



FUTURE AIR QUALITY MONITORING FOR LEAD IN METROPOLITAN ADELAIDE



Government
of South Australia



South Australia



**Future Air Quality Monitoring for Lead
in Metropolitan Adelaide—
a report to the National Environment Protection Council**

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SUMMARY

This report provides an overview of the currently available data on ambient air levels of atmospheric particulate lead in metropolitan Adelaide, with a view to identifying and discussing trends found in the data and making recommendations regarding future monitoring.

The ambient concentration of atmospheric particulate lead is routinely measured in the metropolitan areas of Australia, where the main emission sources are motor vehicle exhausts. In metropolitan Adelaide, the amount of lead in the air has been measured for more than two decades at a variety of locations, including peak sites at Thebarton and Gilles Plains. This long-term monitoring has shown that, since the reduction of lead levels in petrol began in late 1980s, the concentration of total suspended particulate (TSP) lead in Adelaide's air has reduced to levels well below the accepted standards.

In 1995, when leaded petrol was still extensively used, the average ambient lead level at the heavily trafficked Thebarton monitoring site was $1.0 \mu\text{g}/\text{m}^3$. By 2000 the level had dropped to around $0.2 \mu\text{g}/\text{m}^3$. In 2002, when lead in petrol was phased out completely, it was $0.02 \mu\text{g}/\text{m}^3$. Over a period of fourteen years since lead-free petrol was first introduced, lead concentrations in metropolitan Adelaide's air have reduced significantly. In both 2001 and 2002, levels were well below 10% of the National Environment Protection Measure (NEPM) standard of $0.5 \mu\text{g}/\text{m}^3$. At some monitoring sites, lead levels have dropped to below 1% of the standard.

On the basis of this data, TSP lead monitoring is no longer required in metropolitan Adelaide for NEPM purposes as there is no major emission source of lead in the air-shed.

INTRODUCTION

According to the 2001 Census, just over 70% (73.3%) of South Australia's population is concentrated in the Adelaide metropolitan area.

Adelaide is a Type 1 region as detailed in the National Environment Protection Council (NEPC) Peer Review Committee (PRC) guideline paper No. 2. The metropolitan area is confined by the Mount Lofty Ranges to the east and south, where they meet the sea at Willunga, and by the sea to the west. To the north the air-shed is open and pollutants, given suitable meteorological conditions, are able to move up the coast beyond Gawler.

In the Adelaide metropolitan area an air quality monitoring network has been developed, based on knowledge of local conditions and a need to protect specific populations such as school children from particular pollutants, e.g. roadside lead (Pb). Long-term monitoring for lead in atmospheric particulates, mainly as TSP, has been conducted over two decades because of the presence of lead in petrol and concerns about exposure of the local population to lead.

This report provides an assessment of the currently available data on ambient air levels of atmospheric particulate lead in metropolitan Adelaide, and identifies and discusses the long-term trends found in the data.

DESCRIPTION AND SOURCES

Sources of lead

Lead is a cumulative toxic metal emitted into the air from both mobile and stationary sources. Mobile sources are vehicles that use leaded fuel. Major stationary sources include metal smelters, lead battery plants, mining operations and waste incinerators.

Lead emissions due to leaded fuels and associated activities contribute about 98% of airborne lead in Adelaide's air-shed¹ as seen in Table 1. Motor vehicle emission control is therefore a priority in Adelaide's air quality management, and removal of leaded petrol from the market will remove the majority of sources of airborne lead.

Table 1 NPI emission data for Adelaide air-shed for lead and compounds (1998-1999)

Source	Total (kg)	% of Total
Motor vehicles	35301.24	54.6
Paved roads ²	28000.00	43.3
Aeroplanes	920.13	1.4
Lawn mowing	350.00	0.5
Solid fuel burning (domestic)	58.00	0.1
Fuel combustion - sub reporting threshold facilities	13.47	0.0
Recreational boating	8.60	0.0
Gaseous fuel burning (domestic)	1.72	0.0
Commercial shipping/boating	0.72	0.0
Service stations	0.41	0.0
Railways	0.38	0.0

Health effects

Lead ranks as one of the more serious environmental threats to human health, especially in urban areas. Exposure can occur through a number of pathways including ingestion and inhalation. Lead affects several physiological processes including the blood-forming, reproductive, nervous and renal (kidney) systems.

