THE CROSS CITY TUNNEL PROJECT

AIR QUALITY MONITORING REPORT

FOR NOVEMBER, DECEMBER AND JANUARY 2000/01

March 2001

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 from November 2000 to January 2001. This monitoring program is part of the Cross City Tunnel (CCT) project and has been established since June 2000. Monitoring of carbon monoxide, total oxides of nitrogen, nitrogen dioxide and particulate matter (PM_{10}) has been carried out in the Darling Harbour 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 in Day Street is ongoing.

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

Sydney Police Station

For the three month period there was no exceedances of the air quality goals for any monitored emission. In the case of nitrogen dioxide, the average value over the study period was 21 % of the 1-hour air quality goal. The carbon monoxide goals were not exceeded and the average 8-hour concentration was 12 % of the goal. The average PM_{10} value was 38 % of the air quality goal.

In comparison, data collected for this report differs from that reported previously (refer **RTA(a) & RTA(b), 2000**) in the following ways:

- Maximum total oxides of nitrogen concentrations occur during the morning in summer months, rather than during the evening in winter months;
- The PM_{10} concentrations are lower resulting in no exceedances of the NEPM goal; and
- Overall concentrations of all pollutants are lower.

Seasonality is a major contributor to the differences observed between monitoring periods. 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. During summer months, the ability of the atmosphere to disperse emissions increases and lower concentrations are observed. It is for this reason that monitoring results collected during winter months 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 expected to occur. These monitoring sites are not appropriate places for testing compliance with the NEPM air quality goals. However, they do provide information on local air quality.

Air quality in the project area is 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.

CONTENTS

FIGURES

TABLES

GLOSSARY AND ABBREVIATIONS

CBD	Central Business District
CCT	Cross City Tunnel
CO	Carbon monoxide
EIS	Environmental Impact Statement
µm	micrometre
$\mu g/m^3$	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	Total 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. This report summarises concentrations of carbon monoxide (CO), total oxides of nitrogen (NO_x), nitrogen dioxide (NO_2) and particulate matter (PM_{10}) recorded at the Sydney Police Station from November 2000 to January 2001. The CCT project development process has been reporting the results of the monitoring program since June 2000. From this monitoring program, two separate reports in July and November have been published (**RTA(a) & RTA(b), 2000**).

The location where the monitoring program is being conducted is shown in **Figure 1**. Currently, monitoring is taking place at the Sydney Police Station on Day Street, on the western edge of the CBD.

Figure 1: Location of Sydney Police Station monitoring site.

Until October 2000, monitoring was also being conducted at the Sydney Art Gallery on Harris Street, Ultimo. The building that housed the Art Gallery was sold in October and as a result monitoring has been suspended. The monitoring program in the area near Harris Street will re-commence in the future and potential replacement sites are currently being considered.

Since the beginning of the monitoring program, the location of the monitors has been temporary. More permanent monitoring stations would be located in secure, air-conditioned buildings. The current location at the Police Station also has some difficulties in terms of power disruption and some data have been lost because of this. Further, the data collected at both sites is representative of very localised urban canyons rather than the more general environment to which the NEPM goals apply. Nevertheless, the data provide useful information about the level of air pollution currently experienced in urban street canyons on the outskirts of the CBD.

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 highlighted 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 mg/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 mg/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 the monitoring station, 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 current monitoring site chosen for the Cross City Tunnel is a heavily trafficked street canyon and would therefore not be an appropriate site 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 NEPM goals, 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 mg/m^3** *PM_{10} 24-hour 0-75 mg/m^3*	Good	None for the general population.	None required.
50 to 100 *$PM_{2.5}$ 24-hour 33-65 mg/m^3* *PM_{10} 24-hour 75-150 mg/m^3*	Moderate	Few or none for the general population.	None required.
100 to 200 *$PM_{2.5}$ 24-hour 65-130 mg/m^3* *PM_{10} 24-hour 150-300 mg/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 mg/m^3* *PM_{10} 24-hour 300-450 mg/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 mg/m^3* *PM_{10} 24-hour over 450 mg/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**).

