Ambient Air Quality Monitoring

South Australia

1979–2003




Government of South Australia

EPA South Australia

AIR

Ambient Air Quality Monitoring

South Australia 1979–2003

July 2004

Environment Protection Authority
South Australia

Ambient Air Quality Monitoring—
South Australia 1979–2003

Authors: David Gooding and Donna Riordan

For further information please contact:
Environment Protection Authority
GPO Box 2607
Adelaide SA 5001

Telephone: (08) 8204 2004
Facsimile: (08) 8204 9393
Free call (country): 1800 623 445

ISBN 1 876562 72 2

JULY 2004

CONTENTS

Figures

Tables

Definitions

Air NEPM	National Environment (Ambient Air Quality) Protection Measure
AQI	air quality index
CO	carbon monoxide
CBD	central business district
EPA	Environment Protection Authority
EPHC	Environment Protection Heritage Council (now incorporates the NEPC)
HVS	high volume sampler
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
O_3	ozone
Pb	lead
PM_{10}	particulate matter less than 10 μm in diameter (aerodynamic equivalent)
$PM_{2.5}$	particulate matter less than 2.5 μm in diameter (aerodynamic equivalent)
PMS	performance monitoring station
Ppm	parts per million (by volume)
SO_2	sulfur dioxide
TEOM	tapered element oscillating microbalance
TSP	total suspended particulates
VOCs	volatile organic compounds
WHO	World Health Organization
$\mu g/m^3$	micrograms per cubic metre
μm	micrometre

Updated air quality information and data from many of the sites described in this report can be found on the EPA's web site: *www.environment.sa.gov.au/reporting/atmosphere/airqual.html*

SUMMARY

This report summarises air monitoring data for six National Environment Protection (Ambient Air Quality) Measure (Air NEPM) air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM_{10}, $PM_{2.5}$ and total suspended particles (TSP)), from 21 air monitoring stations for the period from 1979 to 2003. Data come only from currently operational sites or recently decommissioned sites that still provide important trend information.

Air quality in Adelaide has significantly improved over the last ten years—a positive trend that has been confirmed by the monitoring network of the Environment Protection Authority (EPA).

Air quality data obtained from the EPA monitoring network in Adelaide have determined that levels of CO, NO_2, O_3 and SO_2 are well within the NEPM criteria. Particle concentrations are also low most of the time. In the regional centre of Port Pirie lead continues to be a major problem and at the eastern end of Whyalla particle concentrations exceed acceptable air quality criteria. Air quality in Port Augusta has improved, with exceedences of the NEPM criterion for particulates falling from seven in 1997 to one in 2003, with none in 2001 and 2002.

The dramatic decline in airborne lead concentrations in the metropolitan area, attributed to the reduction of lead in petrol, was one of the first outcomes in a series of strategies aimed at improving Adelaide's air quality. Further improvements in fuel quality and design rules for motor vehicles will see this trend continue for other pollutants. Lead is no longer monitored in metropolitan Adelaide as it is no longer considered to be a significant issue.

The Air Quality Index, a twice daily update of Adelaide's air quality over the previous 24 hours, and the production of validated air quality reports on the internet, highlight the EPA's commitment to deliver current information that will inform, drive community discussion and motivate us to change our behaviour.

Trends

Metropolitan Adelaide

- **Carbon monoxide**: CO is measured at two sites to evaluate exposures in the central business district (Hindley Street) where vehicle emissions predominate, and in the suburbs (Elizabeth) for residential exposure. The goal, to keep emissions below 9.0 ppm over eight hours, has been met since 1997. Overall, ambient CO concentrations have decreased in the Adelaide airshed.
- **Sulfur dioxide**: Ambient SO_2 has been measured at four sites. The goal is to keep emissions below 0.20 ppm measured over one hour. This figure has been exceeded only once, at Christies Beach, since 1997; as the refinery in that area has now been closed, it is not expected that this will be repeated. Overall, ambient SO_2 concentrations are negligible in the Adelaide airshed.
- **Nitrogen dioxide**: Ambient NO_2 is measured at five sites and, overall, concentrations have decreased in the Adelaide airshed. There have been no exceedences of the one-hour NEPM criterion of 0.12 ppm since 1991.
- **Ozone**: The goal for ozone, which is measured at five sites over Adelaide, is to keep concentrations below 0.10 ppm over one hour and 0.08 ppm over four hours. These figures have not been exceeded at any site since 1986 and it can be concluded that Adelaide does not have a significant problem with photochemical smog.
- **Particulates (PM_{10})**: Ambient concentrations of particulate matter smaller than 10 μm (PM_{10}) have been measured at six sites over Adelaide (two now decommissioned) with samples taken one day in six. Ambient concentrations of PM_{10} have shown little change in the Adelaide

airshed, with occasional occurrences of daily maximum 24-hour concentrations above the NEPM criterion for PM_{10} since monitoring began. Large exceedences of the NEPM criterion of 50 $\mu g/m^3$ in recent years can mainly be attributed to dust storms in July. The industrial site at Osborne measured three exceedences in 2003.

- **Particulates ($PM_{2.5}$)**: Monitoring for particulate matter smaller than 2.5 µm ($PM_{2.5}$) began at Netley in 2001 and Kensington in 2002. In 2003 the average concentrations for the sites were 9 $\mu g/m^3$ at Netley and 7 $\mu g/m^3$ at Kensington. The NEPM criterion of 8 $\mu g/m^3$ for one year was exceeded in 2002 and 2003 at Netley, and the daily criterion of 25 $\mu g/m^3$ was exceeded a number of times at Kensington in 2002 and Netley in 2003. Due to the limited data available, it is not yet possible to make any firm conclusion about trends in ambient $PM_{2.5}$ concentrations.

Mount Gambier

A one-year campaign (2001–2002) to measure NO_2, O_3 and SO_2 revealed no exceedence of NEPM criteria for any of these pollutants at Frew Park, a residential area in Mount Gambier. Monitoring data identified that, on occasion, PM_{10} levels in the Frew Park area exceeded 50 $\mu g/m^3$.

Whyalla

Particulates are measured at three Whyalla sites, one next to the pellet plant, one in the main area of the city, as a site for general population exposure, and a new site at Walls Street. The new site aims to monitor the exposure of the community living adjacent to the OneSteel pellet plant to PM_{10} particles and in 2003 recorded 8 exceedences of the 50 $\mu g/m^3$ NEPM criterion.

Port Augusta

Only PM_{10} is measured in Port Augusta. The 90th percentile of the daily maximum 24-hour concentration decreased from 1996 to 2003. Overall, the PM_{10} monitoring site showed a decrease in the number of days when measurements exceeded 50 $\mu g/m^3$.

Port Pirie

PM_{10}, SO_2, NO_2 and lead are measured in Port Pirie. In 2003 there were no exceedences of the criteria for particulates or NO_2, and 27 exceedences of the criterion for SO_2. The criterion for lead was exceeded at two out of three community sites. At the Port Pirie West Primary School annual averaged lead concentrations have exceeded the NEPM criterion of 0.5 $\mu g/m^3$ (as an annual average) every year, except 1996, since the station began operating in 1995.

INTRODUCTION

Air pollution is a problem in all Australian capital cities. Adelaide is fortunate, by virtue of its meteorology and relatively low industrial and population densities, to have good air quality most of the time.

The Environment Protection Authority (EPA) is responsible for monitoring ambient air quality in South Australia. This Ambient Air Quality Report summarises data collected from 1979 to 2003.

Society's growing interest in environmental data has significantly altered the potential audience for this type of information. Interested groups include not only 'decision makers' but also the public, news media, non-government organisations, research scholars, school and university students, and many other interested groups. To cater for the need of this wide audience, this document presents data in both graphical and tabular form. Some graphs show long-term trends; others present data for 2003 for a particular site. The tables provide both long-term and short-term data. Taken together, however, the air quality data present a coherent picture that supports our overall understanding of past and current trends in South Australian air quality.

Being the first publication of ambient air monitoring data for South Australia since 1997, this report includes a reasonable amount of background information (i.e. measurement methods, site locations, pollutants measured and the period of monitoring). Future publications are likely to be annual with a primary focus on results and trends.

Ambient and hotspot air quality monitoring

Ambient air quality refers to the quality of the surrounding outdoor air. The EPA monitors ambient air at a number of sites throughout Adelaide and assesses the air quality at these sites to determine urban air quality trends for the whole of Adelaide. Ambient monitoring is also conducted at Whyalla, Port Pirie and Port Augusta. A short-term monitoring program has also been conducted at Mount Gambier.

The EPA also conducts 'hotspot' monitoring with mobile monitoring stations. This type of monitoring is designed to investigate pollution sources and assess air quality at a specific location. Rather than monitoring emissions directly from a stack or chimney, the air is measured as it moves towards areas where it may impact on the health and quality of life of the local population. Thus other sources, such as roads or other industry impacting on a local area, can also be accounted for. Source specific monitoring carried out by the EPA has not been included in this report.

National Environment Protection (Ambient Air Quality) Measure

The *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) was introduced in 1998 to provide a consistent approach to the measurement of air quality around Australia, with the ultimate aim of providing equivalent protection to all Australians, wherever they live. The Air NEPM established air quality standards (NEPM Standards) for six common pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), particulate matter less than 10 micrometres (µm) in diameter (PM_{10}) and lead (Pb).

NEPM Standards are set to provide adequate protection for human health and well-being. The goal of the Air NEPM is to achieve the NEPM Standards, as assessed by EPA monitoring, within 10 years (see National Environment Protection Council 1998).

Recently, a variation to the Air NEPM was made to include particulate matter of less than 2.5 µm in diameter ($PM_{2.5}$) with monitoring beginning at two metropolitan sites in 2001 and 2002 (see *www.ephc.gov.au/nepms/ air/air_variation.html*).

On 16 April 2004 the National Environment Protection Council (NEPC), the council of all state, territory and Commonwealth environment ministers that develops NEPMs, made a new *National Environment Protection (Air Toxics) Measure* (see *www.ephc.gov.au/news.html.#AS_NEPM*).

South Australian Ambient Air Monitoring Plan

In June 2001, the EPA presented the *Ambient air quality monitoring plan for South Australia* (Environment Protection Agency 2001) to the NEPC to ensure that monitoring in South Australia would be consistent with other states (Environment Protection Agency 2001). The plan contains information on the requirements of monitoring in populous regions, the placement of air monitoring sites, instrumentation, data collection, management and reporting.

As a result of its removal from fuel, lead is no longer present at significant concentrations in ambient air and monitoring for airborne lead is no longer required in Adelaide. All stations measuring lead in Adelaide were decommissioned in June 2003.

Development of the air monitoring network

The EPA has been expanding its air quality monitoring network throughout the Adelaide metropolitan area in accordance with the monitoring plan. New sites have been constructed and monitoring instruments at current sites upgraded. The disruptive nature of this upgrade and expansion meant that data at many sites in 2000–2001 were not available. At some sites data from 1997 to 2000 have been deemed unreliable and were not considered in this report. The monitoring network will be fully functioning and providing valid data in 2004.

Air quality standards and guidelines

NEPMs are defined in the NEPC Act and made by the NEPC. They are similar to policies and are set to ensure environmental protection. NEPMs can be defined by any combination of goals, standards, protocols and guidelines (Environment Protection and Heritage Council 2004).

A goal means the desired outcome of the NEPM (e.g. protection of human health). A standard is a 'measure of environmental quality' (e.g. a pollutant concentration). Protocol is the 'procedure to be followed to determine whether a standard or goal is being met' (e.g. looking at the location of sites and methods of monitoring and analysis). Guidelines outline how to meet the standards and goals (see Definitions of Terms and Explanations at *www.ephc.gov.au/nepms/goals_nepm.html*).

A NEPM site is one that has been nominated by the EPA in the *Ambient air quality monitoring plan for South Australia* (2001), as one that meets the standards set out by the NEPM with respect to, for example, placement of the site and monitoring methods, and has been approved by NEPC.

Table 1 outlines the NEPM Standards and World Health Organization (WHO) guidelines for common air pollutants along with the NEPM goals for each pollutant (World Health Organization 2001; see also *www.ephc.gov.au/nepms/air/ air_nepm.html*).

An exceedence of the NEPM is characterised by an exceedence of the maximum allowable concentration, for a greater number of times as set by the goal, at a NEPM designated site (see Table 2 for metropolitan NEPM sites). In this report exceedence of the maximum concentration (shown in Table 1) will be described as exceedence of the NEPM criterion.

Table 1 Air quality standards and guidelines used by the EPA

Pollutant measured	Averaging period	Maximum concentration	Maximum allowable exceedences (NEPM Goal)	Source
Carbon monoxide (CO)	8 hours	9.0 ppm	1 day/year	NEPM
Nitrogen dioxide (NO_2)	1 hour	0.12 ppm	1 day/year	NEPM
	1 year	0.03 ppm	none	
Ozone (O_3)	1 hour	0.10 ppm	1 day/year	NEPM
	4 hours	0.08 ppm	1 day/year	
Sulfur dioxide (SO_2)	1 hour	0.20 ppm	1 day/year	
	1 day	0.08 ppm	1 day/year	NEPM
	1 year	0.02 ppm	none	
Lead (Pb)	1 year	0.50 µg/m^3	none	NEPM
Particles as PM_{10}	1 day	50 µg/m^3	5 days/year	NEPM
Particles as total suspended particles (TSP)	1 day	120 µg/m^3	Not applicable	WHO

µg/m^3 = micrograms per cubic metre
ppm = parts per million by volume

Air pollutants measured

This section summarises the health effects and common sources of each pollutant measured. For more information on health see the Environment Protection and Heritage Council (EPHC)[1], Environment Australia, US Environment Protection Agency and EPA Air Quality Index web sites (see Bibliography).

Carbon monoxide

Health effects

The main threat to health from exposure to CO is the formation of carboxyhaemoglobin, which substantially reduces the capacity of the blood to carry oxygen and deliver it to the tissues. CO binds to haemoglobin 200-240 times more strongly than oxygen (National Occupational Health and Safety Commission no date). CO also blocks important biochemical reactions in cells. People who have an existing disease, such as coronary artery disease or angina, are likely to be at particular risk if these delivery systems are further impaired by CO.

The NEPM criterion of 9 ppm as a running 8-hour mean is intended to limit the exposure of the population, including susceptible individuals.

Sources

CO is a gas formed by the incomplete combustion of fuels containing carbon. The main outdoor source of CO is currently motor vehicles, in particular petrol-fuelled vehicles which, in Adelaide, account for almost 85% of emissions (Ciuk 2002). Industrial sources include steel plants, foundries, oil refineries and chemical manufacturing facilities, such as those that make lime.

[1] The EPHC was formed following changes to natural resource and environment related ministerial councils agreed by the Council of Australian Governments in June 2001. The NEPC, which is a statutory body, continues to exist under the umbrella of the EPHC.

Lead

Health effects

Lead is poisonous in all forms. The poison is cumulative and the toxic effects are many and severe. Lead is especially dangerous for unborn and young children. It inhibits intellectual development and behaviour, and has been linked with low birth weights (O'Dwyer 2001).

The Air NEPM aims to keep the ambient concentration of lead in the air to less than 0.5 µg/m^3 averaged over one year. Because leaded petrol is no longer used this goal will be easily met in areas where the main source was from motor vehicles.

Sources

Lead in the atmosphere is mostly in the form of very small particles. Up to 97% of the lead in Adelaide's atmosphere used to originate from the exhaust of motor vehicles that used leaded petrol (Ciuk 2002). Lead also enters the atmosphere from lead smelters, mining operations, waste incinerators, battery recycling and the production of lead sinkers for fishing. It has also been used in lead solder found in plumbing and electrical joints. Many older houses were painted with lead-based paint and unsafe house renovations can release high levels of lead indoors.

Because lead is dense, approximately 80% of it does not stay in the atmosphere for very long, so most lead is found close to where it is produced—near roads and other major sources. The phasing out of leaded petrol nationally was completed on 1 January 2002.

Nitrogen dioxide

Health effects

NO_2 exposure has been linked to an increased risk of respiratory symptoms, especially in asthmatic children (Ciuk et al. 2001; Gehring et al. 2002), to lung function changes and to symptoms of bronchitis (University of Western Cape 2001).

The Air NEPM short-term air quality criterion is 0.12 ppm, measured as an hourly average. There is also a longer-term NEPM criterion of 0.03 ppm averaged over one year.

Sources

All combustion processes in air produce oxides of nitrogen (NO_X), including NO_2 and nitric oxide (NO). It is NO_2 that is associated with adverse effects upon human health. Motor vehicles account for about 68% of total Adelaide emissions of NO_X (Ciuk 2002). Other sources include electricity generation, foundries and domestic wood burning. NO_X is also a precursor in the production of ozone and photochemical smog.

Ozone

Health effects

Exposure to elevated concentrations of ozone may cause slight irritation to the eyes and nose (University of Western Cape 2001; New York State Department of Health 2001). Ozone may also increase reactions to allergens in people with known allergies (Brunekreef and Holgate 2002; US Environment Protection Agency 2004). Very high levels of exposure (0.5–1 ppm) over several hours may damage the airway lining, and inflammatory reactions may follow. Respiratory function (Woodward et al. 1995) may be impaired at lower concentrations, down to about 0.08 ppm.

The NEPM criterion for ozone is 0.1 ppm as a one-hour mean. A four-hour criterion at 0.08 ppm has also been set—a level at which effects on healthy individuals have been demonstrated (National Environment Protection Council 1998). A review of this criterion has begun.

Sources

Ozone at ground level is formed by a complicated series of chemical reactions, initiated by sunlight. NO_X and volatile organic compounds (VOCs) derived from man-made sources, and biogenics[2], react to form ozone. Combustion, industrial processes, activities such as solvent use, and petrol distribution and handling, produce these substances. NO_X and VOCs are the most important precursors for generating ozone. Emissions from motor vehicles account for 40% of Adelaide's VOCs (Ciuk 2002). CO, methane or other VOCs that arise from plants, trees and other natural sources can also promote ozone production.

These chemical reactions do not take place instantaneously but over several hours or even days depending on the VOCs and meteorological conditions. Once ozone has been produced, it may persist for several days. Ozone measured at a particular location may therefore have arisen from VOC and NO_X emissions many kilometres away. Maximum concentrations of ozone generally occur downwind of the source areas of the precursor pollutant emissions and in the warmer months.

Particulate matter and total suspended particles

Health effects

PM_{10} refers to particulate matter of less than 10 µm aerodynamic diameter, $PM_{2.5}$ to particulate matter of less than 2.5 µm aerodynamic diameter and TSP to particles with a diameter of less than about 50 µm. Particulate air pollution is associated with a range of effects on human health including respiratory and cardiovascular difficulties, asthma and mortality (Gehring et al. 2002; Brunekreef and Holgate 2002; Woodruff et al. 1997).

The most applicable evidence relates daily average concentrations of particles to effects on health, thus PM_{10} and $PM_{2.5}$ are measured over 24 hours. The NEPM criterion for PM_{10} is 50 µg/m^3 as a 24-hour average. An advisory NEPM criterion has $PM_{2.5}$ of 25 µg/m^3 for one day and 8 µg/m^3 as an annual average (National Environment Protection Council 2003). The WHO guideline for TSP of 120 µg/m^3 as a 24-hour average, is used as the criterion in this report.

Sources

Unlike individual gaseous pollutants that are single and well-defined substances, PM_{10} particles in the atmosphere comprise a wide range of materials from a variety of sources:

- coarse particles such as suspended soils and dusts, sea-salt
- biological particles
- particles from construction work
- smaller particles arising from combustion sources, mainly motor vehicles (in Adelaide motor vehicles contribute approximately 11% of PM_{10} (Ciuk 2002))
- particles, mainly sulfate and nitrate, formed by chemical reactions in the atmosphere.

The relative contribution of each source type varies from day to day, depending on meteorological conditions and quantities of emissions from mobile and static sources. The first two particle types listed (coarse and biological) constitute about 64% of particulate matter (Ciuk 2002).

Sulfur dioxide

Health effects

SO_2 causes constriction of the airways by stimulating nerves in the lining of the nose, throat and airways of the lung; the constriction is particularly likely in those suffering from asthma or other

[2] Biogenics—natural source emissions can make a significant contribution to total VOC.

chronic lung disease (Devalia et al. 1996). High concentrations can also aggravate existing cardiovascular disease (American Lung Association 2000).

The NEPM criterion is 0.20 ppm measured over a one-hour averaging period. This standard is intended to reduce the exposure of the population, including individuals who may be particularly sensitive to SO_2, to a level at which adverse health effects are unlikely to occur. A review of the practicability of a 10-minute standard for sulfur dioxide has begun. An issues paper released for public comment aimed to encourage discussion on the issues and give stakeholders a voice in the review.

Sources

Motor vehicles contributed about 41% of the SO_2 in Adelaide in 2001 (Ciuk 2002) and about 53% came from industrial sources. A major source of SO_2 in Adelaide was removed with the decommissioning of the refinery at Port Stanvac. Other major sources include: fossil fuel combustion, particularly coal-burning power plants; and industrial processes such as wood pulping, paper manufacture, metal refining and metal smelting, particularly from ores containing sulfide. Many of these activities do not occur in the Adelaide airshed.

Other sources of SO_2 may include the manufacture of fumigants, use of food preservatives, bleaches and wine making. Residual amounts can be ingested by eating preserved foods.

METHODS

Up to mid-2002, ambient air quality was monitored mostly in the Adelaide region, the South East region at Mount Gambier, and the Spencer region at Whyalla, Port Pirie and Port Augusta. Figure 1 shows the locations of monitoring sites in Adelaide and Table 2 describes the air quality parameters measured at each Adelaide site.

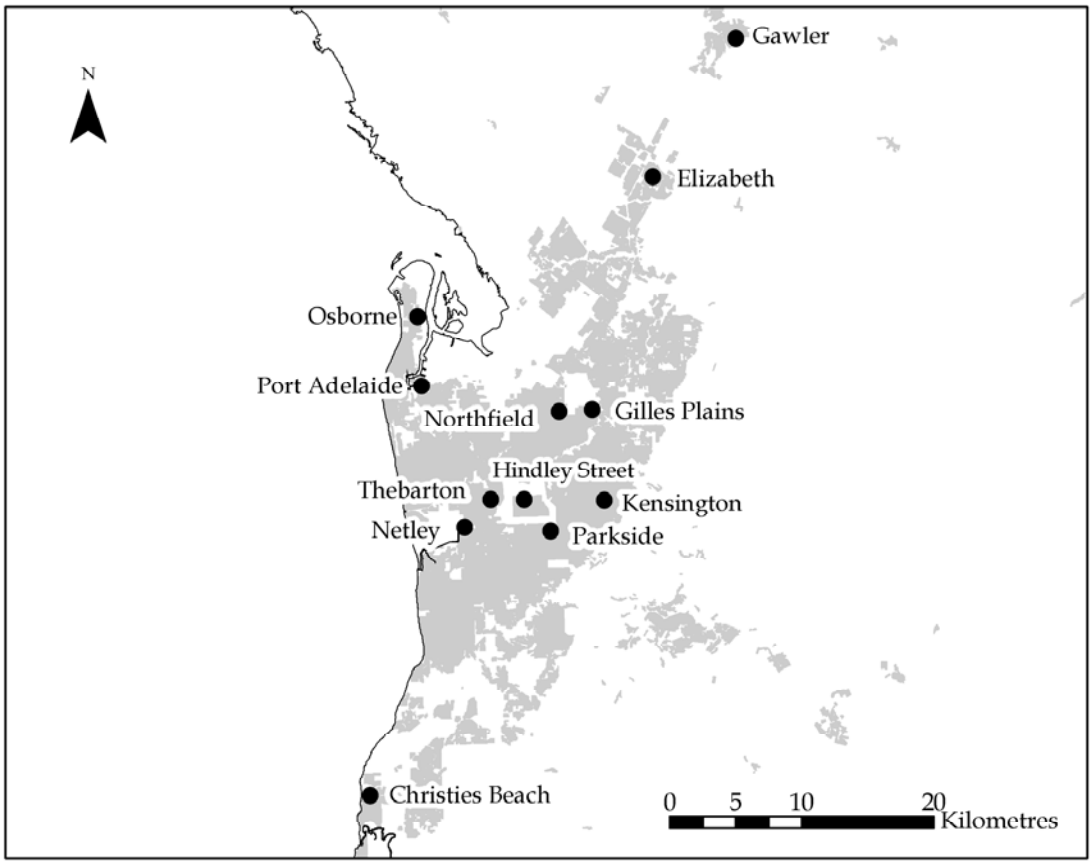

Figure 1 Ambient air quality sites in the Adelaide airshed

Air monitoring regions

Air pollutants measured at the Mount Gambier site (Figure 2) included NO_2, O_3, SO_2 and PM_{10}. Lead is monitored at all Port Pirie sites (Figure 3), with PM_{10} particulates, NO_2, and SO_2 monitored at the Oliver Street site.

PM_{10} is measured at the Whyalla (Figure 4) and Port Augusta (Figure 5) sites, and TSP at Whyalla.

Table 2 Pollutants measured in the Adelaide airshed, showing site classifications*

Monitoring site	CO	SO_2	NO_2	O_3	Pb	PM_{10}
Christies Beach		Trend				
Elizabeth	Trend	Campaign	PMS	PMS		
Gawler			Campaign	Campaign		Campaign
Gilles Plains					PMS	Discontinued
Hindley Street**	Trend					
Kensington		Campaign	Trend	Trend	Trend	Trend
Netley			Trend	Trend		Trend
Northfield		Campaign	Trend	Trend	Trend	
Osborne						Industrial
Parkside					Trend	
Port Adelaide					Discontinued	
Thebarton					Discontinued	Discontinued

* Sites are classified according to NEPM recommendations: a performance monitoring station (PMS) measures performance against national standards and is intended to remain in place over at least five years; a trend station aims to reveal trends over a set period, usually at least 10 years (thus also a PMS site); a campaign monitor is temporary (usually 12 months) to determine if ongoing monitoring is necessary for that site; an industrial monitor is requested by the industry or required by legislation These sites are all NEPM sites except for Osborne and Port Adelaide, which are industry monitoring sites, and Thebarton.

** The 'peak' site at Hindley Street in the city is also a PMS site. It has been placed to measure the peak exposure of CBD workers, visitors and residents (elevated levels of CO are generally found in areas of high traffic) and to measure the trend of that exposure over a long period of time. This can be compared with community levels at Elizabeth.

