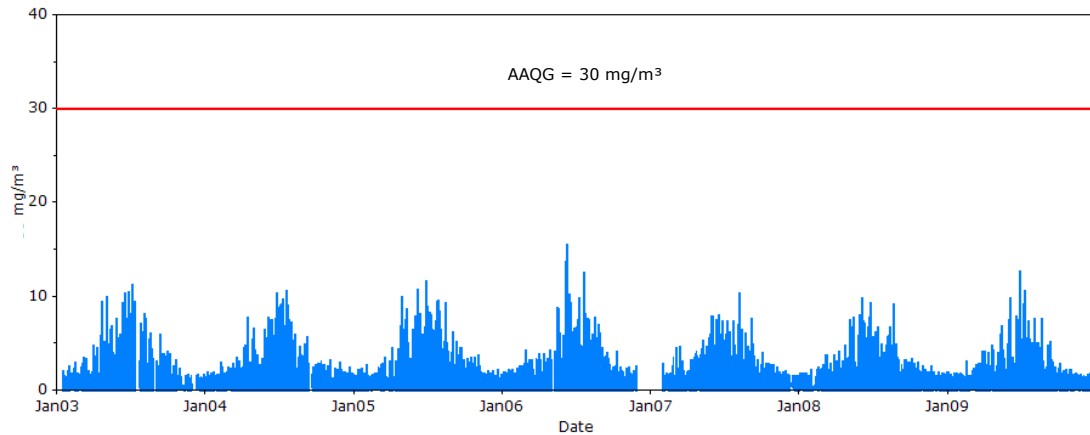
**Figure 6: MfE lead three-month average results, 1996–2009**



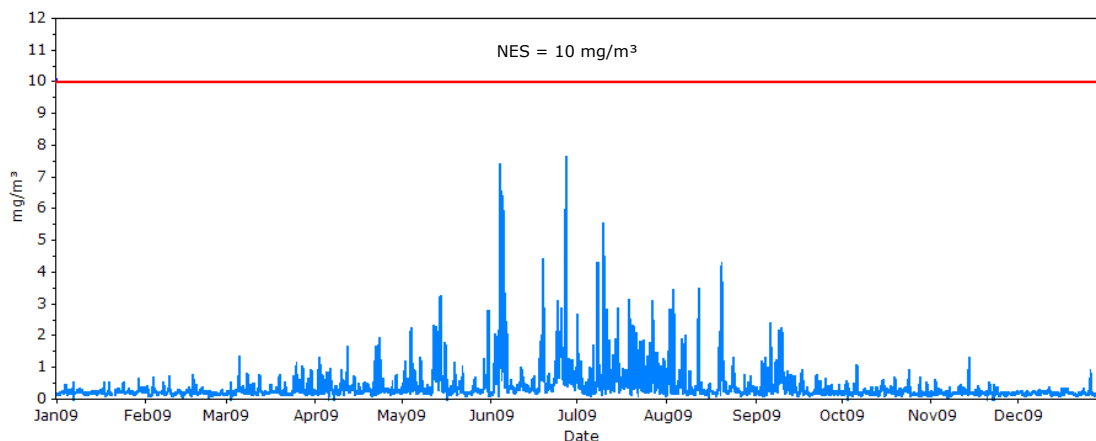
**Figure 7: MfE Burnside CO 1-hour fixed average, January–December 2009**



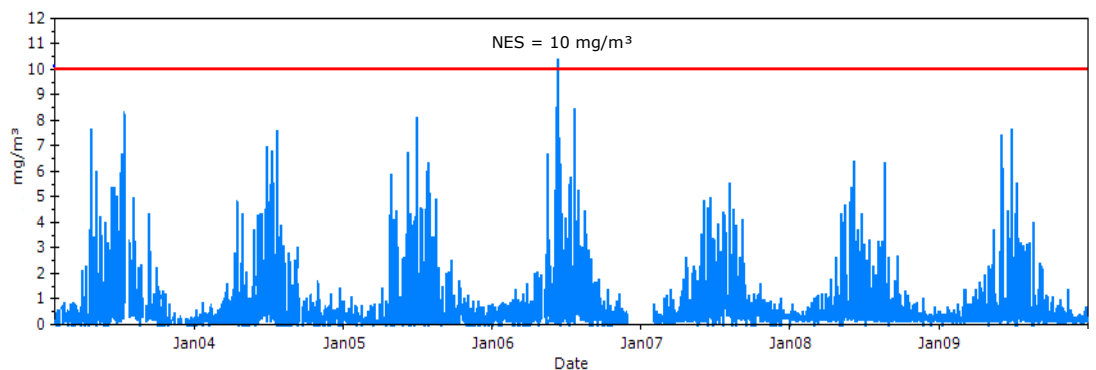
**Figure 8: MfE Burnside CO 1-hour fixed average, 2003–2009**



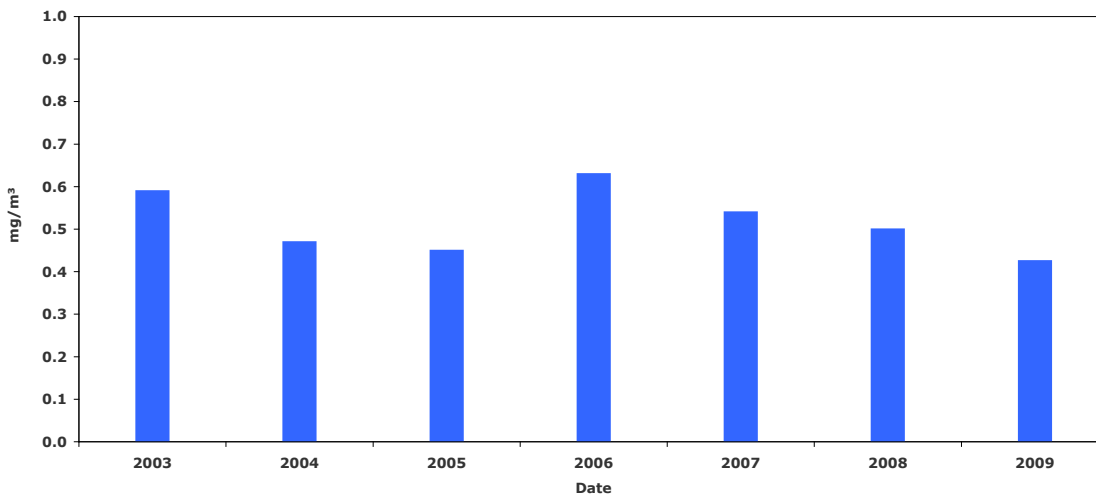
**Figure 9: MfE Burnside CO 8-hour rolling average, January–December 2009**



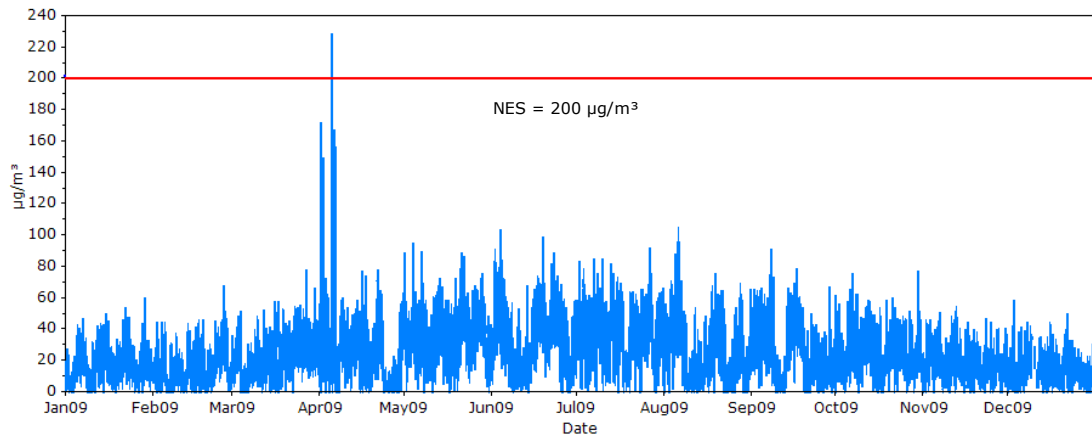
**Figure 10: MfE Burnside CO 8-hour rolling average, 2003–2009**



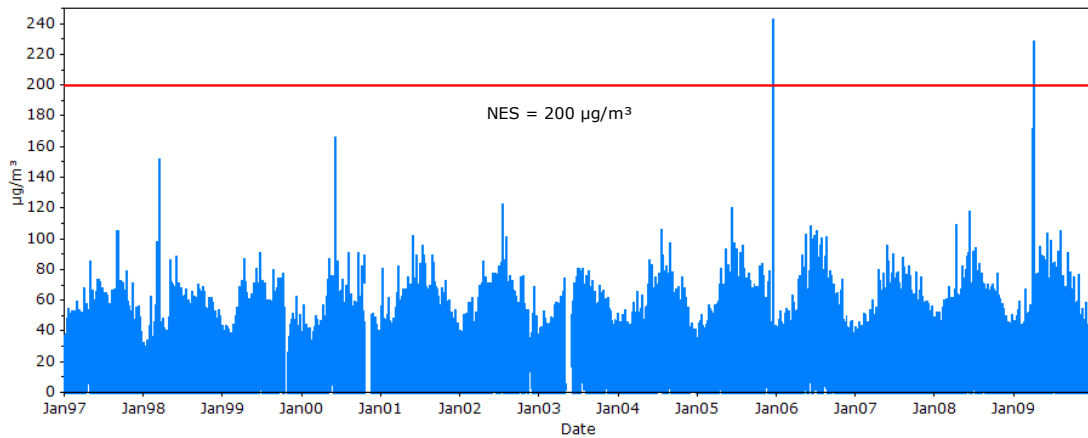
**Figure 11: MfE Burnside CO annual average, 2003–2009**



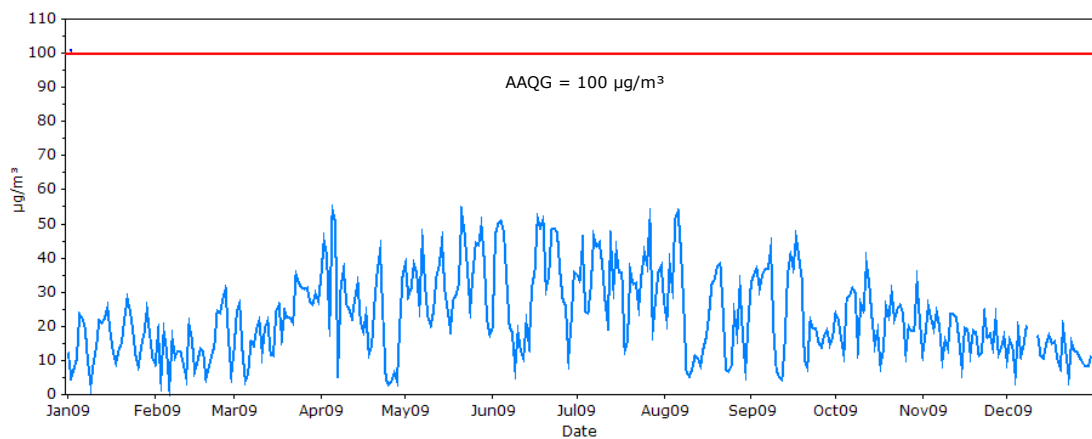
**Figure 12: MfE Penrose NO<sub>2</sub> 1-hour fixed average, January–December 2009**



