THE CROSS CITY TUNNEL PROJECT

AIR QUALITY MONITORING REPORT

FOR AUGUST, SEPTEMBER AND OCTOBER, 2000

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Prepared
for
Roads and Traffic Authority

by

Holmes Air Sciences
Suite 2B, 14 Glen Street
Eastwood NSW
ACN 003 741 035

Phone (02) 9874 8644
Fax (02) 9874 8904
Email holmair@ozemail.com.au

EXECUTIVE SUMMARY

This report presents the results of an air quality monitoring program for August, September and October, 2000. This monitoring program is part of the Cross City Tunnel (CCT) project and has been established since June 2000. Monitoring of the pollutants carbon monoxide, nitrogen dioxide and particulate matter (PM_{10}) has been carried out at two sites in the project area.

The building which houses the Sydney Art Gallery monitoring station is no longer available and, as a result, measurements at this location have been discontinued. Potential replacement sites are currently being considered, while monitoring at the Police Station is ongoing.

In summary, the data collected to date shows the following trends:

Sydney Police Station

For the three month period there was no exceedance of the air quality goal for nitrogen dioxide. The average value over the study period was 21 % of the air quality goal. The carbon monoxide goal was not exceeded and the average 8-hour concentration was 18 % of the goal. There have been nine exceedances of the NEPM goal for PM_{10} in the three month period. The average PM_{10} value was 46 % of the air quality goal.

Sydney Art Gallery

There was no exceedance of the nitrogen dioxide air quality goal. The average value over the study period was 28 % of the air quality goal. There was one exceedance of the 8-hour carbon monoxide goal. The average 8-hour CO value was 28 % of the air quality goal. Monitoring of PM_{10} concentration showed 15 exceedances of the NEPM goal. The average PM_{10} value was 64% of the air quality goal.

Exceedances of PM_{10} goals in early August, late September and early October were exacerbated by external influences of unfavourable meteorological conditions and bushfires.

The following trends in air quality at both monitoring sites have been observed:

- No exceedances of the nitrogen dioxide goal
- One exceedance of the 8-hour carbon monoxide goal at the Art Gallery site.
- A number of exceedances of the 24-hour PM_{10} goal

These trends have also been observed in the June and July, 2000 CCT monitoring period (refer **RTA, 2000**).

Monitoring of air quality began in mid-winter when atmospheric stability is high. This high stability, which occurs before sunset and continues overnight until mid-morning, can inhibit dispersion of pollutants, often leading to exceedances of air quality goals. Therefore, the start of the CCT monitoring program coincided with the worst-case meteorological conditions from an air quality perspective. It is for this reason that the monitoring results from both sites, recorded over a five month period cannot be extrapolated to a full year.

In addition, the monitoring sites chosen for the CCT are heavily trafficked street canyons where high concentrations of pollutants are likely to occur. Therefore, the relatively high levels of pollutants recorded at CCT monitoring sites are, to some extent, expected. These monitoring sites are not appropriate places for testing compliance with the NEPM air quality goals.

The measured exceedances of the NEPM PM_{10} goal should not be a cause for alarm. Air quality in the Pyrmont/Ultimo area is still well within the bounds of acceptable limits as defined by the US EPA. By these standards, air quality in Sydney with respect to particulate matter would on most occasions be classified as good.

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GLOSSARY AND ABBREVIATIONS

CBD	Central Business District
CCT	Cross City Tunnel
CO	Carbon monoxide
$\mu g/m^3$	micrograms per cubic metre
mg/m^3	milligrams per cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measures
NHMRC	National Health and Medical Research Council
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NSW EPA	New South Wales Environment Protection Authority
PM_{10}	particulate matter with equivalent aerodynamic diameter less than 10 μm
ppm	parts per million
pphm	parts per hundred million
PSI	Pollution Standards Index
RTA	Roads and Traffic Authority of New South Wales
SPI	Sydney Pollution Index
US EPA	United States Environment Protection Agency
WHO	World Health Organisation

1 INTRODUCTION

This report has been prepared by Holmes Air Sciences for the Roads and Traffic Authority of New South Wales (RTA). It presents the results of an air quality monitoring program established as part of the Cross City Tunnel (CCT) project development process.

Monitoring is being conducted at two locations near Darling Harbour, to the immediate west of the Sydney CBD. The sites are located at Sydney Police Station on Day Street and Sydney Art Gallery on Harris Street, Ultimo. These locations are shown in **Figure 1**.

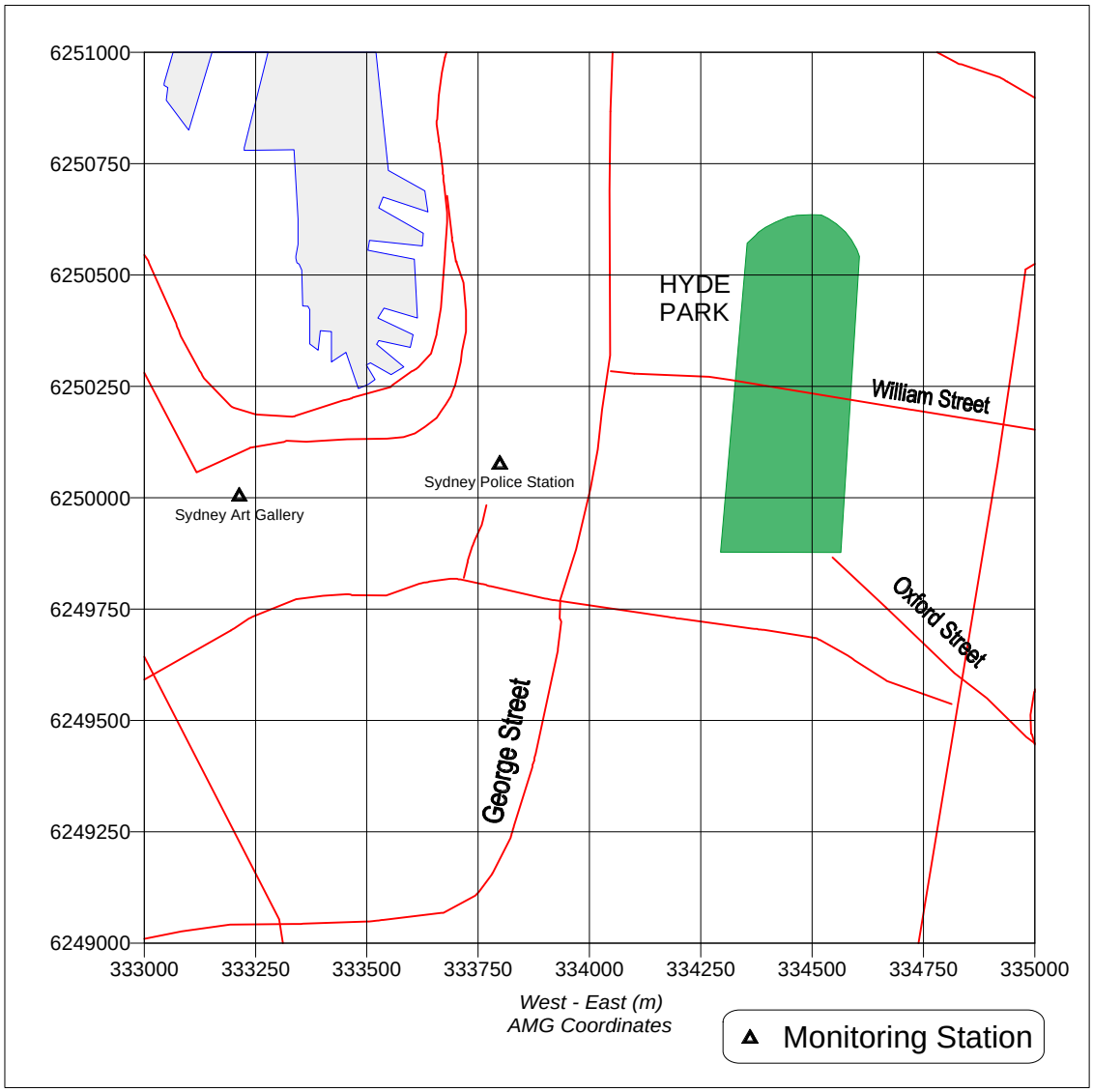

Figure 1: Location of Sydney Police Station and Sydney Art Gallery monitoring stations.

Both sites are temporary and will be replaced by a more permanent monitoring station where equipment would be located in secure, air-conditioned buildings. The current locations have some difficulties in terms of instrument security and power disruption and some data have been lost due to these factors. They represent an inevitable compromise in collecting data in a complex urban environment. Nevertheless, the data provide useful information about the level of air pollution currently experienced in urban street canyons on the outskirts of the CBD.

This report summarises concentration of carbon monoxide (CO), oxides of nitrogen (NO_x) and particulate matter (PM_{10}) recorded at the sites from August to October, 2000. The data supplement monitoring which was undertaken at these sites in June and July, 2000. The results from June and July, 2000 data are contained in a previous report (**RTA, 2000)**.