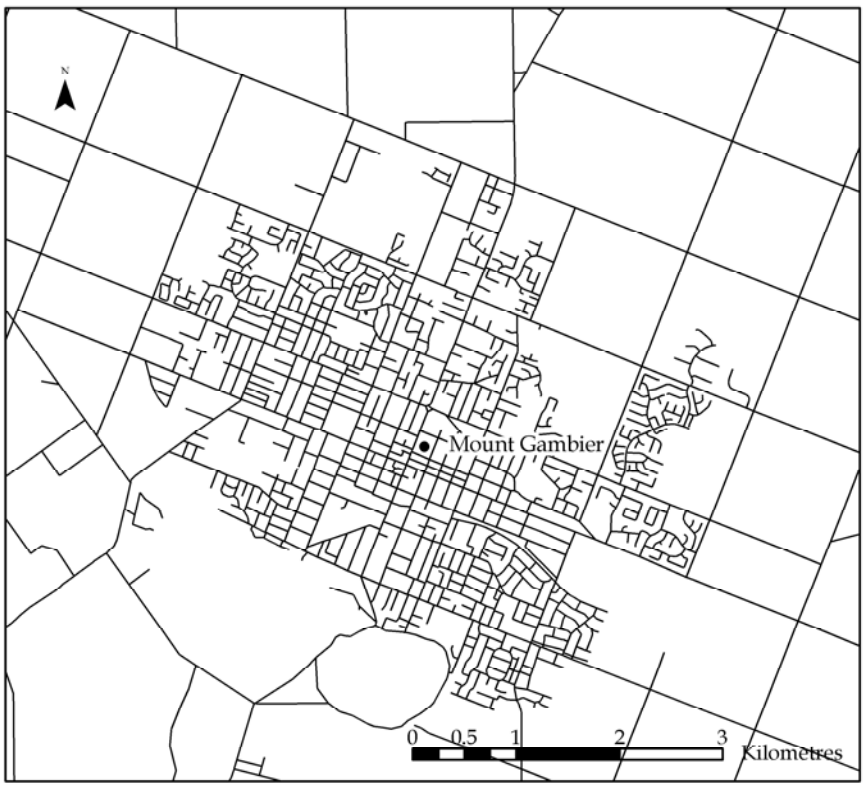

Figure 2 Ambient air quality (NEPM) site in Mount Gambier

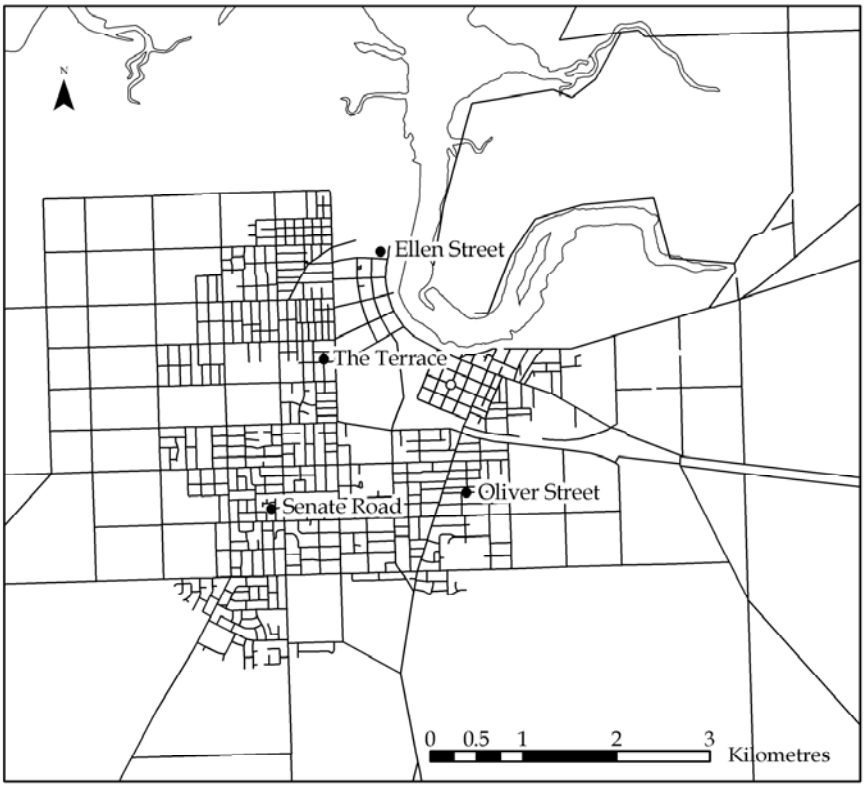

Figure 3 Ambient air quality sites in Port Pirie; Oliver Street, Senate Rd and The Terrace are NEPM sites

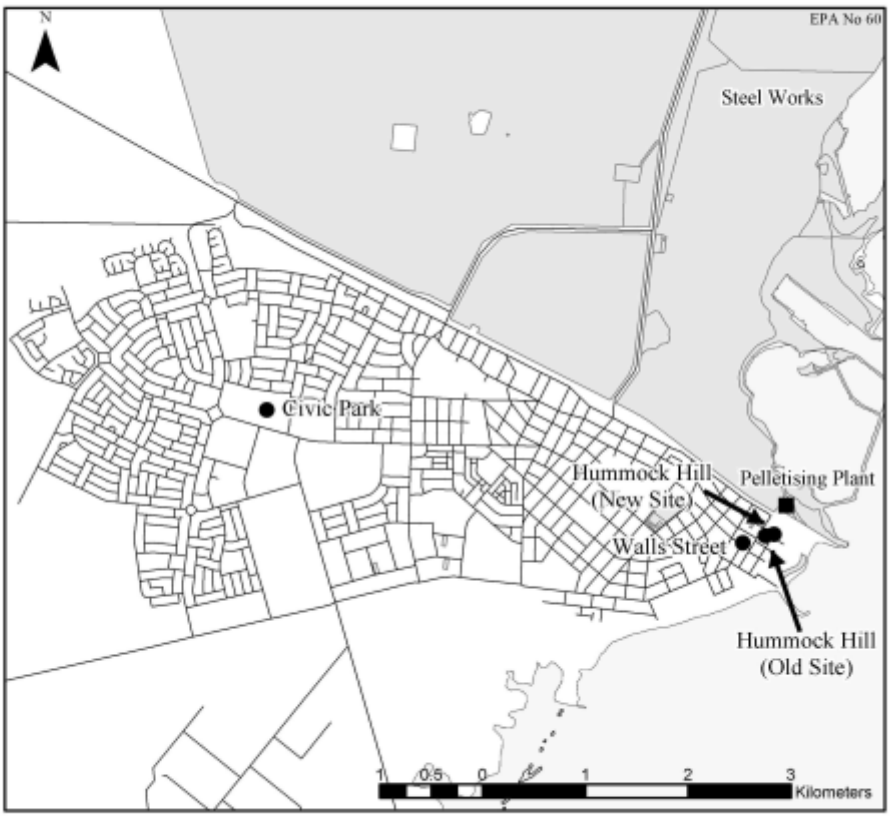

Figure 4 Ambient air quality sites in Whyalla; Civic Park is a NEPM site

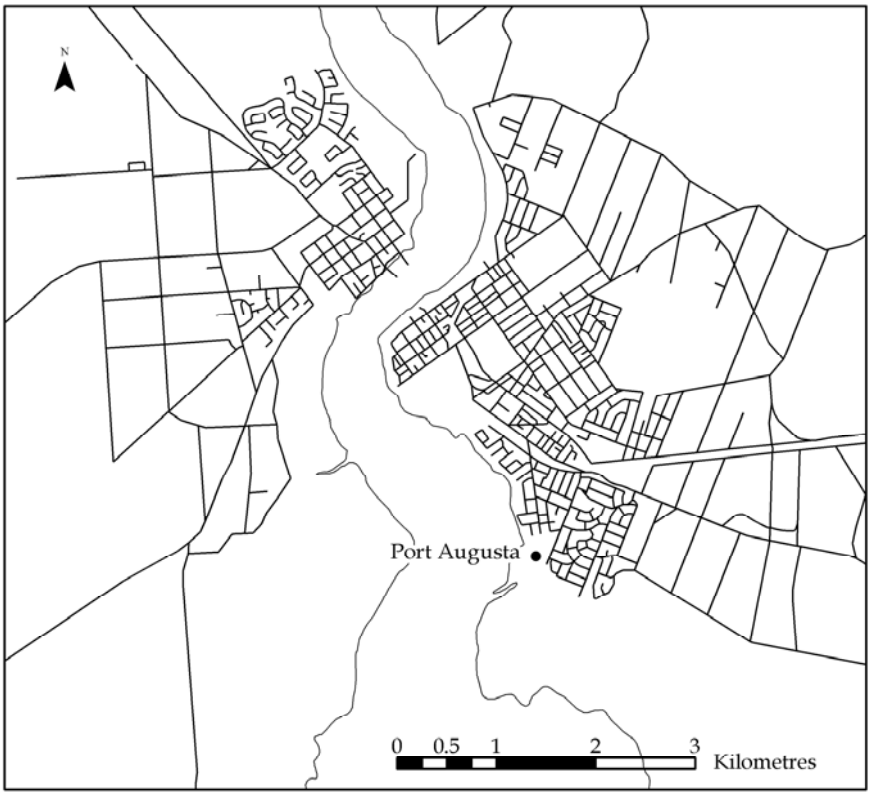

Figure 5 Ambient air quality (NEPM) site in Port Augusta

The use of descriptive statistics

A number of summary statistics are commonly used to describe ambient air quality. For all pollutants, data were averaged so that direct comparisons could be made to the NEPM Standards and other air quality guidelines. Data assessment is mainly driven by a focus on the occurrence, or otherwise, of exceedences of thresholds (i.e. standards) set by legislation.

Summary statistics for gaseous pollutants include the number of annual exceedences of the NEPM criteria, annual maximum, the 90th and 99th percentiles of each data set, and the percentage of data availability (some data were removed through the validation process or lost because of instrument failure and maintenance).

The 90th and 99th percentiles are used to determine the distribution of the data over the year in relation to the NEPM criteria. For example, in 2003, the 90th percentile for CO in Hindley Street was 3.6 ppm. This means that 90% of all measurements of CO taken through the year were lower than or equal to 3.6 ppm and 10% of measurements were higher. The NEPM criterion for CO is 9.0 ppm. As the 99th percentile (5.1 ppm) is also well below this level, we conclude that the NEPM criterion is only going to be exceeded very rarely (in substantially less than 1% of measurements) or not at all at this site.

In this report, the percentage data recovery describes the number of samples taken in relation to the potential number that could be taken over that year. This is generally calculated by counting the number of useable (valid) one-hour averages (for gaseous pollutants). Reporting to NEPC under the NEPM Standards requires stricter collection criteria (Environment Protection Agency 2001). Many sites described in this report began monitoring in September and October 2001, so the number of results (data availability) are low for 2001.

For PM_{10} particles, averaged over 24 hours, the second and sixth highest measurements taken throughout the year are also given. This statistic relates to the NEPM Goal, where in one year up to five days may exceed the NEPM criterion of 50 µg/m^3. Therefore, if the sixth highest concentration is higher than 50 µg/m^3, then that site exceeds the NEPM Goal.

Many pollutants are averaged over either one hour or one day. Depending on standards and guidelines, data may also be averaged for four hours, eight hours or over one year (see Table 1). For particles, the median (or middle value) is also given to determine whether the data are skewed (skewness is determined by the magnitude of the difference between the mean and the median values). The maximum is defined in this report as the highest value recorded in a year and is calculated from the averaged values (e.g. one-hour concentrations for SO_2).

Air quality monitoring methods

The methods used to measure air quality parameters are summarised below. Different methods are often used at different sites but their results are comparable.

Tapered element oscillating microbalance

The tapered element oscillating microbalance (TEOM) mass measurement system measures continuous PM_{10} concentrations. It relies on an instrument that draws air through a filter at a constant flow rate and constant temperature, continuously weighing the filter and continuously calculating the mass concentration. Mass is determined from the measured change in frequency at which the element attached to the filter is oscillating. The TEOM instrument uses an impacting mechanism to separate particles and measures PM_{10} as an equivalent aerodynamic diameter**.**

Non-dispersive infrared

CO is measured using a non-dispersive infrared analyser, of the gas filter correlation type. A pre-filtered air sample is drawn through a sample cell. Infrared radiation is passed through the sample cell and a CO free reference cell. The detector measures the infrared light absorbed by CO in the sample. By comparing the light intensity received by the detector through this cell with the cell containing reference gas, the concentration of CO is determined.

High-volume particulate sampling

One-day averages of particulate matter as PM_{10} and TSP are measured using high volume samplers (HVSs). The sampler draws air through a filter paper in an evenly distributed pattern at a known constant flow rate for 24 hours. The resulting increase in the weight of the filter paper is the total airborne particulates in the air volume (flow rate x time). The flow rate is automatically controlled to within ±1 standard m^3/hour. Collected particles on the filter are analysed for lead (Australian Standard AS 2800) using a nitric acid extraction method. The HVS conforms to Australian Standard AS 2724.3 and siting requirements AS 2922.

Chemiluminescence

At some sites NO, NO_2 and total NO_X are measured using gas-phase chemiluminescence.

A sample of air is divided into two parts: Sample A and Sample B.

Sample A is passed over a heated catalyst to convert all the NO_2 it contains into NO. Then it is sent to a reaction chamber where it is mixed with ozone. The ozone reacts with all the NO to produce NO_2 and light. The light is detected with a photomultiplier and represents all the NOx (i.e. NO + NO_2) that was in Sample A.

Sample B is sent directly to the reaction chamber and the light it emits represents only the NO in that sample.

If the light energy detected from Sample B is taken away from that of Sample A, the remaining energy represents the amount of NO_2 in the original sample of air: NOx – NO = NO_2.

Fluorescence

SO_2 measurements rely on the excitation of the SO_2 molecule in the presence of ultraviolet light. The SO_2 then emits photons of light as the molecule returns to its ground state (its lowest energy state), which are measured in a photomultiplier. A hydrocarbon scrubbing system removes interfering hydrocarbons before the ambient sample is measured.

Ultraviolet photometer

Ozone is measured by an ultraviolet photometric analyser. A filtered sample is drawn in through the instrument. Ozone concentration is determined by measuring the reduction of the intensity of ultraviolet light due to ozone in the air sample.

Air quality index

In addition to comparing pollutant concentrations with health criteria, an air quality index (AQI) describes Adelaide's air quality at each site that monitors pollutants continuously. In 2003 these sites were Netley, Elizabeth and Kensington. A fourth site is being constructed at Port Noarlunga (due to be operating in 2004). A site has recently been constructed at Port Pirie (Oliver Street) and another is planned for Whyalla off Nicholson Avenue.

The index is a simple transformation of air pollutant monitoring data into a scale of five air quality classifications (from very good to very poor). The index is calculated for any given pollutant as its concentration expressed as a percentage of the relevant criterion.

$$\text{Air quality index} = \frac{\text{Pollutant concentration}}{\text{NEPM criterion}} \times 100$$

An index value of greater than 100 means the pollutant has exceeded the relevant air quality criterion and is classified as poor.

To assess overall air quality at a particular monitoring station, the highest calculated index is taken to be the AQI for that monitoring station as it represents the worst (or highest concentration) of the pollutants measured. The site with the highest index is then used to summarise Adelaide's air quality.

The AQI is updated twice daily on the EPA's web site (see *www.epa.sa.gov.au/airindex*) at 9.45 a.m. and 5.45 p.m. Unlike the validated data in this report, which are used to analyse trends, the data used to compile the daily AQI come directly from EPA air monitoring stations and are unchecked.

Table 3 describes each classification and the associated index ranges used in the assessment.

Table 3 Air quality index ranges

Category	Index range and colour
Very poor air quality	150 or greater (black)
Poor air quality	100–149 (red)
Fair air quality	67–99 (yellow)
Good air quality	34–66 (green)
Very good air quality	0–33 (blue)

Figure 6 is a map of Adelaide showing the air quality sites and the regions each site 'represents'. An assessment of Adelaide's daily air quality in 2002, expressed in terms of the index, is described at the end of the results section.

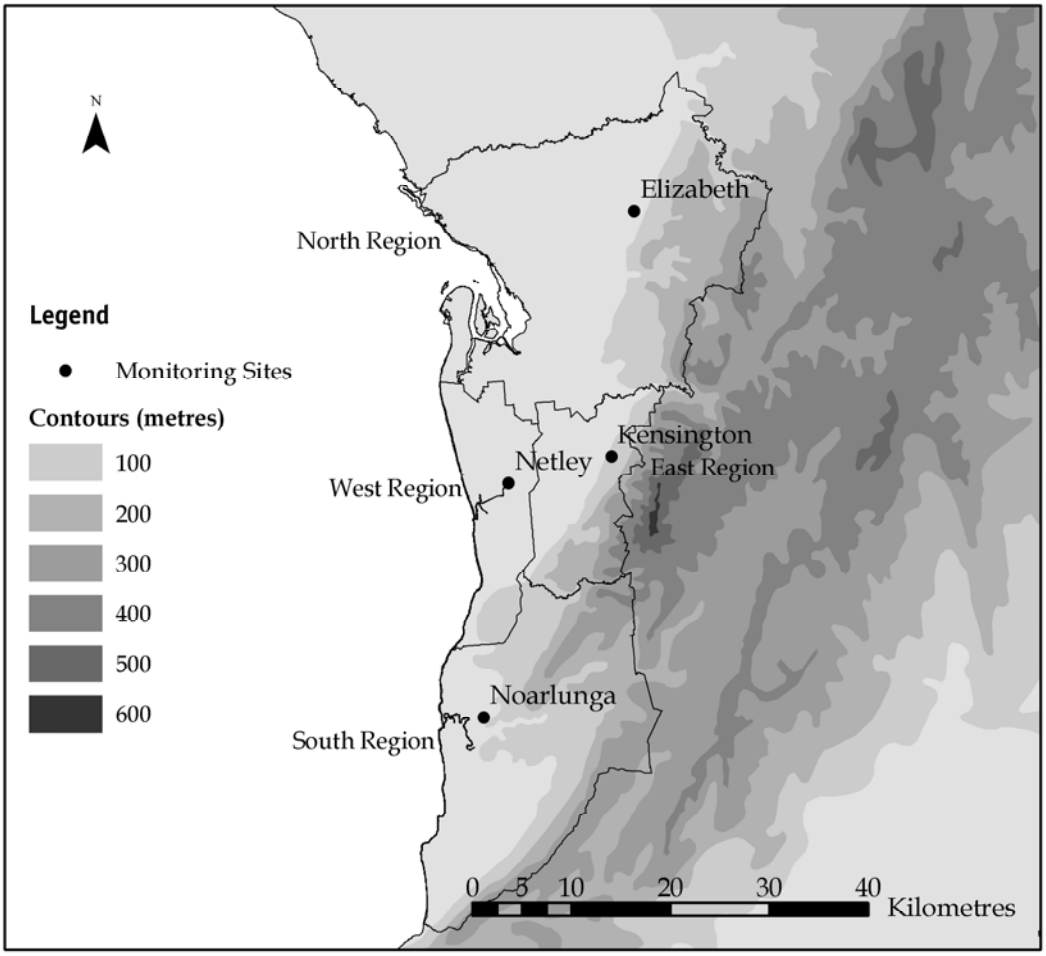

Figure 6 Air quality index sites in the Adelaide metropolitan area

Note: The site at Noarlunga will be operational in 2004; boundaries based on local council areas

RESULTS

Ambient air quality in Adelaide

Carbon monoxide

CO is measured at the NEPM site in Hindley Street in the Adelaide central business district (Table 4), where monitoring began in 1988.

At Hindley Street in 2002, eight-hour averages of CO were within the range 0–7.2 ppm, below the NEPM criterion of 9.0 ppm (eight-hour average). Since 1996, concentrations of CO have been generally low; the last exceedences of the NEPM were in 1997 (Figure 8). The dramatic reduction in the number of exceedences of the NEPM is attributed to improved traffic flow, and vehicle and fuel standards. There were, again, no exceedences in 2003 (Figure 7), and a reduced range in the eight-hour average to 0–6.0 ppm. The annual average in 2002 was 1.8 ppm. The mean eight-hour average for 2003 was 1.2 ppm, well below the NEPM criterion.

In 2002 monitoring for CO began at Elizabeth (Table 5, Figure 9).

Table 4 Carbon monoxide statistics at Hindley Street Adelaide, 1988–2003

Year	Number of exceedences of 8-hour NEPM criterion for CO (9.0 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1988	71	14.6	5.6	9.3	72
1989	100	12.7	5.4	9.2	100
1990	140	37.5	5.5	9.8	100
1991	74	14.4	4.9	8.8	97
1992	44	12.7	4.3	8.2	96
1993	39	12.6	4.5	8.0	100
1994	109	16.2	5.0	9.4	93
1995	41	12.2	3.9	7.6	86
1996	0	8.4	4.0	7.0	95
1997	2	9.3	3.4	6.1	49
1998	0	8.3	2.7	5.7	57
1999	0	7.1	2.4	4.7	51
2000	0	7.0	3.1	5.1	100
2001	0	7.1	2.9	4.8	80
2002	0	7.2	3.0	4.7	95
2003	0	6.0	2.4	4.0	85

Table 5 Carbon monoxide statistics at Elizabeth, 2002–July 2003

Year	Number of exceedences of 8-hour NEPM criterion for CO (9.0 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.9	0.1	0.4	84
2003	0	1.4	0.1	0.5	92

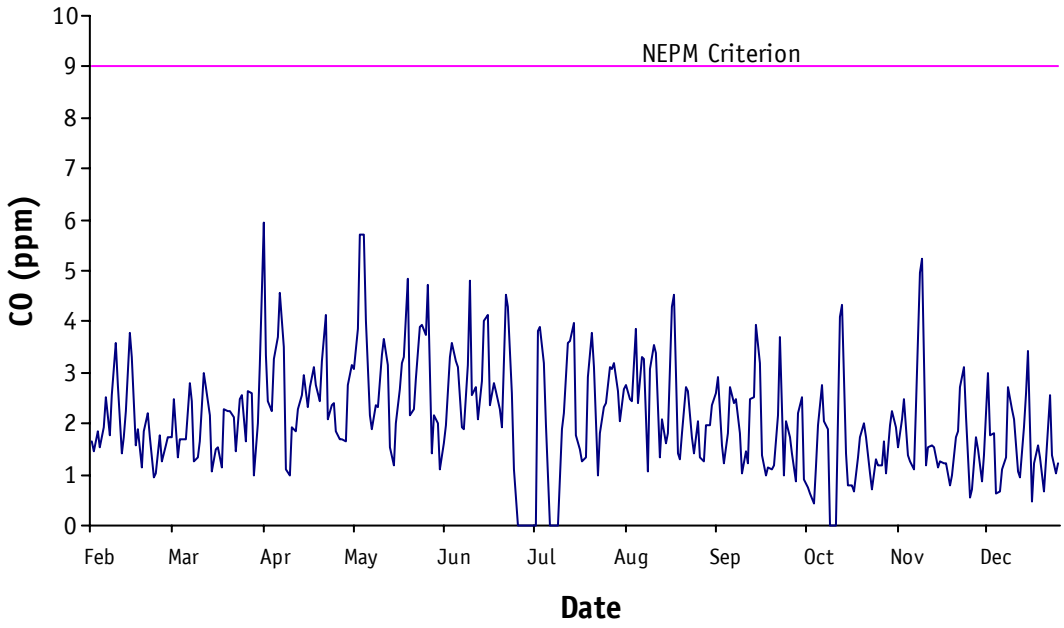

Figure 7 Maximum daily eight-hour averaged data for CO at Hindley Street, 2003

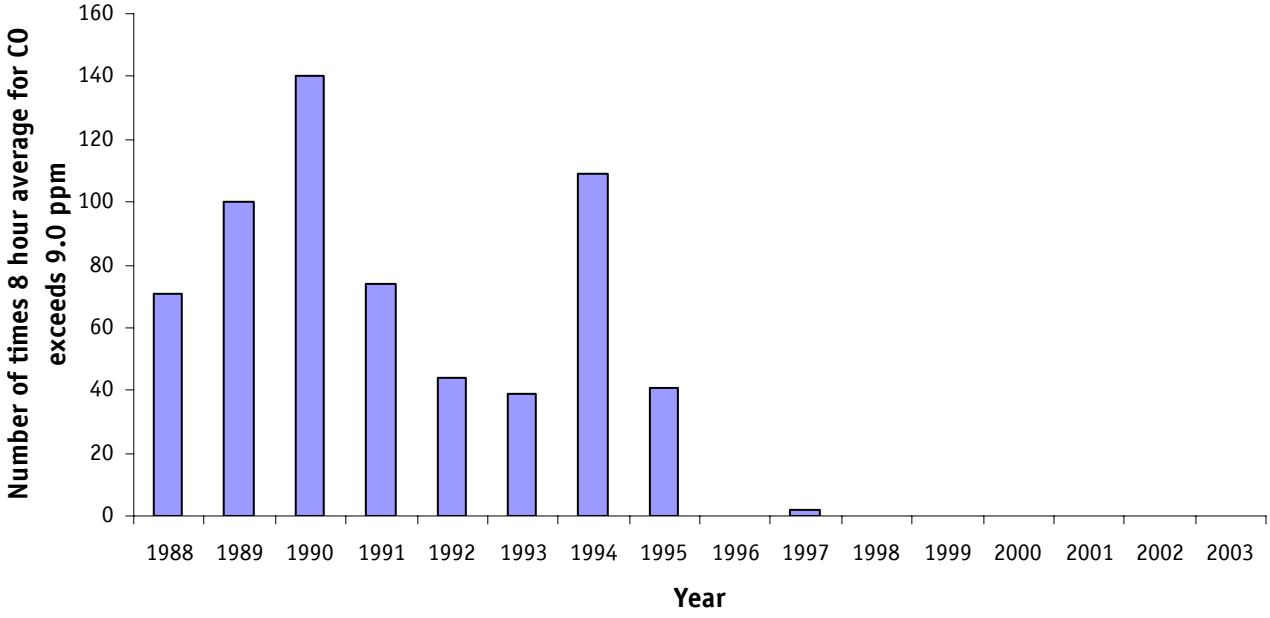

Figure 8 Number of exceedences of eight-hour NEPM criterion for CO at Hindley Street

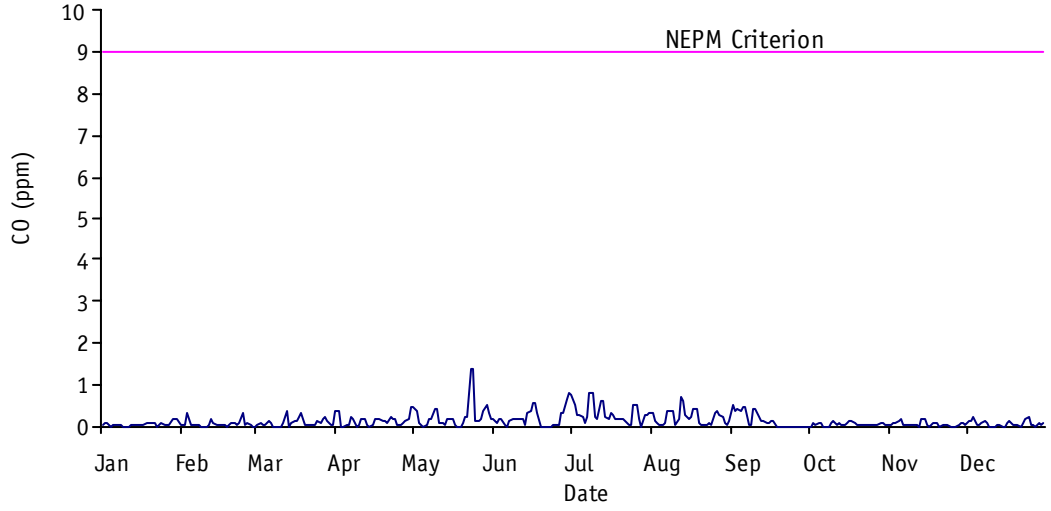

Figure 9 Maximum daily eight-hour averaged data for CO at Elizabeth, 2003

Sulfur dioxide

SO_2 has been measured at Christies Beach since 1992, in order to monitor air quality near the oil refinery (decommissioned in July 2003). In 2002 monitoring for SO_2 started at Elizabeth (May), Kensington (August) and Northfield (October). In 2004 monitoring will begin at Port Noarlunga and Hope Valley.