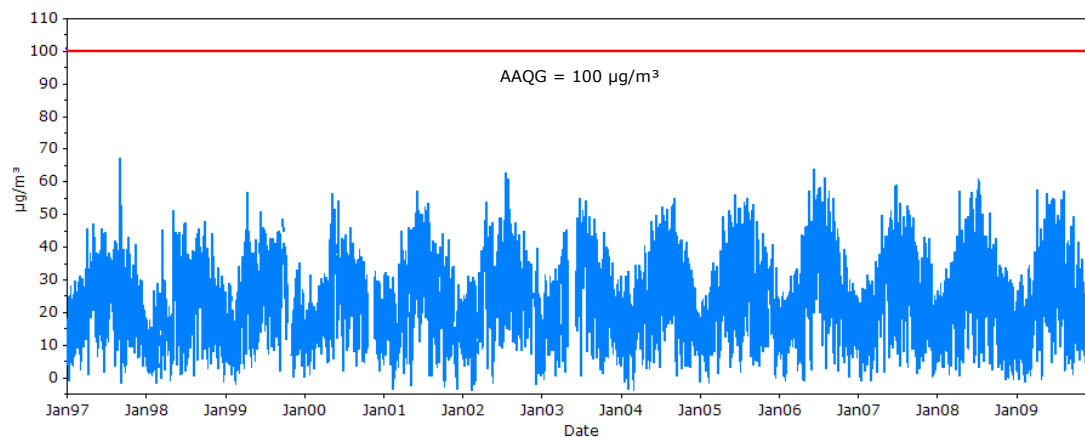
**Figure 13: MfE Penrose NO<sub>2</sub> 1-hour fixed average, 1997–2009**



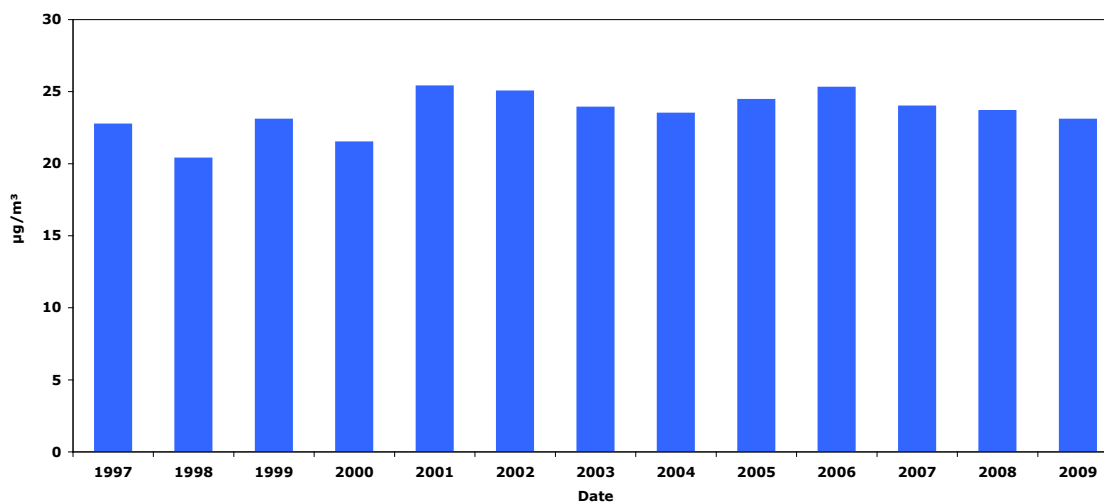
**Figure 14: MfE Penrose NO<sub>2</sub> 24-hour fixed average, January–December 2009**



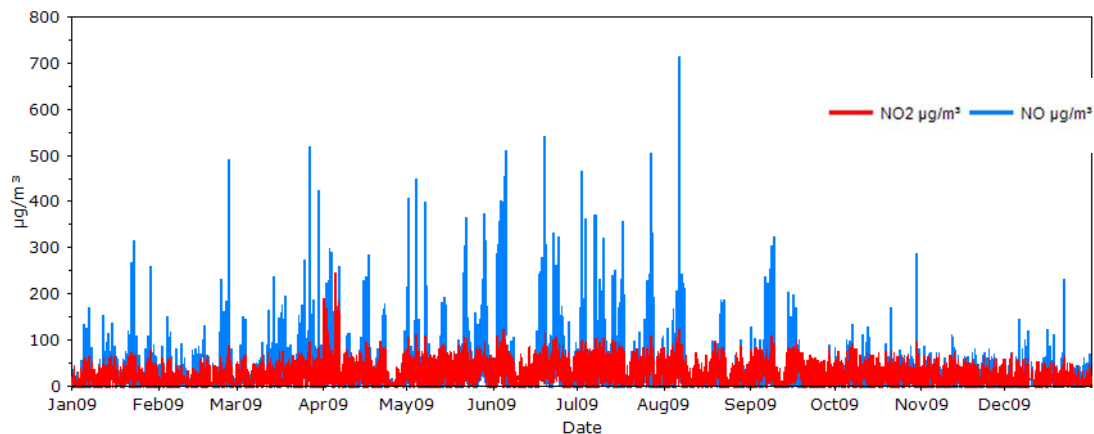
**Figure 15: MfE Penrose NO<sub>2</sub> 24-hour fixed average, 1 January 1997–2009**



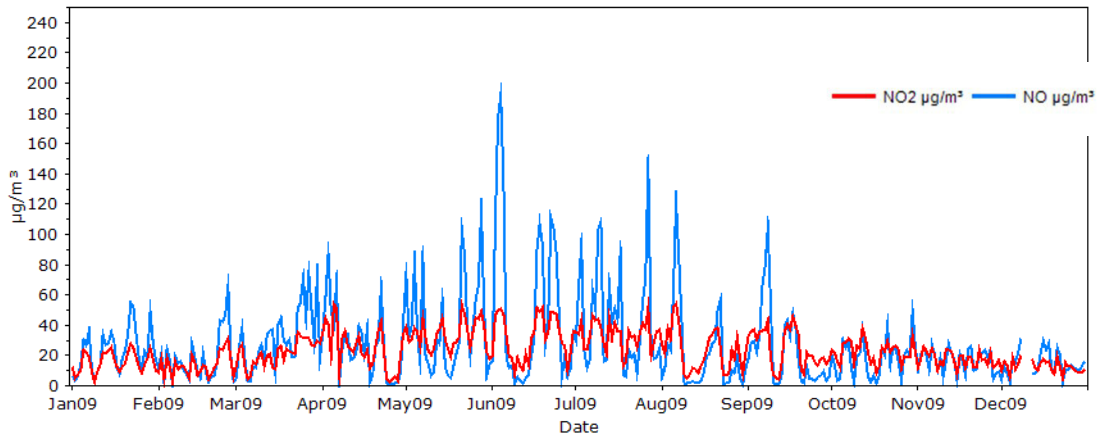
**Figure 16: MfE Penrose NO<sub>2</sub> annual average, 1997–2009**



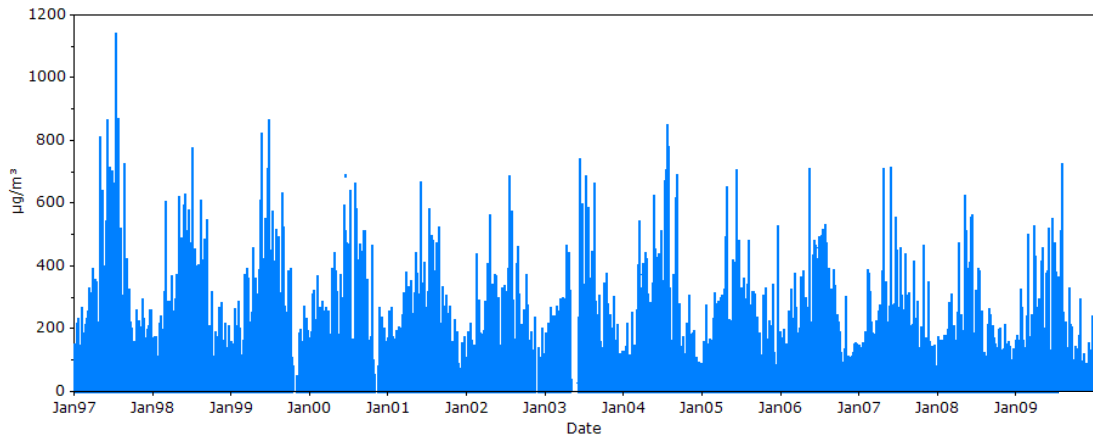
**Figure 17: MfE Penrose NO<sub>2</sub> and NO 1-hour fixed average, January–December 2009**



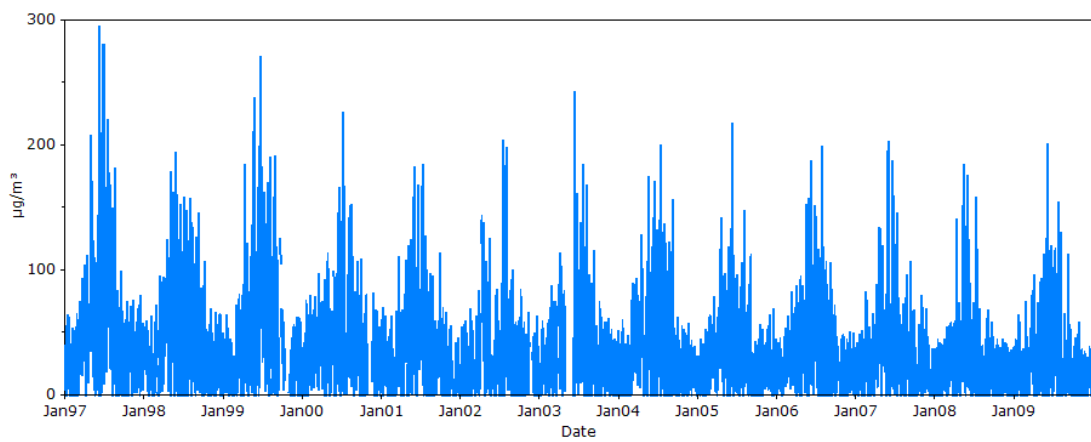
**Figure 18: MfE Penrose NO<sub>2</sub> and NO 24-hour fixed average, January–December 2009**