* Figures in italics are inferred from the knowledge that a PSI value 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 µg/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 µg/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 µg/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 µg/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 particulates 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 Sydney Police Station site is a "peak" site.

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. Measurements are made at 1-minute intervals and 10-minute averages are then stored in memory. The 10-minute average concentration was used to determine longer time averages, such as the 1-hour average.

Total oxides of nitrogen and nitrogen dioxide measurements were disrupted from 5 to 11 November, due to instrument malfunction.

3.1 Total 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 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 November to January are shown in **Figure 2**.

The mean NO_2 concentration in the three months was 2.5 pphm. The 1-hour NEPM goal for nitrogen dioxide, which is 12 pphm, was not exceeded. The maximum 1-hour NO_2 concentration was 8.1 pphm.

The results of the 10-minute concentration of nitrogen dioxide are also 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.

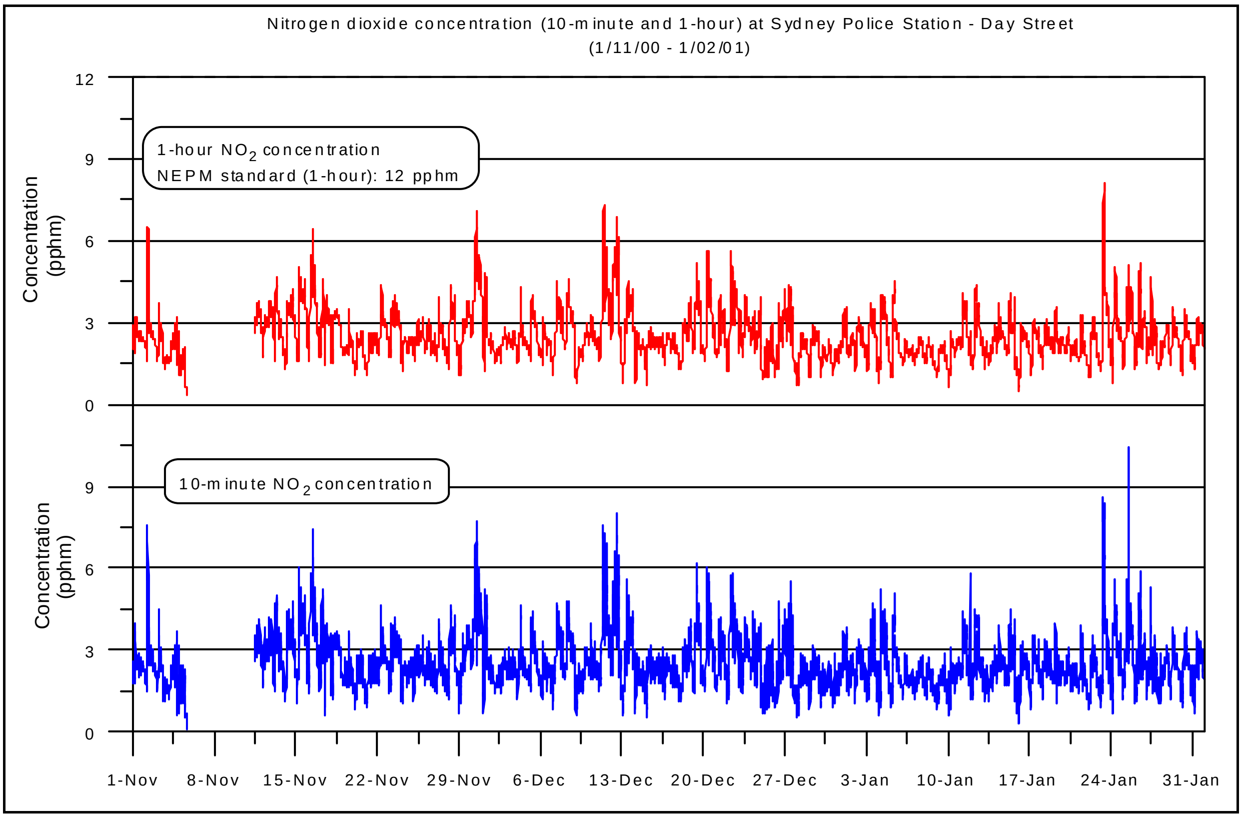

Figure 2: The 1-hour and 10-minute concentration of nitrogen dioxide at Sydney Police Station.