Lead standard for ambient air

The NEPM for ambient air quality was finalised by the NEPC in 1998. It establishes national standards and goals for the six most significant ambient (outdoor) air pollutants: carbon monoxide (CO), nitrogen dioxide (NO₂), photochemical oxidants such as ozone, sulfur dioxide (SO₂), lead (Pb), and particulate matter of less than ten microns (PM₁₀).

¹ The major source of lead in air in the region was due to the addition of tetra ethyl lead to petrol to enhance the anti-knock and octane qualities of fuel.

² The paved road contribution comes from secondary re-entrainment of lead deposited on the road due to wind and vehicle movement.

The desired outcome of the ambient air quality NEPM is the adequate protection of human health and wellbeing. The NEPM standard for lead is $0.5 \mu\text{g}/\text{m}^3$ measured as a component of TSP, averaged over one year.

National phasing out of leaded petrol

Lead standard for fuel

The principal source of public exposure to airborne lead in major Australian cities is the emissions from motor vehicles using leaded petrol. Historically, lead alkyl additives were added to petrol as inexpensive octane extenders. Concerns over health effects associated with the use of this additive resulted in many markets eliminating leaded petrol.

Since the introduction of unleaded petrol in the late 1980s, amounts of lead in Australia's atmosphere have been steadily decreasing. The nation-wide phasing out of leaded petrol was completed on 1 January 2002.

A significant aspect of the national fuel quality standard was that the supply of leaded petrol (i.e. containing more than 0.005 grams per litre of lead in any grade) was prohibited nationally from 1 January 2002. The new standards are prescribed in the *Fuel Standard (Petrol) Determination 2001* and the *Fuel Standard (Diesel) Determination 2001*, which have been made under the *Fuel Quality Standards Act 2000* (the Act). The Act is also implemented through the *Fuel Quality Standards Regulations 2001*.

SAMPLING LOCATIONS AND MONITORING METHODS

Monitoring sites in metropolitan Adelaide

The monitoring sites in metropolitan Adelaide cover a variety of locations including suburban, inner-city, and alongside major high traffic flows, with most of them directed at measuring the effects of motor vehicle emissions. TSP lead is monitored at Thebarton, Gilles Plains, Kensington Gardens, Northfield and Parkside (refer to Figure 1 for location of monitoring sites). Monitoring at the Port Adelaide site was discontinued in 2001 due to site redevelopment.



Figure 1 TSP lead monitoring sites in metropolitan Adelaide

Monitoring methods

Monitor type

In accordance with NEPM technical paper No. 9 prepared by the PRC (May 2001), particulate lead was sampled using a high volume air sampler (Control Engineering) with a TSP sampling head.

Measurement principle

Lead in particulate matter is determined using Australian Standard AS 2800 (1985), which involves collection of TSP followed by analysis for lead using atomic absorption spectroscopy.

High volume air samplers are run on a six-day rotational cycle. The sampler draws air through a filter paper in an evenly distributed pattern at a known constant flow rate for 24 hours. Prior to loading, and after exposure, the filter papers are conditioned in a controlled environment at 25°C and less than 50% humidity. The filter papers are weighed before and after exposure using a high precision, four-place balance. The resulting increase in the weight of the filter paper represents the total airborne particulates in the air of volume (flow rate x time). The Q (flow rate) is automatically controlled to within ± 1 standard cubic metre per hour.

Collected particles on the filter paper are analysed for lead (Australian Standard AS 2800) using a nitric acid extraction method followed by analysis using atomic absorption spectroscopy. The high volume sampler conforms to Australian Standard AS 2724.3, and siting requirements to Australian Standard AS 2922.