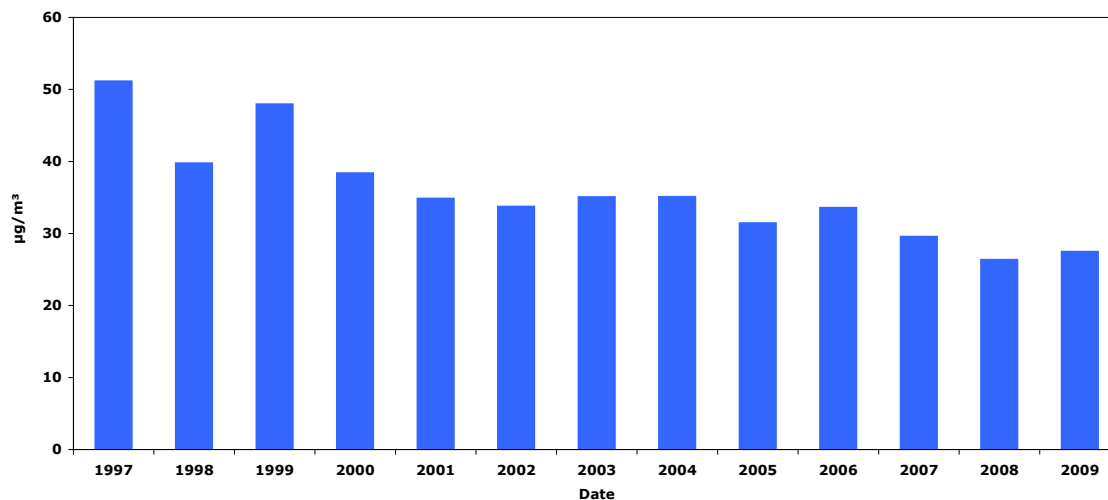
**Figure 19: MfE Penrose NO 1-hour fixed average, 1997–2009**



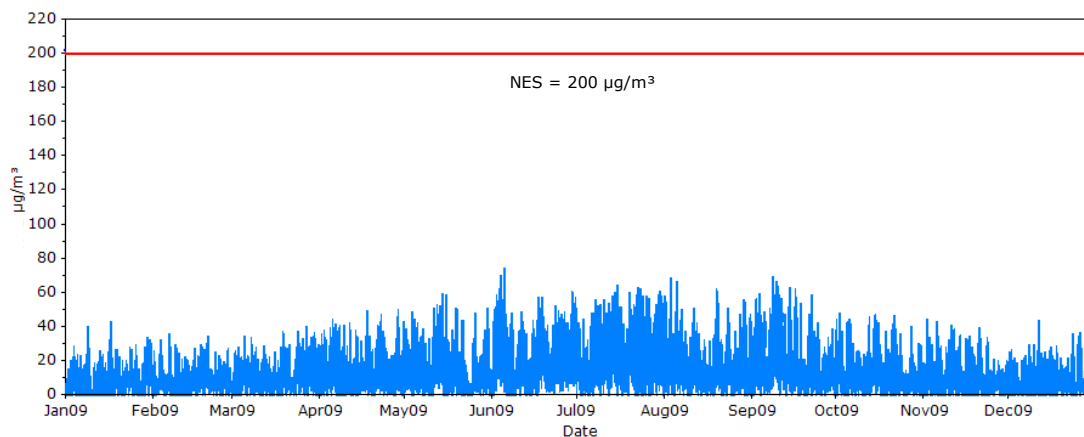
**Figure 20: MfE Penrose NO 24-hour fixed average, 1997–2009**



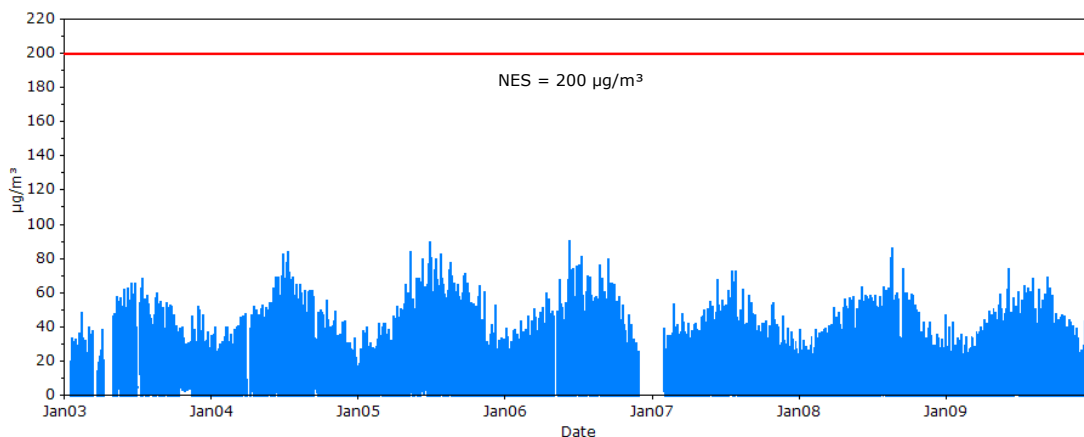
**Figure 21: MfE Penrose NO annual average, 1997–2009**



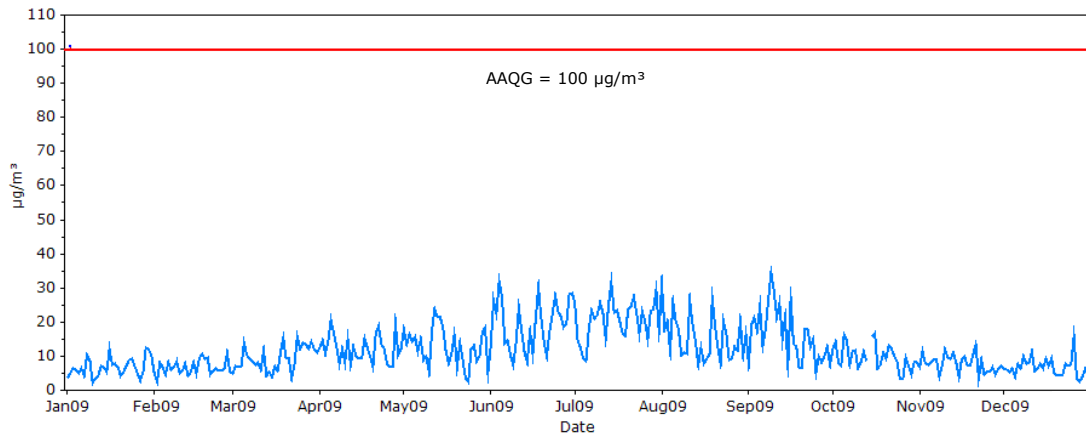
**Figure 22: MfE Burnside NO<sub>2</sub> 1-hour fixed average, January–December 2009**



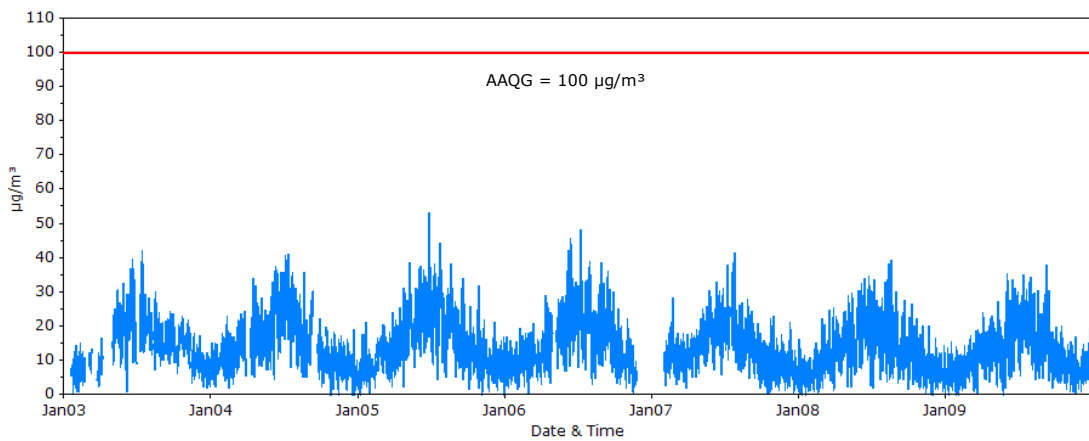
**Figure 23: MfE Burnside NO<sub>2</sub> 1-hour fixed average, 2003–2009**



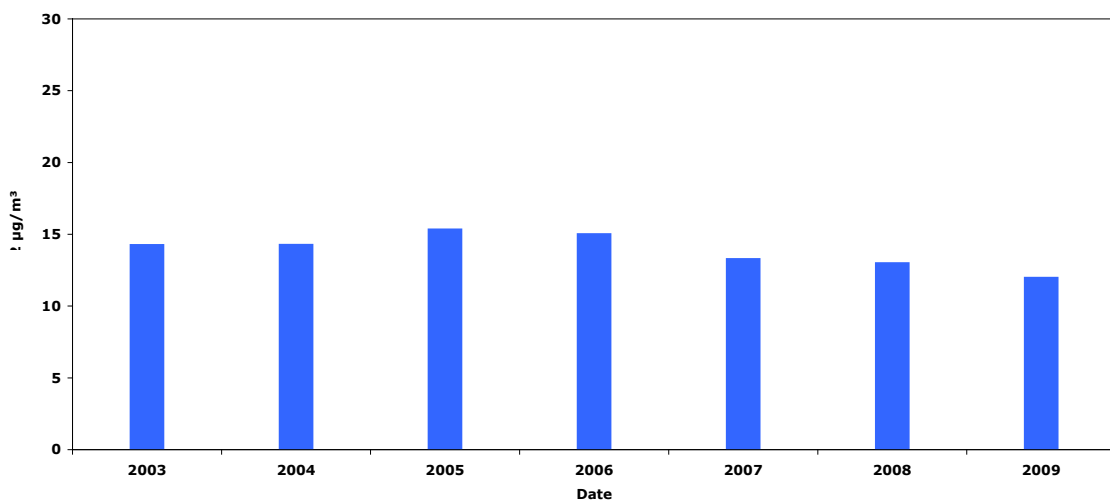
**Figure 24: MfE Burnside NO<sub>2</sub> 24-hour fixed average, January–December 2009**