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 the total oxides of nitrogen. Analysis of the EPA's total 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 between November and January. All of these occurred in November. Over this period, the proportion of NO and NO_2 in the total oxides of nitrogen was 85.1% and 14.9% 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, 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 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 (%)
02/11/00	7:00 am	43.9	6.5	14.8
16/11/00	10:00 am	34.4	5.9	17.1
16/11/00	9:00 am	33.2	5.3	15.9
16/11/00	6:00 am	32.5	5.4	16.7
02/11/00	6:00 am	31.8	3.5	10.9
16/11/00	8:00 am	31.0	5.3	16.9
16/11/00	7:00 am	29.5	5.2	17.6
17/11/00	8:00 am	29.3	4.5	15.4
03/11/00	6:00 am	29.2	3.2	11.0
23/11/00	6:00 am	28.6	3.7	12.8
Average		**32.3**	**4.8**	**14.9**

As the concentrations of total oxides of nitrogen decrease, (ie. dilutes 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 occur in the morning during the three months. In summer, thermal breezes such as a sea breeze, generally aid dispersion of emissions in the evening resulting in lower NO_x concentrations. In winter months the combination of peak traffic and atmospheric stability favours peak NO_x concentrations in the evening. Highest NO_x concentration is dependent on the co-incidence of peak traffic periods and prevailing atmospheric conditions, as outlined in the previous paragraph.

The 10-minute concentrations of total oxides of nitrogen are shown in **Figure 3**. The maximum concentration for NO_x was 49.2 pphm, recorded on 2 November.