At Christies Beach in 2003, one-hour averages of SO_2 were within the range 0–0.0.059 ppm (Table 6), with an average for the year of 0.0001 ppm. As shown in Figure 10, there were no exceedences of the NEPM criterion (0.20 ppm as a one-hour average) recorded in 2003. Similarly, no exceedences have been measured for either the one-day (0.08 ppm) or yearly (0.02 ppm) NEPM criteria. All exceedences are directly attributed to plant failure at the refinery and specifically to the sulfur recovery plant failure in 1996 (Figure 11). The maximum concentration recorded in 2003 (0.059 ppm, 74% lower than the previous year), could be attributed to the closure of the refinery in July.

Table 6 Sulfur dioxide statistics at Christies Beach, 1992–2003

Year	Number of exceedences of 1-hour NEPM criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1992	0	0.188	0.003	0.053	97
1993	7	0.319	0.002	0.038	96
1994	0	0.187	0.002	0.060	97
1995	8	0.349	0.002	0.065	98
1996	12	0.479	0.003	0.053	88
1997	0	0.134	0.002	0.033	75
1998	0	0.105	0.005	0.018	97
1999	0	0.076	0.003	0.024	86
2000	0	0.057	0.003	0.014	30
2001	0	0.098	0.000	0.014	51
2002	1	0.225	0.003	0.049	62
2003	0	0.059	0.001	0.006	84

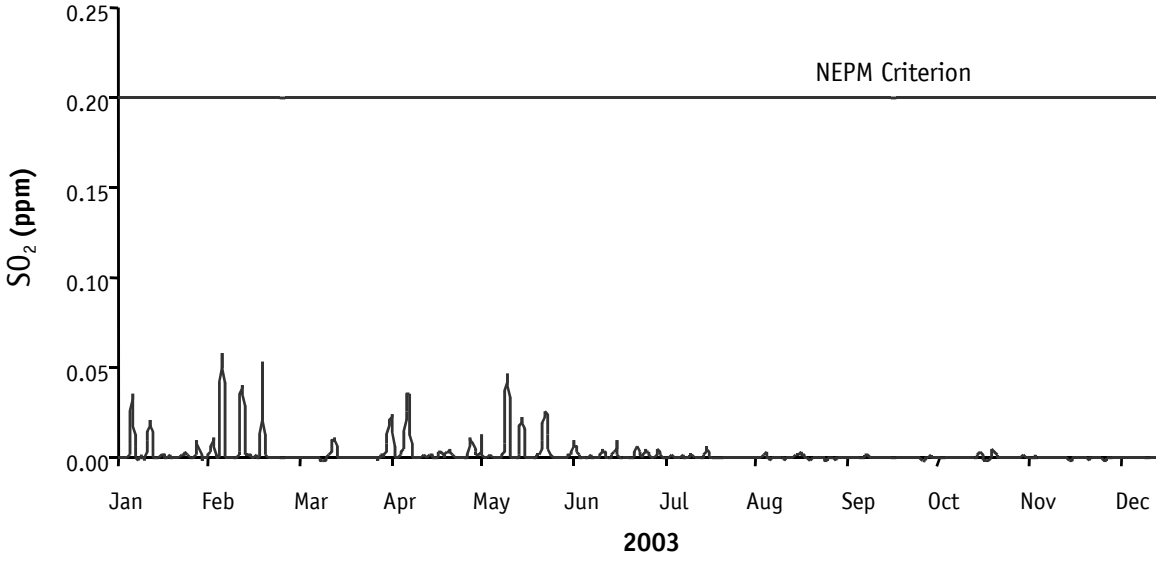

Figure 10 Maximum daily one-hour averaged SO_2 at Christies Beach, 2003

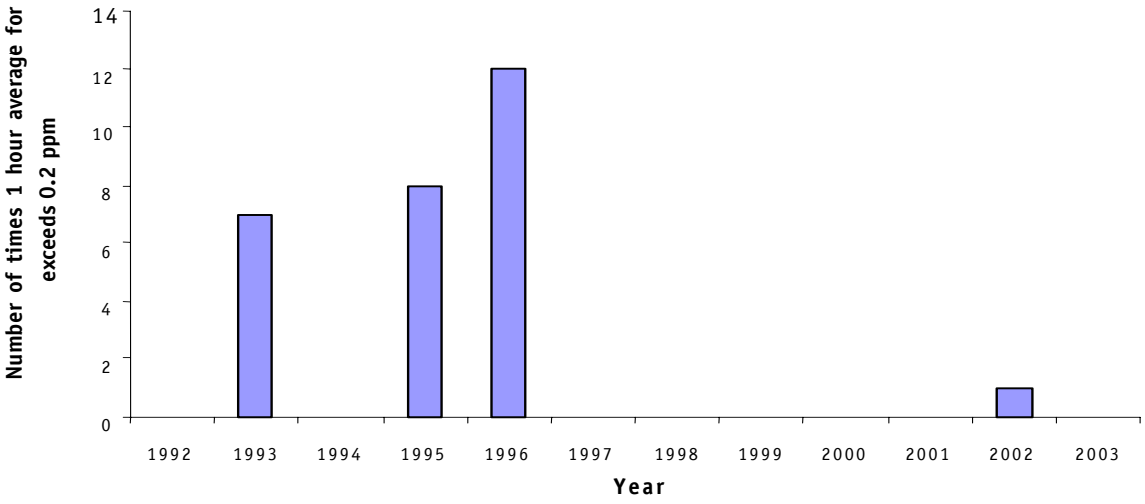

Figure 11 Number of exceedences of one-hour NEPM criterion for SO_2 at Christies Beach

At Elizabeth, in 2002, one-hour averages of SO_2 were within the range 0–0.013 ppm, with an average for the year (from May) of 0.002 ppm (Table 7). There were no exceedences of the NEPM criterion (0.20 ppm as a one-hour average) and thus no exceedences of either the one-day (0.08 ppm) or yearly (0.02 ppm) NEPM criterion for that period. There were also no exceedences in 2003 when the yearly average was 0.001 ppm.

Table 7 Sulfur dioxide statistics at Elizabeth, May 2002–December 2003

Year	Number of exceedences of 1-hour NEPM criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.013	0.004	0.006	48
2003	0	0.032	0.002	0.004	96

One-hour averages of SO_2 at Northfield from October to December 2002 were within the range 0-0.039 ppm (Table 8), with an average for the period of 0.002 ppm. There were no exceedences of the hourly NEPM criterion (0.20 ppm) and no exceedences of the daily NEPM criterion (0.08 ppm) for that period. There were also no exceedences in 2003 when the annual average was 0.001 ppm.

Table 8 Sulfur dioxide statistics at Northfield, October 2002–December 2003

Year	Number of exceedences of 1-hour NEPM criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.039	0.005	0.024	16
2003	0	0.009	0.002	0.004	95

One-hour averages of SO_2 at Kensington from August 2002 were within the range 0–0.019 ppm (Table 9), with an average for the period of 0.003 ppm. There were no exceedences of the NEPM criterion (0.20 ppm as a one-hour average) and no exceedences of the daily NEPM criterion (0.08 ppm) for that period. The one-hour average for 2003 was 0.002 ppm.

Table 9 Sulfur dioxide statistics at Kensington, August 2002–December 2003

Year	Number of exceedences of 1-hour NEPM criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.019	0.005	0.007	37
2003	0	0.045	0.005	0.014	87

Nitrogen dioxide

NO_2 monitoring began in 1979 at Northfield, in 1988 at Netley and in October 2001 at Kensington. Data from 1997 to 2000 have been deemed unreliable and were not considered in this analysis. Monitoring resumed in 2001 in September and October, hence the low data recovery for that year.

In 2002 monitoring for NO_2 began at Elizabeth and Gawler. Monitoring will also begin in 2004 at Port Noarlunga.

In 2003, averages for the year were 0.007 ppm for Northfield, 0.008 ppm for Netley and 0.005 ppm at Kensington, all below the NEPM criterion of 0.03 ppm for a one-year average (Tables 10–12). All concentrations are well below the NEPM criterion of 0.12 ppm as a one-hour average (Figures 12 and 13). Exceedences of NO_2 at Netley in 1988, 1989 and 1990 were mostly attributed to the power station at Dry Creek with wind transporting the NO_2 to Netley.

Monitoring for NO_2 at Gawler and Elizabeth began in January 2002. The averages over that year—0.004 ppm (Gawler) and 0.005 ppm (Elizabeth)—did not exceed the one-year NEPM criterion (0.03 ppm). All concentrations were well below the NEPM criterion of 0.12 ppm as a one-hour average with ranges of 0–0.05 ppm (Tables 13 and 14). The one-hour average over the year 2003 was 0.003 ppm for Gawler and 0.004 ppm for Elizabeth, again well below the NEPM criterion.

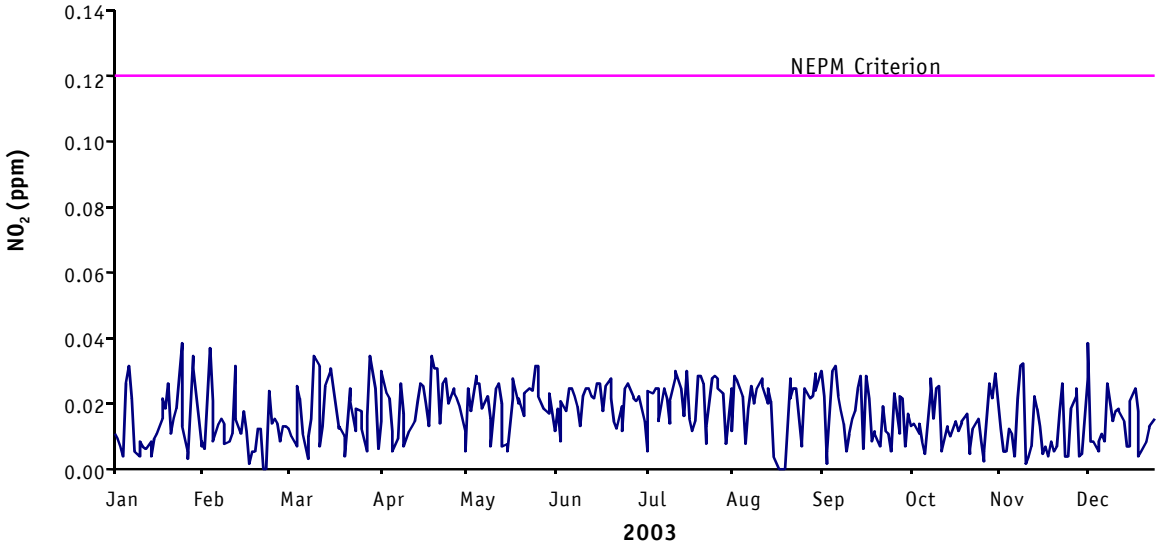

Figure 12 Maximum daily one-hour averaged data for NO_2 at Northfield, 2003

Table 10 Nitrogen dioxide statistics at Northfield, 1979–2003

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1979	0	0.086	0.016	0.034	40
1980	12	0.380	0.040	0.085	41
1981	0	0.080	0.015	0.030	37
1982	0	0.100	0.020	0.051	86
1983	0	0.068	0.020	0.036	93
1984	52	0.276	0.022	0.094	92
1985	0	0.086	0.022	0.035	88
1986	0	0.085	0.018	0.032	77
1987	0	0.063	0.022	0.039	91
1988	0	0.110	0.021	0.048	90
1989	0	0.046	0.014	0.028	94
1990	5	0.198	0.012	0.028	90
1991	0	0.080	0.006	0.010	92
1992	0	0.056	0.010	0.024	95
1993	0	0.076	0.022	0.038	95
1994	0	0.061	0.023	0.033	69
1995	0	0.024	0.006	0.013	96
1996	0	0.060	0.019	0.029	82
1997		*No data available*			
1998		*No data available*			
1999		*No data available*			
2000		*No data available*			
2001	0	0.027	0.008	0.016	17
2002	0	0.047	0.017	0.027	94
2003	0	0.039	0.017	0.027	95

Table 11 Nitrogen dioxide statistics at Netley, 1988–2003

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1988	5	0.196	0.030	0.082	11
1989	35	0.220	0.040	0.072	96
1990	1	0.130	0.024	0.048	91
1991	0	0.080	0.024	0.036	97
1992	0	0.071	0.022	0.034	100
1993	0	0.063	0.022	0.035	93
1994	0	0.050	0.020	0.030	90
1995	0	0.087	0.019	0.035	98
1996	0	0.083	0.024	0.037	95
1997		*No data available*			
1998		*No data available*			
1999		*No data available*			
2000		*No data available*			
2001	0	0.052	0.017	0.029	12
2002	0	0.050	0.022	0.032	86
2003	0	0.039	0.021	0.029	97

Table 12 Nitrogen dioxide statistics at Kensington, 2001–2003

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2001	0	0.027	0.007	0.016	27
2002	0	0.041	0.013	0.024	94
2003	0	0.040	0.013	0.023	97

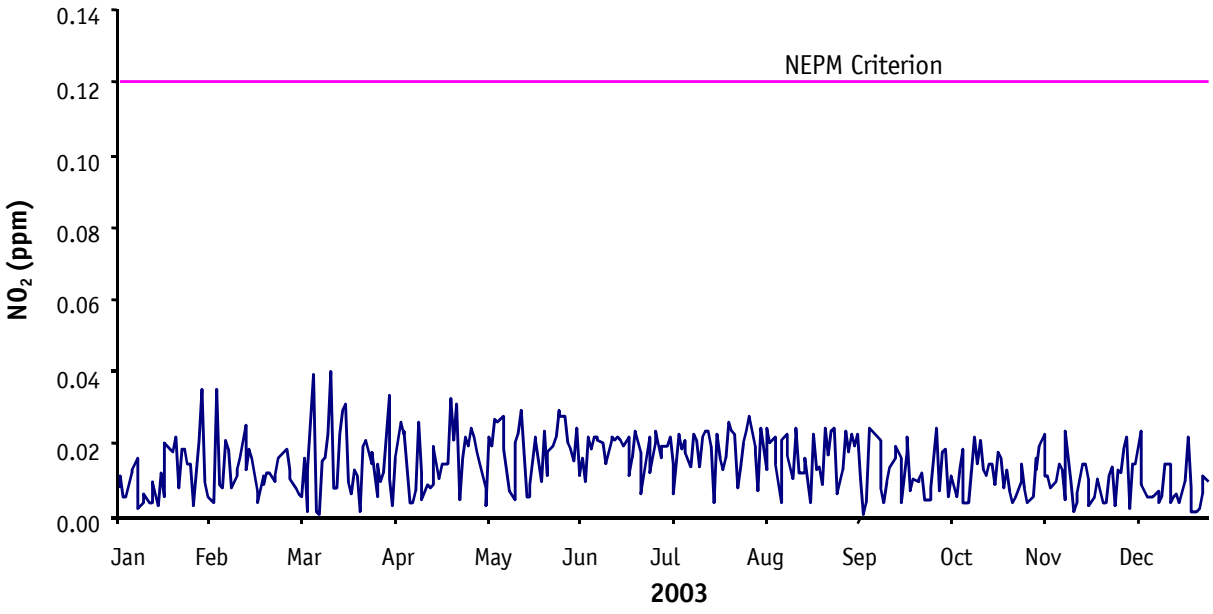

Figure 13 Maximum daily one-hour averaged data for NO_2 at Kensington, 2003

Monitoring for NO_2 at Gawler and Elizabeth began in January 2002. The average over that year—0.004 ppm (Gawler) and 0.005 ppm (Elizabeth)—did not exceed the one-year NEPM criterion (0.03 ppm). All concentrations were well below the NEPM criterion of 0.12 ppm as a one-hour average with ranges of 0–0.05 ppm (Tables 13 and 14). The one-hour average over the year 2003 was 0.003 ppm for Gawler and 0.004 ppm for Elizabeth, again well below the NEPM criterion.

Table 13 Nitrogen dioxide statistics at Gawler, 2002–2003

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.050	0.010	0.025	92
2003	0	0.036	0.007	0.018	97

Table 14 Nitrogen dioxide statistics at Elizabeth, 2002–2003

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.040	0.012	0.025	94
2003	0	0.043	0.010	0.021	97

Ozone

Ozone monitoring began at Northfield in 1979 (Table 15), Netley in 1988 (Table 16), Kensington during 2001 (Table 17), and Elizabeth and Gawler in 2002. In 2004 monitoring will also begin at Port Noarlunga. Northfield and Netley data from 1997 to 2000 have been deemed unreliable and were not considered in this analysis. Monitoring resumed in 2001 in September and October, hence the low data recovery for that year.

In 2002, one-hour averages of ozone at three sites were within the range 0–0.087 ppm, with an average for the year of 0.017 ppm at Netley, 0.002 ppm at Kensington and 0.019 ppm at Northfield, all well below the NEPM criterion of 0.10 ppm as a one-hour average. There were no exceedences of the four-hour (0.08 ppm) NEPM criterion.

In 2003, one-hour averages of ozone at three sites were within the range 0–0.074 ppm, with an average for the year of 0.017 ppm at Netley (Figure 14), 0.022 ppm at Kensington (Figure 15) and 0.020 ppm at Northfield. Ozone did not exceed the NEPM criterion at these sites.

Table 15 Ozone statistics at Northfield, 1979–2003

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1979	4	0.113	0.033	0.066	49
1980	2	0.108	0.035	0.050	68
1981	5	0.125	0.035	0.065	36
1982	1	0.102	0.029	0.059	83
1983	2	0.109	0.029	0.050	93
1984	0	0.082	0.028	0.041	92
1985	0	0.091	0.026	0.047	92
1986	1	0.117	0.026	0.043	91
1987	0	0.082	0.025	0.041	89
1988	0	0.097	0.027	0.042	83
1989	0	0.092	0.028	0.044	88
1990	0	0.076	0.025	0.040	89
1991	0	0.064	0.024	0.040	91
1992	0	0.068	0.024	0.036	94
1993	0	0.078	0.029	0.040	94
1994	0	0.068	0.025	0.042	69
1995	0	0.064	0.022	0.031	96
1996	0	0.080	0.032	0.039	85
1997		*No data available*			
1998		*No data available*			
1999		*No data available*			
2000		*No data available*			
2001	0	0.040	0.026	0.034	16
2002	0	0.080	0.030	0.042	98
2003	0	0.068	0.030	0.045	97
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2001	0	0.035	0.026	0.031	16
2002	0	0.064	0.029	0.040	99
2003	0	0.061	0.030	0.043	100

Table 16 Ozone statistics at Netley, 1988–2003

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
1988	0	0.056	0.028	0.044	9
1989	0	0.080	0.024	0.036	93
1990	0	0.072	0.024	0.040	98
1991	0	0.054	0.020	0.031	91
1992	0	0.056	0.025	0.037	95
1993	0	0.083	0.028	0.060	93
1994	0	0.060	0.020	0.036	79
1995	0	0.072	0.029	0.040	66
1996	0	0.080	0.020	0.039	65
1997		*No data available*			
1998		*No data available*			
1999		*No data available*			
2000		*No data available*			
2001	0	0.044	0.027	0.035	26
2002	0	0.087	0.029	0.039	98
2003	0	0.069	0.029	0.043	97
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2001	0	0.037	0.027	0.034	26
2002	0	0.071	0.028	0.037	98
2003	0	0.060	0.029	0.041	99

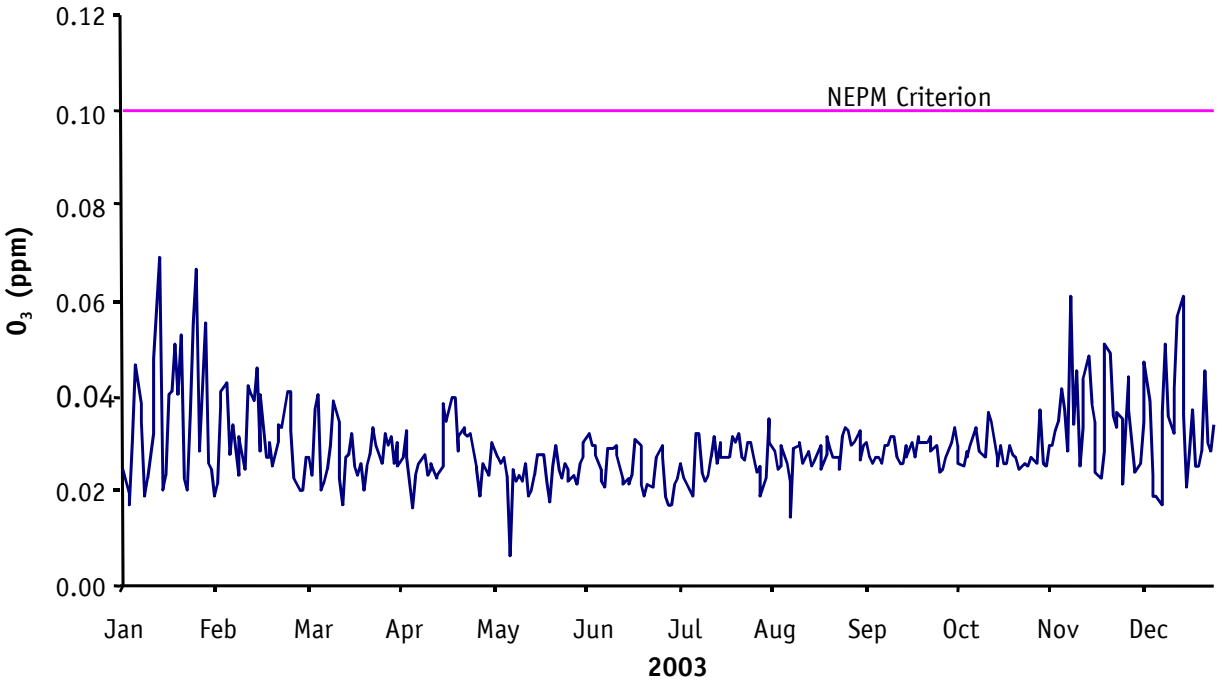

Figure 14 Maximum daily one-hour averaged data for ozone at Netley, 2003

Table 17 Ozone statistics at Kensington, 2001–2003

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2001	0	0.048	0.030	0.037	28
2002	0	0.086	0.031	0.043	96
2003	0	0.074	0.032	0.047	97
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2001	0	0.048	0.030	0.037	28
2002	0	0.073	0.031	0.041	96
2003	0	0.071	0.031	0.046	99

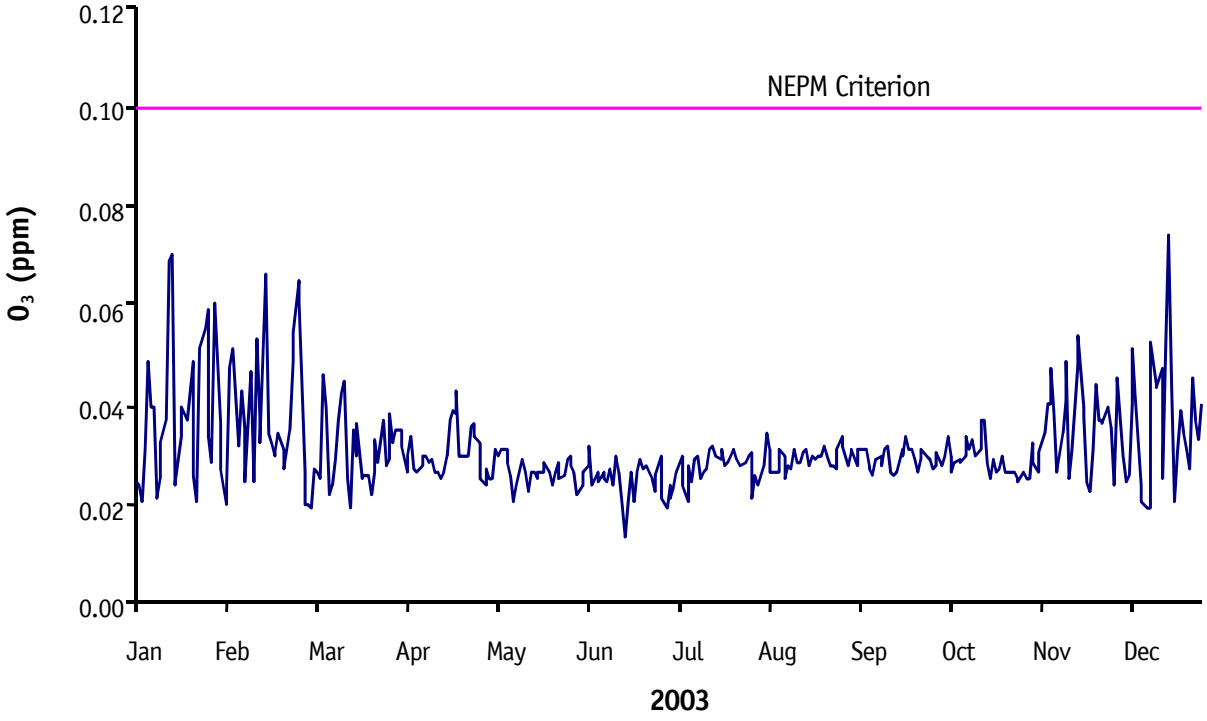

Figure 15 Maximum daily one-hour averaged data for ozone at Kensington, 2003

Daily maxima of one-hour averaged ozone concentrations measured at Kensington in 2003 (Figure 15) show how ozone concentrations varied throughout the year. The availability of ozone precursors and increased levels of sunlight mean that more ozone is produced in summer months.

Monitoring for ozone at Elizabeth and Gawler began in January 2002. One-hour averaged concentrations at Elizabeth did not exceed the NEPM criterion, with a range of 0–0.072 ppm (Table 18, Figure 16). There were no exceedences of the NEPM criterion at Gawler, the range being 0–0.056 ppm (Table 19). The average over the year was 0.014 ppm at Elizabeth and 0.021 ppm at Gawler; neither exceeded the one-year NEPM criterion (0.03 ppm). In 2003 the average was 0.022 ppm at Elizabeth and also 0.022 ppm at Gawler.