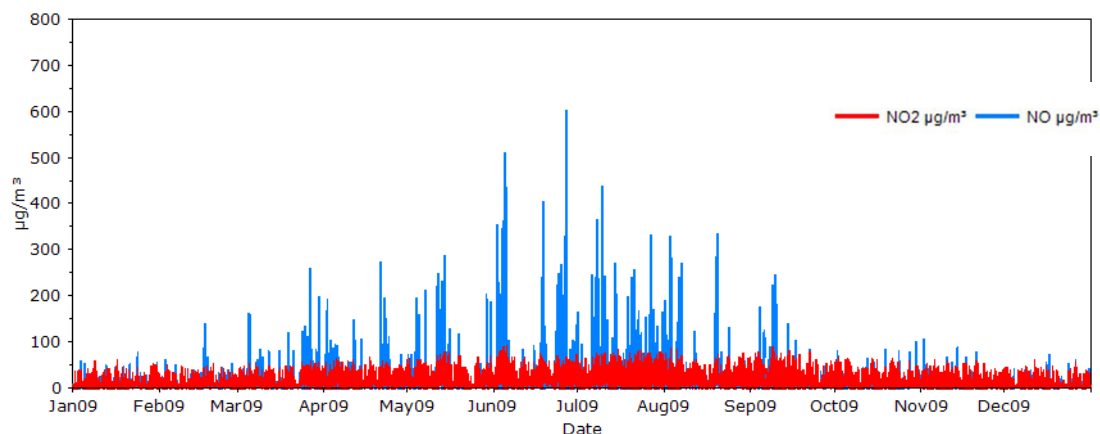
**Figure 25: MfE Burnside NO<sub>2</sub> 24-hour fixed average, 2003–2009**



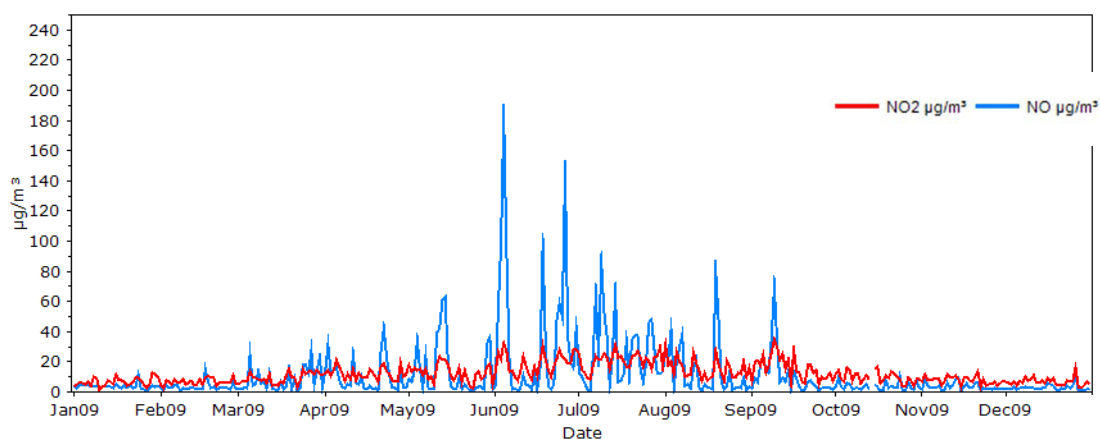
**Figure 26: MfE Burnside NO<sub>2</sub> annual average, 2003–2009**



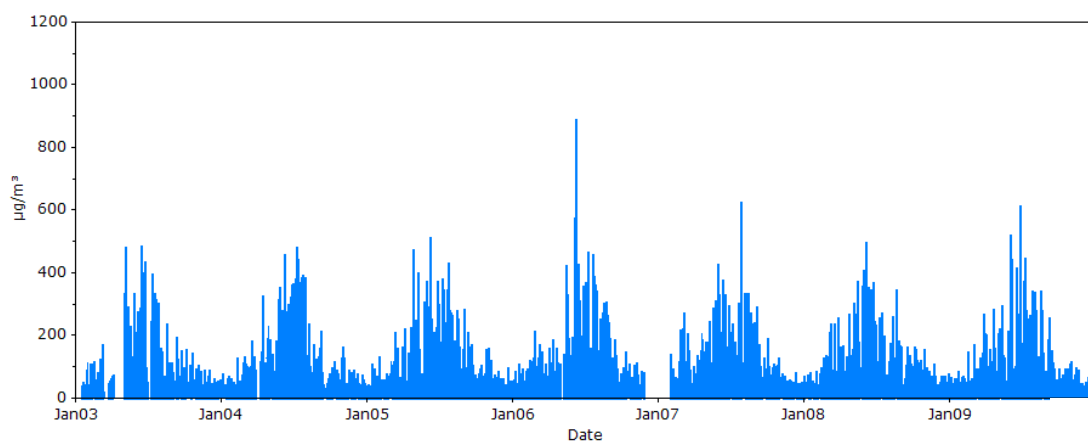
**Figure 27: MfE Burnside NO<sub>2</sub> and NO 1-hour fixed average, January–December 2009**



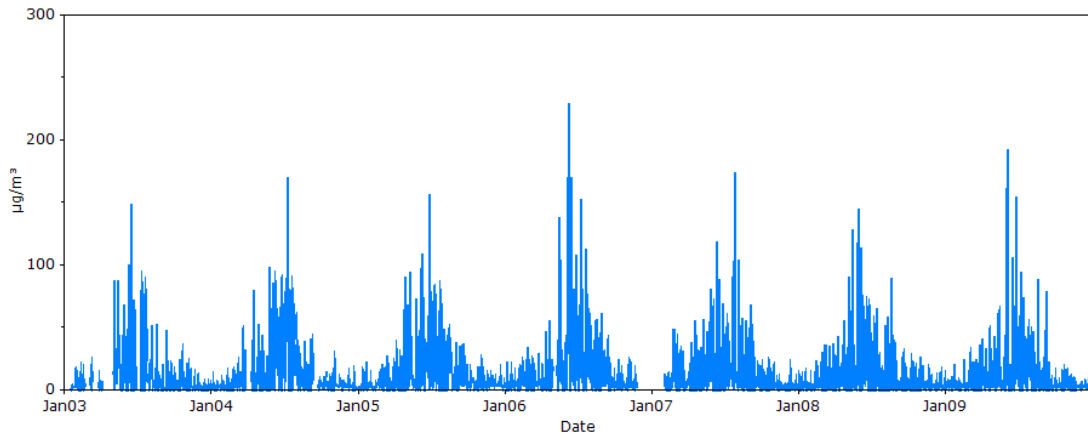
**Figure 28: MfE Burnside NO<sub>2</sub> and NO 24-hour fixed average, January–December 2009**



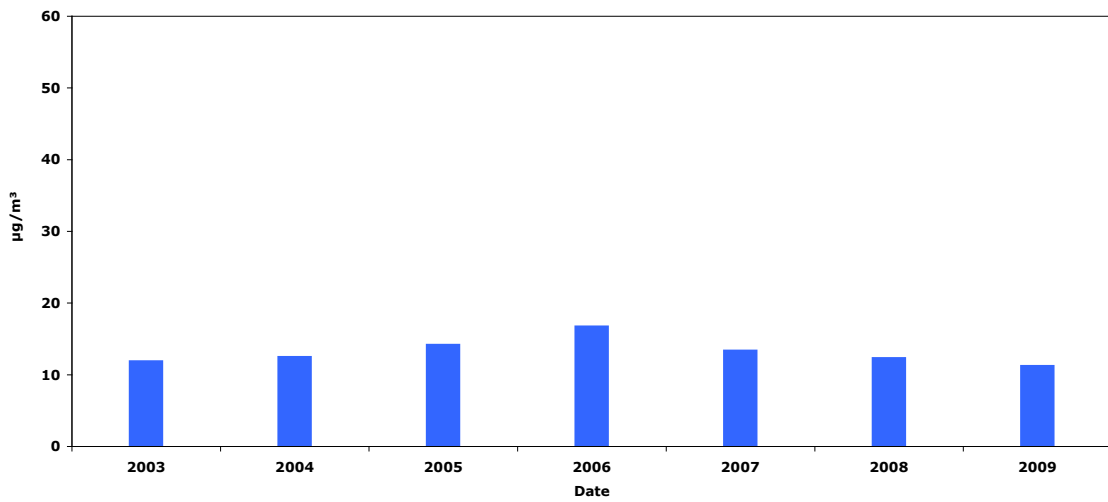
**Figure 29: MfE Burnside NO 1-hour fixed average, 2003–2009**



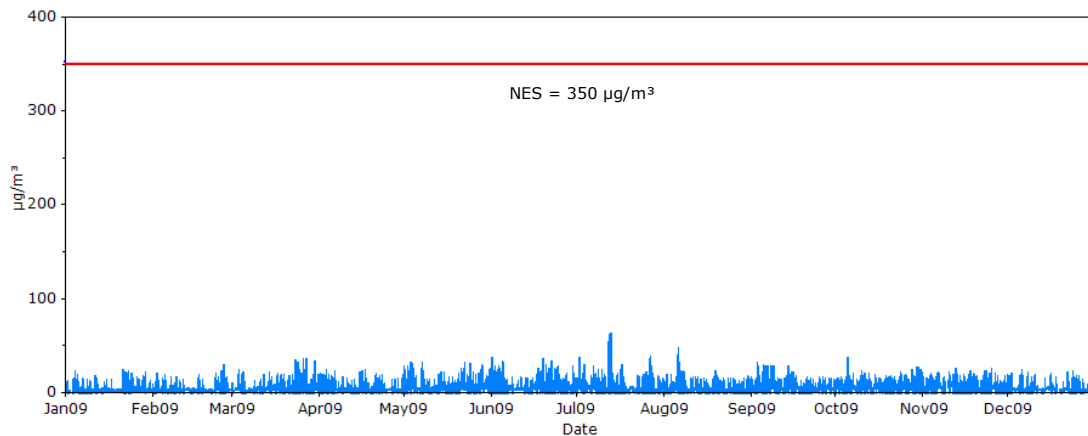
**Figure 30: MfE Burnside NO 24-hour fixed average, 2003–2009**