The building which houses the Sydney Art Gallery was sold in October and the RTA was advised that this location was no longer available. Monitoring was discontinued at this site at the end of October, but continues at the police station.

2 AIR QUALITY CRITERIA

A full description of the air quality goals adopted by the New South Wales Environment Protection Authority (NSW EPA) is provided in the CCT Environmental Impact Statement (EIS). For completeness, the goals applied to this project and those relevant to the monitoring program are summarised in **Table 1**.

Table 1: NSW Air Quality Goals and other relevant goals

Pollutant	*Standard**	*Agency*
Carbon monoxide	87 ppm or 108 mg/m^3 (15-minute maximum) **25 ppm or 31 mg/m^3 (1-hour maximum)** **9 ppm or 10 mg/m^3 (8-hour maximum)**	WHO **WHO** **NHMRC, NEPM**
Nitrogen dioxide	16 pphm or 320 μg/m^3 (1-hour maximum) 5 pphm or 103 μg/m^3 (annual mean) **12 pphm or 245 μg/m^3 (1-hour maximum)** 11 pphm or 200 μg/m^3 (1-hour maximum) 3 pphm or 60 μg/m^3 (annual mean)	NHMRC US EPA **NEPM,NSW EPA** WHO, NSW EPA long-term reporting goal NEPM, NSW EPA
Particulate matter < 10 μm (PM_{10})	50 μg/m^3 (annual mean) 30 μg/m^3 (annual mean) 150 μg/m^3 (24-hour maximum) **50 μg/m^3 (24-hour maximum)**	US EPA NSW EPA US EPA **NEPM, NSW EPA**

* *all concentration units have been converted at 0°C*

The goals shown in bold print are those used to assess the air quality at both monitoring stations, however it is important to note the following points.

The NEPM standards are general airshed standards, not "hot spot" standards. Compliance with these standards is to be tested at locations where a significant proportion of the population resides. In the National Environment Protection Measure for Ambient Air Quality, (**NEPC, 1998**) on page *v* of the Introduction, the following comments are made:

'The air quality of some localised areas within major airsheds are dominated by local activities such as that experienced in a road tunnel or a heavily trafficked canyon street. Air quality management in these areas is complex and needs a different approach to that directed at meeting ambient air quality standards intended to reflect the general air quality in the airshed. The NEPM is intended to apply to the latter (that is, general ambient air) allowing for the protection of the overwhelming majority of Australians wherever they live in Australia.'

The sites chosen to monitor for the Cross City Tunnel are heavily trafficked street canyons and would therefore not be appropriate sites for compliance testing.

On page 5, Chapter 1 of the same document it is noted that the standards (NEPM) are designed to be measured at specifically nominated performance monitoring stations located to give (average) representation of general air quality and of population exposure to the six main pollutants. The NEPM monitoring protocol does not apply to monitoring and controlling peak concentrations from major sources such as heavily trafficked roads and major industries.

Further comments are made in Chapter 7 on performance monitoring as follows:

'Ambient air quality standards for the protection of human health, rely on toxicology, controlled exposure studies and epidemiology. Epidemiology relates to observed effects to air quality monitoring data. Air quality data are normally based on monitoring stations sited to give an average representation of general air quality and population exposure. These stations are normally sited away from the influence of specific sources such as major roads and other major sources.

However, to provide a representative assessment of exposure, monitoring networks would include regions of generally high or low air quality levels excluding localised source-related peaks. Understanding the implications of ambient air monitoring data measured in this way requires an understanding of the studies on which the standards are based. In summary, the standards, especially that for the particulate matter, are based on epidemiological studies where measurements have been made at these so-called average monitoring stations. It is expected that within any airsheds there will be, on average, locations with higher and lower concentrations particularly those near busy roads.'

Therefore to test compliance with the NEPM goal, monitoring at sites such as those selected for the Cross City Tunnel project are not appropriate. Nevertheless, these sites are representative of peak locations where levels of pollutants are expected to be relatively high. They are equivalent to the EPA monitoring site in the CBD. These factors must be taken into account when considering the health impacts of the findings of this study.

Further, it is worth noting the approach that the US EPA has adopted in setting its air quality goals for particulate matter. In Appendix A of the Cross City Tunnel EIS, a table has been included which refers to the health effects of various levels of pollutants. This table is also included below.

Table 2 (**US EPA, 1998**) identifies health effects associated with different levels of air pollution, along with the descriptor of air quality and a cautionary statement. The US EPA suggests an appropriate statement for the community if air pollution were to fall into one of the "unhealthful" categories. These categories are based on the US EPA Pollutants Standards Index (PSI) scale.

Table 2: General health effects and cautionary statements (US EPA)

Pollutants Standard Index (PSI) Scale	PSI Descriptor	General Health Effects	Cautionary Statements
Up to 50 *$PM_{2.5}$ 24-hour 0-33 $\mu g/m^3$*[1] *PM_{10} 24-hour 0-75 $\mu g/m^3$*	Good	None for the general population.	None required.
50 to 100 *$PM_{2.5}$ 24-hour 33-65 $\mu g/m^3$* *PM_{10} 24-hour 75-150 $\mu g/m^3$*	Moderate	Few or none for the general population.	None required.
100 to 200 *$PM_{2.5}$ 24-hour 65-130 $\mu g/m^3$* *PM_{10} 24-hour 150-300 $\mu g/m^3$*	Unhealthful	Mild aggravation of symptoms among susceptible people, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity. General population should reduce vigorous outdoor activity.
200 to 300 *$PM_{2.5}$ 24-hour 130-260 $\mu g/m^3$* *PM_{10} 24-hour 300-450 $\mu g/m^3$*	Very Unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease; widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity. General population should avoid vigorous outdoor activity.
Over 300 *$PM_{2.5}$ 24-hour over 260 $\mu g/m^3$* *PM_{10} 24-hour over 450 $\mu g/m^3$*	Hazardous	Early onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons. At PSI levels above 400, premature death of ill and elderly persons may result. Healthy people experience adverse symptoms that affect normal activity.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. At PSI levels above 400, general population should avoid outdoor activity. All people should remain indoors, keeping windows and doors closed, and minimise physical exertion.

This table highlights the fact that by US EPA standards, air quality in Sydney with respect to particulate matter would on most occasions be classified as good, even within the CBD. As will be seen later, the levels that have been recorded at the Cross City Tunnel monitoring sites are well within the levels which the US EPA consider to be acceptable for air quality.

It is also useful to note some of the comments of the United Kingdom's Expert Panel on Air Quality Standards in relation to particles (**UK DETR, 1998**).

[1] Figures in italics are inferred from the knowledge that a PSI value of 100 applies when the pollutant concentration is equal to the US EPA primary standard.

The panel recommended a 24-hour goal for PM_{10} of 50 $\mu g/m^3$ which was close to the 90th percentile of 24-hour measurements made to that date (1995) in the United Kingdom. That is, one out of 10 measurements made in the UK exceeded this level. In making this recommendation the panel took the following views:

- Episodes of particulate air pollution are responsible for causing premature mortality among those with pre-existing lung and heart disease.
- A value of 50 $\mu g/m^3$ was likely to be a safe concentration for exposure for the very large majority of individuals.
- While there appears to be no threshold below which health effects are undetectable, this may in part reflect the fact that monitoring is carried out at central locations and that susceptible individuals may be exposed to much higher levels.
- It was therefore considered that the most effective means of ensuring a reduction in adverse health effects of particulate pollution on the population would be by progressively lowering the average concentrations of particles in cities throughout the year, rather than simply by action aimed at limiting the number of peak concentrations exceeding 50 $\mu g/m^3$.

These views are consistent with the NEPM considerations and the approach of the NSW EPA in setting a 24-hour PM_{10} goal of 50 $\mu g/m^3$ at central monitoring locations (to be achieved over a 10-year timeframe) rather than at "hot spots", and at the same time introducing and supporting measures which would decrease the general level of particulate pollution in the airshed. These measures include the reduction of particulate from diesel vehicles, a major source of particulate pollution in urban areas. Measures which reduce overall pollution levels also help to decrease peak concentrations.

In summary, the relatively high levels of pollutants recorded at the CCT monitoring sites (compared to EPA suburban monitoring sites which are more consistent with NEPM compliance sites) are not unexpected. The CCT sites are "peak" sites.

3 SYDNEY POLICE STATION

The Police Station is located on Day Street on the western edge of the Sydney CBD, between Liverpool and Bathurst Streets. The monitoring site was chosen as it is near the proposed ventilation stack for the CCT. The height of the monitoring station is at street level. The monitors measure concentration at 1-minute intervals and log 10-minute averages. The 10-minute concentration was used to determine longer time averages, such as the 1-hour average. In August, carbon monoxide measurements were disrupted from 7th to 18th, due to an instrument breakdown. Particulate measurements were not recorded from 3 to 17 August because of a software failure.

3.1 Oxides of Nitrogen

Nitrogen oxides (NO_x) emitted by motor vehicles are comprised mainly of nitric oxide (NO, approximately 95% at the point of emission) and nitrogen dioxide (NO_2, approximately 5% at the point of emission). Nitric oxide is much less harmful to humans than nitrogen dioxide and is not generally considered a pollutant with health impacts at the concentrations normally found in urban environments. Concern with nitric oxide relates to its transformation to nitrogen

dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function although the evidence concerning effects has been mixed and conflicting.