Table 18 Ozone statistics at Elizabeth, 2002–2003

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.072	0.031	0.042	95
2003	0	0.077	0.031	0.046	97
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2002	0	0.057	0.030	0.038	96
2003	0	0.063	0.031	0.046	99

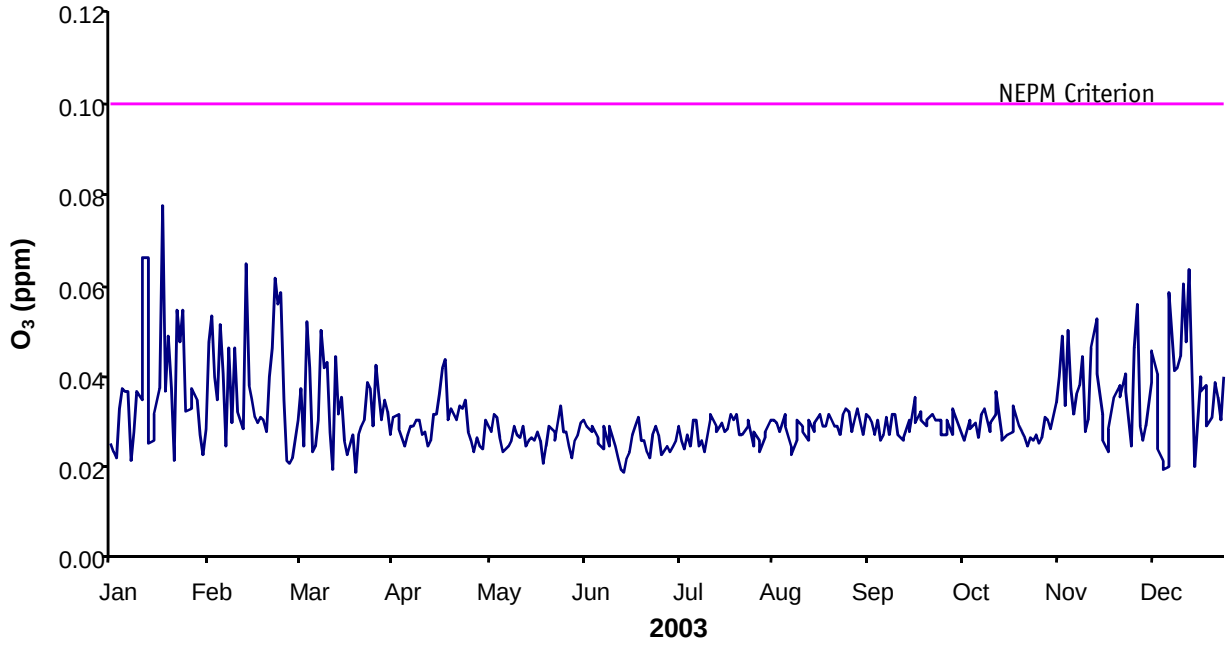

Figure 16 Maximum daily one-hour averaged data for ozone at Elizabeth, 2003

Table 19 Ozone statistics at Gawler, 2002–2003

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.056	0.030	0.040	96
2003	0	0.078	0.031	0.046	98
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2002	0	0.050	0.030	0.038	96
2003	0	0.069	0.030	0.045	100

Particulate matter (PM_{10})

PM_{10} monitoring began at Netley during 2001, using the TEOM method[3]. In 2002 monitoring for PM_{10} using TEOMs began at Kensington and Gawler. PM_{10} monitoring is also conducted using HVS at Osborne and, previously, at Thebarton and Gilles Plains.

One-day averaged concentrations of PM_{10} at Thebarton did not exceed the NEPM criterion of 50 µg/m^3 during 2002. At Gilles Plains there were two exceedences of the NEPM criterion and at Netley and Kensington one exceedence. All Adelaide exceedences of the NEPM criterion in 2002 occurred during the two days of dust storms, 8 and 11 July. During the worst, on 11 July, the daily average PM_{10} levels recorded at Kensington (104 µg/m^3) and Netley (79 µg/m^3) were well in excess of the NEPM criterion. The daily average PM_{10} level recorded at Gawler on the same day was 51 µg/m^3. The AQI on this day described air quality as very poor.

The PM_{10} monitoring site at Thebarton was constructed in 1993 to determine impacts of particles and lead next to a major roadway, and the source of particles measured here was mostly motor vehicles. No exceedences of the NEPM criterion were recorded after 1999 (Table 20) and the site was decommissioned in 2003.

Table 20 Particulate matter (PM_{10}) HVS statistics at Thebarton, 1993–2002

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1993	0	27	29	46	43	37	37	61
1994	1	25	25	62	42	35	36	43
1995	2	25	23	82	62	37	37	61
1996	5	27	24	66	57	44	44	53
1997	2	27	24	61	57	41	40	56
1998	2	23	21	68	58	34	33	59
1999	5	36	28	295	117	47	47	57
2000	0	25	22	41	39	33	34	42
2001	0	18	17	31	25	21	25	21
2002	0	24	23	46	42	38	36	58

The exceedences shown in Figure 17 occurred during periods when a neighbouring school was being constructed and when the intersection of South and Henley Beach roads was being re-aligned, restricting traffic over a considerable period of time.

[3] Data presented in this report measured using the TEOM are not corrected for HVS equivalency.

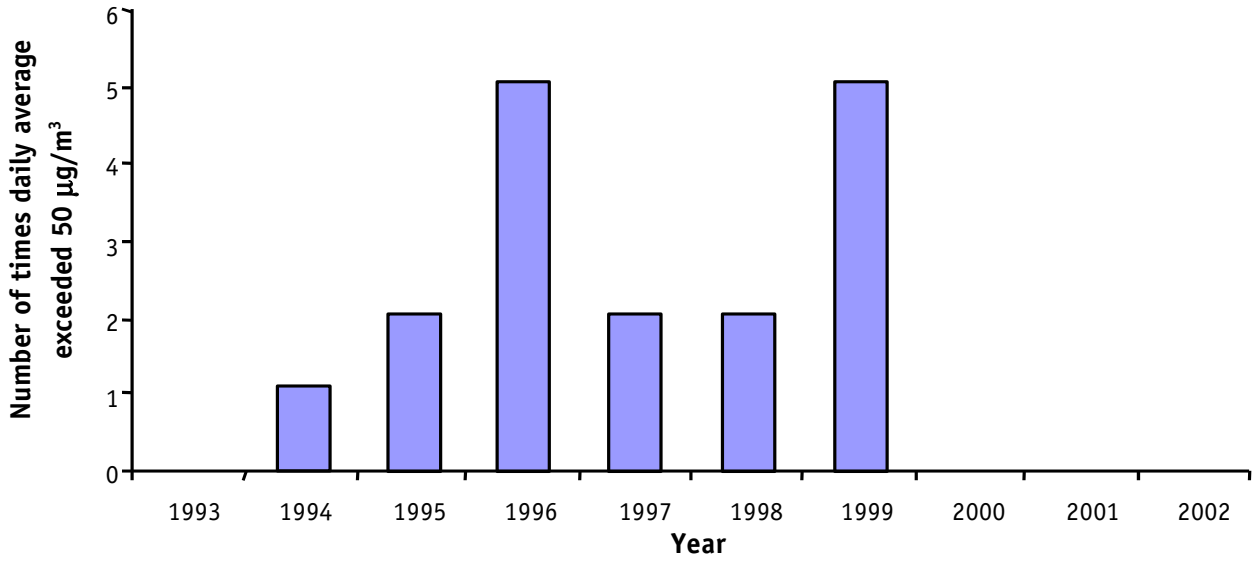

Figure 17 Number of PM_{10} NEPM criterion exceedences from peak site at Thebarton

Sampling for PM_{10} ceased at Gilles Plains in October 2002. In July 2002 there were two exceedences of the NEPM criterion (Table 21), both caused by the dust storms driven by strong westerly winds.

Table 21 Particulate matter (PM_{10}) HVS statistics at Gilles Plains, 1995–2002

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m³)	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	6th highest (µg/m³)	90th percentile (µg/m³)	Number of samples
1995	1	22	21	61	37	30	29	59
1996	2	25	23	56	54	34	33	58
1997	2	28	27	68	55	38	38	58
1998	2	27	24	59	51	39	39	60
1999	2	26	25	92	67	38	38	56
2000	0	21	22	46	41	34	35	39
2001	1	20	16	76	25	18	23	15
2002	2	23	22	54	54	33	33	50

PM_{10} monitoring at Netley began in September 2001 (Table 22). In July 2002 there was one exceedence of the NEPM criterion caused by the July dust storm. In 2003 there were six exceedences of the NEPM criterion (Figure 18). The highest, on 11 July 2003, was from another dust storm, from the west of the Netley station. The others are of uncertain origin.

Table 22 Particulate matter (PM_{10}) TEOM statistics at Netley, September 2001–2003

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m³)	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	6th highest (µg/m³)	90th percentile (µg/m³)	Data recovery (%)
2001	0	13	13	31	23	22	18	33
2002	1	20	19	79	45	43	28	100
2003	6	20	18	119	65	52	29	97

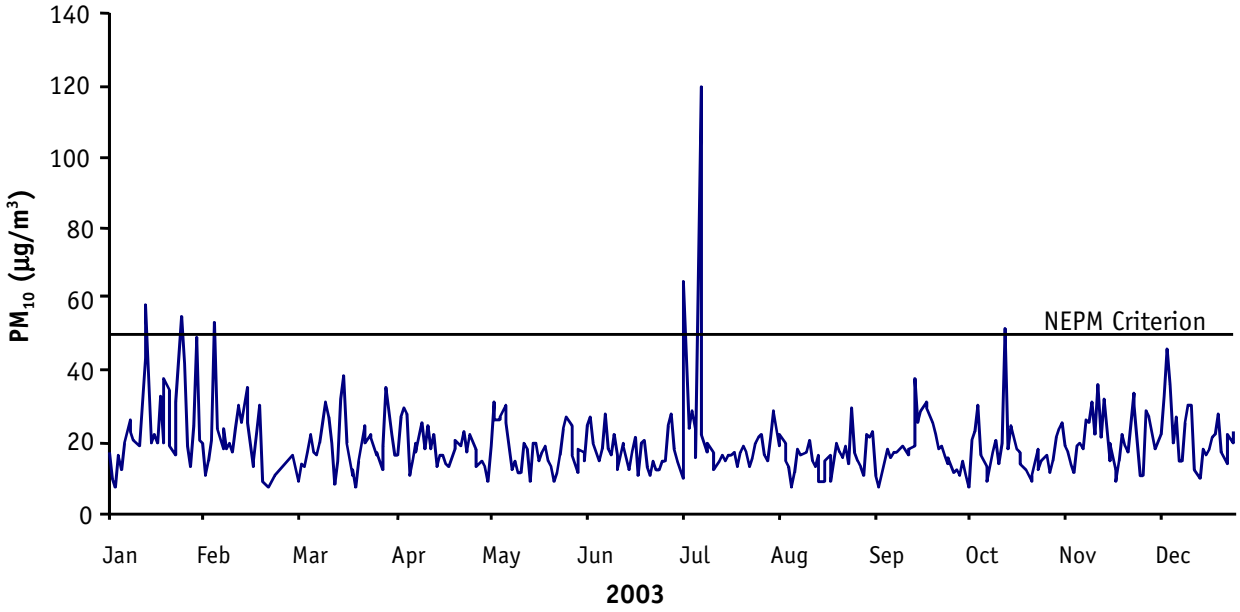

Figure 18 Daily averaged PM_{10} at Netley, 2003

PM_{10} monitoring at Kensington began in June 2002. In July 2002 there was one exceedence of the NEPM criterion, on 11 July, caused by the dust storm and, in 2003, the major exceedence was from another dust storm, also on 11 July (Table 23 and Figure 19).

Table 23 Particulate matter (PM_{10}) TEOM statistics at Kensington, June 2002–December 2003

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Data recovery (%)
2002	1	15	14	104	36	26	22	47
2003	2	15	13	86	53	39	21	89

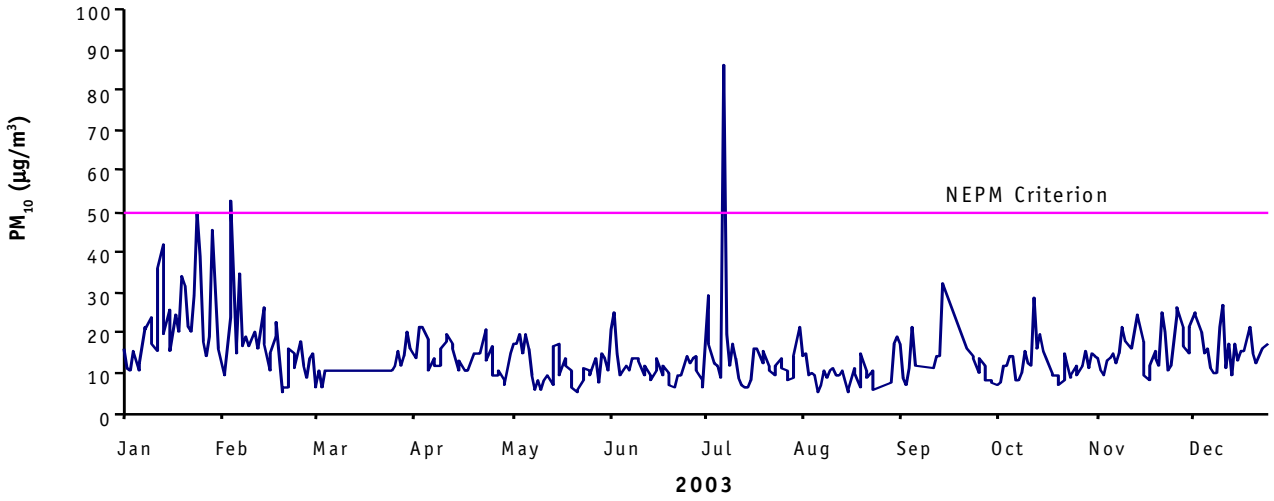

Figure 19 Daily averaged PM_{10} at Kensington, 2003

PM_{10} monitoring at Gawler began in June 2002 and continued to 31 December 2003 (Table 24 and Figure 20).

Table 24 Particulate matter (PM_{10}) TEOM statistics at Gawler, June 2002–July 2003

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Data recovery (%)
2002	1	17	15	51	49	39	27	50
2003	3	15	13	52	52	45	24	98

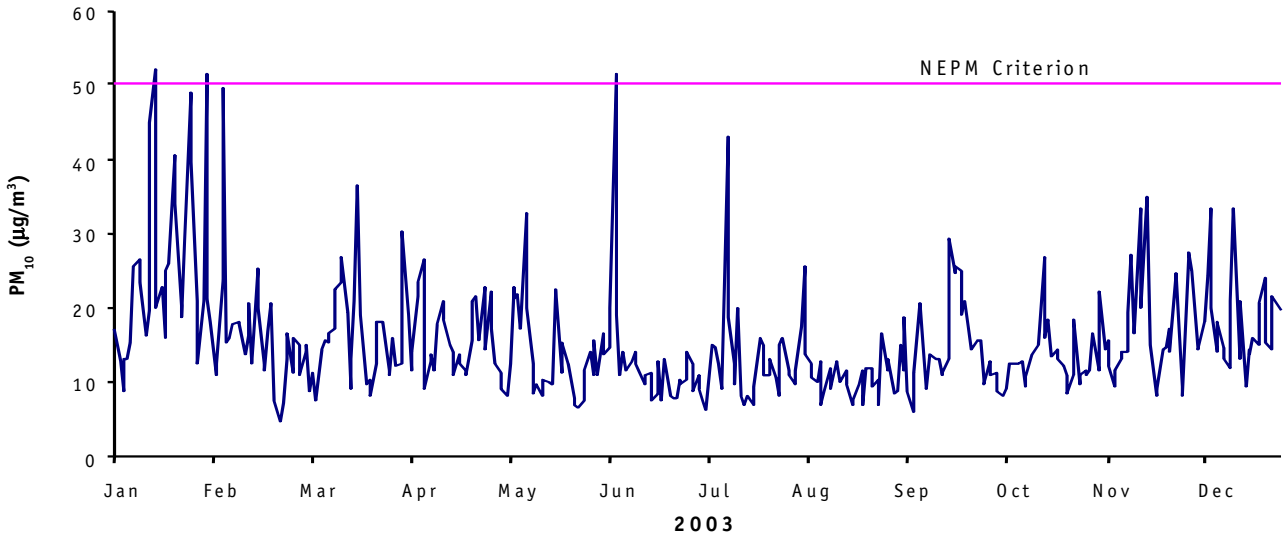

Figure 20 Daily averaged PM_{10} at Gawler, 2003

Current PM_{10} monitoring at Osborne (Table 25) aims to determine the air pollution impact that a cement manufacturing plant has on the surrounding residential area. As the monitor is located on the boundary of the plant, data are not formally compared with the NEPM criteria. Even so, the NEPM goal of no more than five days per year over 50 µg/m^3 has not been exceeded since 1999 when there were six daily exceedences.

Table 25 Particulate matter (PM_{10}) HVS statistics at Osborne, 1988–2003

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1988	0	13	11	30	25	19	23	31
1989	1	21	19	58	50	36	35	59
1990	5	27	19	211	60	49	49	57
1991	6	23	16	78	78	52	50	54
1992	4	21	15	62	61	45	45	52
1993	5	24	15	83	80	50	50	48
1994	6	22	19	83	80	57	42	100
1995	2	18	14	93	64	31	31	51
1996	1	18	14	84	46	40	40	51
1997	3	25	23	94	69	43	43	56
1998	6	25	21	99	87	53	51	56
1999	6	28	22	99	94	55	53	54
2000	3	24	21	90	66	43	43	43
2001	1	14	12	53	22	16	21	23
2002	0	19	17	41	33	27	32	31
2003	3	25	21	60	58	44	45	45

Particulate matter ($PM_{2.5}$)

Monitoring for smaller particles, with an equivalent aerodynamic diameter of up to 2.5 µm, began at Netley in 2001 and Kensington in June 2002 (Tables 26 and 27). The Netley site is continuing but the Kensington site ran for a period of time and the unit was then moved to Elizabeth to monitor PM_{10} in line with the *Ambient air quality monitoring plan for South Australia* (Environment Protection Agency 2001).

Table 26 Particulate matter ($PM_{2.5}$) data for Netley, September 2001–2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Data recovery (%)
2001	7	6	11	11	10	9	32
2002	9	9	25	20	17	13	99
2003	9	8	28	26	20	12	98

The NEPM criteria for $PM_{2.5}$ is 25 µg/m^3 for one day and 8 µg/m^3 for one year. The yearly averages at Netley site of 9 µg/m^3 in both 2002 and 2003, exceed the annual criterion. The yearly average at Kensington for 2003 was 7 µg/m^3.

The 2003 maximum for Netley of 28 µg/m^3 occurred on 11 July, the day of the dust storm. Netley recorded two one-hour averaged concentrations of PM_{10} between 800 µg/m^3 and 1500 µg/m^3 in the afternoon of that day. The corresponding values for $PM_{2.5}$ were between 150 µg/m^3 and 250 µg/m^3. The low ratio of $PM_{2.5}$ to PM_{10} suggests that the particles are windblown soil (i.e. sourced from the land, including particles rich in silicon and aluminium).

Table 27 Particulate matter ($PM_{2.5}$) data for Kensington, 2002–2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Data recovery (%)
2002	8	7	39	33	20	10	60
2003	7	7	22	18	16	10	88

Lead

Total suspended particulate lead was measured at Thebarton (Table 28 and Figure 21), Northfield (Table 29 and Figure 22), Gilles Plains (Table 30 and Figure 23), Kensington (Table 31) and Parkside (by HVS; Table 32 and Figure 24). Monitoring from Port Adelaide was discontinued in 2001 due to site redevelopment (Table 33 and Figure 25). The Port Adelaide, Thebarton, Parkside and Gilles Plains sites were located directly adjacent to major arterial roads. The Kensington and Northfield sites were located approximately 100 metres from the nearest arterial road. Although data are available from most sites from 1981 (see Figure 26), most sites' statistics were only calculated from 1995, when the EPA was created.

Ambient lead concentrations in air have been steadily falling since monitoring began in the early 1990s. This can be attributed to the introduction of unleaded petrol in 1986 and its progressive use. In 2001, concentrations were negligible and at Northfield and Kensington averaged daily concentrations were zero. Other sites were also well below the NEPM criterion of 0.5 µg/m^3 as an annual average. The NEPM criterion was last exceeded in 1996 at Gilles Plains.

Table 28 Lead (TSP Pb) statistics at Thebarton, 1993–2002

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1993	1.58	1.54	3.42	2.97	2.39	59
1994	0.99	0.95	2.08	1.91	1.64	43
1995	0.48	0.45	0.94	0.93	0.80	61
1996	0.41	0.39	0.85	0.79	0.64	57
1997	0.35	0.34	0.69	0.63	0.53	58
1998	0.27	0.29	0.61	0.55	0.36	59
1999	0.23	0.21	0.48	0.46	0.34	56
2000	0.20	0.17	0.68	0.39	0.30	41
2001	0.03	0.02	0.04	0.04	0.04	21
2002	0.02	0.02	0.06	0.06	0.03	58

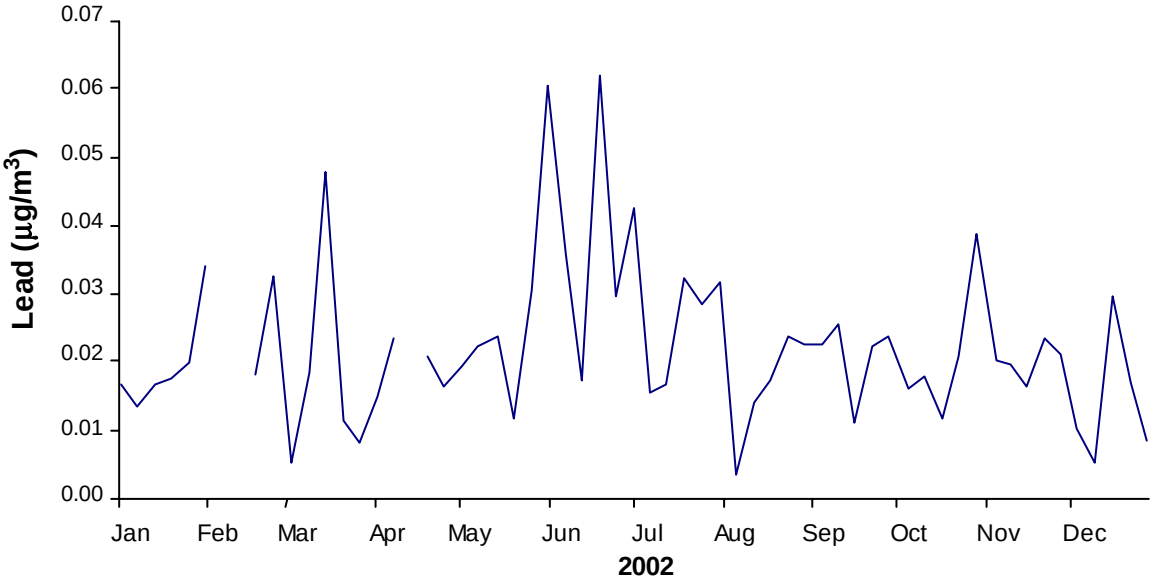

Figure 21 Daily averaged lead at Thebarton, 2002

Table 29 Lead (TSP Pb) statistics at Northfield, 1995–2002

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1995	0.07	0.05	0.50	0.14	0.12	31
1996	0.06	0.04	0.18	0.17	0.13	60
1997	0.05	0.04	0.20	0.11	0.09	60
1998	0.05	0.03	0.18	0.17	0.12	59
1999	0.03	0.03	0.10	0.08	0.07	57
2000	0.04	0.03	0.15	0.09	0.07	41
2001	0.005	0.004	0.02	0.02	0.01	25
2002	0.004	0.001	0.02	0.02	0.01	57

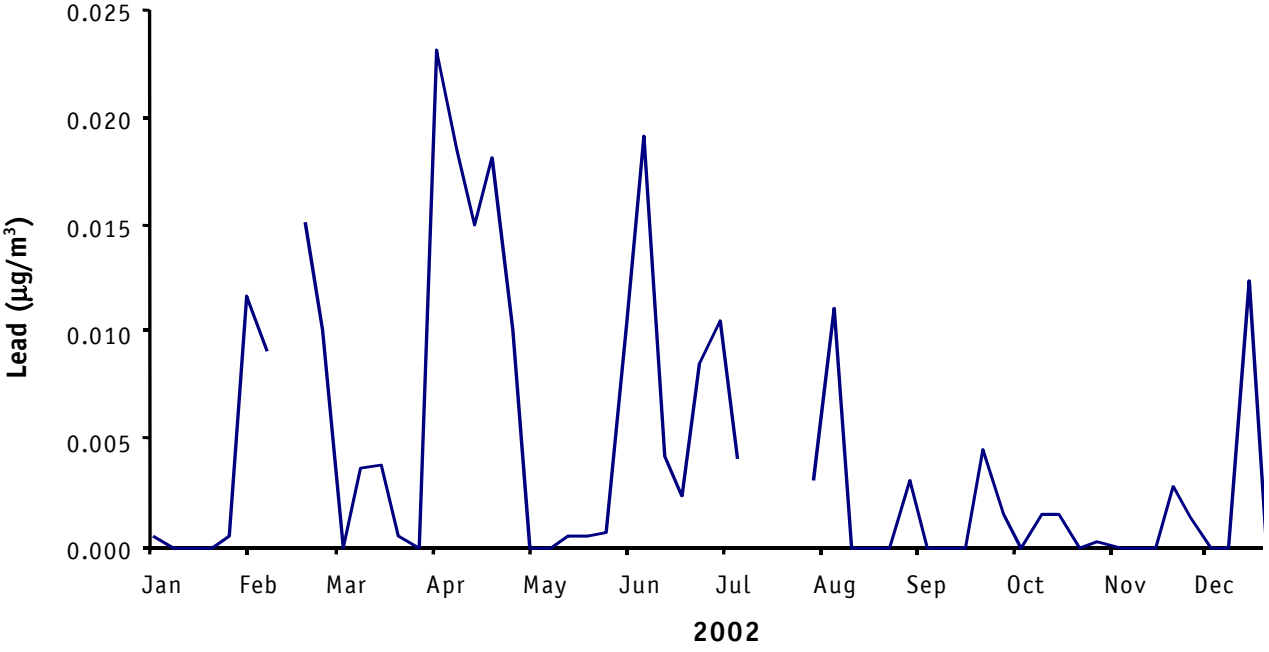

Figure 22 Daily averaged lead at Northfield, 2002

Table 30 Lead (TSP Pb) statistics at Gilles Plains, 1995–2002

Year	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	90th percentile (µg/m³)	Number of samples
1995	0.65	0.60	1.24	1.23	1.02	59
1996	0.57	0.54	1.20	1.12	0.84	57
1997	0.43	0.40	0.88	0.81	0.64	59
1998	0.37	0.37	0.70	0.66	0.56	60
1999	0.26	0.25	0.52	0.48	0.39	56
2000	0.22	0.22	0.47	0.44	0.35	41
2001	0.03	0.03	0.08	0.05	0.05	20
2002	0.02	0.02	0.05	0.04	0.03	49

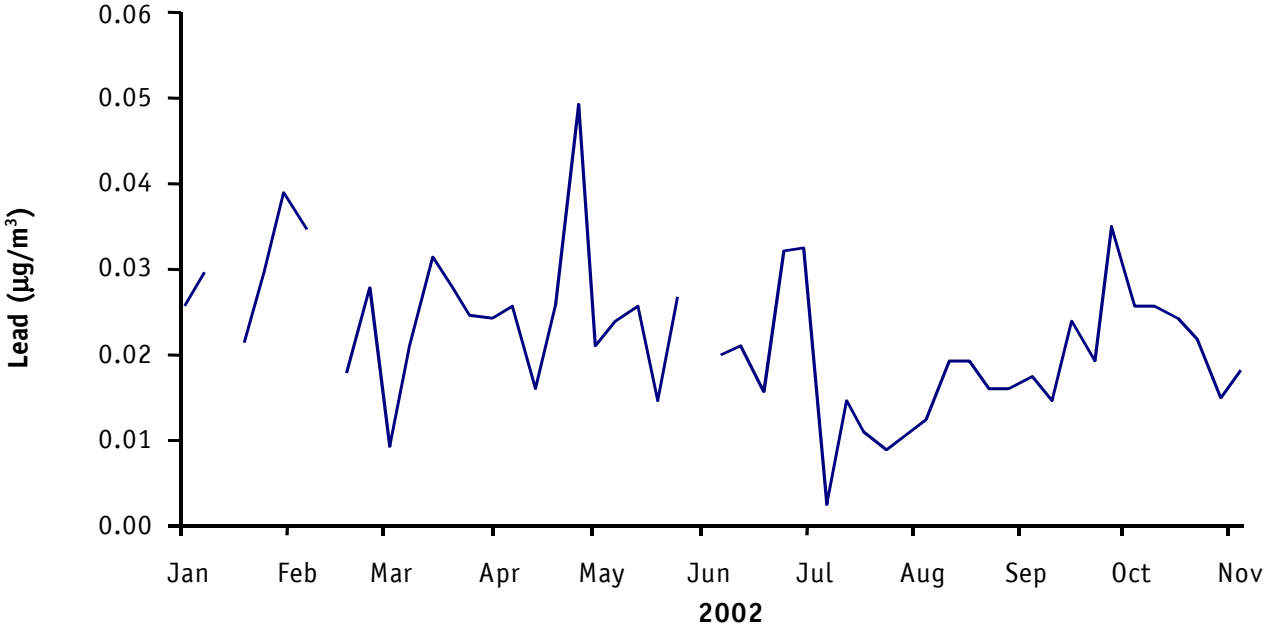

Figure 23 Daily averaged lead at Gilles Plains, 2002

Table 31 Lead (TSP Pb) statistics at Kensington, 1995–2002

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1995	0.05	0.04	0.14	0.12	0.09	56
1996	0.04	0.04	0.13	0.12	0.09	57
1997	0.03	0.03	0.10	0.07	0.06	49
1998	0.03	0.03	0.10	0.07	0.06	59
1999	0.02	0.02	0.06	0.05	0.05	59
2000	0.02	0.02	0.06	0.05	0.04	36
2001	0.002	0.0005	0.01	0.01	0.01	19
2002	0.0003	0.0	0.01	0.01	0.007	59