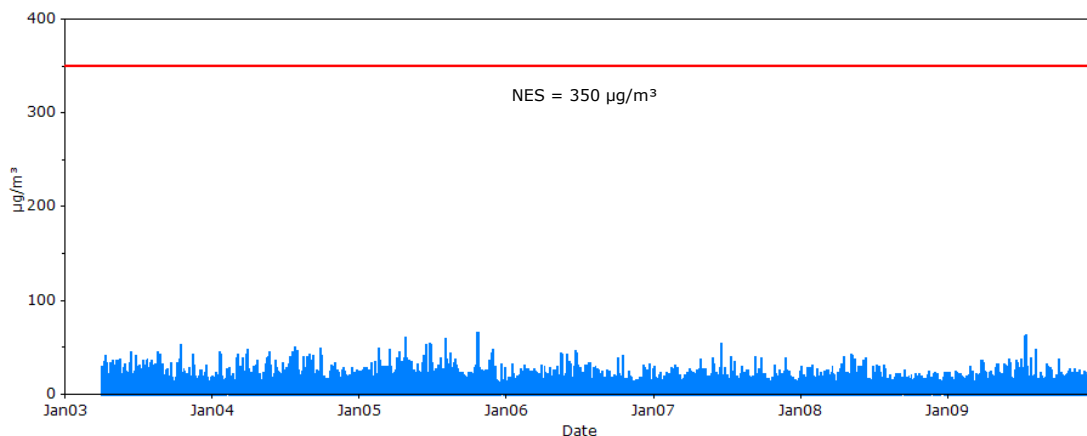
**Figure 31: MfE Burnside NO annual average, 2003–2009**



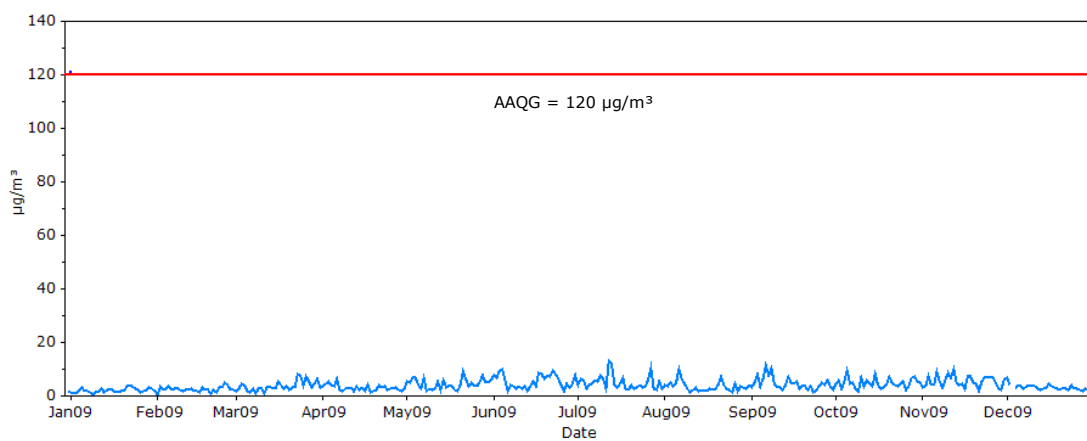
**Figure 32: MfE Penrose SO<sub>2</sub> 1-hour fixed average, January–December 2009**



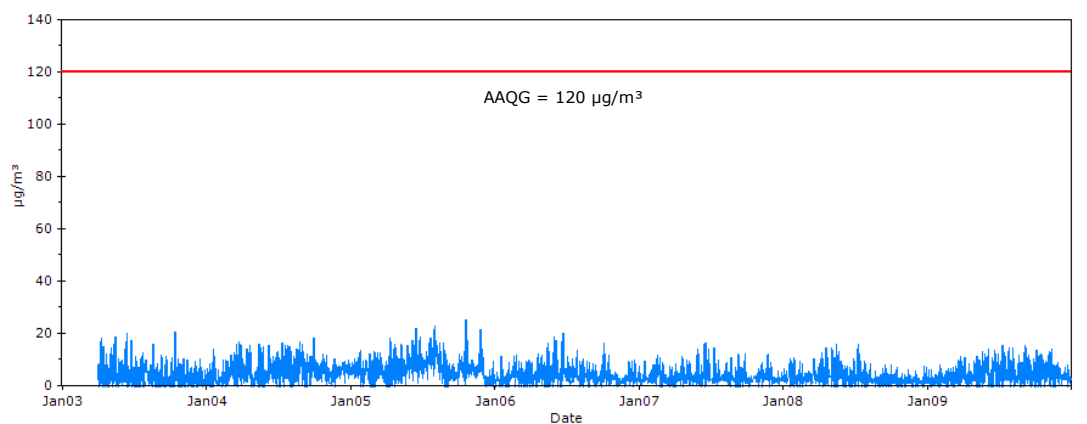
**Figure 33: MfE Penrose SO<sub>2</sub> 1-hour fixed average, 2003–2009**



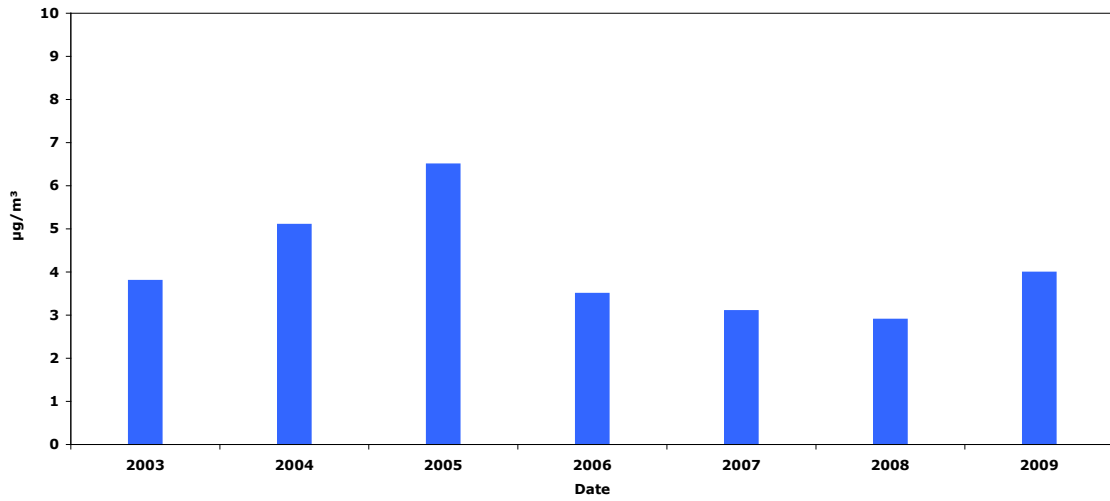
**Figure 34: MfE Penrose SO<sub>2</sub> 24-hour fixed average, January–December 2009**



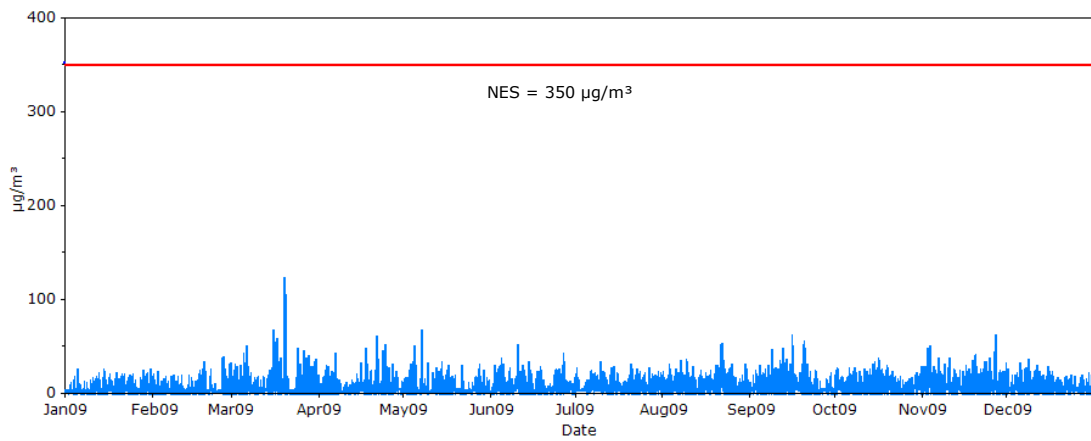
**Figure 35: MfE Penrose SO<sub>2</sub> 24-hour fixed average, 2003–2009**



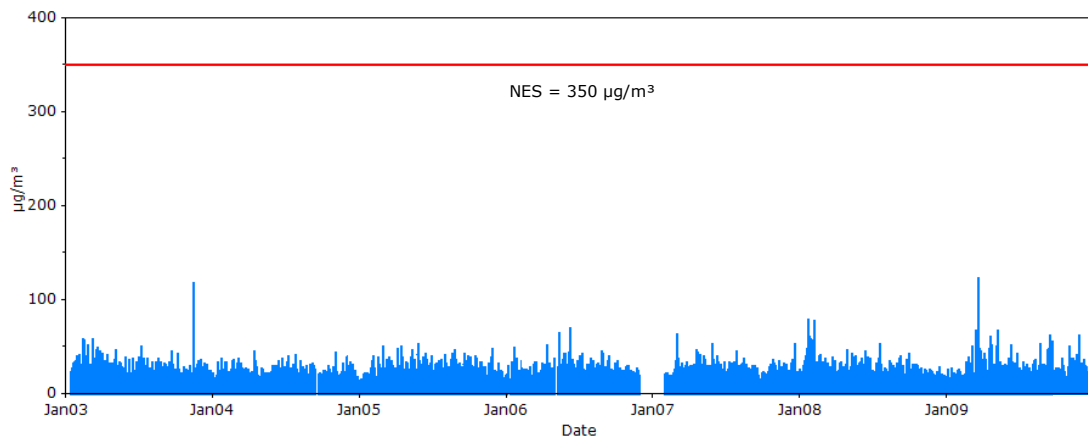
**Figure 36: MfE Penrose SO<sub>2</sub> annual average, 2003–2009**



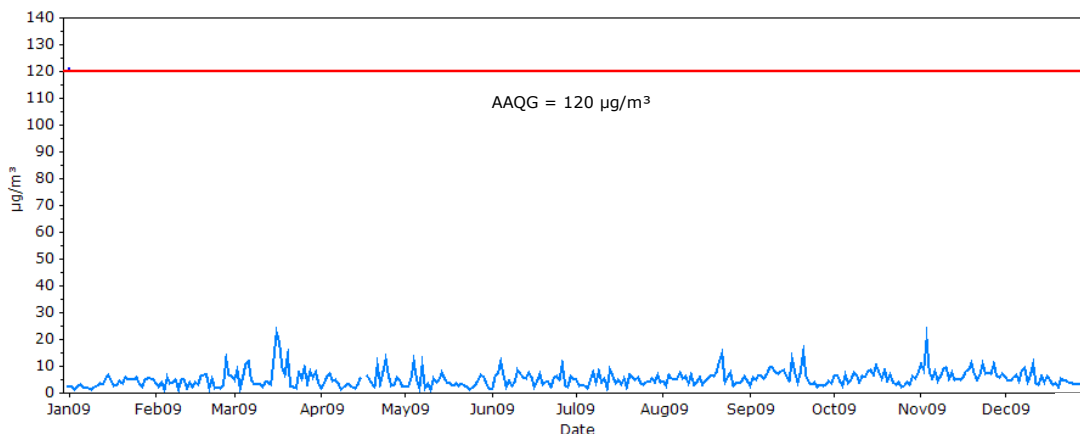
**Figure 37: MfE Burnside SO<sub>2</sub> 1-hour fixed average, January–December 2009**