RESULTS AND DISCUSSION

Eliminating leaded petrol has had a swift and marked effect on ambient lead levels. As Figure 2 (a-e) shows, the average ambient lead levels at all monitoring sites declined as lead was phased out over the period 1989 to 2002. In 1995, when leaded petrol was still used extensively, the average ambient lead level at the heavily trafficked Thebarton monitoring site³ was $1.0 \mu\text{g}/\text{m}^3$. In 2000 it had dropped to around $0.2 \mu\text{g}/\text{m}^3$, and in 2002 it was $0.02 \mu\text{g}/\text{m}^3$. Consistently decreasing trends in TSP lead concentrations were also noticed at the Gilles Plains peak monitoring station, where the lead concentration dropped from $0.65 \mu\text{g}/\text{m}^3$ in 1995 to $0.02 \mu\text{g}/\text{m}^3$ in 2002 (Figure 2 d). Similar improvements in lead air quality have been observed at all other historical monitoring sites in Adelaide. Lead measurements at these sites are consistently below 10% of the annual NEPM standard of $0.5 \mu\text{g}/\text{m}^3$, with the maximum individual sample for 2002 being $0.049 \mu\text{g}/\text{m}^3$ at the Thebarton monitoring site.

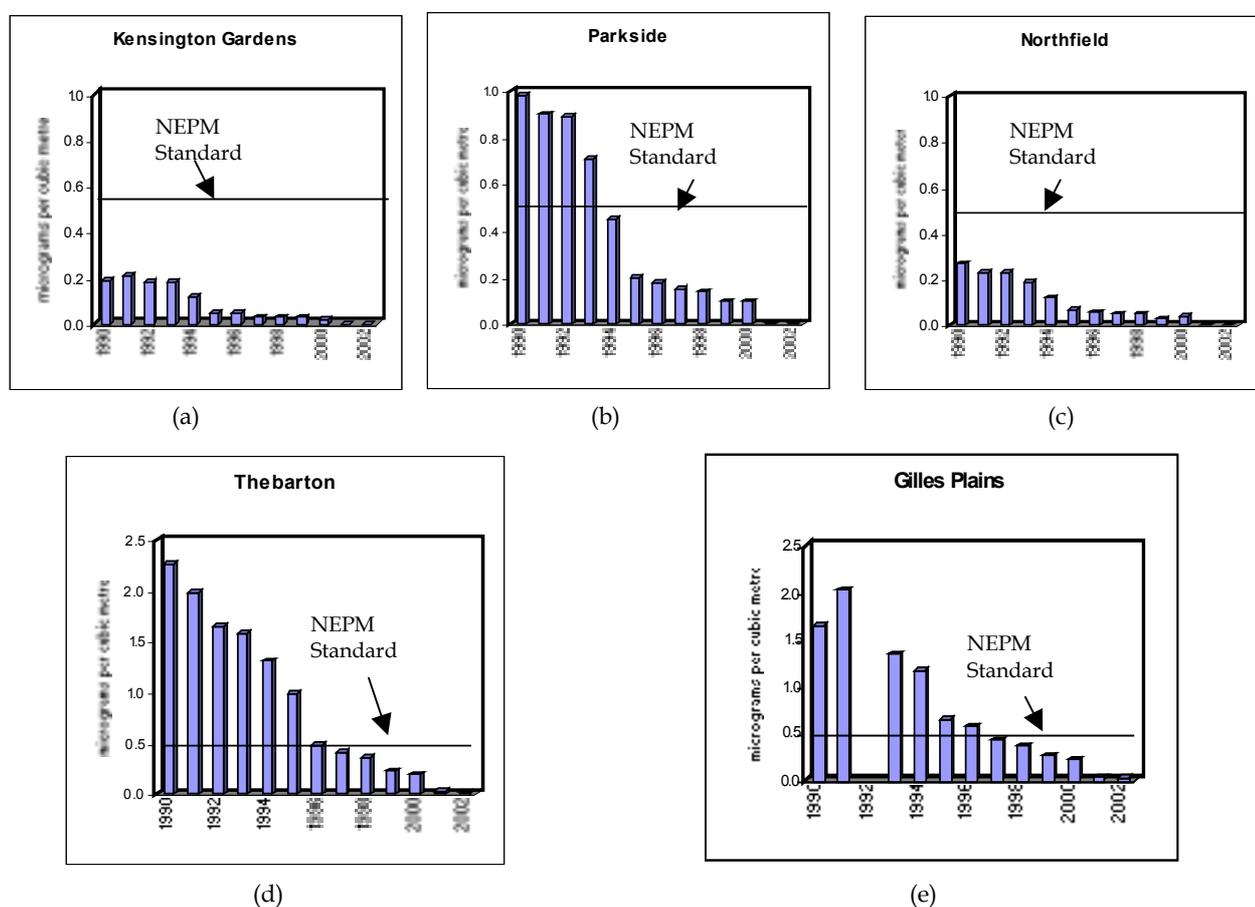


Figure 2 Annual average airborne lead concentration at various monitoring sites in metropolitan Adelaide, 1990-2002

³ Thebarton monitoring site provides an upper limit on concentrations caused by motor vehicle emissions, which are the only significant source of particulate lead in metropolitan Adelaide.