Table 32 Lead (TSP Pb) statistics at Parkside, 1995– June 2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1995	0.20	0.15	0.61	0.54	0.40	44
1996	0.18	0.12	0.68	0.54	0.37	60
1997	0.15	0.12	0.34	0.33	0.27	57
1998	0.12	0.10	0.31	0.29	0.22	59
1999	0.10	0.09	0.27	0.24	0.18	55
2000	0.10	0.07	0.35	0.24	0.17	38
2001	0.01	0.01	0.06	0.04	0.03	31
2002	0.01	0.01	0.03	0.03	0.02	59
2003	0.006	0.005	0.018	0.017	0.013	27

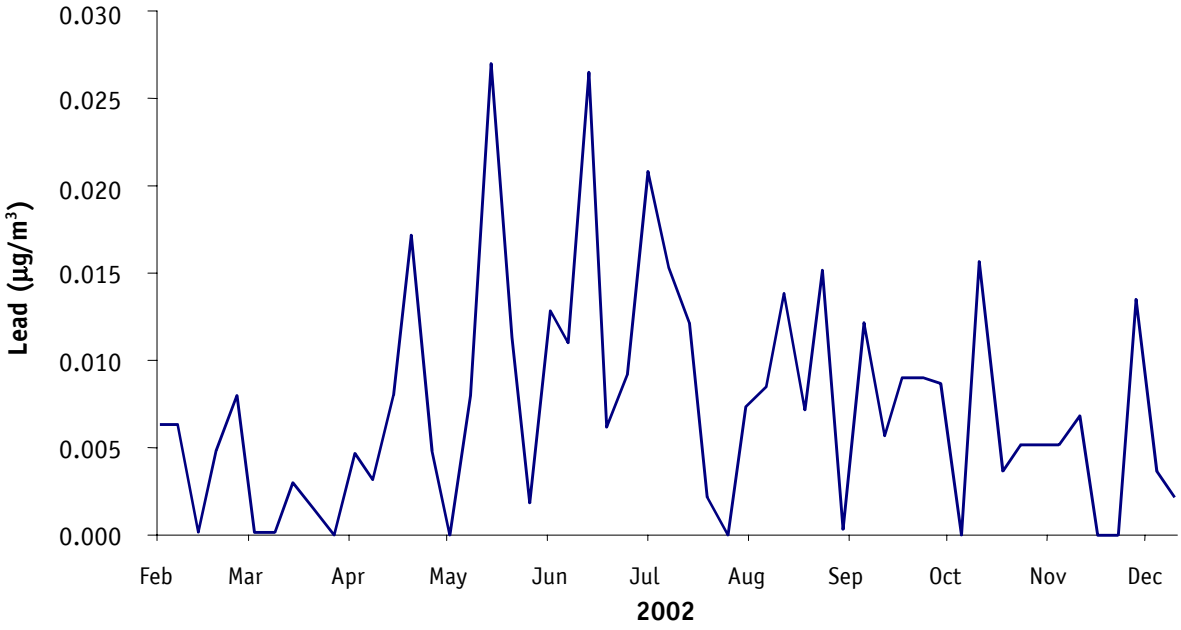

Figure 24 Daily averaged lead at Parkside, 2002

Table 33 Lead (TSP Pb) statistics at Port Adelaide, 1981–2001

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1981	1.74	1.64	3.88	3.27	2.55	58
1982	2.09	2.08	5.10	4.30	3.03	54
1983	1.24	1.14	5.59	2.56	1.88	46
1984	1.37	1.44	2.74	2.66	2.28	58
1985	1.18	1.13	2.42	2.40	2.03	60
1986	1.24	1.22	2.40	2.35	2.06	55
1987	0.88	0.79	2.81	2.31	1.64	59
1988	1.30	1.22	3.49	2.47	1.94	59
1989	1.07	1.11	2.29	2.06	1.58	60
1990	0.89	0.77	2.60	2.41	1.47	61
1991	0.92	0.87	2.35	2.23	1.63	56
1992	0.86	0.88	2.15	1.79	1.52	58
1993	0.84	0.84	1.82	1.81	1.40	60
1994	0.51	0.43	1.37	1.18	0.80	61
1995	0.27	0.28	0.57	0.51	0.43	59
1996	0.21	0.19	0.63	0.49	0.35	57
1997	0.16	0.15	0.34	0.34	0.26	58
1998	0.14	0.13	0.34	0.31	0.22	59
1999	0.12	0.11	0.28	0.26	0.21	60
2000	0.10	0.08	0.46	0.24	0.19	57
2001	0.04	0.03	0.15	0.06	0.05	24

The long-term downward trend in lead at Port Adelaide (Figure 25), and the dramatic fall in annual air lead concentrations for all sites using HVS (Figure 26), compared with the annual NEPM criterion for lead (0.5 µg/m^3), results from the introduction of unleaded petrol in 1986 and the banning of lead in fuel altogether in 2000. As a result of this trend, lead monitoring in Adelaide was stopped in 2003 (see *www.environment.sa.gov.au/epa/pdfs/lead_aq_report.pdf)*.

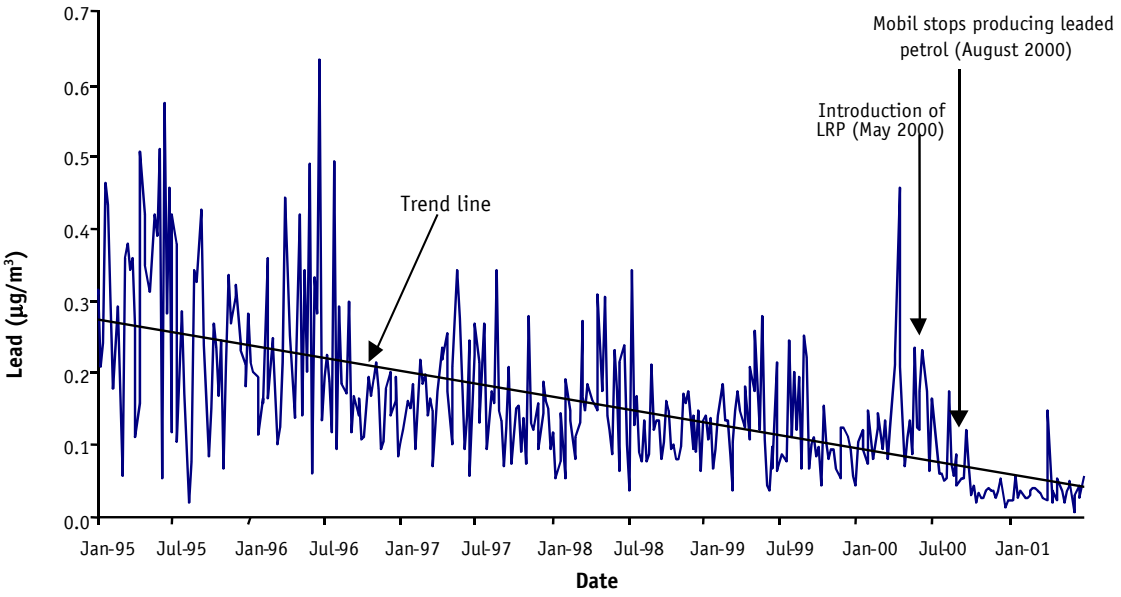

Figure 25 Trend of lead concentrations at Port Adelaide since 1995 (LRP—lead replacement petrol)

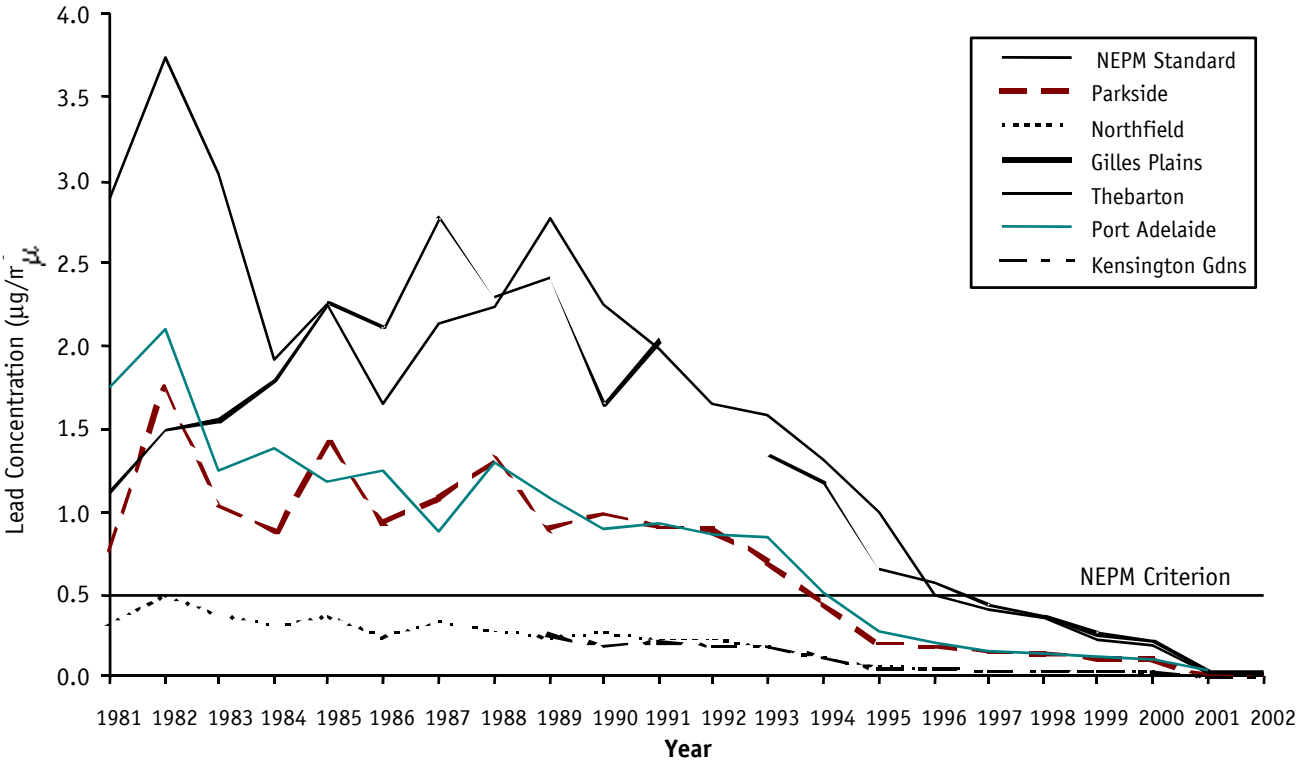

Figure 26 Annual average lead concentrations (all metropolitan HVS sites)

Ambient air quality in Mount Gambier

Monitoring for most pollutants began in September 2001 at Frew Park, Mount Gambier (a NEPM site). As the data recovery is expressed as an annual fraction, the percentage recovery quoted is low. However, over the three months of monitoring in 2001, only a small percentage of data was actually removed in the validation process. Thus, for the period of monitoring, data recovery was high. Measurements of particles (TEOM) began in October 2000 and the site was decommissioned in September 2002. The EPA has published a separate report describing ambient, and two hotspot, air quality sites within Mount Gambier, indicating its concern about particle concentrations in the region (Adeeb 2003).

Monitoring site and industry in Mount Gambier

Mount Gambier has a population of about 24,000 and is situated 460 km south-east of Adelaide (37° 50′ S, 140° 45′ E). Major EPA licensed industry in Mount Gambier includes wood processing and preservation, and fuel burning. Two such industries, and all other EPA licensed premises (in grey), are identified in Figure 27.

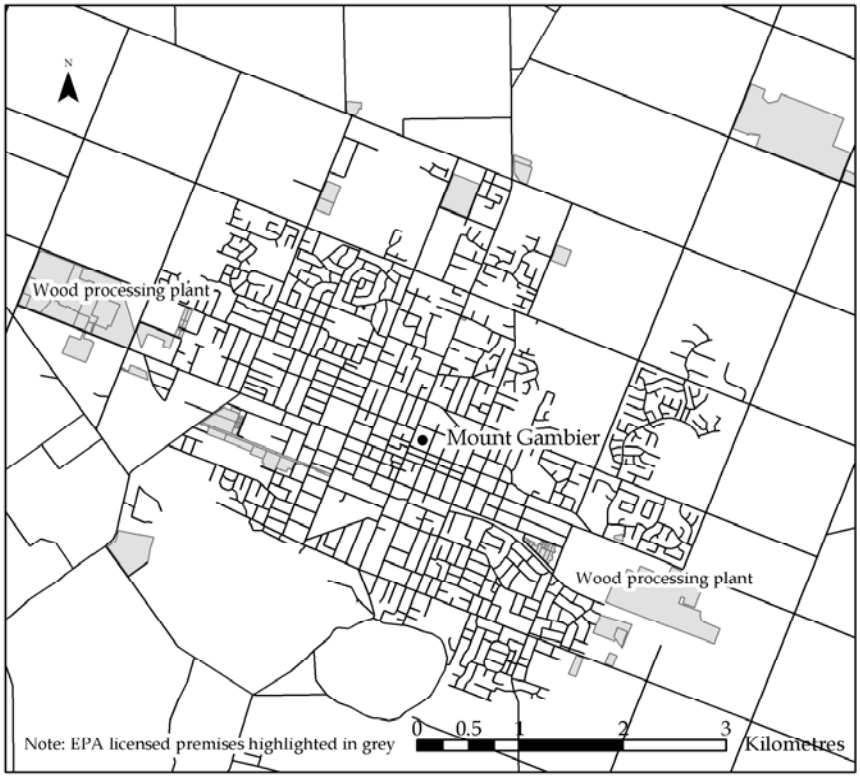

Figure 27 Map of the Mount Gambier monitoring site and location of EPA licensed industry

Nitrogen dioxide

During the monitoring period, one-hour averages of NO_2 at Mount Gambier were within the range 0–0.038 ppm (Table 34), with an annual average for 2001 and 2002 of 0.004 ppm and 0.001 ppm respectively, well below the NEPM criterion of 0.12 ppm. Averages did not exceed the one-year NEPM criterion (0.03 ppm). Monitoring ceased in September 2002.

Table 34 Nitrogen dioxide statistics at Mount Gambier, 2001–2002

Year	Number of exceedences of 1-hour NEPM criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2001	0	0.025	0.008	0.019	32
2002	0	0.038	0.014	0.024	65

Ozone

In the monitoring period, one-hour averages of ozone at Mount Gambier were within the range 0–0.044 ppm (Table 35), with yearly averages of 0.018 ppm (2001) and 0.015 ppm (2002). These concentrations are well below the NEPM criterion of 0.10 ppm as a one-hour average. There were also no exceedences of the four-hour NEPM criterion (0.08 ppm).

Table 35 Ozone statistics at Mount Gambier, 2001–2002

Year	Number of exceedences of 1-hour NEPM criterion for O_3 (0.10 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2001	0	0.035	0.026	0.031	33
2002	0	0.044	0.026	0.033	67
	Number of exceedences of 4-hour NEPM criterion for O_3 (0.08 ppm)				
2001	0	0.033	0.026	0.030	33
2002	0	0.042	0.025	0.031	67

Sulfur dioxide

In the monitoring period, one-hour averages of SO_2 were within the range 0–0.012 ppm (Table 36), with an average for both years of 0.001 ppm, well below the NEPM criterion of 0.20 ppm as a one-hour average. No exceedences were measured for the one-day NEPM criterion (0.08 ppm). The average of 0.0014 ppm for the 12-month period September 2001 to August 2002 is below the NEPM yearly criterion of 0.02 ppm.

Table 36 Sulfur dioxide statistics at Mount Gambier, 2001–2002

Year	Number of exceedences of 1-hour NEPM criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2001	0	0.007	0.003	0.006	29
2002	0	0.012	0.004	0.007	47

Particulate matter

Particles at Mount Gambier were continuously measured by TEOM from October 2000 to September 2002. The data presented for particles measured by TEOM below were not adjusted to HVS method equivalents—the measurement method by which the NEPM criterion was compared in a recent EPA report that gave a comprehensive seasonal evaluation of air quality in Mount Gambier (Environment Protection Authority 2003). The report showed that when TEOM measurements were adjusted so that data could be deemed equivalent to HVS data, the number of exceedences of the NEPM criterion increased.

One-day averaged concentrations of PM_{10} at Mount Gambier exceeded the NEPM criterion of 50 g/m^3 during one day in 2001 and two days in 2002 (Table 37). Variations in particle concentrations compared with the NEPM criterion are also described in Figures 28 and 29.

Table 37 Particulate matter (PM_{10}) statistics (TEOM) at Mount Gambier, 2000–2002

Year	Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Data recovery (%)
2000	0	17	17	32	30	25	23	25
2001	1	17	16	59	43	35	27	98
2002	2	18	17	70	54	36	27	67

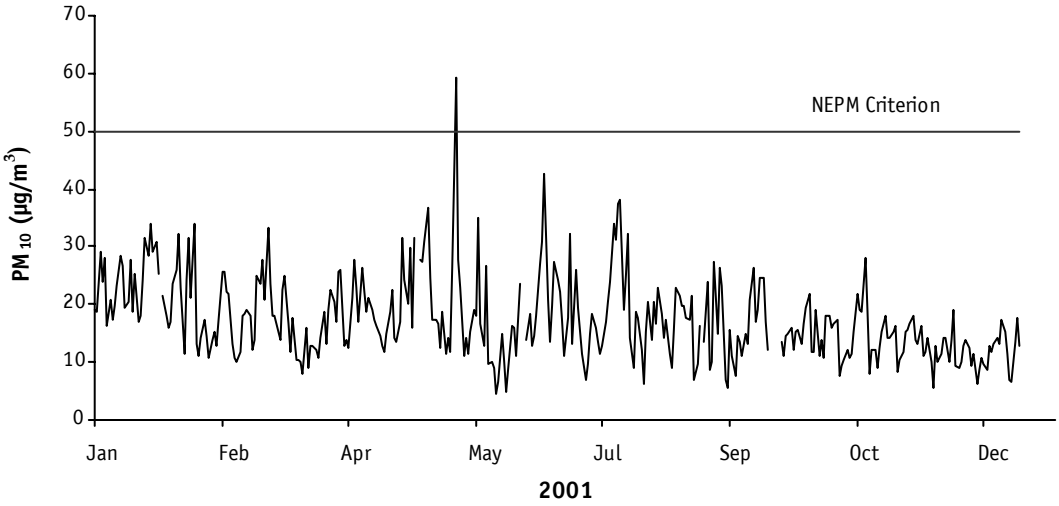

Figure 28 Daily averaged PM_{10} (TEOM) at Mount Gambier, 2001

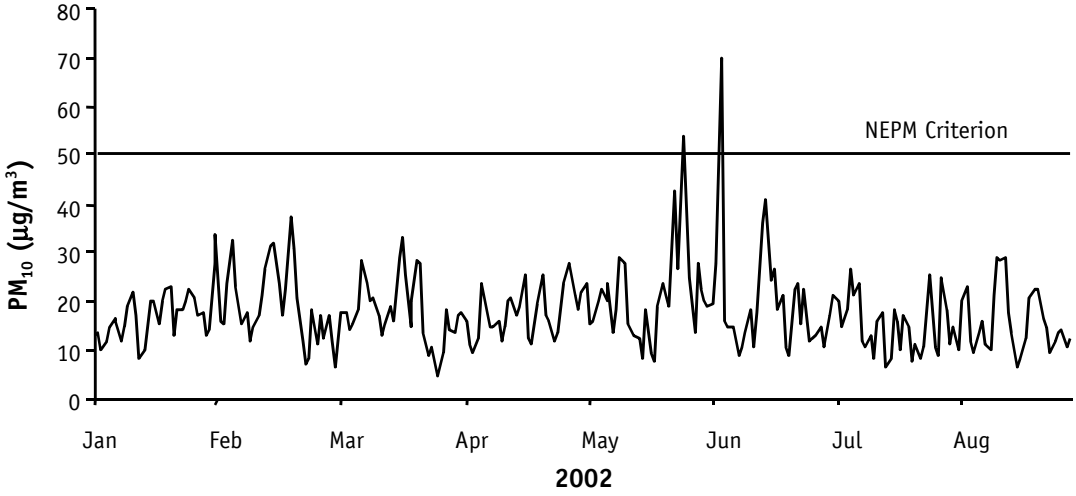

Figure 29 Daily averaged PM_{10} (TEOM) at Mount Gambier, 2002

PM_{10} was also measured using an HVS at the site (Table 38) with one day in six sampling. One-day averaged concentrations of PM_{10} at Mount Gambier exceeded the NEPM criterion of 50 µg/m^3

during two days in 2001 and on three days in 2002. Particle concentrations for the entire sampling period are compared with the NEPM criterion in Figure 30.

Table 38 Particulate matter (PM_{10}) statistics (HVS) at Mount Gambier, 2001–2002

Year	Number of exceedences of daily NEPM Criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
2001	2	20	16	56	51	28	40	30
2002	3	26	19	131	76	43	44	41

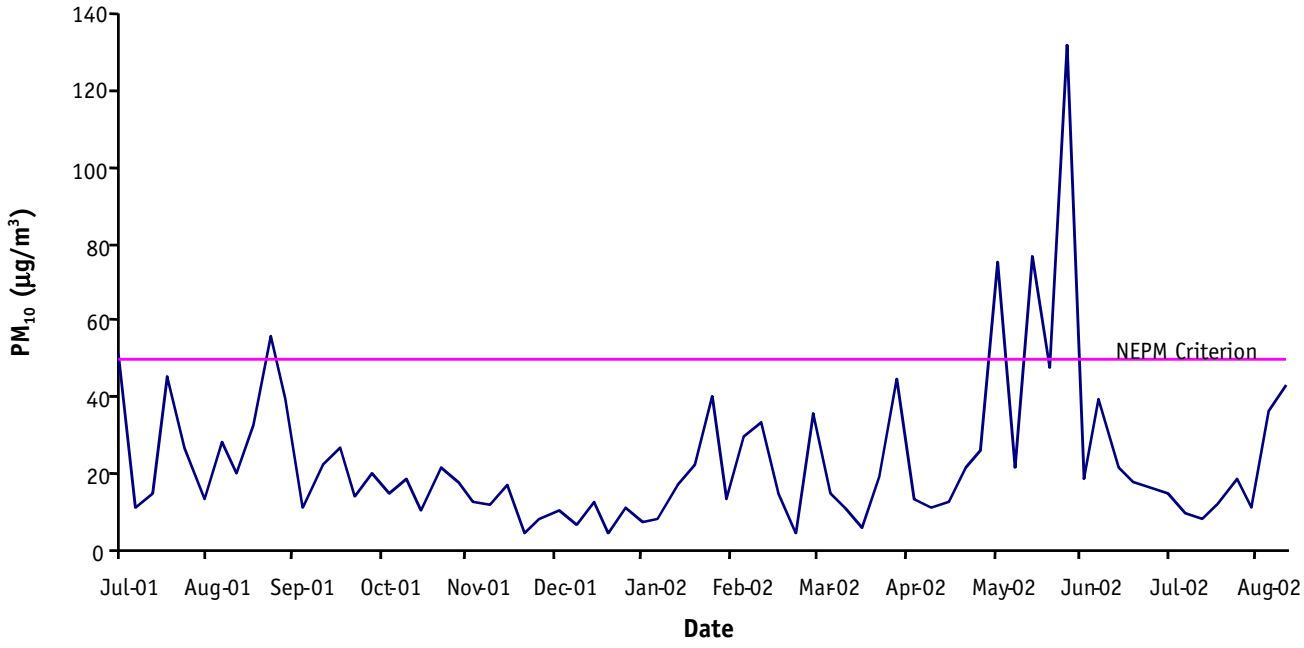

Figure 30 Daily averaged PM_{10} (HVS) at Mount Gambier, 2001–2002

Ambient air quality in Whyalla

Monitoring sites and industry in Whyalla

Whyalla is a city of about 24,000 people located on the western side of Spencer Gulf. Major EPA licensed industry in Whyalla includes the activities of iron ore pelletising, metal melting and ore transport along a railway system. The locations of the pellet plant, close to Whyalla, the monitoring sites and other EPA licensed premises (in grey) are shown in Figure 31.