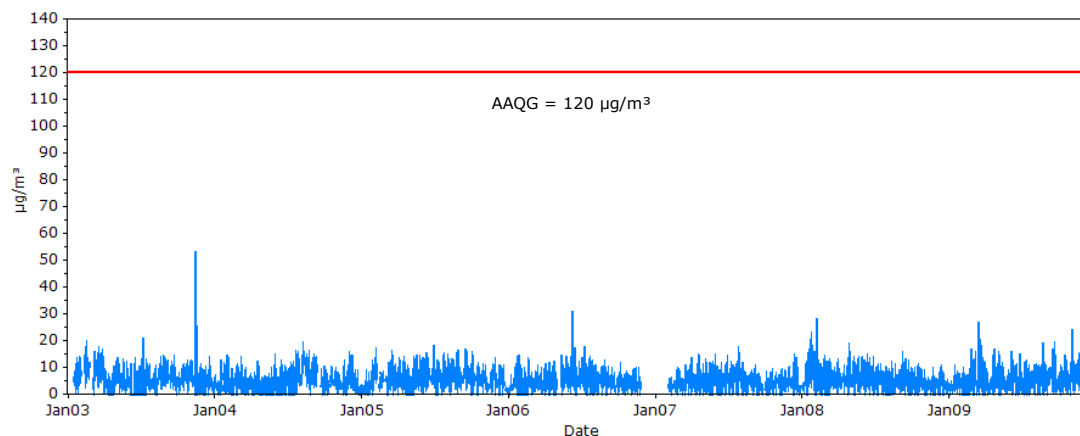
**Figure 38: MfE Burnside SO<sub>2</sub> 1-hour fixed average, 2003–2009**



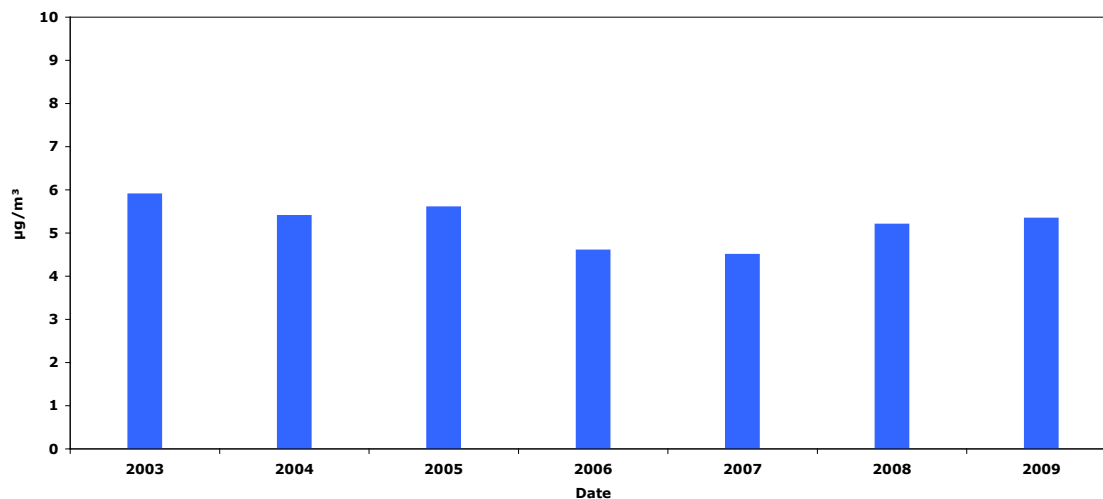
**Figure 39: MfE Burnside SO<sub>2</sub> 24-hour fixed average, January–December 2009**



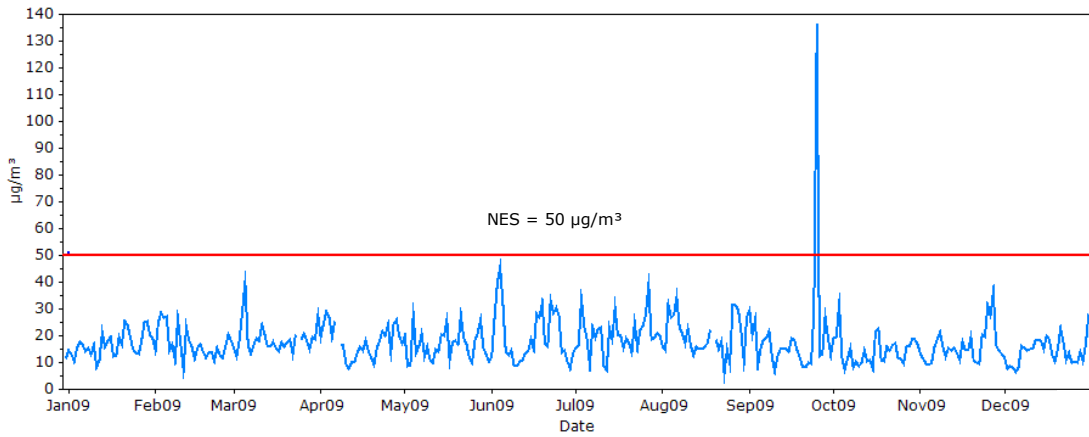
**Figure 40: MfE Burnside SO<sub>2</sub> 24-hour fixed average, 2003–2009**



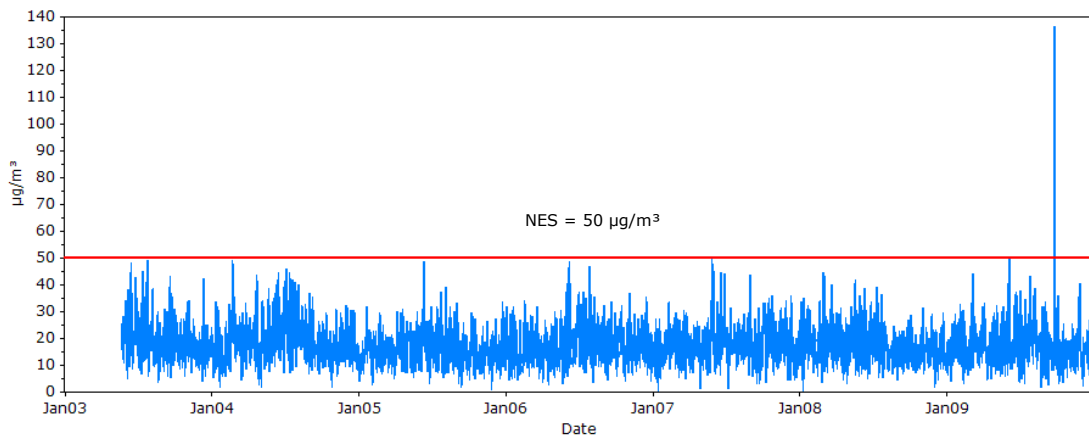
**Figure 41: MfE Burnside SO<sub>2</sub> annual average, 2003–2009**



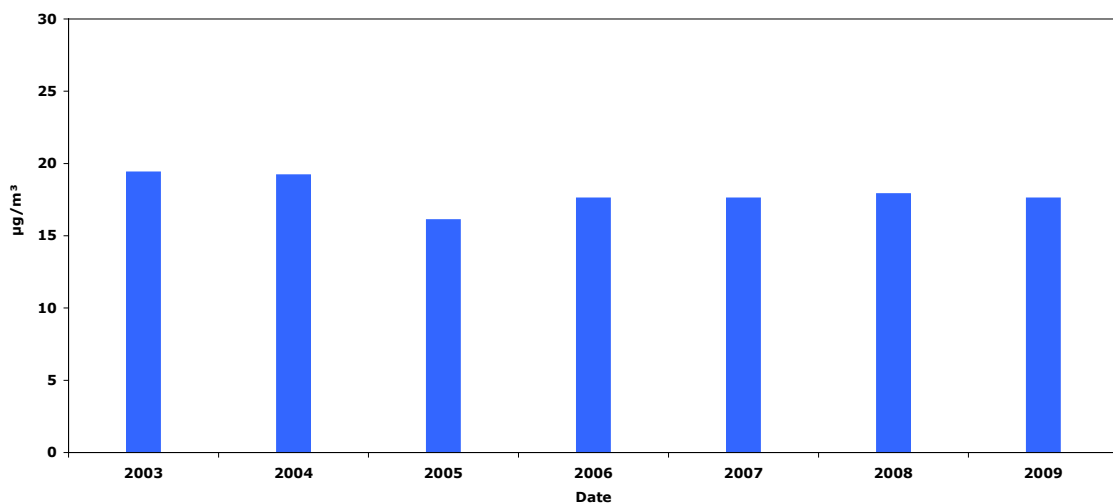
**Figure 42: MfE Penrose PM<sub>10</sub> 24-hour fixed average, January–December 2009**



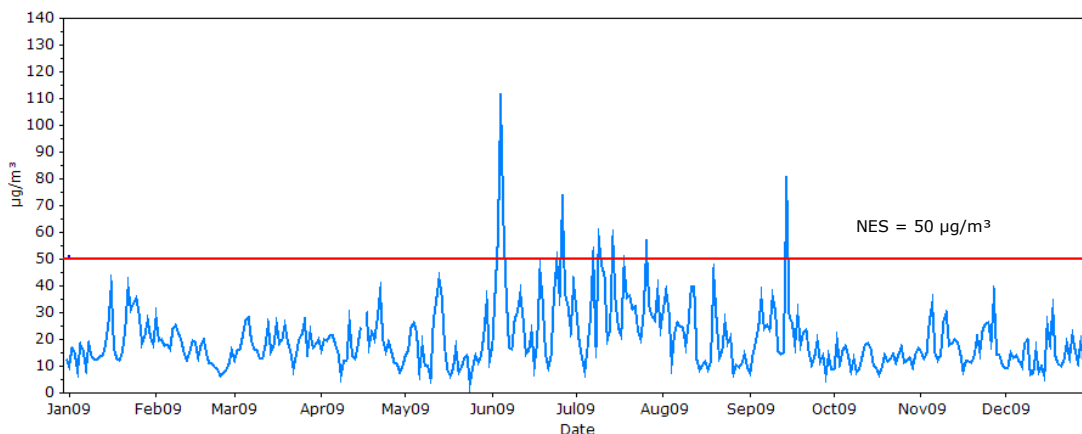
**Figure 43: MfE Penrose PM<sub>10</sub> 24-hour fixed average, 2003–2009**