Nitrogen dioxide (NO_2) concentrations gathered from the Police Station (and the Art Gallery) site display a daily pattern. This pattern exhibits peak concentrations, primarily from vehicle emissions in the morning and evening peak traffic periods. The results of the 1-hour concentration of nitrogen dioxide for August to October are shown in **Figure 2**.

The mean NO_2 concentration in the three months was 2.6 pphm. The vast majority of measurements were below 6 pphm, as shown in **Figure 2**. As a result, the 1-hour NEPM goal for nitrogen dioxide was not exceeded.

The result of the 10-minute concentration of nitrogen dioxide are shown in **Figure 2**. These data are not used to assess air quality because even at elevated concentrations over a short period of time, such as ten minutes, evidence of an impact on health is inconclusive. The 1-hour goal is applied so that a margin of safety is kept for sensitive members of the community.

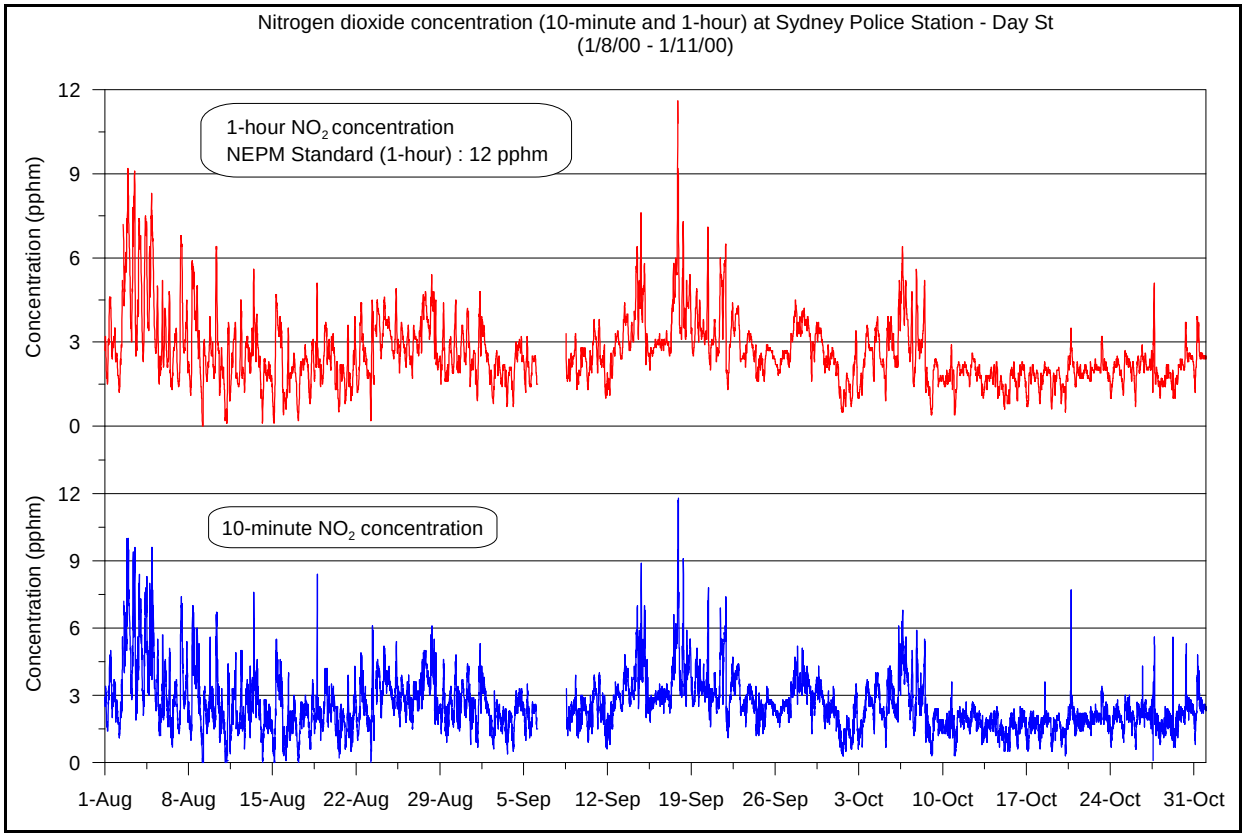

Figure 2: The 1-hour and 10-minute concentration of nitrogen dioxide at Sydney Police Station.

As discussed, there are no ambient air quality goals for nitric oxide, the major nitrogen oxide emission from motor vehicles. The principal focus in this report is on the proportion of nitrogen dioxide in total oxides of nitrogen. Analysis of the EPA's oxides of nitrogen monitoring data shows that the percentage of nitrogen dioxide in the air is inversely proportional to the total oxides of nitrogen concentration.

Table 3 contains the ten highest 1-hour concentration of NO_x for each month between August and October. Over this period, the proportion of NO and NO_2 in the oxides of nitrogen was 86.8 % and 13.2 % for the ten highest measurements of NO_x. Monitoring data collected by the RTA in Sydney (**RTA, 1997**) indicate that at sites like the Police Station (and Art Gallery), nitrogen dioxide would make up from 5 to 20% by weight of the total oxides of nitrogen.

Table 3: The ten highest hourly average concentrations of nitrogen oxides each month and the proportion of NO_2 for Sydney Police Station monitoring site.

Date	Hour	Concentration of oxides of nitrogen (pphm)	Concentration of nitrogen dioxide (pphm)	Percentage of NO_2 in NOx (%)
August				
4	10:00 pm	54.1	7.7	14.2
28	7:00 am	49.7	5.3	10.7
2	10:00 pm	43.1	9.2	21.4
4	9:00 pm	42.9	7.4	17.3
4	8:00 pm	42.4	6.7	15.8
10	7:00 am	42.3	6.3	14.9
4	11:00 pm	42.0	7.0	16.7
2	11:00 pm	41.8	8.3	19.9
8	7:00 am	41.1	5.9	14.4
5	12:00 am	41.1	6.7	16.3
Average		**44.0**	**7.1**	**16.1**
September				
17	9:00 pm	61.6	11.4	18.5
17	10:00 pm	45.3	8.0	17.7
18	7:00 am	44.9	6.2	13.8
17	8:00 pm	43.8	7.8	17.8
18	6:00 am	41.6	5.3	12.7
15	2:00 am	40.9	5.8	14.2
1	8:00 am	36.6	4.7	12.8
18	8:00 am	36.0	6.4	17.8
14	7:00 pm	35.6	7.6	21.3
28	7:00 am	34.9	3.9	11.2
Average		**42.1**	**6.8**	**15.9**
October				
6	7:00 am	41.9	3.7	8.8
5	7:00 am	36.3	2.0	5.5
4	6:00 am	34.3	1.6	4.7
5	6:00 am	32.5	1.0	3.1
13	8:00 am	32.1	1.2	3.7
6	8:00 am	30.5	4.5	14.8
6	6:00 am	30.4	2.1	6.9
30	7:00 am	29.9	3.7	12.4
31	6:00 am	29.7	3.7	12.5
13	9:00 am	29.0	1.1	3.8
Average		**32.6**	**2.5**	**7.6**
Overall Average		**39.6**	**5.4**	**13.2**

As the concentrations of nitrogen oxides decrease, (ie. dilute with ambient air) they also oxidize into a greater proportion of nitrogen dioxide. The rate at which this oxidation takes place is dependent on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the emissions from a ventilation stack to the point where the concentration is very low it is unimportant that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO_2 can occur.

Table 3 shows that periods of highest NOx concentration shift from evening to the morning in the three months from August to October. In winter months the combination of peak traffic and atmospheric stability favours the evening. While in summer months atmospheric stability is higher in the morning peak traffic period. In summer, thermal breezes such as a sea breeze, generally aid dispersion of emissions in the evening resulting in lower NO_x concentration. Highest NO_x concentration is dependent on the coincidence of peak traffic and periods of high atmospheric stability.