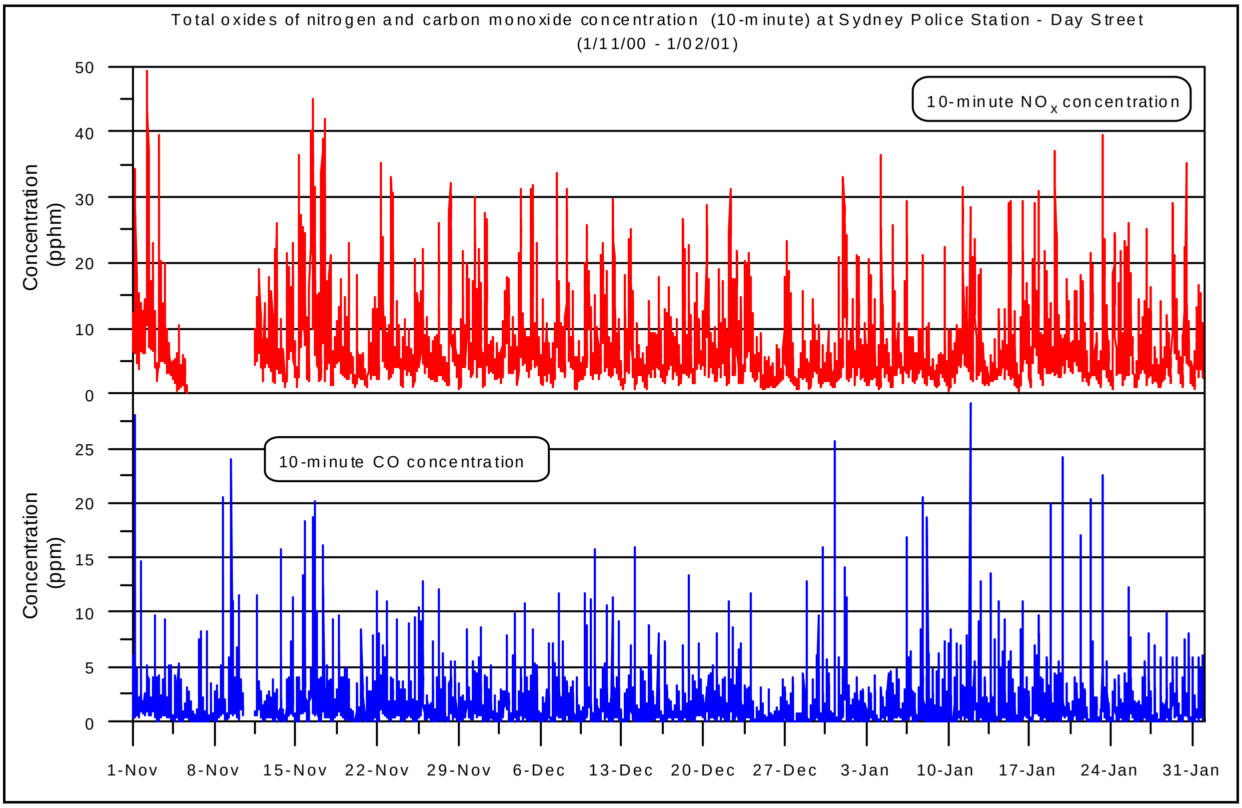

Figure 3: The 10-minute concentrations of carbon monoxide and total oxides of nitrogen at Sydney Police Station.

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 improved 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 concentrations.

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 1.1 ppm. The maximum 1-hour and 8-hour CO concentrations were 8.9 ppm and 3.6 ppm, respectively. The 1-hour CO WHO standard of 25 ppm was not exceeded in the three month period.