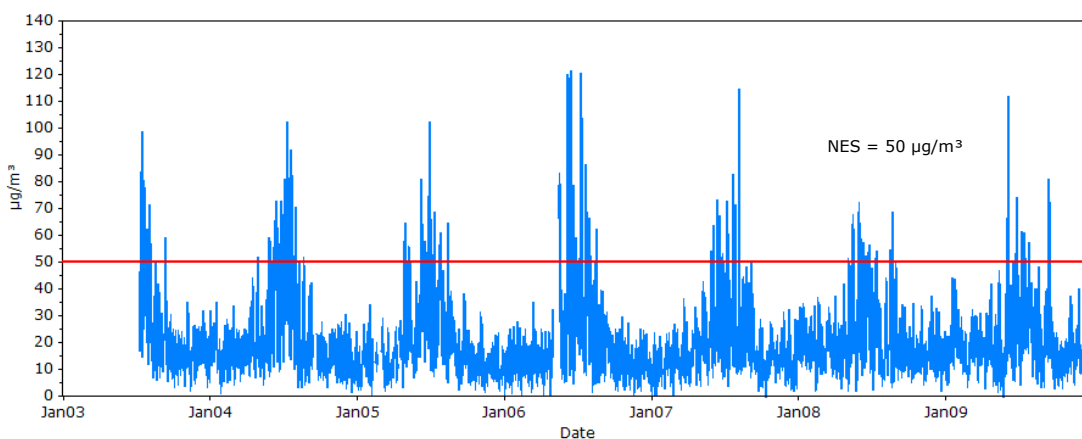
**Figure 44: MfE Penrose PM<sub>10</sub> annual average, 2003–2009**



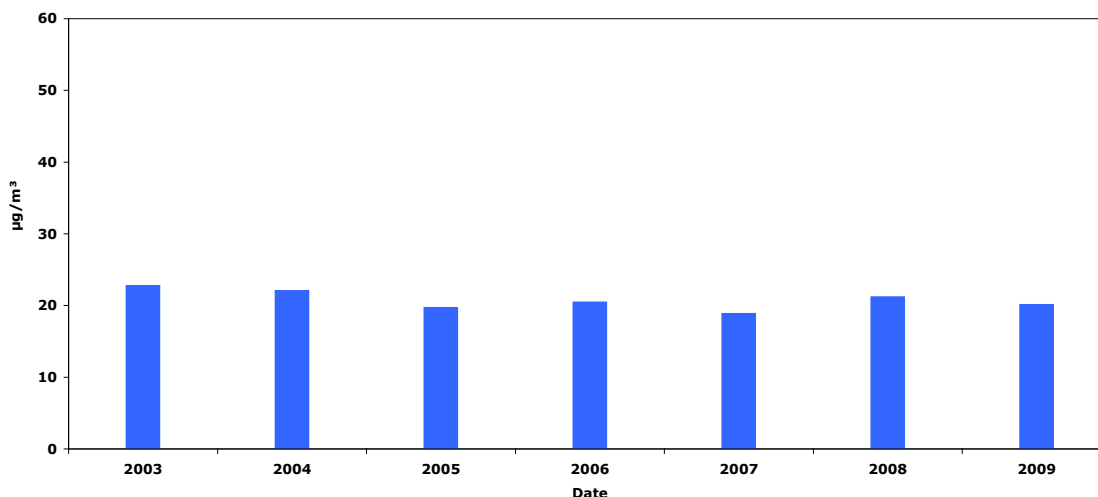
**Figure 45: MfE Burnside PM<sub>10</sub> 24-hour fixed average, January–December 2009**



**Figure 46: MfE Burnside PM<sub>10</sub> 24-hour fixed average, 2003–2009**



**Figure 47: MfE Burnside PM<sub>10</sub> annual average, 2003–2009**



## 7.9 Analysis of exceedences

There was one NO<sub>2</sub> national environmental standard exceedence at Penrose with the likely source being construction works near the monitoring station. There was also one PM<sub>10</sub> standard exceedence at Penrose due to Australian dust. The nine PM<sub>10</sub> exceedences recorded during 2009 at Greers Road, Burnside are examined below. 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<sub>10</sub> standard of 50 µg/m<sup>3</sup> was exceeded on eight days in 2009 during the cooler months from June to July. During June there were three consecutive days that incurred exceedences (3–5 June). On 14 September there was one exceedence linked to Australian dust.

#### Time of day

The typical diurnal trend in PM<sub>10</sub> during winter is shown in figure 48. PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> are plotted against time of day. From figure 48, the biggest contributions to PM<sub>10</sub> levels were between the hours of 18:00 and 03:00. This would suggest contributions from wood burning for home heating. On 4 June PM<sub>10</sub> concentrations remained high at night and in the morning. On 5 June elevated PM<sub>10</sub> levels occur from the early morning until 11 am. On 14 September elevated PM<sub>10</sub> levels start around 10am and remained throughout the day.

#### Temperature

Figures 49, 50 and 51 plot PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> 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<sub>10</sub> levels were when temperature measured at 1.5 m was below 5°C. Figure 50 shows the biggest contributions to PM<sub>10</sub> levels were when temperature measured at 10 m was below 7°C. Figure 51 shows the biggest contributions to PM<sub>10</sub> 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 PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> against hourly average relative humidity (RH). Figure 52 shows contribution to PM<sub>10</sub> levels began when RH was above 75 per cent and peaked at around 95 per cent, ie, high RH conditions. This is consistent with diurnal RH patterns throughout the day.

## Wind direction

Figure 53 plots PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> against hourly average wind directions. Figure 53 shows no particular wind direction seems to contribute significantly higher concentrations of PM<sub>10</sub> over other wind directions. 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 degrees to 180 degrees as wind frequency from this sector is usually low.

## Wind speed

Figure 54 plots PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> against hourly average wind speeds. Figure 54 shows contributions to PM<sub>10</sub> 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. On 5 June winds increased from mid-afternoon until the evening increasing dispersion and decreasing the PM<sub>10</sub> concentrations.

## NO

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

## CO

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

## SO<sub>2</sub>

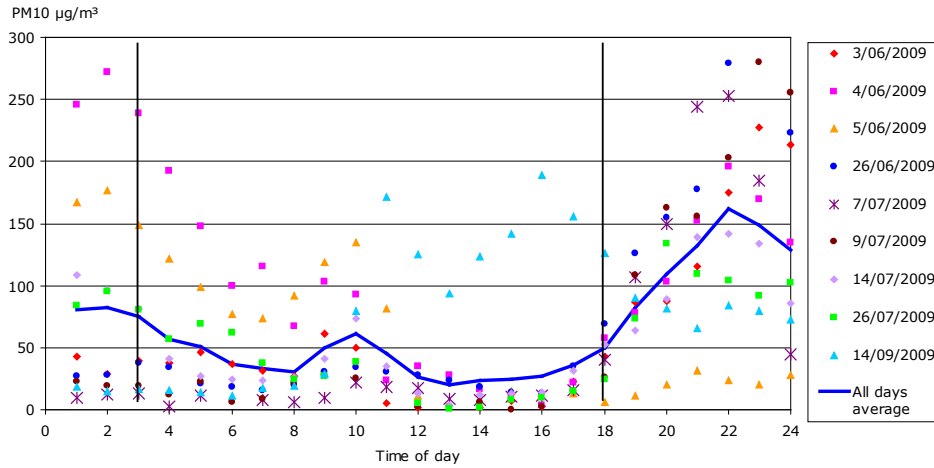
Figure 57 plots PM<sub>10</sub> hourly averages for those days where the daily PM<sub>10</sub> average exceeded 50 µg/m<sup>3</sup> against hourly average SO<sub>2</sub>. Figure 57 shows the relationship between PM<sub>10</sub> and SO<sub>2</sub> concentrations seems to depend on the exceedence day. On a few days there seems to be a positive trend although this is probably due to meteorological conditions.

## Conclusions

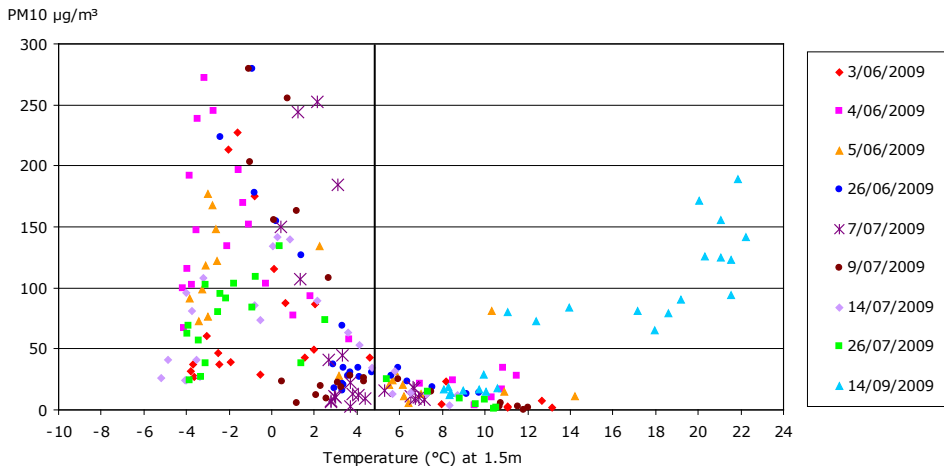
From the comparisons of available meteorological parameters and other pollutants as discussed above, it can be concluded that almost all of the PM<sub>10</sub> exceedences were likely due to home heating during the colder months. This is observed especially in the evenings, when PM<sub>10</sub> levels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

The elevated PM<sub>10</sub> concentrations on 14 September are the exception as the source was linked to Australian dust. The elevated levels occurred from 09:20 onward. With PM<sub>10</sub> concentrations greater than 50 µg/m<sup>3</sup> the meteorological conditions for the day were warm and dry with low to gentle breezes.