The 10-minute concentrations of oxides of nitrogen are shown in **Figure 3**. The maximum concentration for NO_x was 68.5 pphm, recorded on 17 September

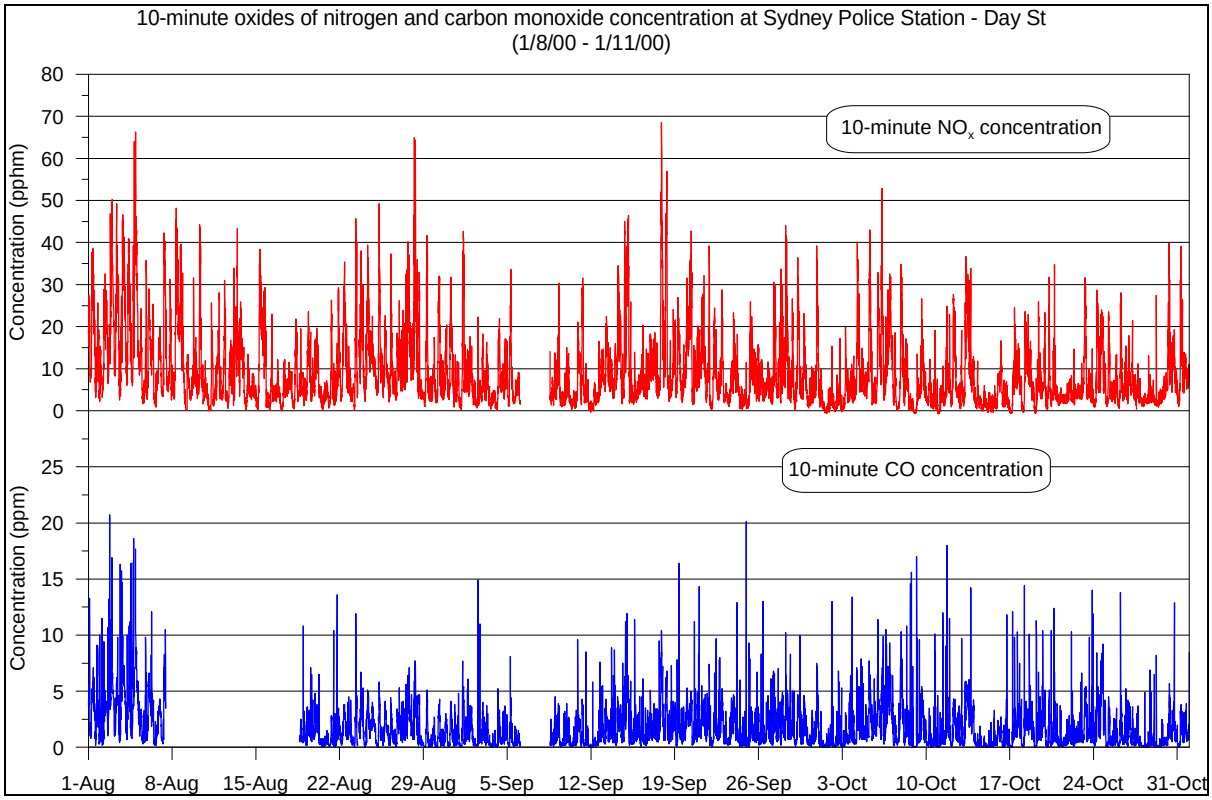

Figure 3: The concentration of carbon monoxide and oxides of nitrogen at Sydney Police Station.

3.2 Carbon monoxide

Carbon monoxide can be harmful to humans because its affinity for haemoglobin is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and reducing the exposure would lead to the establishment of a new equilibrium.

The 15-minute, 1-hour and 8-hour goals noted by the EPA provide a significant margin for safety which is designed to protect a wide range of people in the community including the very young and elderly. The 8-hour goal is particularly relevant as equilibrium between ambient concentration and blood level concentration takes between 4 to 12 hours.

Carbon monoxide is produced as a result of combustion of fuels (as well as from other sources). There is a diurnal pattern in carbon monoxide concentrations, with two daily peaks due to peak traffic periods. Concentrations in the middle of the day are low due to the favourable combination of lower emissions and increased dispersion conditions. The 10-minute concentration of carbon monoxide is shown in **Figure 3**. While these results are not used to determine air quality standards they are useful in understanding the short term fluctuations that contribute to long term concentration.

The 1-hour concentrations of carbon monoxide, which are in **Figure 4**, show that throughout the monitoring period levels remain low. The mean value carbon monoxide concentration for the three months was 1.7 ppm.

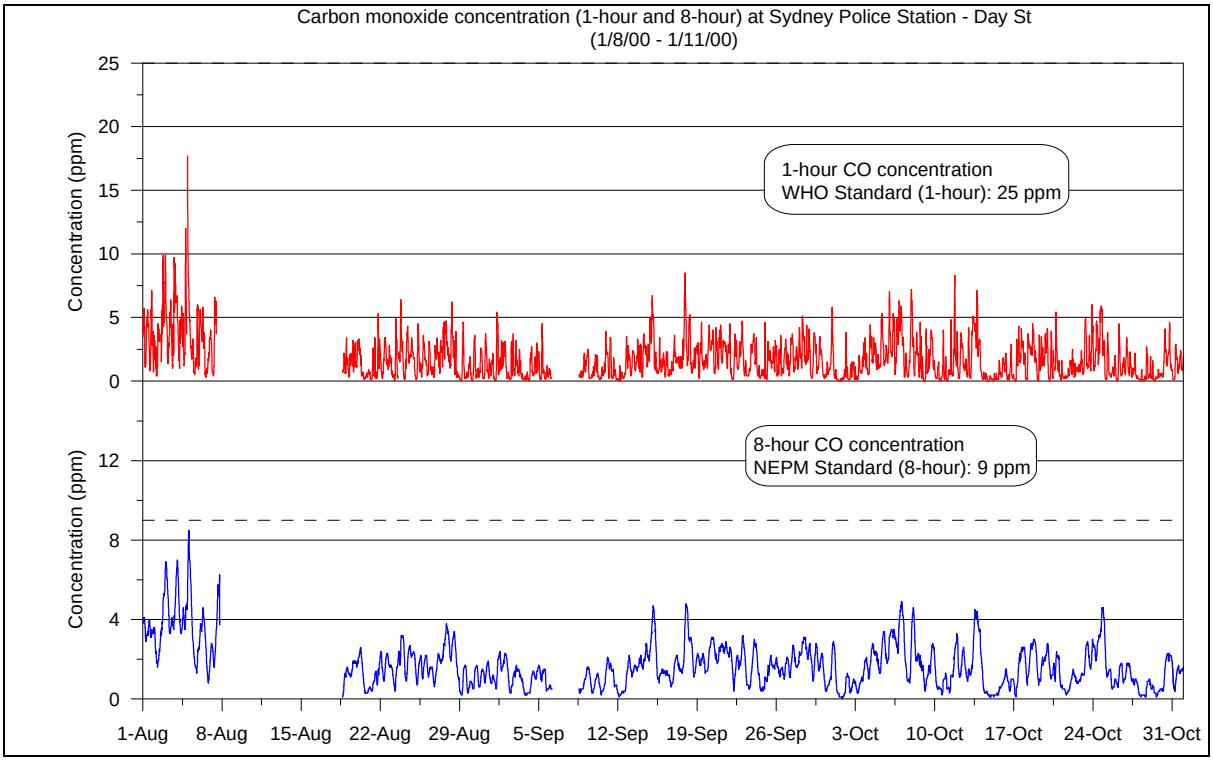

Figure 4: The 1-hour and 8-hour carbon monoxide concentrations at Sydney Police Station.

The 8-hour CO concentration is shown in **Figure 4**, reaching high levels at the start of August. The maximum 8-hour CO concentration was 8.5 ppm, recorded on 5 August. The dashed line in **Figure 4** indicates the level of the NEPM goal and was not exceeded in the monitoring period.

3.3 Particulates (PM_{10})

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, that is those greater than 10 μm in aerodynamic diameter, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. The nature of particles in the air has an inverse relationship between the size of the particle and it's diameter. So that as a particle diameter decreases, the number of similarly sized particles increases. This relationship is a factor resulting in increased scientific concern about the effects of fine particles.

Fine particles are of concern for two principal reasons, since they have the ability to penetrate deeper into the lungs and the increased number of similarly sized particles that can reach the deep regions of the lung, like the alveolar sacs. The presence of particles can inflame tissue in this region since it is quite sensitive to foreign material. The human body does have defenses against deposition of particles in this region but due to the increased number of particles this mechanism may be unable to cope, resulting in inflammation.

The use of wood heaters in urban areas is a source of air pollutants, most notably particulates. As a result, during episodes when meteorological conditions are unfavourable (on clear, calm winter nights), the EPA requests that wood heaters not be used. These "*Don't Light Tonight*" requests are an attempt to minimise air pollution the following morning. In August, the EPA made a "*Don't Light Tonight*" request each day from the 3rd to the 6th. Particulate concentration at both monitoring sites (Police Station and Art Gallery) experienced elevated levels at the start of August. These elevated concentrations, which were experienced across a large area of the Sydney basin, were exacerbated by unfavourable meteorological conditions.

On occasions, the 10-minute concentrations of PM_{10} were above 50 $\mu g/m^3$ for a significant amount of time. These episodes occurred at approximately the start of August, the second half of September and the start of October. The measurements where concentrations were above 50 $\mu g/m^3$ accounted for 8% of the monitoring period. The mean value of the particulate concentration for the three months was 23.1 $\mu g/m^3$. The 10-minute and 24-hour running average PM_{10} concentrations are shown in **Figure 5**. Neither of these averaging periods for PM_{10} have standards by which air quality is assessed.