Table 2 shows trends in ambient lead levels as a percent of the ambient air quality NEPM standard ($0.5 \mu\text{g}/\text{m}^3$) for the period 1990 to 2002. As indicated in Table 1, there were no notable exceedences during 2001 and 2002, and TSP lead levels were below 10% of the ambient air quality NEPM (i.e. $< 0.05 \mu\text{g}/\text{m}^3$) at all five monitoring sites.

Table 2 **Ambient lead levels as percentage (%) of the NEPM standard for the period 1990-2002**
(NA = not available)

Year	Kensington Gardens	Parkside	Northfield	Thebarton	Gilles Plains
1990	38	196	54	452	328
1991	42	180	46	396	406
1992	36	178	46	330	NA
1993	36	142	38	316	268
1994	24	90	24	262	234
1995	10	40	14	198	130
1996	10	36	12	96	114
1997	6	30	10	82	86
1998	6	28	10	72	74
1999	6	20	6	46	52
2000	4	20	8	40	44
2001	0	2	0	6	6
2002	0	2	0	4	4

The natural process of replacement of older vehicles with those designed to use unleaded petrol has automatically reduced the use of leaded petrol, lead emissions, and therefore the lead concentration in ambient air. For example, sales of leaded petrol in South Australia approximately halved from 1990 to 1995 (Figure 3), while sales in 2001 were one-fifth of the 1990 levels. As can be seen in Figure 3, 2001 estimates of vehicle lead emissions in South Australia were approximately one-seventh of the 1995 levels.

According to Peer Review Committee (PRC) technical paper No. 9 (May 2001), in regions where there are no current or anticipated significant non-vehicle sources (e.g. mines, industry), monitoring of 24-hour lead levels will no longer be required once measurements at peak sites are consistently at or below the level of precision threshold (about 10% of the ambient air quality NEPM standards). Airborne lead concentration at peak monitoring sites (i. e. sites close to heavily trafficked areas) in metropolitan Adelaide are consistently well below the ambient air quality NEPM standard.

Screening criteria extracted from the PRC (2000d), against which jurisdictions can assess the monitoring needs of their regions where reduced or no direct monitoring is justified, are outlined in Table 3.

The highest ambient lead concentration measured in 2002, as depicted in Figure 2, was $0.02 \mu\text{g}/\text{m}^3$, which is 4% of the NEPM standard. This clearly meets the acceptance limit for one year of monitoring.

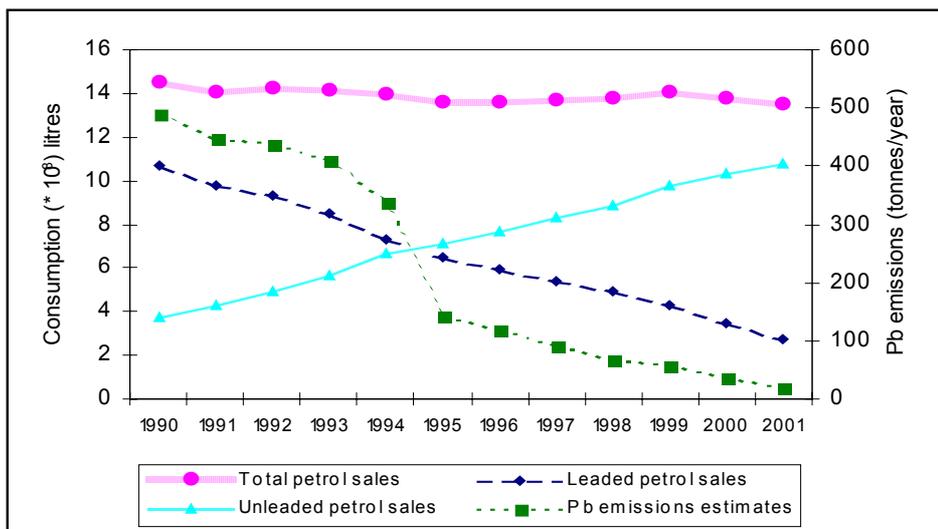


Figure 3 Trends in annual petrol consumption and associated lead emissions in South Australia