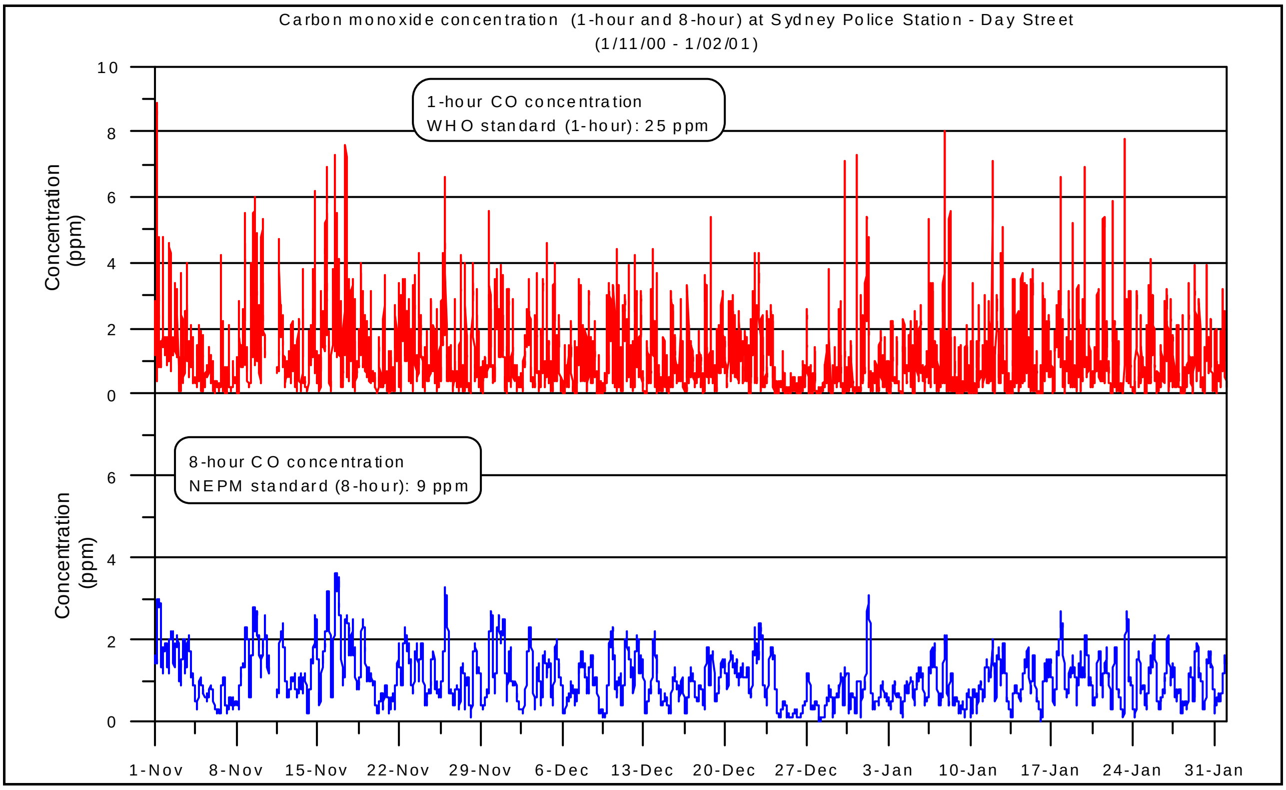

Figure 4: The 1-hour and 8-hour carbon monoxide concentrations at Sydney Police Station.

The 8-hour CO concentrations shown in **Figure 4**, remained at low concentrations throughout the three months. The NEPM standard of 9 ppm was not exceeded in the three month 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 the 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 defences 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 mean value of the particulate concentration for the three months was 19.2 $\mu g/m^3$. 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.