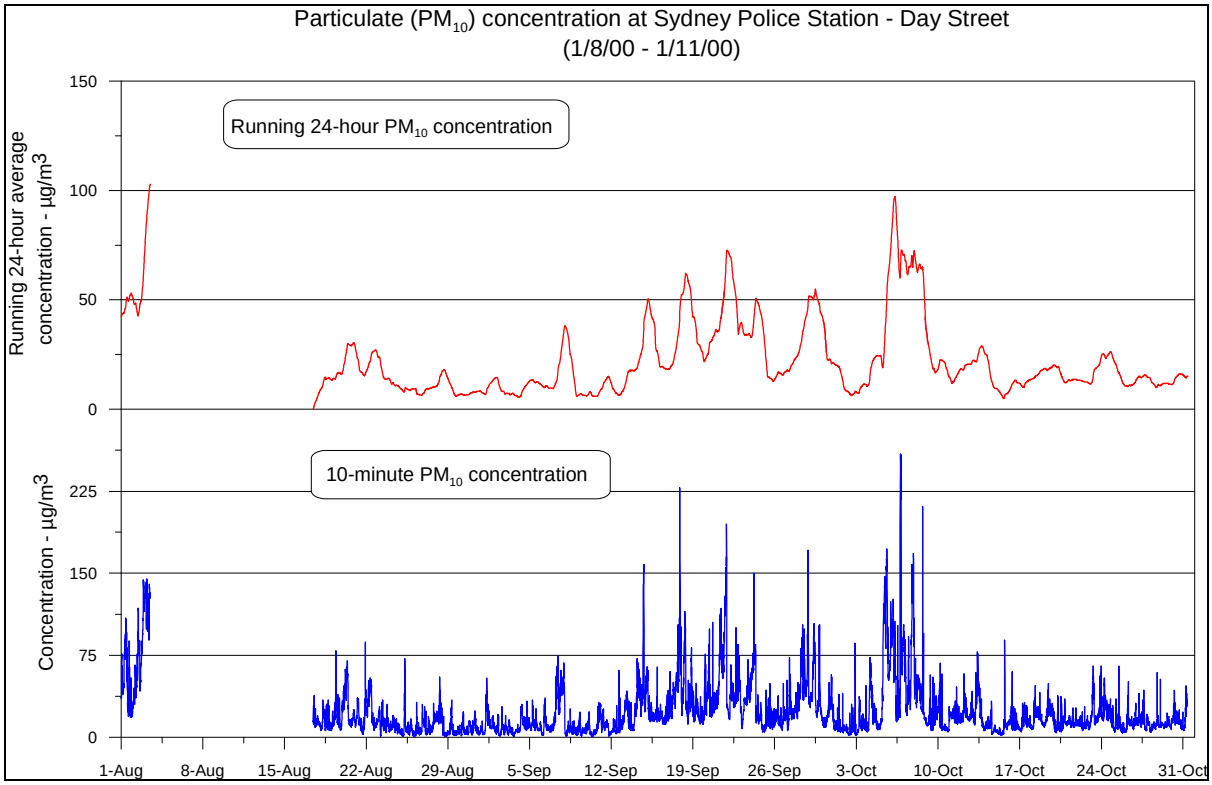

Figure 5: The 10-minute and running 24-hour concentration of PM_{10} at Sydney Police Station.

The PM_{10} concentrations (average and maximum) for three time intervals are shown in **Table 4**. The 24-hour moving average and the daily average measure the PM_{10} concentration over a 24 hour period. The daily average differs in that it measures the 24-hour average from midnight to midnight (eg. from midnight on the 9/8/00, until midnight on the 10/8/00). The daily concentration is therefore calculated once a day. The 24–hour running average measures the average PM_{10} concentration from a particular time for the next 24 hours (eg. from 1:40pm on the 9/8/00, until 1:40pm on the 10/8/00). As a result the 24–hour running average is calculated at every measurement (ie. 10 minutes).

Table 4: The PM_{10} concentrations for three time intervals at the Police Station.

Measurement Interval	Mean µg/m³			Maximum µg/m³			Day of Maximum Concentration			Time of Maximum Concentration		
	AUG	SEP	OCT	AUG	SEP	OCT	AUG	SEP	OCT	AUG	SEP	OCT
10-minute average	22.1	25.1	21.6	145.0	228.0	259.0	23	17	6	1:50 am	8:50 pm	7:20 pm
24-hour running average	21.8	24.7	21.7	103.2	72.8	97.4	27	21	6	9:50 am	9:40 pm	7:20 am
Daily average	21	25	21	70	72	76	2	20	4	N / A	N / A	N / A

The 24-hour goal (daily average) was exceeded on nine occasions over the three month period at the Police Station. These exceedances are shown in **Figure 6**, where daily concentrations are above the 50 µg/m³ dashed line. Due to failure of the dust monitoring software, concentrations of particulate matter are unknown and may have been elevated for a short period of time over this period.

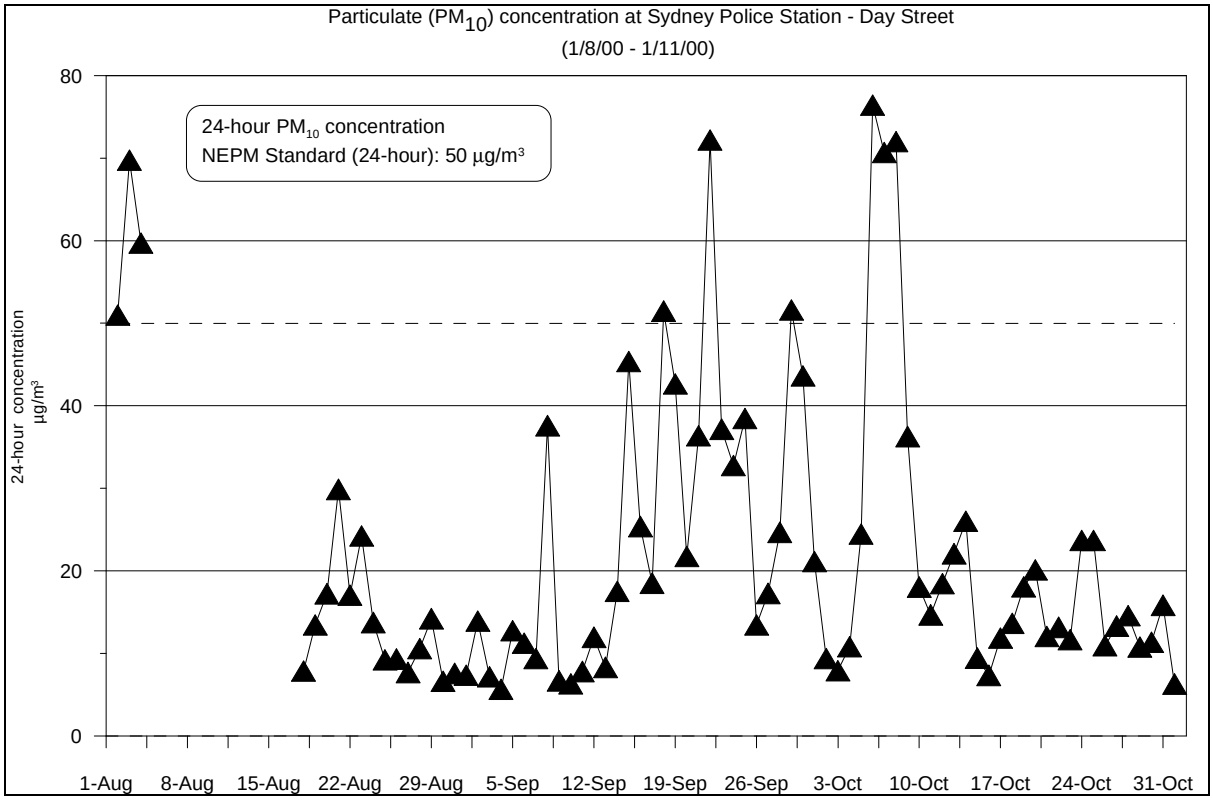

Figure 6: Daily concentration of PM_{10} at Sydney Police Station.

There were three exceedances in August, occurring on consecutive days from the 1st to the 3rd. The levels recorded on these days are shown in **Table 5**. Air quality throughout the Sydney basin on these days was low and, as mentioned, was subject to an EPA request for wood heaters not to be used in an attempt to reduce particulate concentration.

Table 5: Summary of PM_{10} exceedance occasions at Sydney Police Station.

Measurement Interval	Exceedance Occasion	Concentration µg/m³	Day of Exceedance
August			
Daily Concentration	1	51	1
	2	70	2
	3	60	3
September			
Daily Concentration	4	51	17
	5	72	21
	6	52	28
October			
Daily Concentration	7	76	5
	8	71	6
	9	72	7

In September, there were three exceedances, which occurred on the 17th, 21st and 28th. The particulate concentrations on these days are shown in **Table 5**. The first exceedance on the 17th, was the result of particulate concentration steadily increasing throughout the day, reaching a peak 10-minute reading of 228 μg/m^3 at 8:50 pm. The second exceedance in September, measuring 72 μg/m^3 was the result of distinct morning and evening peak concentrations rising above 100 μg/m^3. The third exceedance was of a similar nature to the second, where peak morning and evening concentrations resulted in an exceedance of the 24-hour NEPM goal.