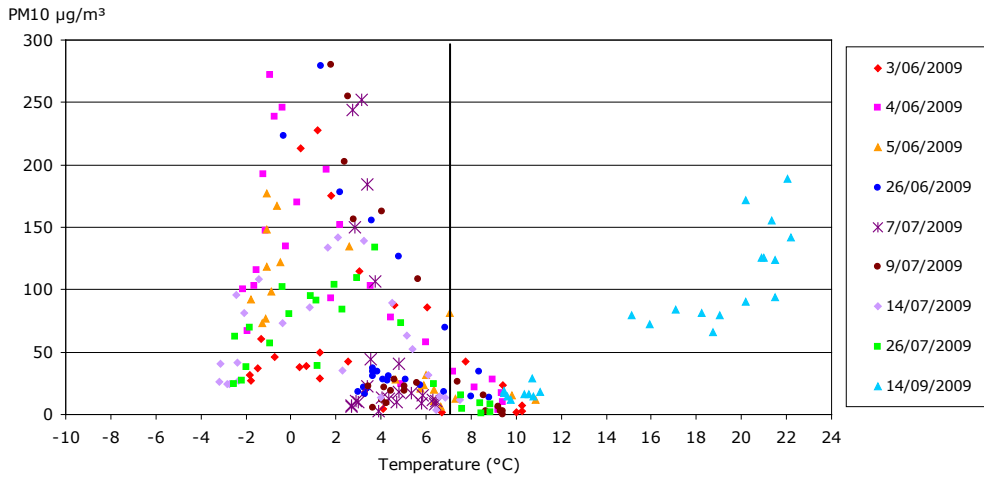
**Figure 48: MfE Burnside, PM<sub>10</sub> vs time of day**



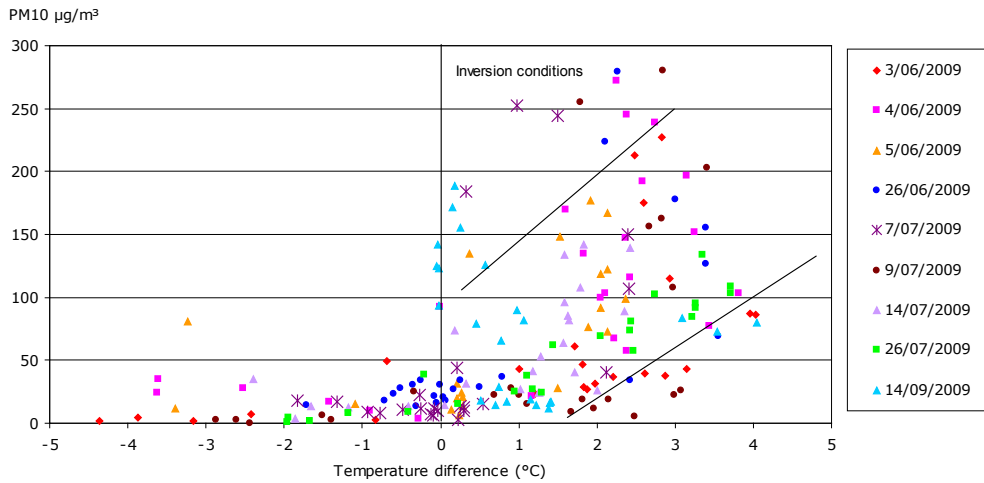
**Figure 49: MfE Burnside, PM<sub>10</sub> vs 1.5 m temperature**



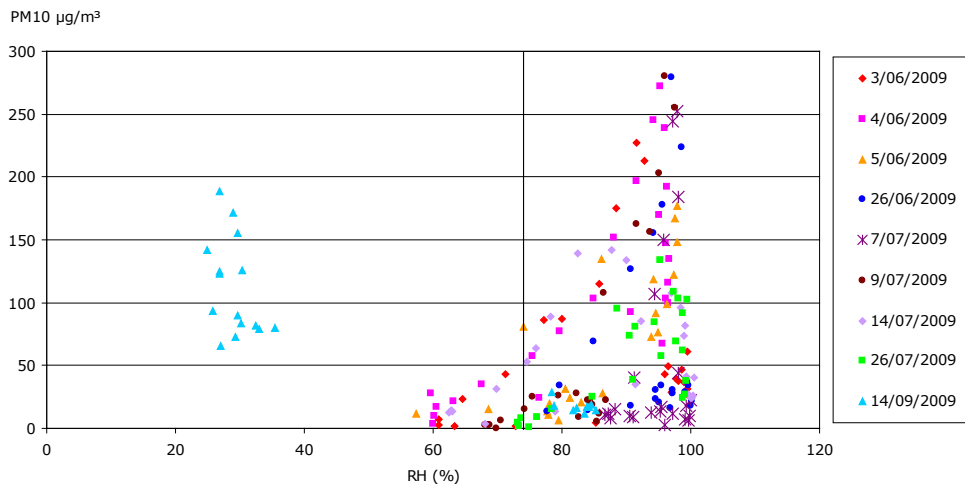
**Figure 40: MfE Burnside, PM<sub>10</sub> vs 10 m temperature**



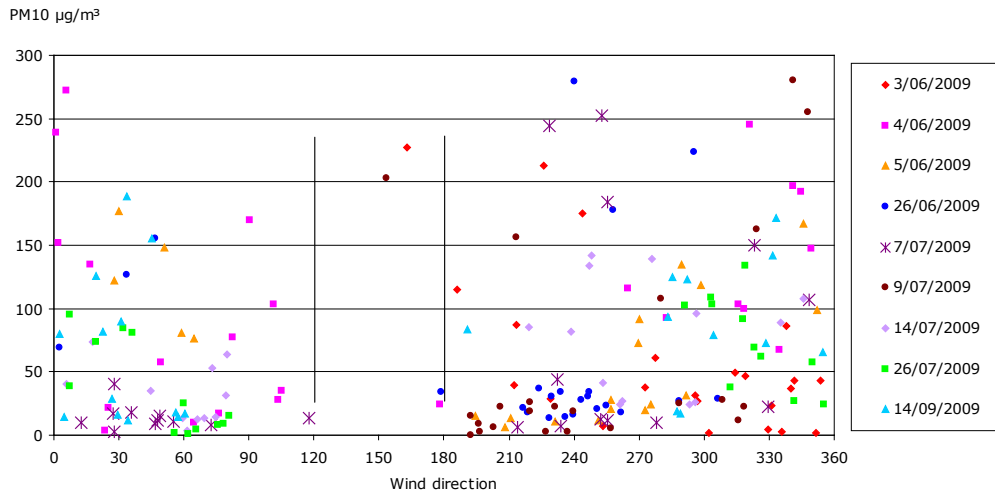
**Figure 51: MfE Burnside, PM<sub>10</sub> vs temperature difference 10 m–1.5 m**



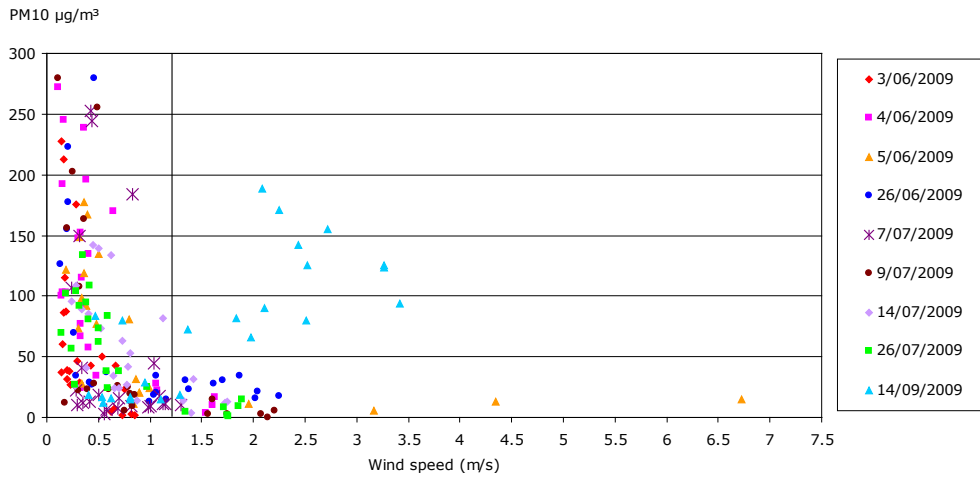
**Figure 52: MfE Burnside, PM<sub>10</sub> vs relative humidity**



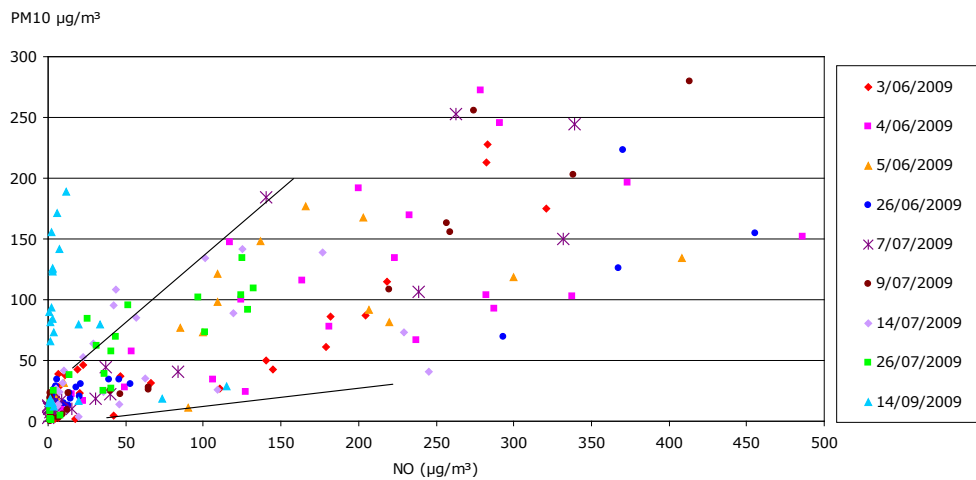
**Figure 53: MfE Burnside, PM<sub>10</sub> vs wind direction**



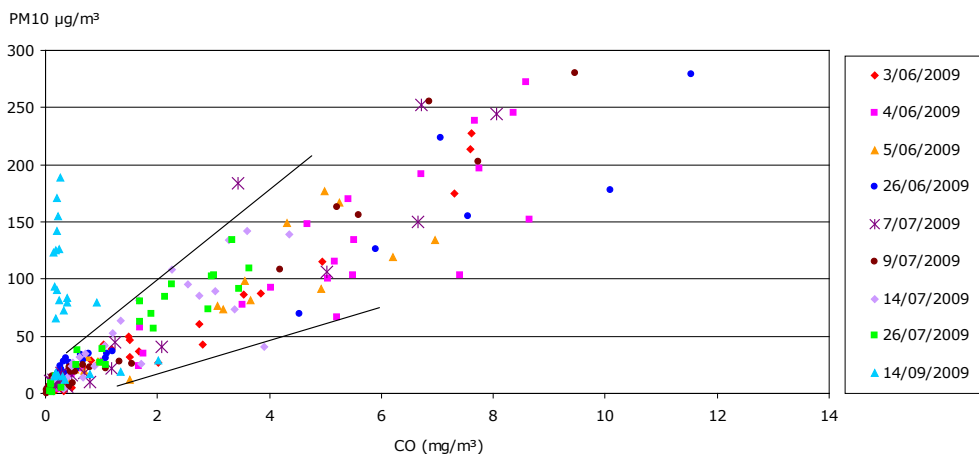
**Figure 54: MfE Burnside, PM<sub>10</sub> vs wind speed**



**Figure 55: MfE Burnside, PM<sub>10</sub> vs NO**



**Figure 56: MfE Burnside, PM<sub>10</sub> vs CO**



**Figure 57: MfE Burnside, PM<sub>10</sub> vs SO<sub>2</sub>**