Table 3 Acceptance limits by screening procedure for carbon monoxide, nitrogen dioxide, sulfur dioxide and lead

Screening Procedure	Acceptance Limit (% of NEPM standard)
Campaign monitoring at a Generally Representative Upper Bound (GRUB) monitoring location (with no significant deterioration expected over 5–10 years).	55% for 1 year of data 60% for 2 or more years of data

CONCLUSION

From the analysis described above, it can be concluded that compliance with the ambient air quality NEPM standard and goal has been achieved.

On the basis of this data, TSP lead monitoring is no longer required in metropolitan Adelaide for NEPM purposes as there is no major emission source of lead in the air-shed.

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ACKNOWLEDGEMENTS

The EPA would like to thank the Department of Human Services and Transport SA for their comments on this report.

Appendix

Metadata for Adelaide metropolitan particulate matter lead - high volume sampling

Site Name	Site Details		Map Coordinates		Pollutants Measured	
Thebarton (EPA site number 1000)	Street address	Henley Beach Rd, Mile End	Datum	GDA 94	Pollutants	Total Suspended Particulate Lead
	Year established	1981	Projection	AMG Zone 54	Instruments	TSP High-Vol Sampler
	Date ending	Ongoing	Easting	277920	Model	Control Engineering Services
	Surrounding landuse	Arterial roadside	Northing	6132540	Units	µg/m ³
	Nearby emission sources	Motor vehicles	Siting guidelines (AS 2922-1987) exceptions	None	Sampling time	24 hour average
					Sampling interval	One day sampled every six days
Northfield (EPA site number 1080)	Street address	Hampstead Rd, Northfield	Datum	GDA 94	Pollutants	Total Suspended Particulate Lead
	Year established	1981	Projection	AMG Zone 54	Instruments	TSP High-Vol Sampler
	Date ending	Ongoing	Easting	282700	Model	Control Engineering Services
	Surrounding landuse	Residential	Northing	6139530	Units	µg/m ³
	Nearby emission sources	Motor vehicles	Siting guidelines (AS 2922-1987) exceptions	None	Sampling time	24 hour average
					Sampling interval	One day sampled every six days
Gilles Plains (EPA site number 0440)	Street address	North East Road, Hillcrest	Datum	GDA 94	Pollutants	Total Suspended Particulate Lead
	Year established	1981	Projection	AMG Zone 54	Instruments	TSP High-Vol Sampler
	Date ending	Ongoing	Easting	285200	Model	Control Engineering Services
	Surrounding landuse	Arterial roadside	Northing	6139790	Units	µg/m ³
	Nearby emission sources	Motor vehicles	Siting guidelines (AS 2922-1987) exceptions	None	Sampling time	24 hour average
					Sampling interval	One day sampled every six days
Kensington Gardens (EPA site number 0840)	Street address	West Tce, Kensington Gardens	Datum	GDA 94	Pollutants	Total Suspended Particulate Lead
	Year established	1989	Projection	AMG Zone 54	Instruments	TSP High-Vol Sampler
	Date ending	Ongoing	Easting	286400	Model	Control Engineering Services
	Surrounding landuse	Residential	Northing	6132900	Units	µg/m ³
	Nearby emission sources	Motor vehicles	Siting guidelines (AS 2922-1987) exceptions	None	Sampling time	24 hour average
					Sampling interval	One day sampled every six days
Parkside (EPA site number 0390)	Street address	Glen Osmond Rd, Parkside	Datum	GDA 94	Pollutants	Total Suspended Particulate Lead
	Year established	1981	Projection	AMG Zone 54	Instruments	TSP High-Vol Sampler
	Date ending	Ongoing	Easting	282620	Model	Control Engineering Services
	Surrounding landuse	Arterial roadside and intersection	Northing	6130410	Units	µg/m ³
	Nearby emission sources	Motor vehicles	Siting guidelines (AS 2922-1987) exceptions	None	Sampling time	24 hour average
					Sampling interval	One day sampled every six days