Bushfires at Holsworthy in south-western Sydney and Hornsby in northern Sydney before 20 September, would have contributed to the exceedance on 21 September. Concentrations of PM_{10} throughout the Sydney Basin were high on these days. On the 21st, the SPI for central and eastern Sydney was 116; 50 is regarded as high air pollution..

There were three exceedances in October, occurring on consecutive days from the 5th to the 7th. Diminished air quality on these days was from bushfires, which started on 2 October at a number of locations in the Sydney region.

4 SYDNEY ART GALLERY

The Art Gallery monitoring site is located on the first floor of the Sydney Art Gallery building (approx. 4m above street level). This location is near the intersection of Harris Street and the Western Distributor, which is a major traffic node. The monitors measure concentration at 1-minute intervals and log 10-minute averages. The 10-minute average concentration was used to determine longer time averages. The Art Gallery concluded monitoring gaseous air quality on the 27 October and particulate air quality on the morning of the 31 October. Monitoring of air quality ended at the Art Gallery due to the building not being available to use in the future. The monitoring program in the area will re-commence in the future and potential replacement sites are currently being considered.

Measurements of nitrogen dioxide were disrupted from the 8/9/00 to the 9/10/00, due to an instrument fault. Particulate measurements were not recorded from 3 to 17 August because of a software failure.

4.1 Oxides of nitrogen

The maximum recorded 1-hour concentration for nitrogen dioxide was 9.2 pphm which occurred on 7 September. This high concentration can be seen in **Figure 7**, which includes the graph of the 10–minute concentration for nitrogen dioxide. The mean nitrogen dioxide concentration was 3.4 pphm for the three months. There were no exceedances at the Art Gallery of the 1-hour nitrogen dioxide goal. The maximum 10–minute concentration of nitrogen dioxide was 10.2 pphm.

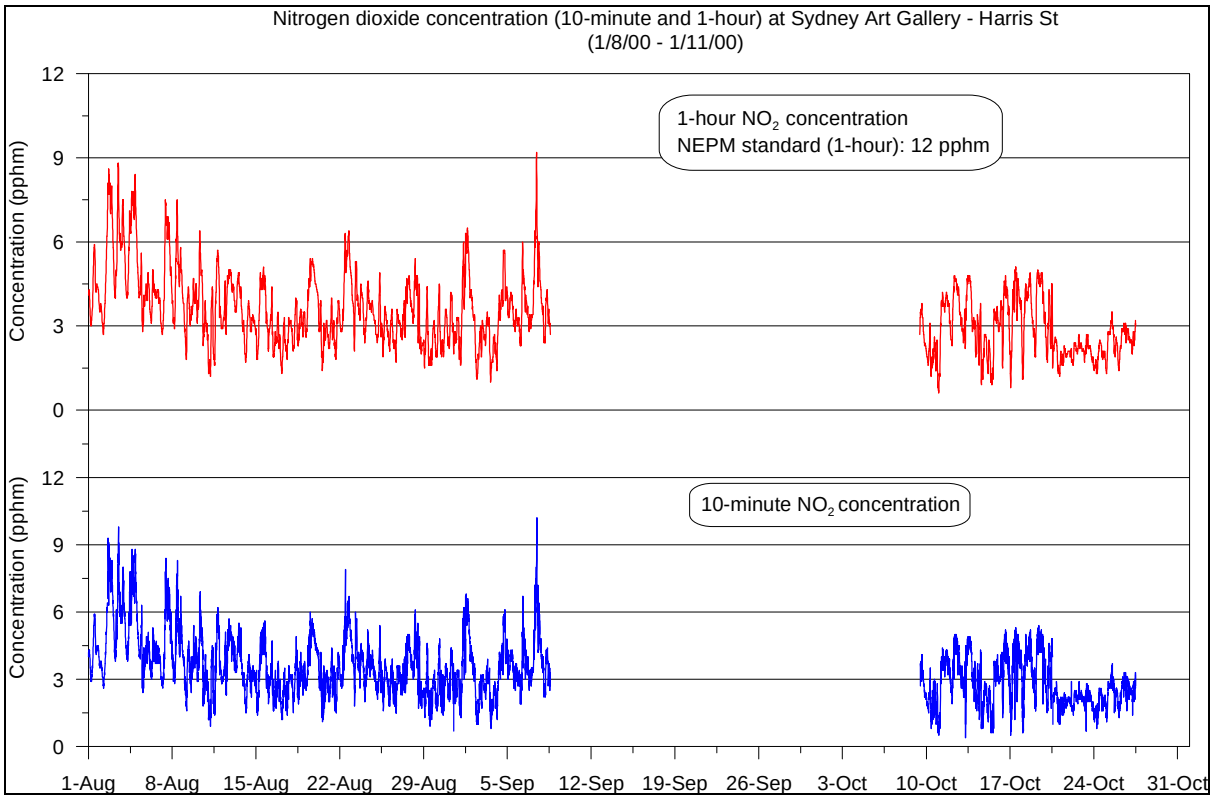

Figure 7: The 1-hour and 10-minute concentration of nitrogen dioxide at Sydney Art Gallery.

The ten highest 1-hour oxides of nitrogen concentration at the Art Gallery site each month are shown in **Table 6**. The proportion of NO and NO_2 within the ten highest total oxides of nitrogen concentrations was 88.8 % and 11.2 % respectively for the three month period.

Table 6: The ten highest hourly average concentrations of nitrogen oxides each month and the proportion of NO_2 for Sydney Art Gallery monitoring site.

Date	Hour	Concentration of oxides of nitrogen (pphm)	Concentration of nitrogen dioxide (pphm)	Percentage of NO_2 in NOx (%)
August				
4	9:00 pm	78.9	8.3	10.5
3	8:00 pm	71.0	7.3	10.3
3	9:00 pm	71.0	7.4	10.5
8	9:00 am	70.2	6.7	9.5
8	8:00 am	66.0	6.0	9.1
2	3:00 pm	64.5	8.0	12.5
10	7:00 am	63.5	6.4	10.0
8	10:00 am	63.4	7.2	11.4
2	4:00 pm	61.5	8.1	13.1
4	10:00 pm	60.1	7.8	12.9
Average		**67.0**	**7.3**	**11.0**
September				
7	7:00 am	60.2	6.4	10.7
6	6:00 am	58.6	5.6	9.5
7	6:00 am	52.8	5.1	9.7
7	11:00 am	52.6	7.7	14.6
4	4:00 pm	52.2	5.7	11.0
1	6:00 am	48.9	5.0	10.2
7	5:00 am	48.4	4.6	9.4
7	12:00 pm	48.2	6.2	12.9
7	9:00 am	47.9	7.2	15.1
7	10:00 am	47.3	8.3	17.6
Average		**51.7**	**6.2**	**12.1**
October				
17	2:00 pm	44.6	3.2	7.1
17	5:00 pm	42.2	4.4	10.4
17	3:00 pm	42.1	4.4	10.5
13	7:00 am	41.5	3.6	8.7
19	8:00 am	40.2	4.8	11.9
13	5:00 pm	40.1	4.5	11.2
17	4:00 pm	39.0	4.4	11.3
13	10:00 am	38.7	4.7	12.0
12	7:00 am	38.0	4.3	11.2
13	11:00 am	37.9	4.5	11.9
Average		**40.4**	**4.3**	**10.6**
Overall Average		**53.0**	**5.9**	**11.2**

The implication of the proportion of NO_2 in the ten highest NO_x concentrations is discussed in detail in the Sydney Police Station section. As noted previously, the lowest ratios of NO_2/NO_x occur when the concentrations of NO_x are highest.

The 10-minute concentrations of oxides of nitrogen are shown in **Figure 8**. The maximum 10-minute concentration for oxides of nitrogen was 96 pphm which was recorded on 8 August.