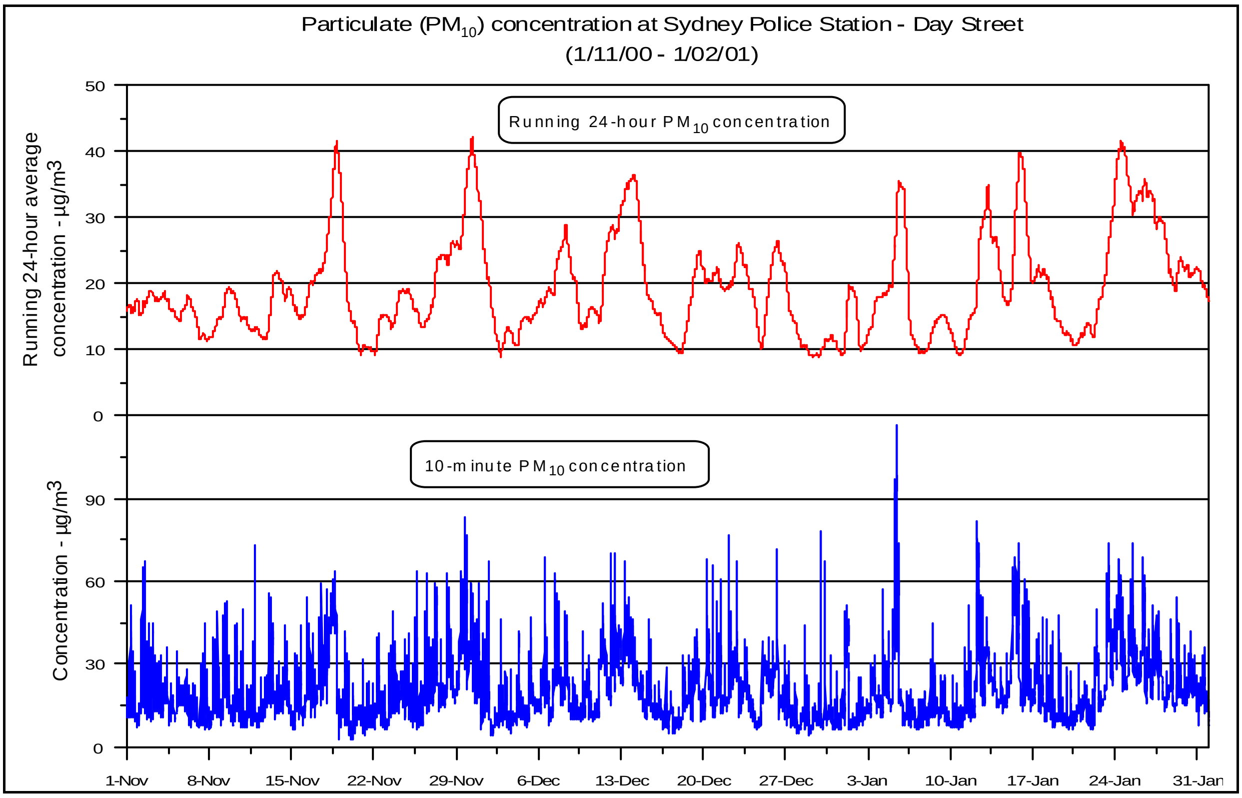

Figure 5: The 10-minute and running 24-hour concentration of PM_{10} at Sydney Police Station.

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 9/1/01, until midnight on the 10/1/01). 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 9/1/01, until 1:40pm on the 10/1/01). As a result the 24–hour running average is calculated at every measurement interval (ie. 10 minutes).

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

Measurement Interval	Mean µg/m^3			Maximum µg/m^3			Day of Maximum Concentration			Time of Maximum Concentration		
	NOV	DEC	JAN	NOV	DEC	JAN	NOV	DEC	JAN	NOV	DEC	JAN
10-minute average	18.8	17.9	21	83	78	117	29	29	5	5:40 pm	11:50 pm	9:30 am
24-hour running average	18.5	18.2	21	42.2	36.5	41.6	30	14	24	8:40 am	1:20 am	1:10 pm
Daily average	18	19	21	39	36	40	20	14	16	N/A	N/A	N/A

The 24-hour average concentrations of PM_{10} at the Police Station are shown in **Figure 6**. The 24-hour goal (daily average) was not exceeded over the three month period at the Police Station.

Air quality measured in the vicinity of the Police Station is 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.