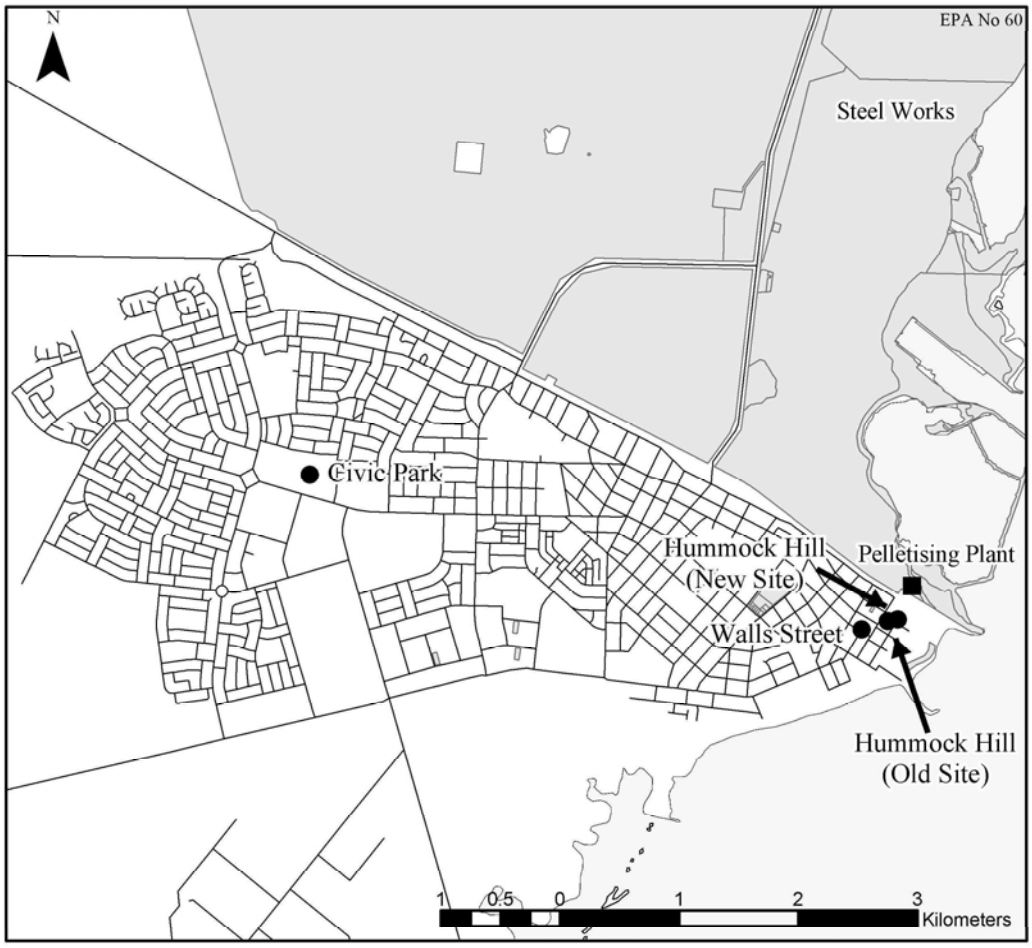

Figure 31 Map of Whyalla monitoring sites and location of EPA licensed industry (in grey)

Particulate matter

Particulate matter as PM_{10} is measured at Whyalla at Hummock Hill, Civic Park and Walls Street. Monitoring at Hummock Hill began in 1990 to study the concentrations of dust near the pellet plant. Civic Park is a NEPM site where monitoring for PM_{10} began in late 2001; it is considered to be a background site. The site at Hummock Hill was relocated to its current position on 12 May 2000. Thus the PM_{10} data in Table 39 is split into 'old' and 'new' Hummock Hill sites. The frequency of sampling, for both Civic Park and Hummock Hill, was increased from one day in six to one day in three from May 2002. Figure 33 should be read with this in mind; many more samples were taken in 2002 (97 in total) than in previous years of monitoring.

In July 2003, the EPA began monitoring at a site in Walls Street as a result of advice from the Department of Human Services on potential human health impacts from exposure to fine particles of the type present in Whyalla. This site is considered by the EPA to be representative of the exposure of the community living adjacent to the OneSteel pellet plant to PM_{10} particles. The Walls

Street site uses a TEOM sampler and will be a compliance site used to assess the performance of OneSteel.

PM_{10} concentrations at Hummock Hill exceeded 50 µg/m³ (51.5–356.2 µg/m³ measured as a daily average) on 18 days during 2002 and 23 days in 2003 (Table 39; Figures 32, 33 and 34). The highest 2003 concentration was 400 µg/m³ (Table 39).

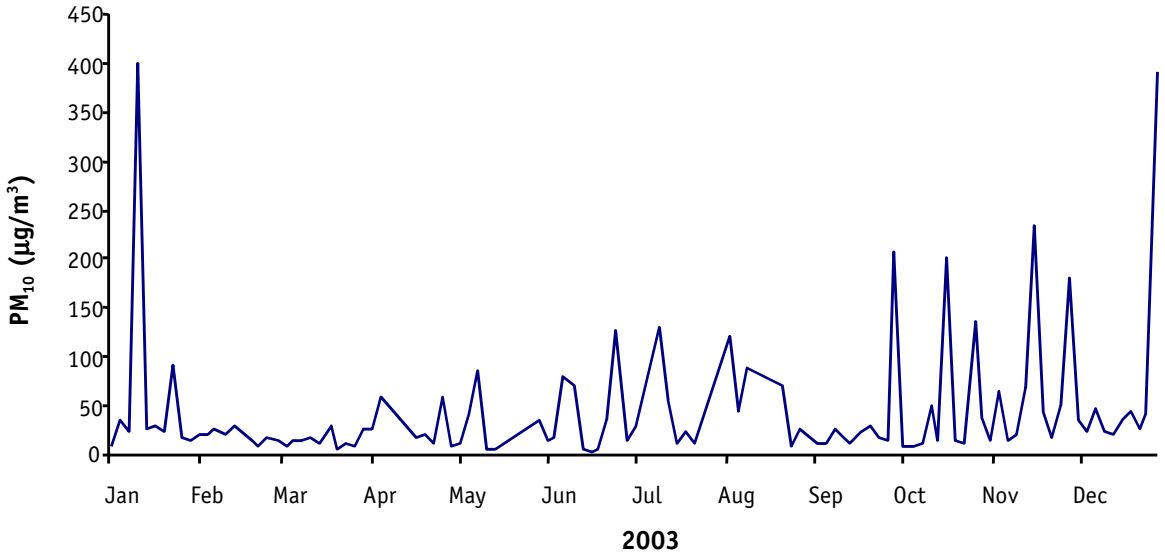

Figure 32 Daily averaged PM_{10} (HVS) at Hummock Hill new, 2003

Table 39 Particulate matter (PM_{10}) statistics at Hummock Hill (old and new) Whyalla, 1990–2003

Year	Number of days greater than 50 µg/m³	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	6th highest (µg/m³)	90th percentile (µg/m³)	Number of samples	Percent of samples greater than 50 µg/m³
1990	10	30	22	123	118	67	66	55	18
1991	7	28	19	100	88	55	59	45	16
1992	10	28	20	96	93	72	68	61	16
1993	3	19	13	141	87	39	38	61	5
1994	2	18	13	93	62	44	35	58	3
1995	5	23	15	123	91	48	48	54	9
1996	3	18	12	73	57	43	43	57	5
1997	2	22	16	92	79	43	43	47	4
1998	3	19	13	94	53	38	37	54	6
1999	7	29	17	170	170	56	52	58	12
2000	3	29	16	124	94	30	65	20	15
				Site relocated to new Hummock Hill site with monitoring beginning 12 May 2000					
2000	4	29	21	84	83	40	74	20	20
2001	4	22	11	102	86	34	70	29	14
2002	18	36	19	356	147	128	79	97	19
2003	23	45	24	400	391	181	92	104	22

Figure 33 has not been normalised, or corrected, for changes in the frequency of monitoring. This is more accurately shown in Figure 34 where exceedences are expressed as a percentage of the number of samples collected.

A rigorous statistical assessment of the monitoring data has been undertaken by independent experts (Fox 2004, Best 2004). They agree that the following is a reasonable summary of their findings:

> *In 2002 the PM10 value of 50 µg/m3 as a daily average at Hummock Hill, adjacent to the OneSteel Pellet Plant, was exceeded 18.5% of the time. This is significantly higher than the mid-1990s when the PM10 value of 50 µg/m3 as a daily average at the old site at Hummock Hill was exceeded about 5% of the time. Relocation of the monitoring station in May 2000 has had a discernible effect on measured dust levels on occasions under certain wind conditions. Nevertheless, since the mid to late 1990s there has been an overall worsening of air quality in the area, with levels in 2002 comparable to those encountered in the early 1990s.*

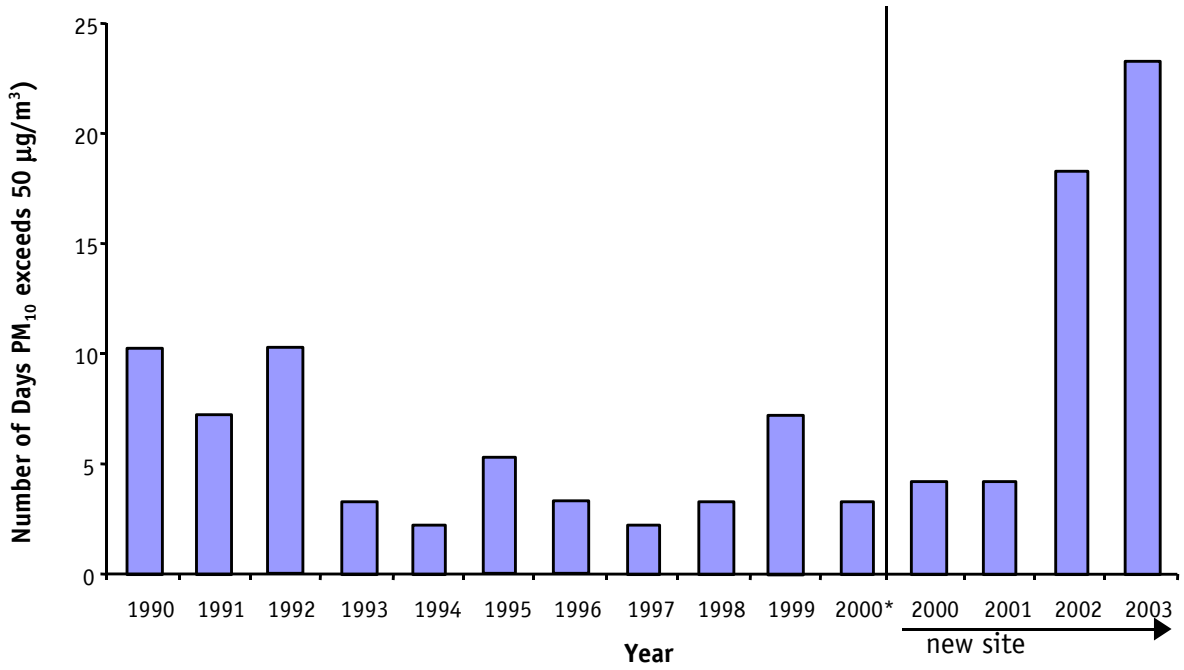

Figure 33 Number of days PM_{10} greater than 50 µg/m^3 at Hummock Hill (old and new) Whyalla

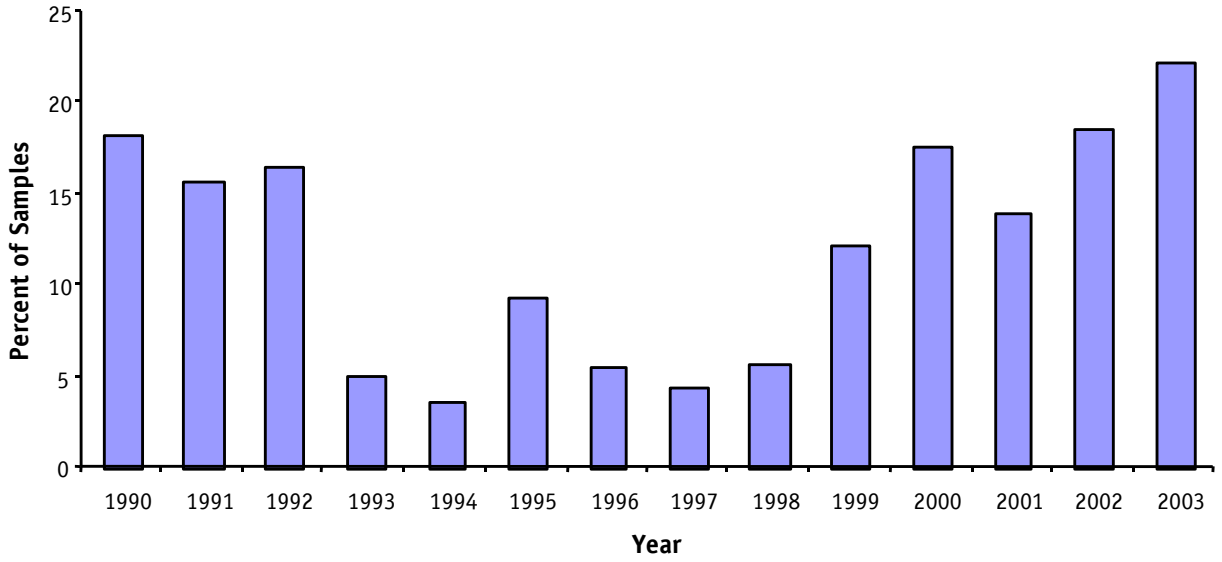

Figure 34 Percentage of samples per year PM_{10} exceeded 50 µg/m^3 in a 24-hour period at Hummock Hill Whyalla, 1990–2003 (after Fox 2004)

Measurements of particle concentrations as PM_{10} at Civic Park began on 10 October 2001. All concentrations in 2001 were well below 50 µg/m^3 and in 2002 the daily average exceeded the NEPM criterion on one day (Table 40). There were no exceedences measured at this site in 2003 (Figure 35).

Table 40 Particulate matter (PM_{10}) statistics at Civic Park Whyalla, 2001–2003

Year	**Number of exceedences of daily NEPM criterion for PM_{10} (50 µg/m^3)**	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
2001	0	12	10	27	21	11	20	14
2002	1	17	14	59	43	40	26	98
2003	0	15	13	48	42	33	25	113

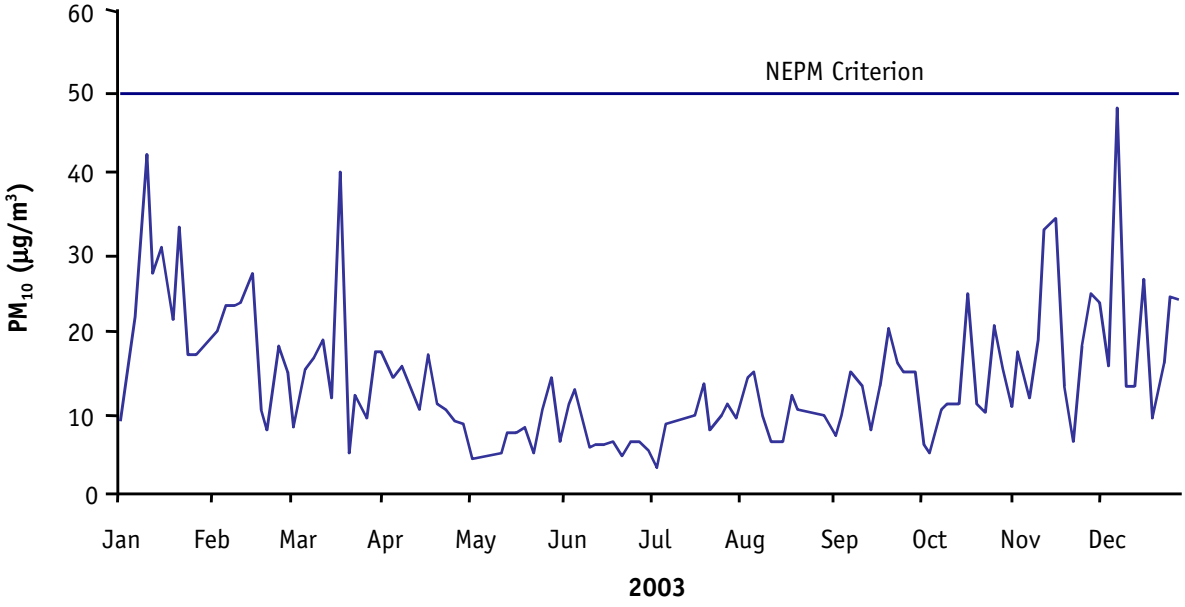

Figure 35 Daily averaged PM_{10} (HVS) at Civic Park Whyalla, 2003

At Walls Street, the EPA has applied the NEPM Standard (maximum 24-hour average PM_{10} concentration of 50 µg/m³, with no more than five exceedences of the criterion in any given calendar year, by 2008) and is working with OneSteel to achieve that standard. There were eight exceedences of 50 µg/m³ at the Walls Street site in 2003 (Table 41).

Table 41 Particulate matter (PM_{10}) statistics (TEOM) at Walls Street Whyalla, July–December 2003

Year	Number of exceedences of daily NEPM Criterion for PM_{10} (50 µg/m³)	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	6th highest (µg/m³)	90th percentile (µg/m³)	Data recovery (%)
2003	8	19	13	82	77	61	38	42

Total suspended particulates

TSP have been measured at both Hummock Hill (Table 42) and Civic Park since 1989. The site at Hummock Hill was moved to its current location on 12 May 2000. Thus the TSP data in Table 42 are split into 'old' and 'new' Hummock Hill sites. The frequency of sampling was increased from one day in six to one day in three from 8 May 2002. The WHO guideline of 120 µg/m³ is used for comparison purposes at Hummock Hill.

Particle concentrations as TSP at Hummock Hill during 2003 were greater than 120 µg/m³ (120.9–1276.8 µg/m³ measured as a daily average) on 25 days out of the 115 days when measurements were made (22% of sample days; Figure 36). On 28 days in 2002 (29% of sample days) TSP was greater than 120 µg/m³ (Figures 37 and 38).

Table 42 Particulate matter (TSP) statistics at Hummock Hill (old and new) Whyalla, 1989–2003

Year	Number of days greater than 120 µg/m^3	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples	Percent of samples greater than 120 µg/m^3
1989	6	80	49	581	496	131	50	12
1990	9	74	49	309	286	158	60	15
1991	3	67	38	863	288	75	43	7
1992	12	77	38	567	241	168	59	20
1993	6	63	44	463	253	118	59	10
1994	2	46	32	248	129	97	59	3
1995	9	64	40	303	227	139	57	16
1996	8	57	40	185	159	141	57	14
1997	6	61	34	429	415	113	57	11
1998	6	60	36	360	161	128	56	11
1999	14	103	51	823	630	203	57	25
2000	4	96	57	432	341	239	20	20
	Site relocated to new Hummock Hill site with monitoring beginning 12 May 2000							
2000	7	121	84	451	318	235	21	33
2001	5	85	47	378	337	269	30	17
2002	28	118	63	1277	552	278	98	29
2003	25	112	50	1344	969	251	115	22

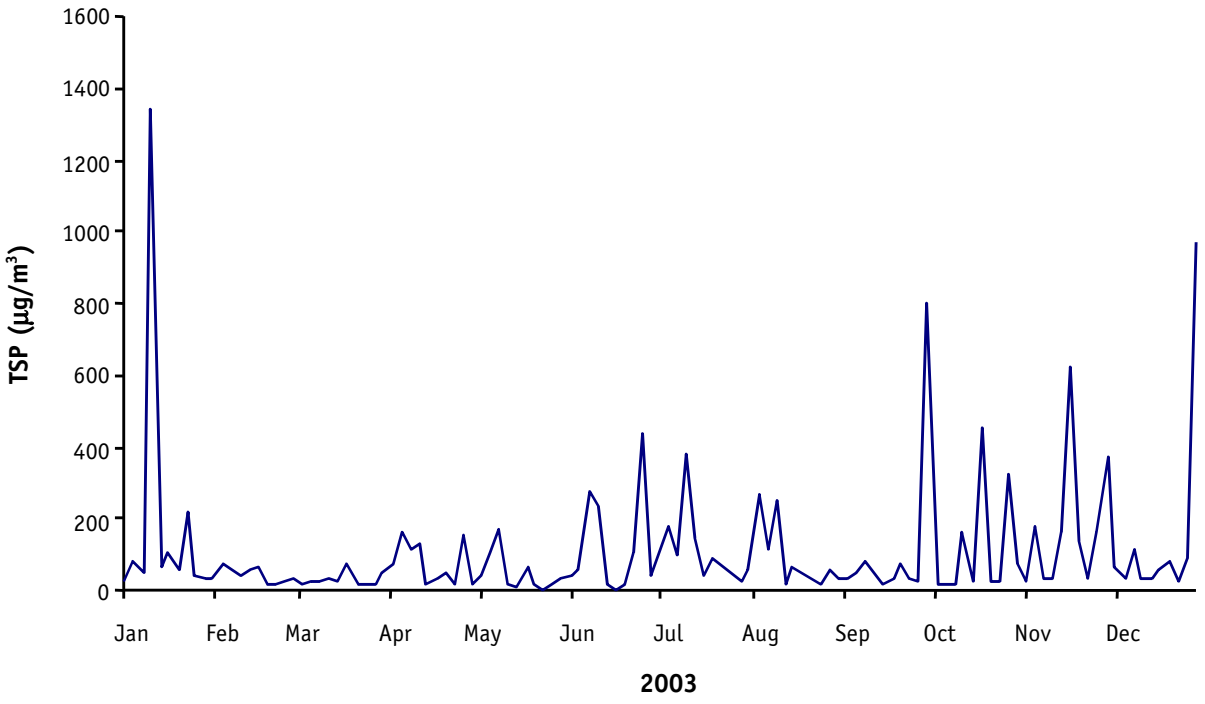

Figure 36 Daily averaged TSP (HVS) at Hummock Hill (new) Whyalla, 2003

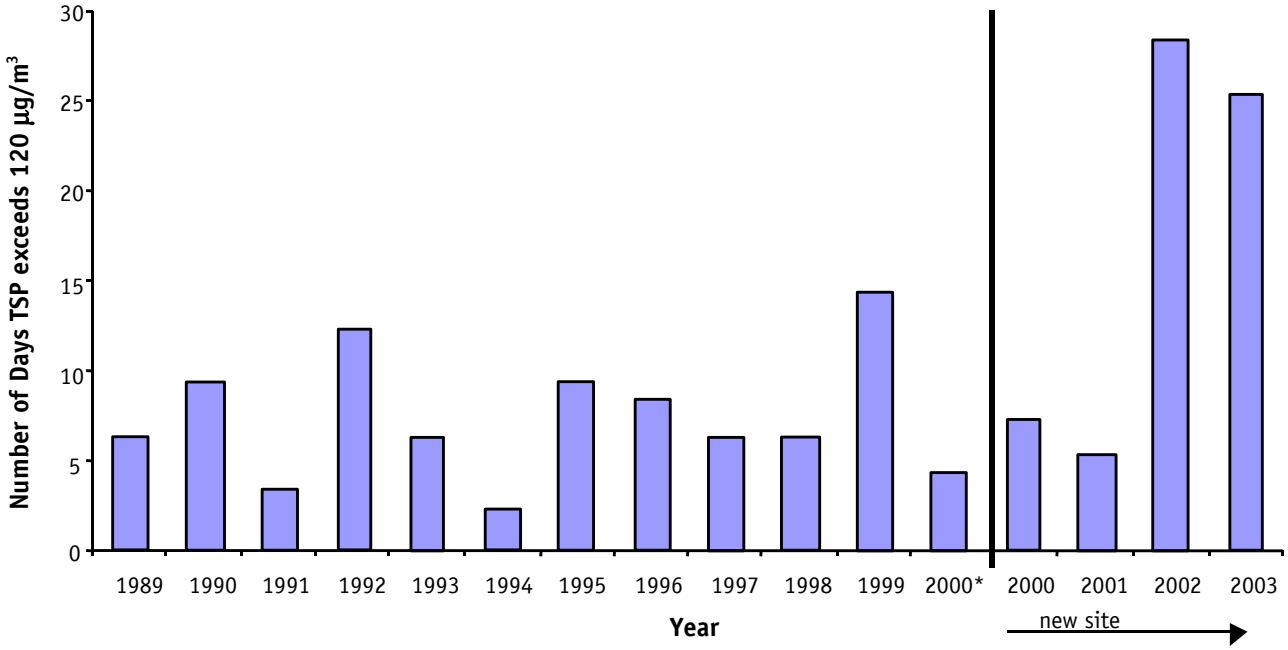

Figure 37 Number of days TSP greater than 120 µg/m^3 at Hummock Hill (old and new) Whyalla

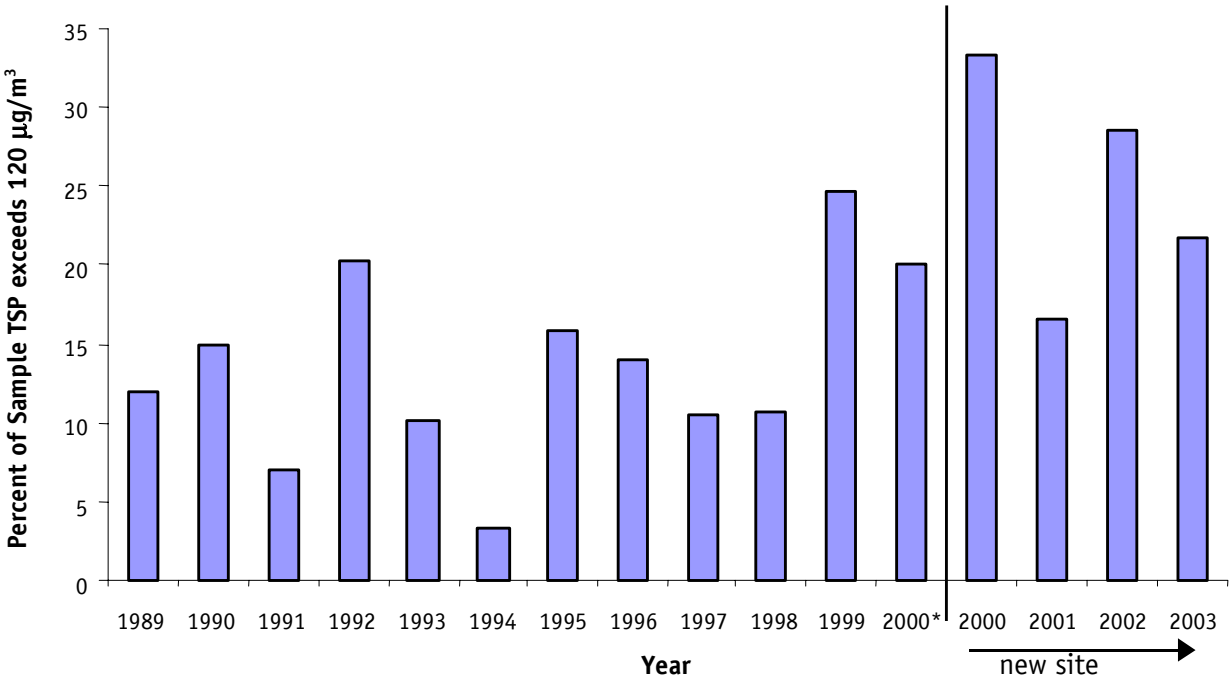

Figure 38 Percentage of samples TSP greater than 120 µg/m^3 at Hummock Hill (old and new) Whyalla

Particle concentrations as TSP did not exceed the WHO guideline of 120 µg/m^3 (measured as a daily average) at Civic Park during 2001 and 2003 but there was one exceedence in 2002 due to a dust storm on 27 August 2002 (Table 43, Figures 39 and 40).