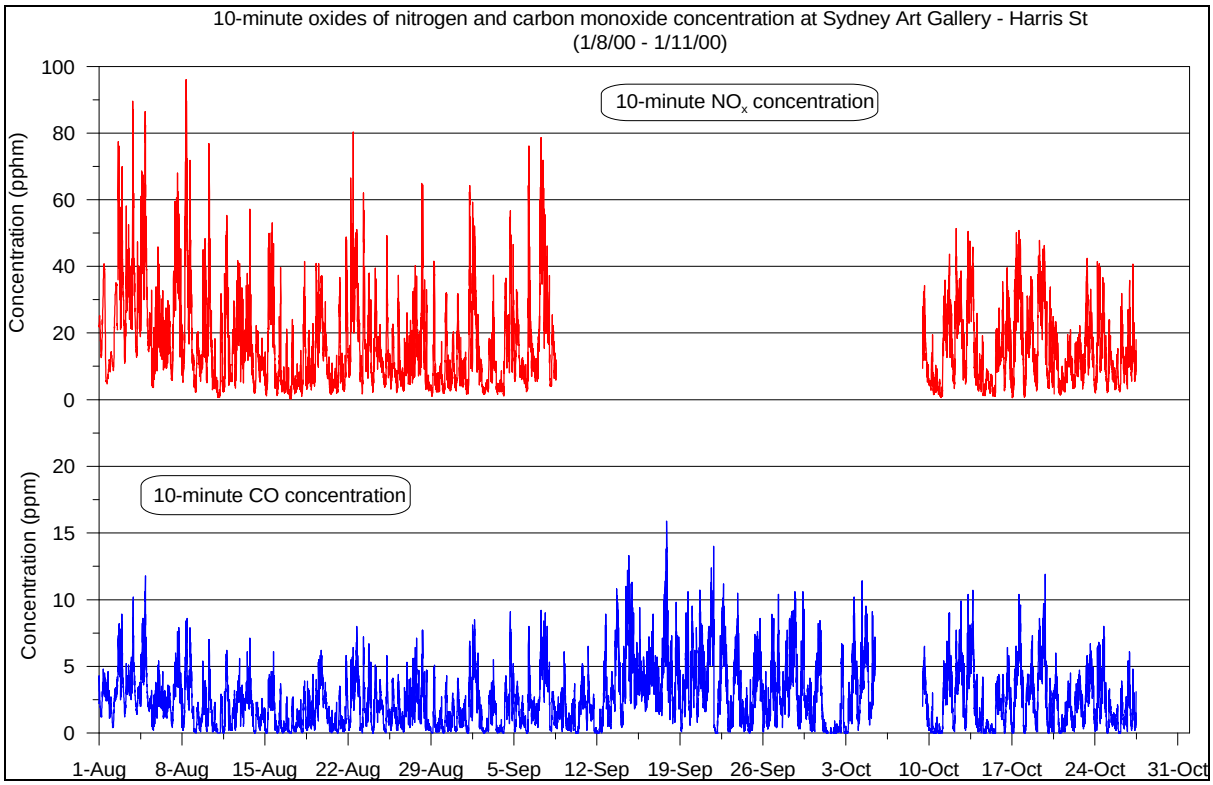

Figure 8: The concentration of carbon monoxide and oxides of nitrogen at Sydney Art Gallery.

4.2 Carbon monoxide

The 10–minute concentrations of carbon monoxide are shown in **Figure 8**. While these results are not used to determine air quality standards they are useful in understanding the short term fluctuations that contribute to longer term concentrations.

The average concentration over the three months was 2.5 ppm. The 1-hour concentrations of carbon monoxide are shown in **Figure 9**. The 1-hour concentrations were elevated in the second half of September, with the peak value of 13.7 ppm occurring on the 17th. Concentration during this period was the highest for the three months but did not exceed the 1-hour WHO goal of 25 ppm.

The CO concentration recorded on 17th led to one exceedance of the 8-hour NEPM goal for the three month period. This exceedance occurred late on the 17th, reaching a peak value of 9.3 ppm. The exceedance was the result of steadily increasing CO concentration from midday on the 17th. The 8-hour CO results are shown in **Figure 9**.

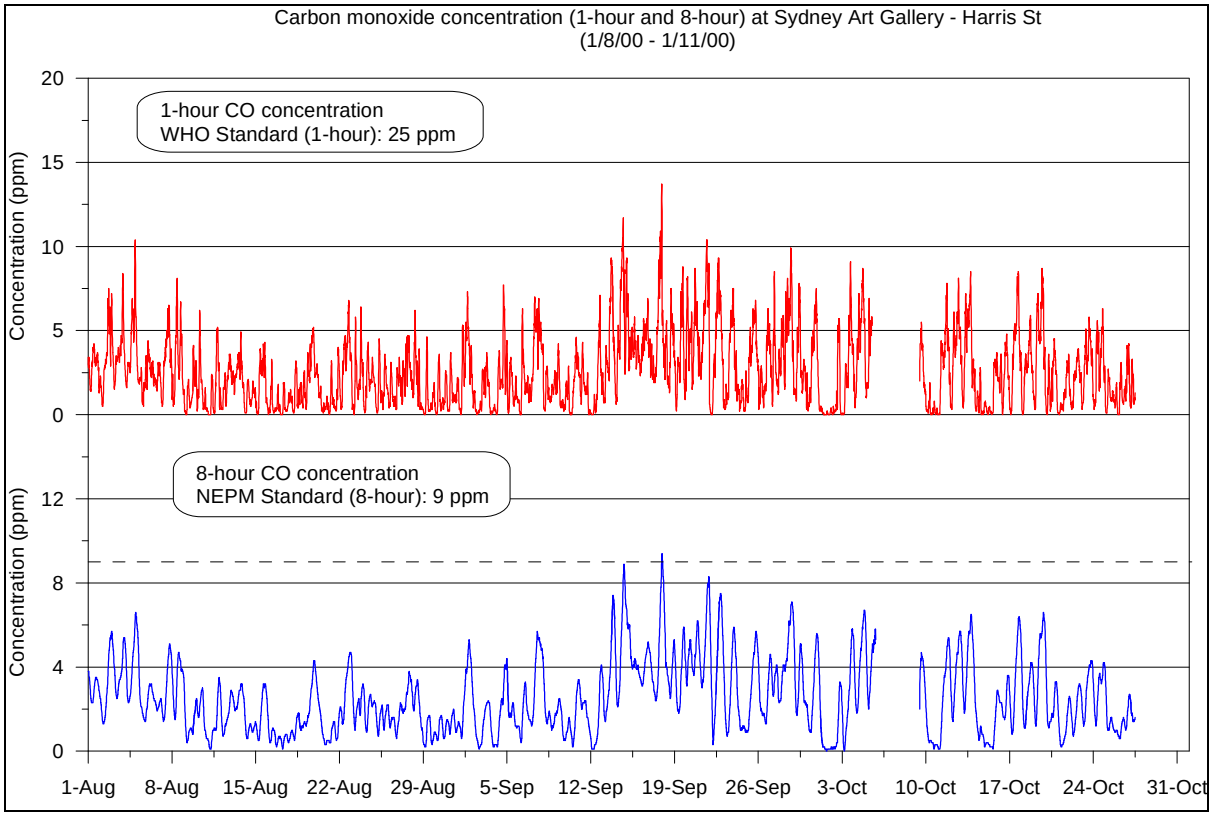

Figure 9: The 1-hour and 8-hour carbon monoxide concentrations at Sydney Art Gallery.

4.3 Particulates (PM_{10})

Particulate concentration measured at the Art Gallery strongly reflect those measured at the Police Station. The Art Gallery and Police Station show the same trend, but concentration at the Art Gallery site were higher. Sustained periods, where 10-minute average concentrations were above 50 $\mu g/m^3$ occurred at approximately the start of August, the second half of September and the start of October. The measurements where 10-minute concentrations were above 50 $\mu g/m^3$ accounted for 19% of the monitoring period. The mean value of the particulate concentration for the three months was 31.8 $\mu g/m^3$. The 10-minute and 24-hour running average PM_{10} concentrations are shown in **Figure 10**. Neither of these averaging periods for PM_{10} have standards by which air quality is assessed.

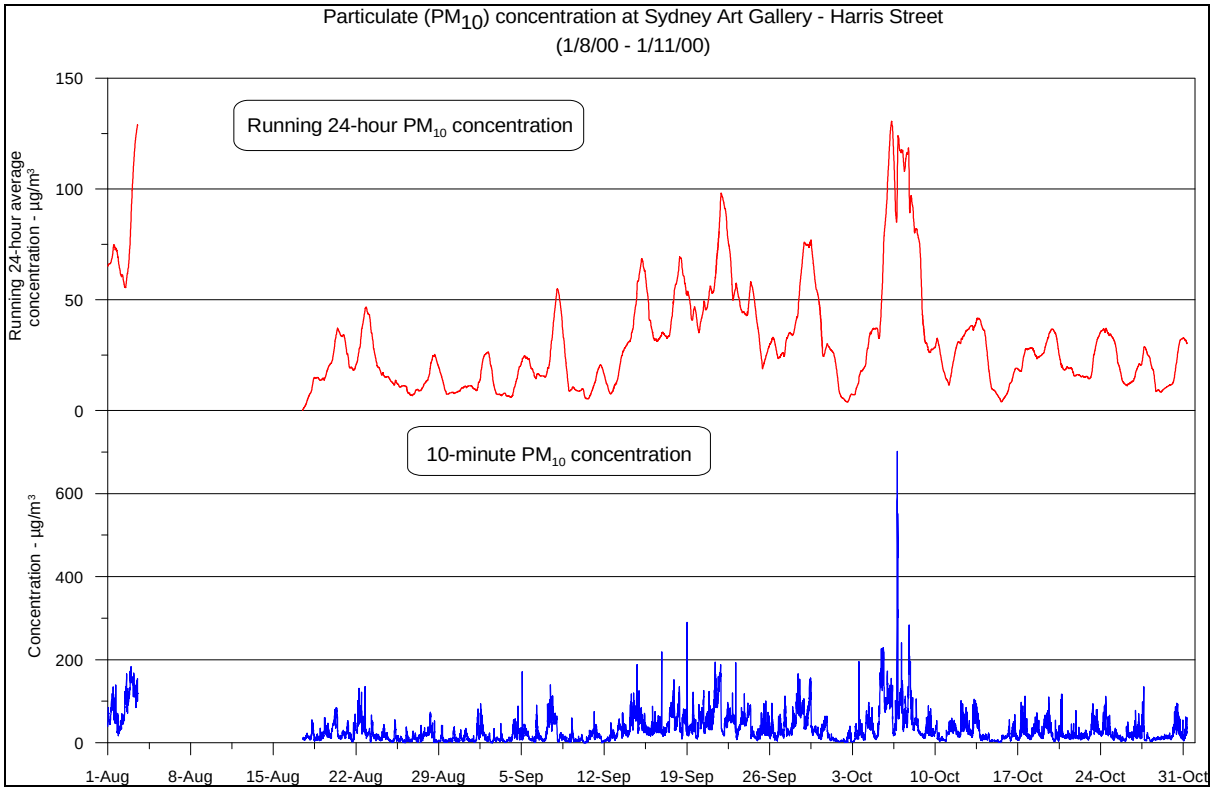

Figure 10: The 10-minute and running 24-hour concentration of PM_{10} at Sydney Art Gallery.