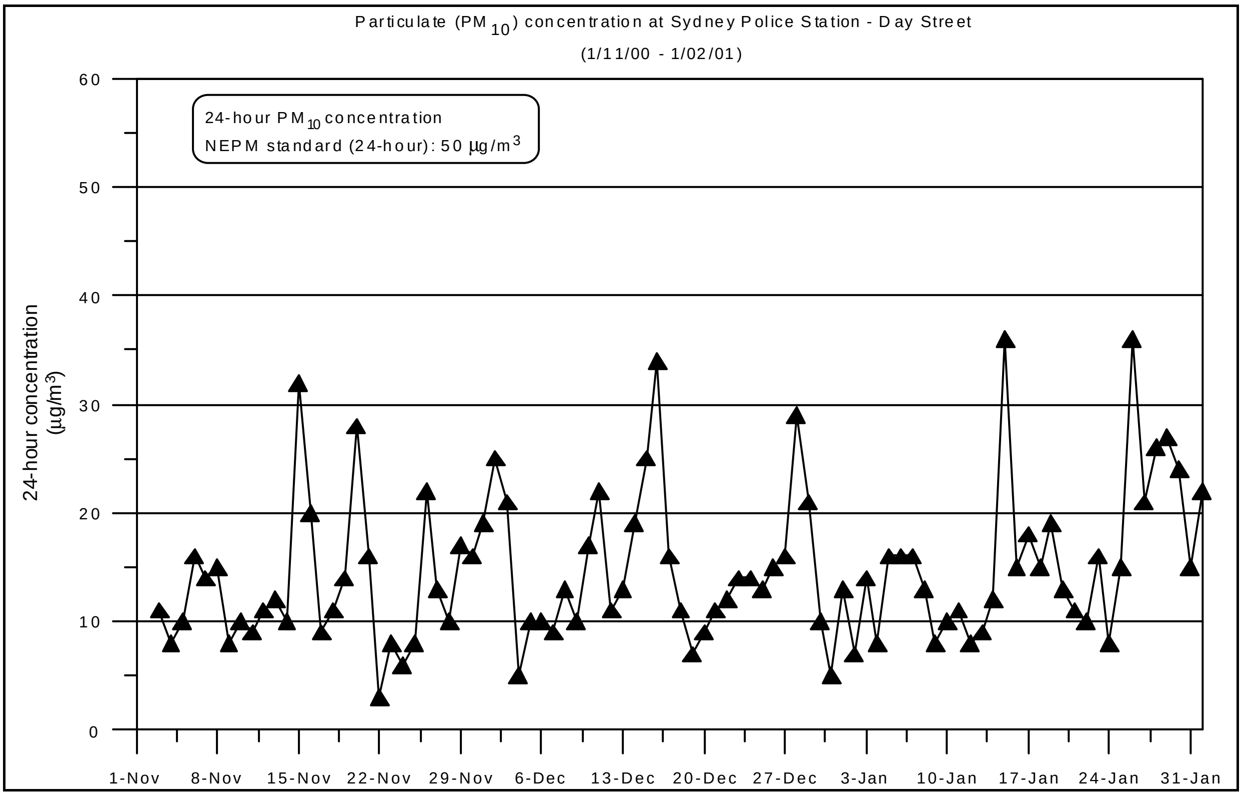

Figure 6: Daily concentration of PM_{10} at Sydney Police Station.

4 CONCLUSIONS

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

For the three months from November to January there were no exceedances of any air quality goals at the Sydney Police Station monitoring site. This compliance with the standards mentioned in **Section 2,** contrasts with the previous CCT monitoring reports, where there were exceedances. This is consistent with the better dispersion conditions which occur during the summer months.

Even though there were no exceedances of the NEPM standards, the enclosed urban canyon surroundings in which air quality is monitored means that the standards would not apply at the Police Station. Concentrations observed at the monitoring site would, in general, be higher than observed at a NEPM performance monitoring station.

Air quality in the Darling Harbour area is 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 be classified as good.

5 REFERENCES

EPA (1993)
"Quarterly Air Quality Monitoring Report" Volume 22 Number 1-4, prepared by NSW EPA ISSN 0314 7835.

EPA (1998)
"Action for Air" prepared by NSW EPA ISBN 0 7313 0160 9.

EPA (2000)
"NSW EPA Website", http://www.epa.nsw.gov.au/air/rpi.htm.

NEPC (1998)
"Final Impact Statement for the Ambient Air Quality National Environment Protection Measure" National Environment Protection Council Service Corporation, Level 5, 81 Flinders Street, Adelaide SA 5000.

RTA (1997)
"RTA Air Quality Monitoring Program" prepared for the RTA by Holmes Air Sciences, January 1997.

RTA(a) (2000)
"Air Quality Monitoring Report at Darling Harbour for the Cross City Tunnel Project for June and July, 2000", August 2000.

RTA(b) (2000)
"Air Quality Monitoring Report at Darling Harbour for the Cross City Tunnel Project for August, September and October, 2000", December 2000.

UK DETR (1998)
"A recommendation for United Kingdom Air Quality Standard for Particles; Expert Panel on Air Quality Standards" refer www.environment.detr gov.uk/airq/particle/1.htm.

US EPA (1998)
"Measuring air quality - the pollutant standards index - EPA 451/K-94-001" refer www.epa.gov/airprogm/oar/oaqps/psi.html.