Table 43 Particulate matter (TSP) statistics at Civic Park Whyalla, 1989–2003

Year	Number of days greater than 120 µg/m^3	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1989	0	30	27	88	83	51	49
1990	0	31	28	111	88	53	60
1991	0	31	25	98	88	56	45
1992	0	31	27	96	80	53	59
1993	0	40	32	105	103	75	61
1994	1	45	44	120	91	82	60
1995	0	34	27	91	79	65	57
1996	2	52	50	142	123	98	58
1997	1	47	38	203	119	82	57
1998	2	40	30	184	143	75	54
1999	2	38	33	147	124	73	54
2000	0	30	24	92	90	54	42
2001	0	28	24	80	60	47	30
2002	1	33	27	135	101	59	90
2003	0	27	22	113	90	50	121

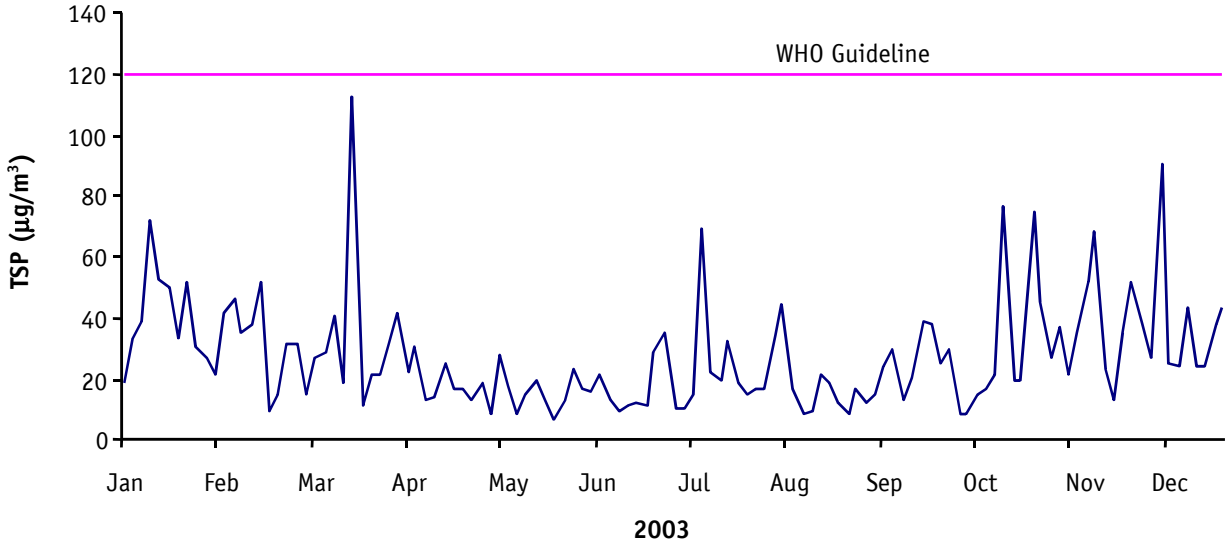

Figure 39 Daily averaged TSP (HVS) at Civic Park Whyalla, 2003

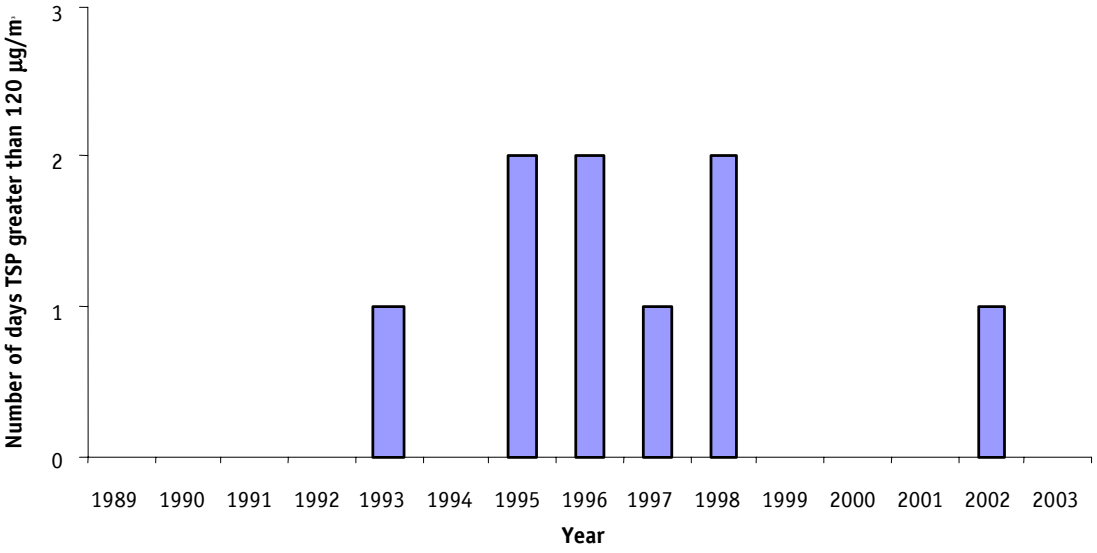

Figure 40 Number of days TSP greater than 120 µg/m^3 at Civic Park Whyalla

Ambient air quality in Port Augusta

Monitoring sites and industry in Port Augusta

Port Augusta is located at the head of the Spencer Gulf and has a population of about 14,000. The major EPA licensed industry in Port Augusta is the production of electricity, by burning brown coal. The locations of the power station and of other EPA licensed premises (in grey) are shown in Figure 41.

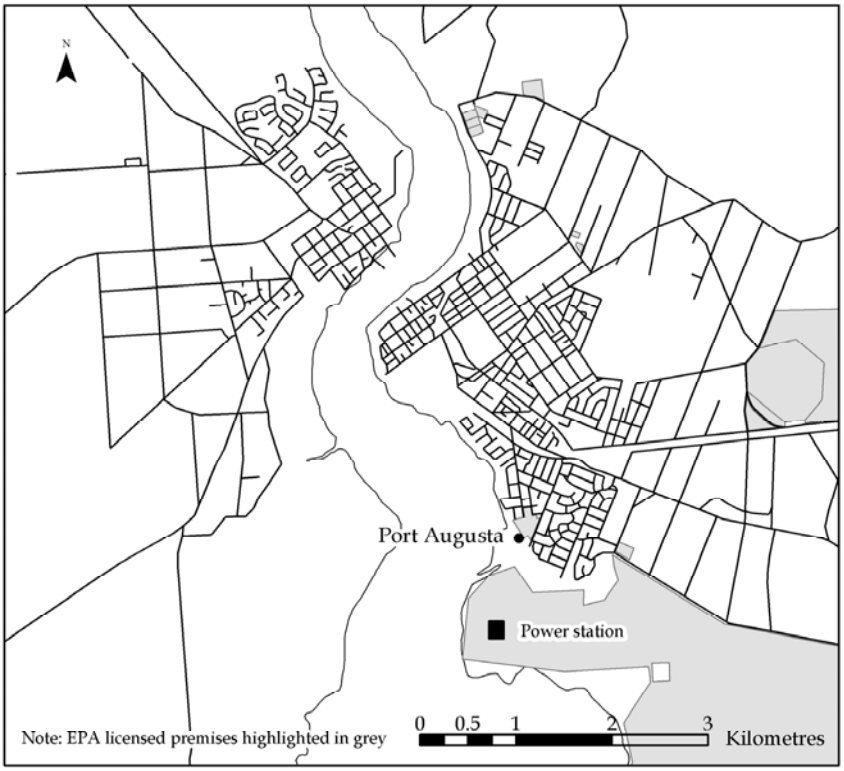

Figure 41 Map of the Port Augusta monitoring site and location of EPA licensed industry

Particulate matter

Particulate matter as PM_{10} (Table 44) is measured at Port Augusta by the HVS method.

One-day averaged concentrations of PM_{10} at Port Augusta did not exceed the NEPM criterion of 50 µg/m^3 in 2001, nor in 2002, but there was one exceedence in 2003 (Figures 42 and 43).

Table 44 Particulate matter (PM_{10}) statistics at Port Augusta, 1996–2003

Year	Number of days greater than 50 µg/m^3	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1996	5	27	19	132	68	40	64	24
1997	7	31	27	86	77	64	55	60
1998	2	17	12	132	54	34	33	60
1999	3	20	14	117	104	28	23	30
2000	2	15	10	100	57	29	23	31
2001	0	11	9	27	26	14	20	27
2002	0	14	12	47	42	29	27	56
2003	1	17	15	62	43	32	32	56

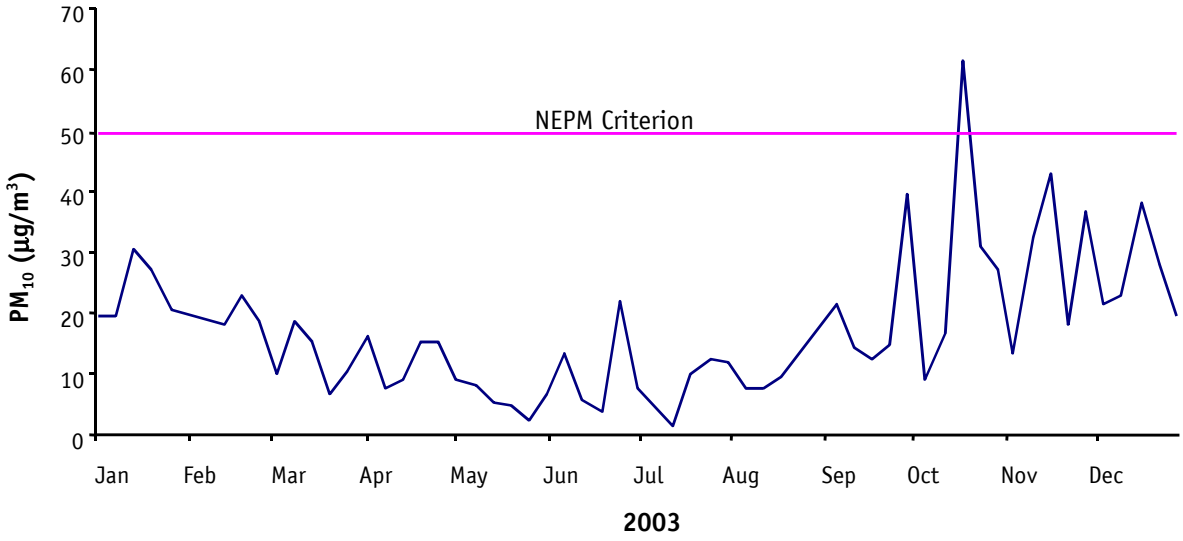

Figure 42 Daily averaged PM_{10} (HVS) at Port Augusta, 2003

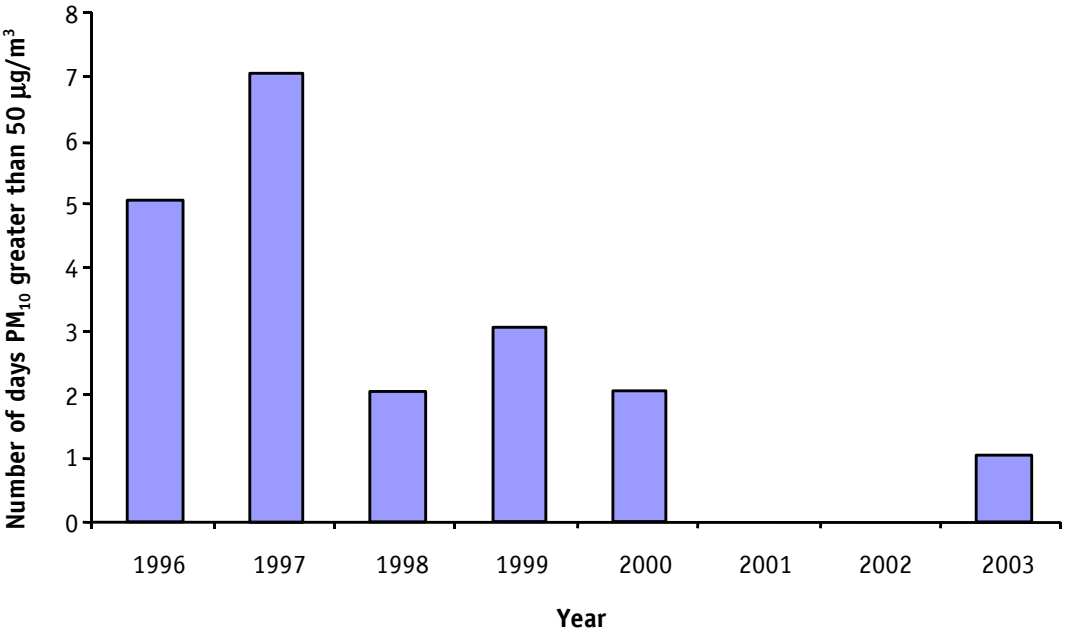

Figure 43 Number of PM_{10} exceedences at Port Augusta

Ambient air quality in Port Pirie

Monitoring sites and industry in Port Pirie

Port Pirie, with a population of about 14,000, lies on the eastern side of the Spencer Gulf. The major EPA licensed industry in Port Pirie is the lead smelter. The locations of the smelter and of other EPA licensed premises (in grey) are shown in Figure 44.

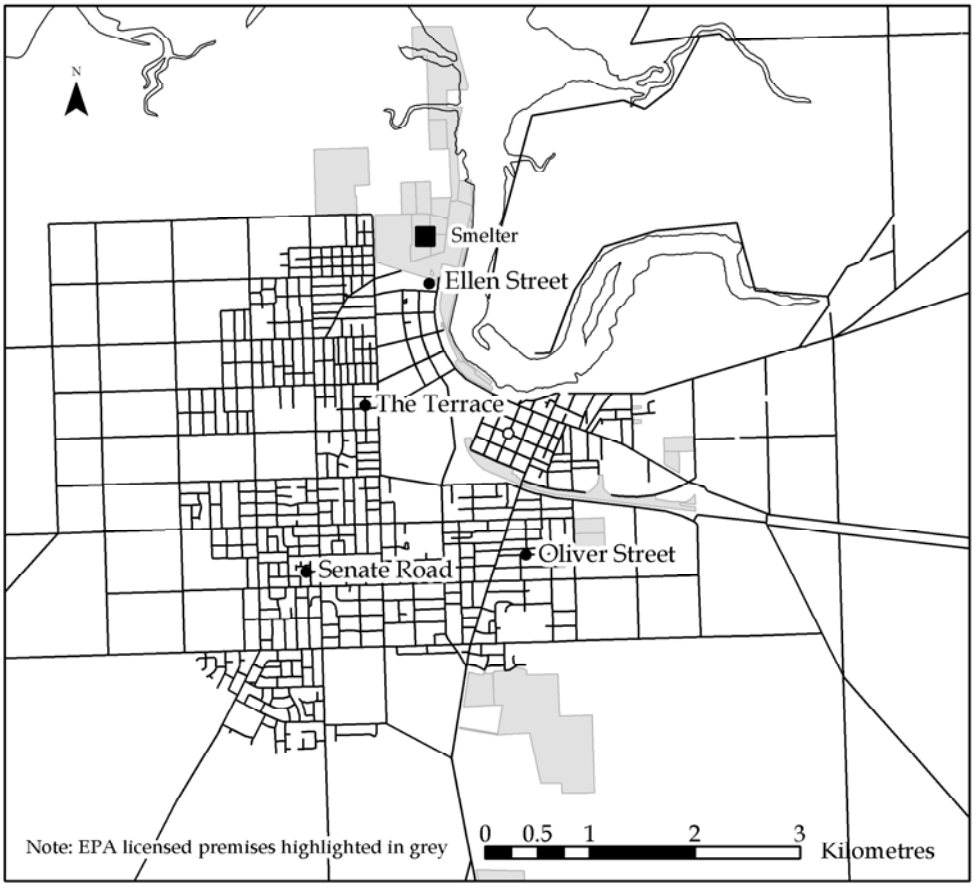

Figure 44 Map of Port Pirie monitoring sites and location of EPA licensed industry

Particulate matter

Particulate matter as PM_{10} (Table 45), which is measured at Port Pirie by the HVS method, TSP and lead have been measured by the EPA and Department of Human Services for many years. Only data collected from sites currently in operation are described in this report.

One-day averaged concentrations of PM_{10} at Oliver Street did not exceed the NEPM criterion of 50 µg/m^3 in 2001. There was one exceedence in 2002 and none in 2003 (Figure 45).

Table 45 Particulate matter (PM_{10}) statistics at Oliver Street Port Pirie, 1998–2003

Year	Number of exceedences of daily NEPM Criterion for PM_{10} (50 µg/m^3)	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	6th highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1998	0	16	16	29	24	19	24	15
1999	3	24	22	143	89	37	33	42
2000	2	23	18	93	58	40	41	44
2001	0	17	17	45	34	21	22	24
2002	1	22	21	57	46	31	31	59
2003	0	21	21	50	46	36	36	53

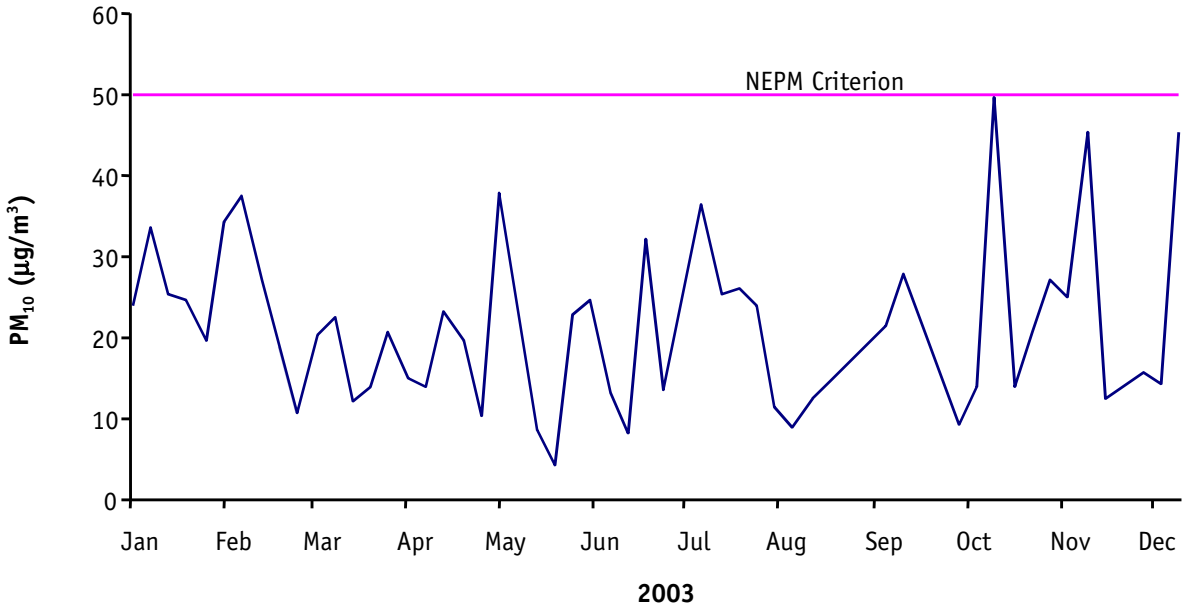

Figure 45 Daily averaged PM_{10} (HVS) at Oliver Street Port Pirie, 2003

Lead

In Port Pirie lead comes from the lead smelter and concentrations remain high compared with suburban Adelaide (Tables 46–49). All lead results are derived from TSP HVS.

Since the mid-1990s, the EPA has monitored lead in Port Pirie, now at four sites. At Oliver Street, the EPA's main ambient monitoring station, the lead criterion of 0.5 µg/m^3 (as an annual average) was very closely approached in 2001 and 2002. In 1999, 2000 and 2003 the lead criterion was exceeded. Data from 2003 are presented in Figure 46.

Table 46 Lead statistics at Oliver Street Port Pirie, 1998–2003

Year	Mean (µg/m³)	Median (µg/m³)	Highest (µg/m³)	2nd highest (µg/m³)	90th percentile (µg/m³)	Number of samples
1998	0.35	0.11	2.76	1.12	0.85	19
1999	1.22	0.44	8.38	5.81	3.89	42
2000	0.50	0.18	3.10	2.56	1.30	43
2001	0.43	0.26	1.63	1.47	0.99	28
2002	0.47	0.25	2.65	2.42	1.14	61
2003	0.59	0.16	4.97	4.71	1.54	59

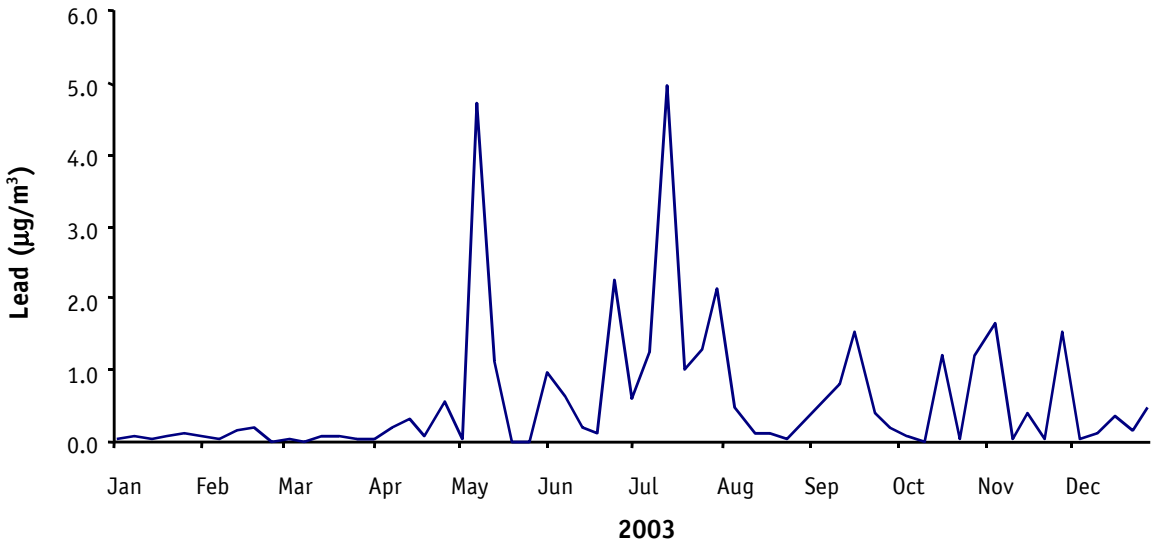

Figure 46 Daily averaged lead at Oliver Street Port Pirie, 2003

Another monitoring site, The Terrace, is located at the Port Pirie West Primary School. Its annual averaged lead concentrations have exceeded the NEPM criterion of 0.5 µg/m³ (as an annual average) each year except 1996, since the station began operating (Table 47, Figure 47).

Table 47 Lead statistics at The Terrace Port Pirie, 1995–2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1995	0.61	0.34	3.45	2.91	1.45	57
1996	0.47	0.22	3.71	3.07	0.91	60
1997	0.67	0.38	6.21	3.38	1.73	60
1998	0.55	0.30	6.55	3.19	1.01	61
1999	0.87	0.42	6.79	4.80	2.05	59
2000	0.59	0.27	3.96	2.47	1.55	44
2001	0.82	0.28	4.48	3.20	2.53	28
2002	0.74	0.23	9.90	3.55	1.30	61
2003	0.72	0.19	4.72	4.37	2.18	54

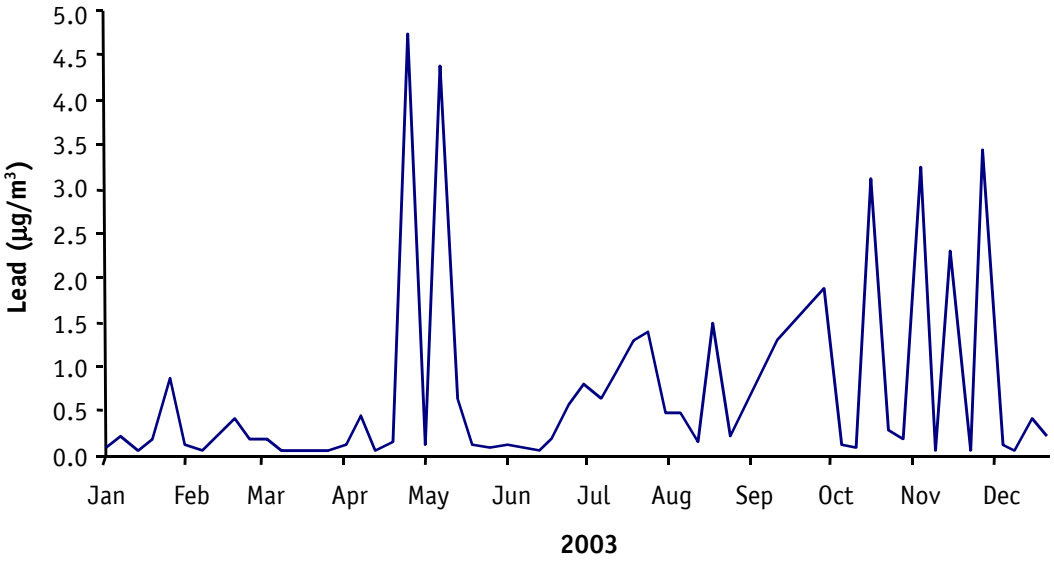

Figure 47 Daily averaged lead at The Terrace Port Pirie, 2003

The Senate Road site is located in Frank Green Park and has the lowest annual averaged concentrations of the four Port Pirie sites. Since 1999, when monitoring at the site began, the annual average has been below the NEPM criterion of 0.5 µg/m^3 (Table 48). All daily averaged lead data in 2003 are presented in Figure 48.

Table 48 Lead statistics at Senate Road Port Pirie, 1999–2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1999	0.37	0.15	1.85	1.68	1.16	48
2000	0.21	0.12	1.56	0.95	0.54	44
2001	0.30	0.06	2.27	0.98	0.75	24
2002	0.21	0.09	1.76	1.04	0.50	61
2003	0.19	0.06	1.00	0.92	0.63	57

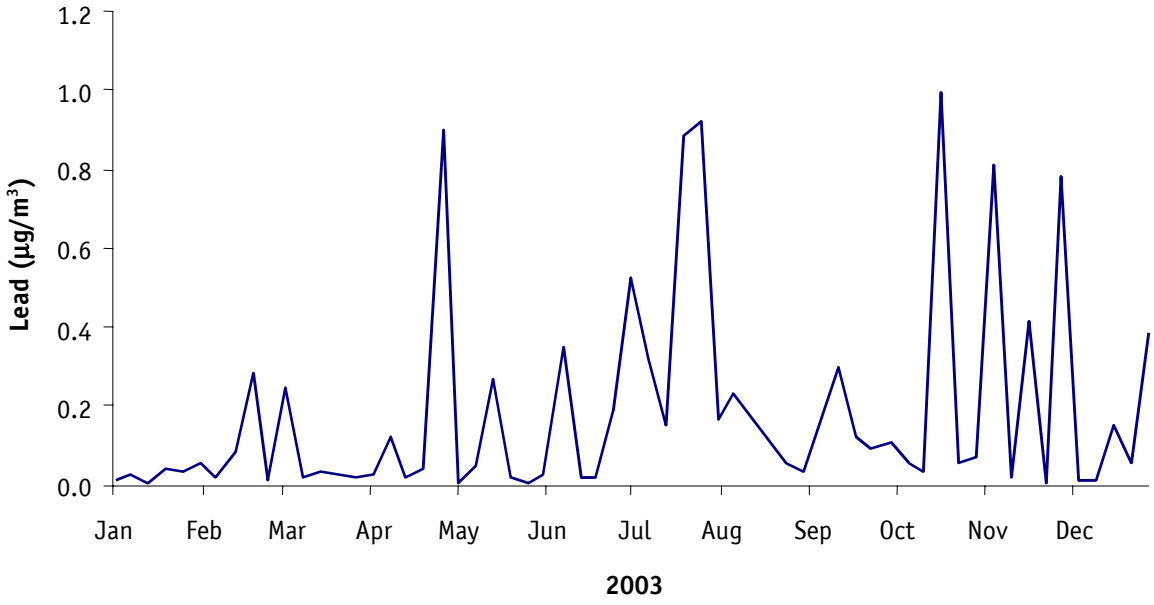

Figure 48 Daily averaged lead at Senate Road Port Pirie, 2003

Monitoring for lead at Ellen Street was discontinued in 1998 but resumed again in July 2001 (Table 49). Being located near the boundary of the smelter, the site's monitoring data are not compared to the NEPM criteria; they are used to evaluate industry performance. All 2003 daily averaged lead data are presented in Figure 49.