The PM_{10} concentrations (average and maximum) for three time intervals are shown in **Table 7**. Relatively high levels were recorded for all averaging periods.

Table 7: The PM_{10} concentrations for three time intervals at the Art Gallery.

Measurement Interval	Mean µg/m³			Maximum µg/m³			Day of Maximum Concentration			Time of Maximum Concentration		
	AUG	SEP	OCT	AUG	SEP	OCT	AUG	SEP	OCT	AUG	SEP	OCT
10 – minute average	28.0	34.9	30.8	184.0	290.0	702.0	2	19	6	10:50 pm	12:30 am	7:20 pm
24 – hour moving average	26.0	34.5	30.9	128.9	98.2	130.5	3	21	6	12:10 pm	9:30 pm	7:50 am
Daily average	27	35	30	91	96	118	2	20	5	N / A	N / A	N / A

The 24-hour goal (daily average) was exceeded on fifteen occasions over the three month period at the Art Gallery. These exceedances are shown in **Figure 6**, where daily concentrations are above the 50 µg/m³ dashed line.

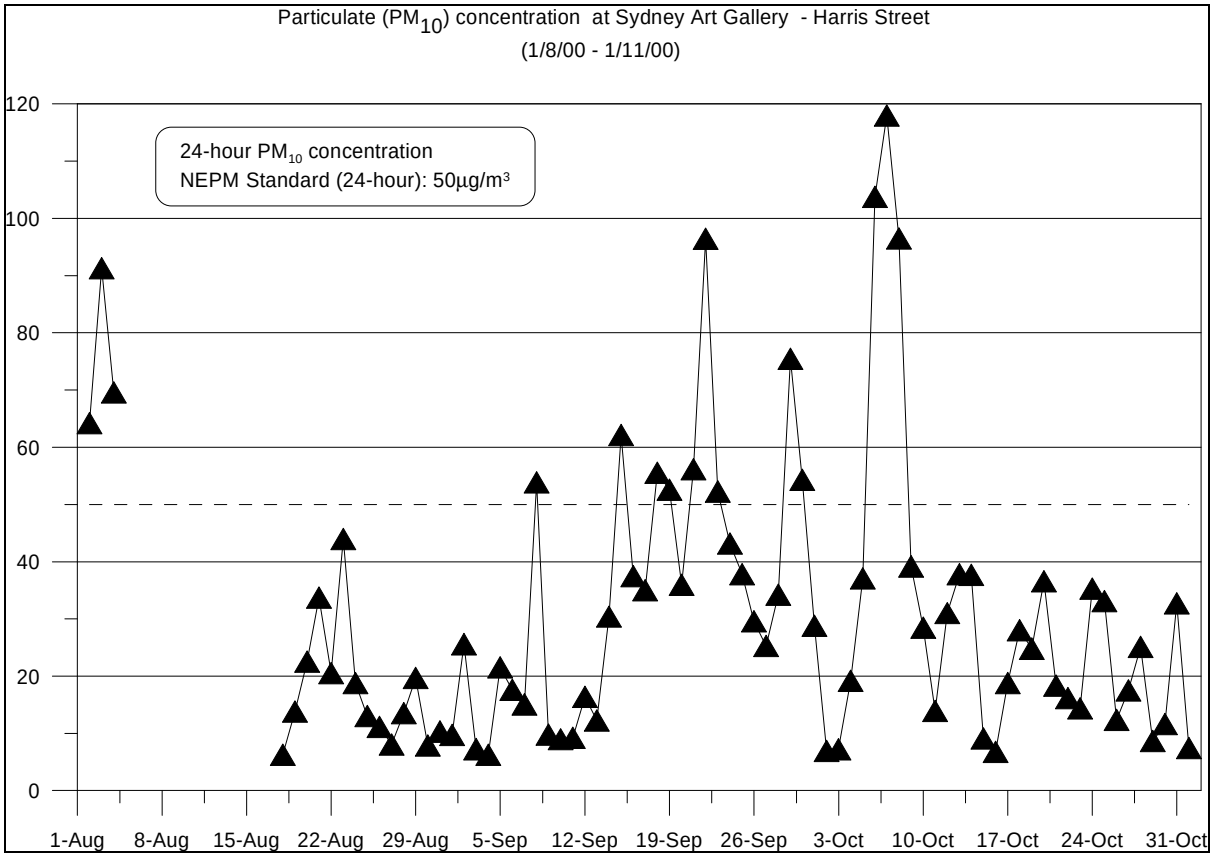

Figure 11: Daily concentration of PM_{10} at Sydney Art Gallery.

There were three exceedances in August, occurring on consecutive days from the 1st to 3rd. The levels recorded on these days are shown in **Table 8**. Air quality throughout the Sydney basin on these days was low and, as mentioned, was subject to an EPA request for wood heaters not to be used in an attempt to reduce particulate concentration.

There were nine exceedances in September, mostly occurring in the second half of the month. The days on which the exceedances occurred are detailed in **Table 8**. The first exceedance (7/9/00) was due to elevated concentrations throughout the day. The second exceedance (14/9/00) was due to elevated concentration during the middle of the day. The exceedances on the 17th and 18th were from concentrations of approximately 80 µg/m³ beginning on the afternoon (of the 17th) and lasting the morning of the 18th.

The exceedances on the 20th to 22nd were the result of separate elevated concentrations on each day, with the 21st having particularly high concentration. The same circumstances of high concentration on the 28th and 29th led to exceedances on these days. Bushfires at Holsworthy in south-western Sydney and Hornsby in northern Sydney before 20 September, would have contributed to the exceedance on 20 to 22 September.

There were three exceedances in October, occurring on consecutive days from the 5th to the 7th. These particulate concentrations were the result of 10-minute measurements being above 100 µg/m³ for significant periods of time throughout the Sydney region. Diminished air quality on these days was exacerbated by bushfires, which started on 2 October at a number of locations in the Sydney region.

Table 8: Summary of PM_{10} exceedance occasions at the Art Gallery.

Measurement Interval	Exceedance Occasion	Concentration μg/m³	Day of Exceedance
August			
Daily Concentration	1	64	1
	2	91	2
	3	70	3
September			
Daily Concentration	4	54	7
	5	62	14
	6	56	17
	7	53	18
	8	56	20
	9	96	21
	10	52	22
	11	76	28
	12	54	29
October			
Daily Concentration	13	104	5
	14	118	6
	15	97	7

5 CONCLUSIONS

Concentration of gaseous emissions have a clearly defined daily pattern which is governed by peak traffic times. These times of peak concentration occur in the morning and evening.

For the three months from August to October there were no exceedances of air quality goals for nitrogen dioxide and carbon monoxide at the Sydney Police Station monitoring site. Monitoring of gases over the three month period showed that concentrations were low for the majority of the time. Monitoring of particulate matter showed nine exceedances of the NEPM goal of 50 μg/m³.

At the Art Gallery site, there was one exceedance of the 8-hour carbon monoxide goal in the three month period. There were no exceedances of other carbon monoxide or nitrogen dioxide goals. For the most part, concentration of gaseous emissions over the three months were low. Monitoring of particulate concentration showed fifteen exceedances of the NEPM goal.

These data are consistent with the measurements made in June and July.

As discussed in **Section 2**, the enclosed urban canyon surroundings in which air quality is monitored at both sites means that the NEPM goals would not apply. Further, exceedances in early August, late September and early October were exacerbated by external influences of unfavourable meteorological conditions or bushfires.

Inspection of the Art Galley site revealed deposits of crustal dust on the footpaths in Harris Street, presumably from previous and existing construction/demolition activities in the area. Re-entrainment of this dust would certainly contribute to the PM_{10} levels monitored at this site. The proximity of this monitor to the Western Distributor is also a significant factor.

The measured exceedances of the NEPM PM_{10} goal should not be a cause for alarm. Air quality in the Pyrmont/Ultimo area is still well within the bounds of acceptable limits as defined by the US EPA. By these standards, air quality in Sydney with respect to particulate matter would on most occasions be classified as good.

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