Table 49 Lead statistics at Ellen Street Port Pirie, 1995–2003

Year	Mean (µg/m^3)	Median (µg/m^3)	Highest (µg/m^3)	2nd highest (µg/m^3)	90th percentile (µg/m^3)	Number of samples
1995	2.77	1.71	13.26	10.70	5.91	60
1996	2.17	1.31	9.40	8.42	5.19	60
1997	2.78	1.27	18.32	17.22	8.20	59
1998	2.32	1.11	13.45	11.79	4.79	39
1999				*No data available*		
2000				*No data available*		
2001	3.52	1.44	18.41	17.08	9.05	29
2002	3.61	1.75	35.15	16.93	6.37	61
2003	3.44	1.32	20.35	14.09	10.20	59

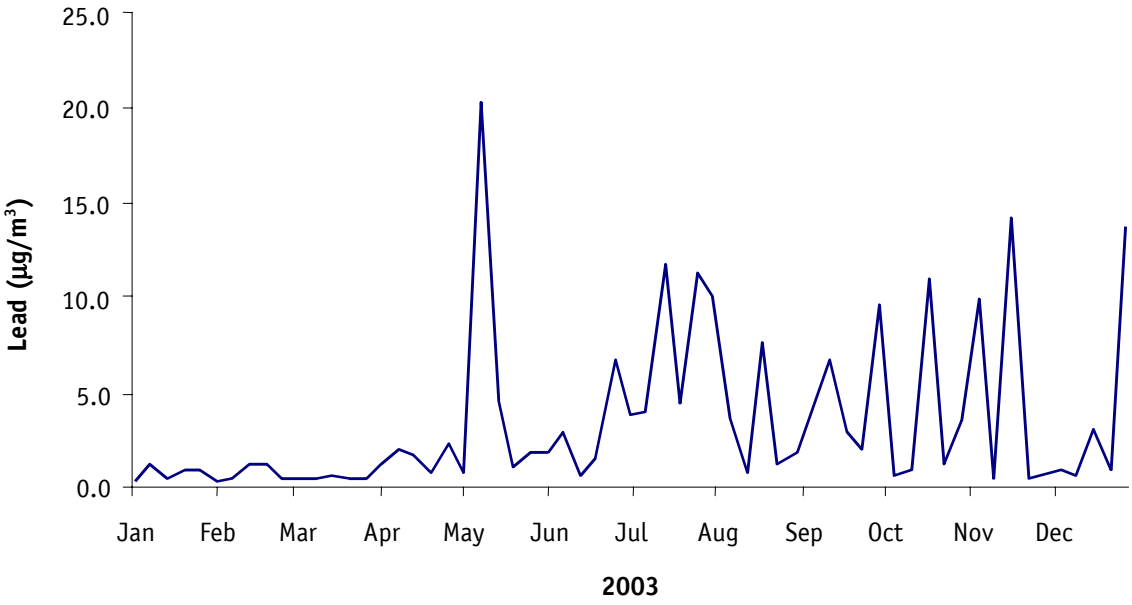

Figure 49 Daily averaged lead at Ellen Street Port Pirie, 2003

For a discussion on the lead abatement program and lead research in Port Pirie see Maynard et al. (2003).

Sulfur dioxide

SO_2 is measured only at the Oliver Street site in Port Pirie where monitoring began in June 2002 as part of NEPM campaign monitoring.

In 2002, one-hour averages of SO_2 were within the range 0–0.656 ppm, with an average for the five months of monitoring of 0.010 ppm. The one-hour average for 2003 was 0.008 ppm. From 26 June to 31 December 2002, 23 exceedences of the one-hour NEPM criterion (0.20 ppm) were recorded and 27 for 2003 (Table 50 and Figure 50). The one-day NEPM criterion was not exceeded in 2002 and was exceeded once in 2003 (Figure 51).

Table 50 Sulfur dioxide statistics at Oliver Street Port Pirie, June 2002–December 2003

Year	Number of exceedences of 1 hour NEPM Criterion for SO_2 (0.20 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	23	0.656	0.021	0.146	98
2003	27	0.487	0.147	0.388	96

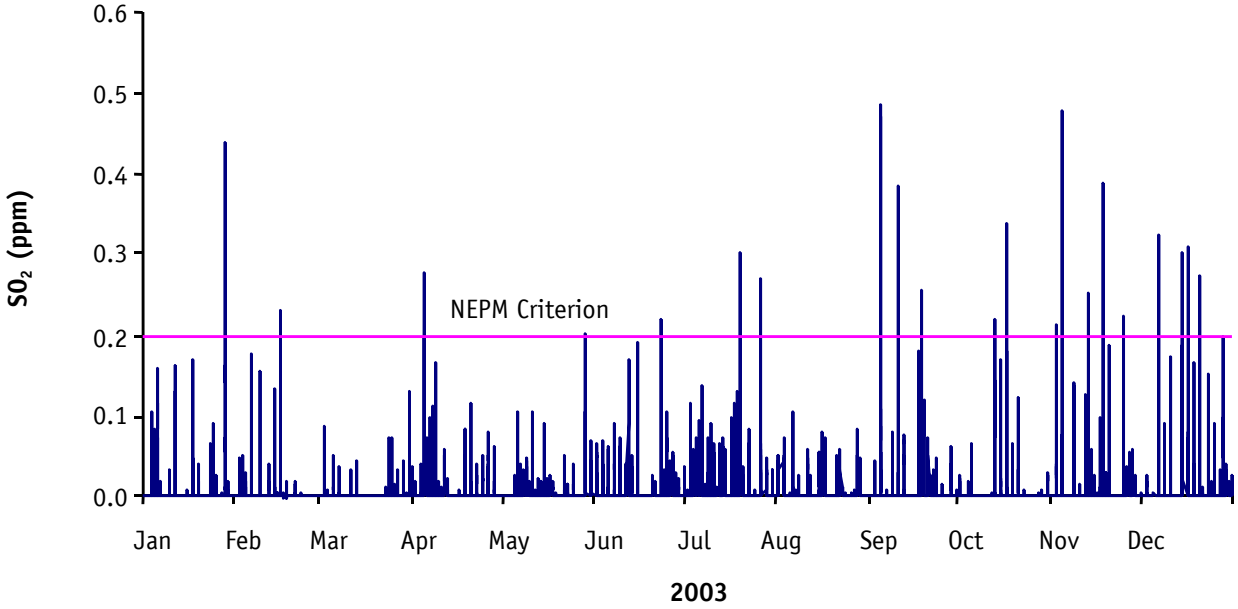

Figure 50 One-hour averaged SO_2 at Oliver Street Port Pirie, 2003

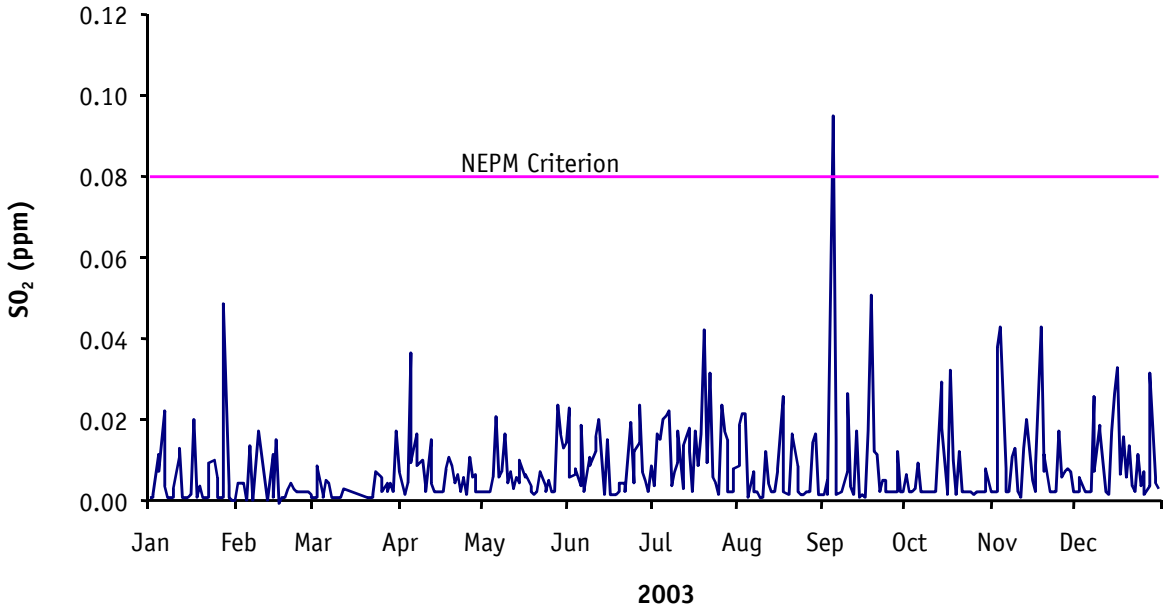

Figure 51 One-day averaged SO_2 at Oliver Street Port Pirie, 2003

Nitrogen dioxide

NO_2 is measured only at the Oliver Street site in Port Pirie where monitoring began in June 2002 as part of NEPM campaign monitoring.

In 2002, one-hour averages of NO_2 were within the range 0–0.019 ppm, with an average for the five months of monitoring of 0.003 ppm. The one-hour average for 2003 was 0.003 ppm. This is very low compared to the averages at Northfield and Netley (in Adelaide), of 0.007 ppm and 0.009 ppm, respectively. No exceedences of the NO_2 NEPM criterion were recorded in either year (Table 51, Figure 52).

Table 51 Nitrogen dioxide statistics at Oliver Street Port Pirie, June 2002–December 2003

Year	Number of exceedences of 1 hour NEPM Criterion for NO_2 (0.12 ppm)	Maximum concentration (ppm)	90th percentile (ppm)	99th percentile (ppm)	Data recovery (%)
2002	0	0.019	0.007	0.013	54
2003	0	0.016	0.006	0.011	93

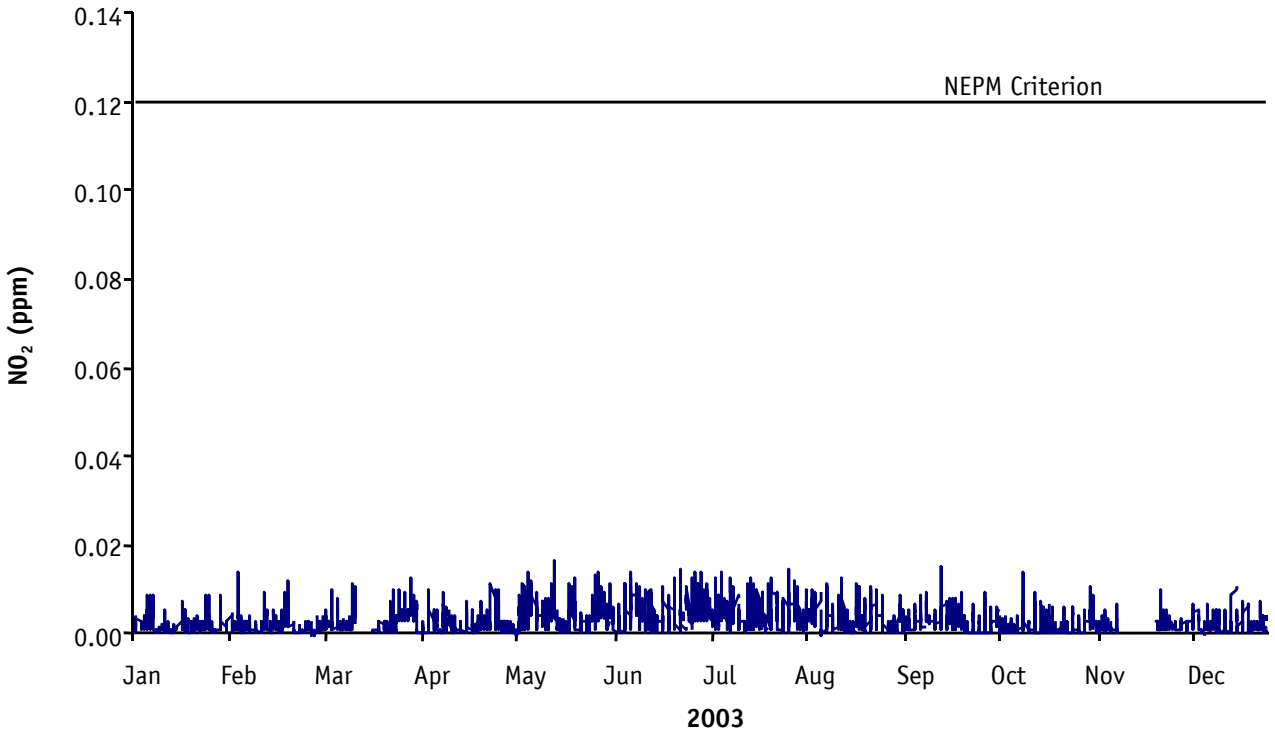

Figure 52 One-hour averaged NO_2 at Oliver Street Port Pirie, 2003

Air quality index—Summary of Adelaide's air quality in 2001–2002

Based on data from two AQI sites (Netley and Kensington) for nearly four months of monitoring during 2001, Adelaide's air quality was classified as 'very good' for 64% of the time, and 'good' for 36% (the remainder) of the time. Results were derived from ozone, NO_2 and particles as PM_{10}.

In 2002 more sites and more parameters were measured. During this time dust storms occasionally elevated the index into the 'fair' and 'very poor' range and were reported on the EPA AQI web site. For example, during 2002, (see Figure 53) for 41% of the time Adelaide's air quality was classified as very good, for 46% as good, for 9% as fair, for 2% as poor and for 1% as very poor (see *www.environment.sa.gov.au/reporting/atmosphere/airindex_sum.html)*.

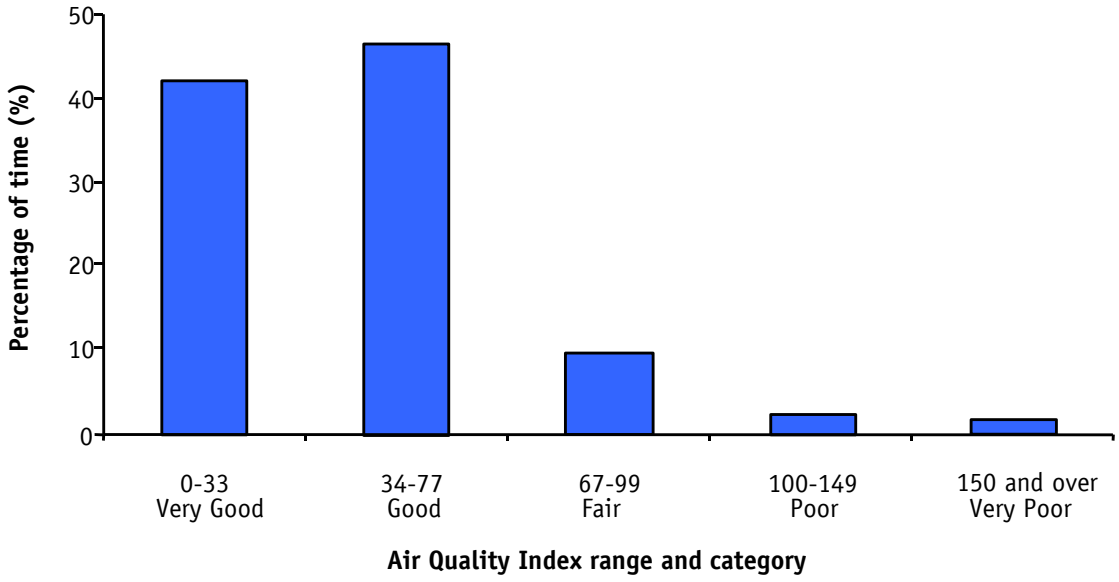

Figure 53 Adelaide air quality summary, 2002

CONCLUDING REMARKS

Trends in South Australia's air quality

CO has been monitored at Hindley Street since 1988, and shown a reduction over that time in exceedences of the NEPM criteria. Improved fuel composition and the manufacture of more efficient engines have been major contributors to the decrease.

SO_2 has been monitored at Christies Beach since 1992, because of the presence of the oil refinery. The number of exceedences decreased significantly when a sulfur recovery plant was installed before the closure of the refinery in July 2003. The high number of exceedences in 1995–1996 can be attributed to the sulfur recovery plant being out of operation for about six months in that period.

NO_2 has been monitored at Northfield since 1979 and Netley since 1988. In general there have been few exceedences at either site. One exception was at Northfield in 1984 when 52 exceedences were recorded, possibly due to the Dry Creek gas-fuelled peak power plant, over an unusually cold winter. Netley, in 1989, had 35 exceedences, which may also be attributed to the Dry Creek power station. The 90th percentile around this time at Netley, or earlier at Northfield, did not vary greatly, so exceedences reflect extreme events, not the norm. There is some evidence of a downward trend in NO_2 at Netley and Northfield.

Since O_3 began to be measured at Northfield in 1979 and Netley in 1988, concentrations at these sites have been consistently low and have changed little.

Particulates as PM_{10} have been measured at Osborne since 1988 and were measured at Thebarton from 1993 to 2002. Exceedences of the NEPM criterion were low at Thebarton and did not occur more than the accepted rate of 5 days per year for any year of operation. Monitoring at Osborne, near a cement manufacturing plant, has shown very few exceedences over the entire time of operation with the average concentration varying little over the period.

Lead was monitored at Thebarton from 1993 to 2002 and at Port Adelaide from 1981 to 2001. Both sites show the dramatic decline of lead in air since unleaded petrol was introduced in 1986 and the unavailability of leaded petrol from August 2000. Lead is no longer monitored in Adelaide.

TSP have been measured at two sites in Whyalla since 1989 and PM_{10} has been measured at Hummock Hill since 1990. The plots for particulates at Hummock Hill show that particle concentrations fell from 1993 to 1998 but then increased over the next three years. Levels of PM_{10} at Civic Park have been low since monitoring began in 1989. Insufficient data are available from the Walls Street site to assess trends.

Only PM_{10} is measured at Port Augusta. This site, which began in 1996, has not been operating long enough to be designated a trend site but data collected so far show that particulate exceedences have reduced since 1996 and are not a significant problem in Port Augusta.

Lead has been monitored at two sites in Port Pirie since 1995. In Port Pirie the mean lead concentration seems to be increasing at Ellen Street (next to the smelter) and at The Terrace (the site of the Port Pirie West Primary School) and reducing at Senate Road.

The variability in data from year to year for all other parameters does not allow firm conclusions to be made about trends in ambient concentrations.

The EPA is reviewing the monitoring program for SO_2 and CO in Adelaide as concentrations have remained consistently well below the NEPM criteria. The monitoring program for particles, ozone and NO_2 is also being assessed.

Recent progress by the EPA

Since July 2001, the EPA has made progress towards improved air pollution monitoring across the State. The redevelopment of the monitoring network is mostly complete and has included:

- purchase and installation of new monitoring equipment;
- improved maintenance of high volume particle samplers;
- complete rebuilding of five fixed and two mobile monitoring stations;
- construction and use of a mobile hotspot pollution and meteorological monitoring caravan;
- substantial renovation of the EPA's Netley air quality monitoring laboratory;
- an automatically updated AQI and internet reports on the ongoing quality of South Australia's air;
- establishment and operation of a hotspot monitoring facility.

Recent initiatives

A number of recent initiatives are helping the EPA gain a better understanding of the impacts that some pollution sources have on our health and well-being. These include:

- taking part in a national particle composition study (trials began in late 2002);
- working with the Department of Human Services to assess health risk and develop hotspot monitoring programs;
- contributing to the development of the Air NEPM for $PM_{2.5}$ particles (see *www.ephc.gov.au/nepms/air/air_variation.html*), the Air Toxics NEPM (see *www.ea.gov.au/atmosphere/airtoxics/index.html* and *www.ephc.gov.au/nepms/air/air_toxics.html)* and a National Air Quality Index (see *www.ea.gov.au/atmosphere/airquality/monitoring.html);*
- investigating methods for estimating biogenic emissions (vegetation sources) and adding the information to anthropogenic emission (human sources) inventories for improved airshed modelling;
- monitoring air quality from more locations throughout Adelaide (see Environment Protection Agency 2001).

How we can all contribute to improving air quality

The goal of further improving air quality will be a challenge for us all as it requires significant changes to our lifestyles. For those with a car-dependent lifestyles, congestion is a problem and the density of traffic and start–stop driving is also likely to affect local air quality. EPA research shows that, together, area based sources and motor vehicles are the largest single contributor to Adelaide's air pollution (Ciuk 2002). Industry must also continue playing its part in reducing emissions.

An integrated and comprehensive response that addresses all emission sources is the most effective approach. The EPA thus continues to focus on:

- the move to cleaner production by industry
- the extent to which we use vehicles
- the way vehicles are maintained and the quality of fuels they use
- choices of heating in the home.

We all need to do things differently if we want to improve air quality.

Acknowledgments

The EPA would like to thank the Department of Human Services and Transport SA for their comments on this report. Special thanks also go to Dr Jorg Hacker and Professor Neville Clark from the School of Physics, Chemistry and Earth Sciences, at Flinders University of South Australia, for reviewing this report.

BIBLIOGRAPHY

Adeeb, F. 2003. *Ambient Air Quality Monitoring – Mount Gambier, September 2001–August 2002*. Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/aq_mtgambier.pdf*

Adeeb, F, Mitchell, R and Hope, L. 2003. *Future air quality monitoring for lead in metropolitan Adelaide.* Report to the National Environment Protection Council. EPA, Adelaide.

American Lung Association. 2000. *Outdoor air quality: sulfur dioxide.* *www.lungusa.org/*

Best, P. 2004. *Report from Katestone Environmental to the South Australian Environment Protection Authority. Causal factors for apparent deterioration of dust levels at Hummock Hill, Whyalla*. Katestone Environmental

Brunekreef, B, and Holgate, ST. 2002. Air pollution and health. *The Lancet*, 360(9341), 1233.

Ciuk, J. 2002. *South Australian National Pollutant Inventory: Summary report – Adelaide and regional airsheds air emissions study 1998–99*. Environment Protection Authority, Adelaide. *http://www.epa.sa.gov.au/pdfs/npi_air.pdf*

Ciuk, J, Volkmer. RE and Edwards, JW. 2001. Domestic nitrogen oxide exposure, urinary nitrate, and asthma prevalence in preschool children. *Archives of Environmental Health*, 56 (5), 433.

Definition of Terms and Explanations, Environment Protection and Heritage Council. *www.ephc.gov.au/nepms/goals_nepm.html*

Devalia, JL, Rusznak, C, Wang, J, Khair, OA, Abdelaziz, MM, Calderon MA and Davies, RJ. 1996. Air pollutants and respiratory hypersensitivity, *Toxicology Letters*, 86, 169–76.

Environment Protection and Heritage Council. 2004 (viewed). NEPMs explained. *www.ephc.gov.au/nepms/nepms.html*

Environment Protection Agency. 2001. *Ambient air quality monitoring plan for South Australia,* for the National Environment Protection (Ambient Air Quality) Measure. Environment Protection Authority, Adelaide. *www.epa.sa.gov.au/pdfs/airnepm.pdf*

Environment Protection Authority Air Monitoring Unit. 2003. *Air Monitoring Report 2002: Compliance with the National Environment Protection (Ambient Air Quality) Measure. www.nepc.gov.au/ephc/pdf/Air_Quality_NEPM/Monitoring2002/sa_2002_air_nepm_report.pdf*

Fox, DR. 2004. *Statistical analysis of Whyalla air quality monitoring data.* Australian Centre for Environmetrics, Report 01/04.

Gehring, U, Cyrys, J, Sedlmeir, G, Brunekreef, B, Bellander, T, Fischer, P, Bauer, CP, Reinhardt, D, Wichmann, HE and Heinrich, J. 2002. Traffic-related air pollution and respiratory health during the first 2 yrs of life, *European Respiratory Journal*, 19: 690-98.

Maynard E, Thomas R, Simon D, Phipps C, Ward C and Calder I. 2003. An evaluation of recent blood lead levels in Port Pirie, South Australia. *The Science of the Total Environment*, 303(1–2), 25–33.

National Environment Protection Council. 1998. *National Environment Protection (Ambient Air Quality) Measure. www.ephc.gov.au/nepms/air/air_nepm.html*

National Environment Protection Council. 1998. *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement. www.nepc.gov.au/ephc/orders.php*

National Environment Protection Council. 2003. *Variation to the National Environment Protection (Ambient Air Quality) Measure for Particles as $PM_{2.5}$.* www.nepc.gov.au/ephc/pdf/Air_Variation_PM25/PM2_5_Variation.pdf

National Environment Protection Council. 2004. *National Environment Protection (Air Toxics) Measure*. *www.ephc.gov.au/news.html.#AS_NEPM*

National Occupational Health and Safety Commission. no date. *Exposure standards, carbon monoxide*. *www.nohsc.gov.au/OHSInformation/Databases/ExposureStandards/az/Carbon_monoxide.htm*

NEPC Peer Review Committee. 2002. *National Environment Protection (Ambient Air Quality) Measure: Technical Paper No 8: Annual Reports*. National Environment Protection Council. *www.ephc.gov.au/prc/pdf/TP8_Annual_Reports.pdf*

New York State Department of Health. 2001. *Info for Consumers: Ozone questions and answers*. *www.health.state.ny.us/nysdoh/environ/ozoneq&a.htm*

O'Dwyer, LA. 2001. Using GIS to identify risk of elevated blood lead levels in children in Adelaide. *Australian Geographical Studies*, 39(1), 75–90.

Swan, N. 2003. Dirty diesel. *The Health Report*, Radio National. Monday 28 April. *www.abc.net.au/rn/talks/8.30/helthrpt/stories/s838424.htm*

Tanner RL. 2003. Measurements in support of air quality improvement – some historical insights. *Atmospheric Environment*, 37, 1271–76.

University of the Western Cape, Department of Botany. 2001. *Enviro Facts: Ozone*. *www.botany.uwc.ac.za/Envfacts/facts/ozone.htm*

US Environmental Protection Agency. 2004. Smog—Who does it hurt? What you need to know about ozone and your health. *www.epa.gov/airnow/health/smog1.html#3*

Woodruff, TJ, Grillo, J and Schoendorf, KC. 1997. The relationship between selected causes of postneonatal infant mortality and particulate air pollution in the United States. *Environmental Health Perspectives*, 105(6), 608.

Woodward, A, Guest, C, Steer, K, Harman, A, Scicchitano, R, Pisaniello, D, Calder, I and McMichael, A. 1995. Tropospheric ozone: respiratory effects and Australian air quality goals. *Journal of Epidemiology and Community Health*, 49, 401–407.

World Health Organization. 2001. *Air quality guidelines for Europe*. WHO Regional Publications, European Series, No. 91 *www.euro.who.int/air/Activities/20020620_1*

Web sites

SA Environment Protection Authority. Air quality publications. *www.epa.sa.gov.au/pub_air.html*

SA Environment Protection Authority. *State of Environment Report 1998 – Summary* *www.environment.sa.gov.au/sustainability/reports/ser_summary/index.html*

SA Environment Protection Authority. *State of Environment Report 2003* *www.environment.sa.gov.au/soe2003/report.html*

SA Environment Protection Authority. Air Quality Index. *www.environment.sa.gov.au/reporting/atmosphere/airindex_sum.html*

Environment Australia. Atmosphere. *www.ea.gov.au/atmosphere/index.html*

Environment Protection Heritage Council (incorporating the National Environment Protection Council). *www.ephc.gov.au*

US Environment Protection Agency. Integrated Risk Information System (IRIS). *www.epa.gov/iriswebp/iris/index.html*