THE CROSS CITY TUNNEL PROJECT

AIR QUALITY MONITORING REPORT

FOR FEBRUARY TO JUNE 2001 AND ANNUAL SUMMARY TO JUNE 2001

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Prepared
for
Roads and Traffic Authority

by

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EXECUTIVE SUMMARY

This report presents the results of an air quality monitoring program from February to June 2001. This monitoring program has been established as part of the Cross City Tunnel (CCT) project and has been underway 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. A summary of the overall air quality for these compounds for the year to June 2001 is presented in this report.

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 suitable places for testing compliance with the NEPM air quality goals, however, they do provide information on local air quality.

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

For the four month period there were six PM_{10} readings above 50 $\mu g/m^3$. These occurred in March and April, consistent with the poor dispersion conditions experienced in autumn. For the gaseous compounds there were no readings above of any respective air quality goal. In the case of nitrogen dioxide, the average value over the study period was 23 % of the 1-hour air quality goal. No readings above the carbon monoxide goals were recorded and the average 8-hour concentration was 17 % of the goal. The average PM_{10} value was 47 % of the air quality goal.

Over the year from June 2000 to June 2001, concentrations have shown a seasonal pattern for carbon monoxide and particulate matter. Monitoring of air quality began and ended in mid-winter when atmospheric stability is high and dispersion is generally poor. Accordingly, higher readings for particulate matter were recorded at the beginning and end of the study period. During summer months, which were reported on in the previous monitoring report (**RTA, 2001**), the ability of the atmosphere to disperse emissions increases and lower concentrations were observed.

Air quality in the project area is, for the majority of the time, within EPA guidelines for gaseous compounds. The readings recorded above the air quality goal for PM_{10} were consistent with the location of the monitors near busy roadways.

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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
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 Sydney Police Station from February to June 2001. Reporting of the Sydney Police Station and Sydney Art Gallery monitoring stations since June 2000 when monitoring began, is contained in three previous reports published by the RTA (**RTA(a), RTA(b) 2000 and RTA 2001**).

As part of the CCT development process, the RTA has established an air quality monitoring program in the project area. This program concluded in June 2001. This report includes an annual summary of the monitoring program conducted at Sydney Police Station from June 2000 to June 2001. Data collected over a full year covers seasonal influences some of which would inhibit dispersion and lead to high concentrations being recorded. A monitoring period longer than a year would provide additional information but it is likely that a similar pattern would emerge.

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

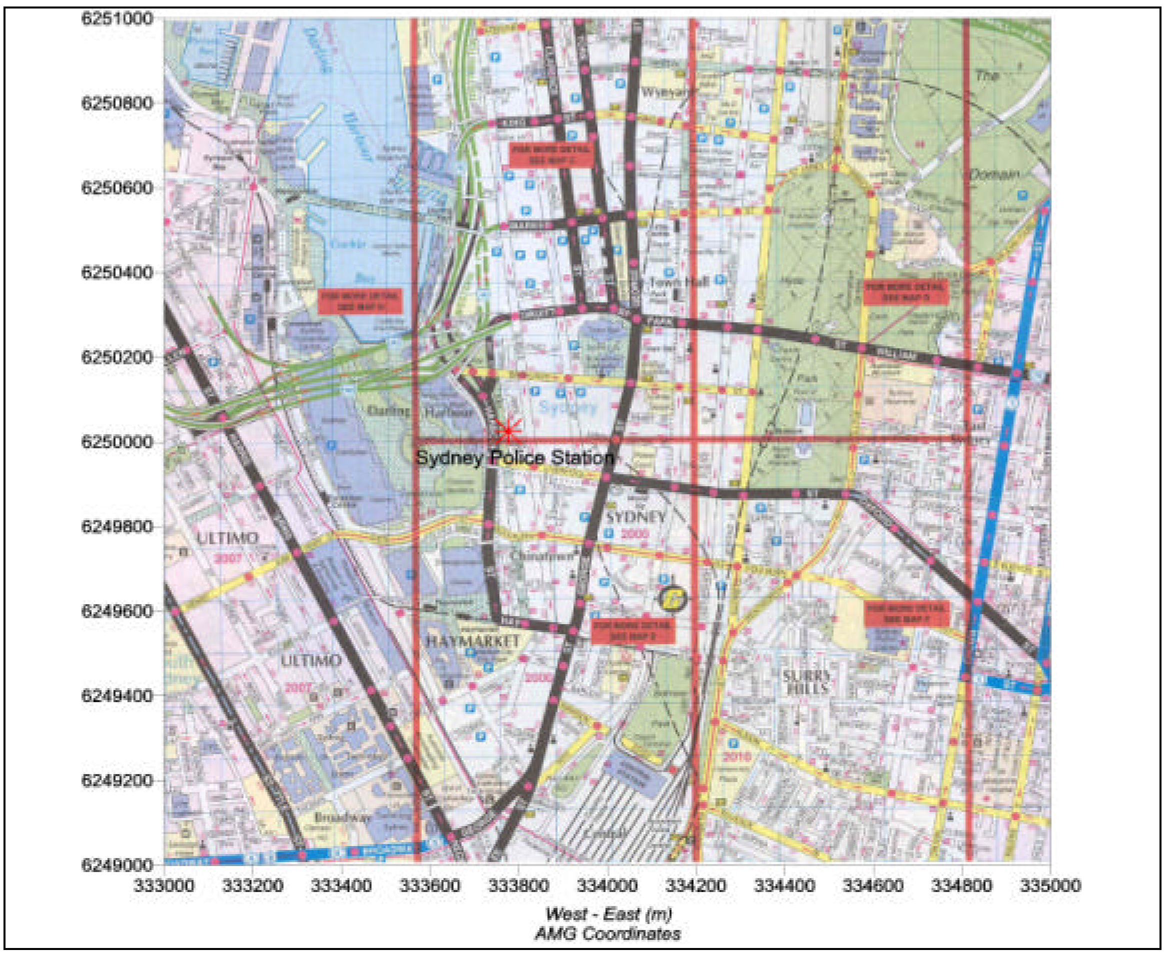

Figure 1: Location of Sydney Police Station monitoring site.

The current location at the Police Station has some difficulties in terms of power disruption and some data have been lost because of this. Further, the data collected are 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 edge 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 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**

 # NEPM Impact Statement

* *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 Impact Statement, (**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.

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 approximately one storey above 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, nitrogen dioxide and carbon monoxide measurements were disrupted from 28 February to 8 March 2001, due to power failure. Monitoring of these compounds at the Police Station began on 19 May 2000 and concluded on 30 May 2001. Measurements of particulate concentrations (PM_{10}) were not disrupted from February to June 2001. Monitoring of PM_{10} commenced on 7 June 2000 and concluded on 20 June 2001.

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.

The mean NO_2 concentration in the four months was 2.8 pphm. No levels were recorded above the 1-hour NEPM goal for nitrogen dioxide, which is 12 pphm. The maximum 1-hour NO_2 concentration was 9.3 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, 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.

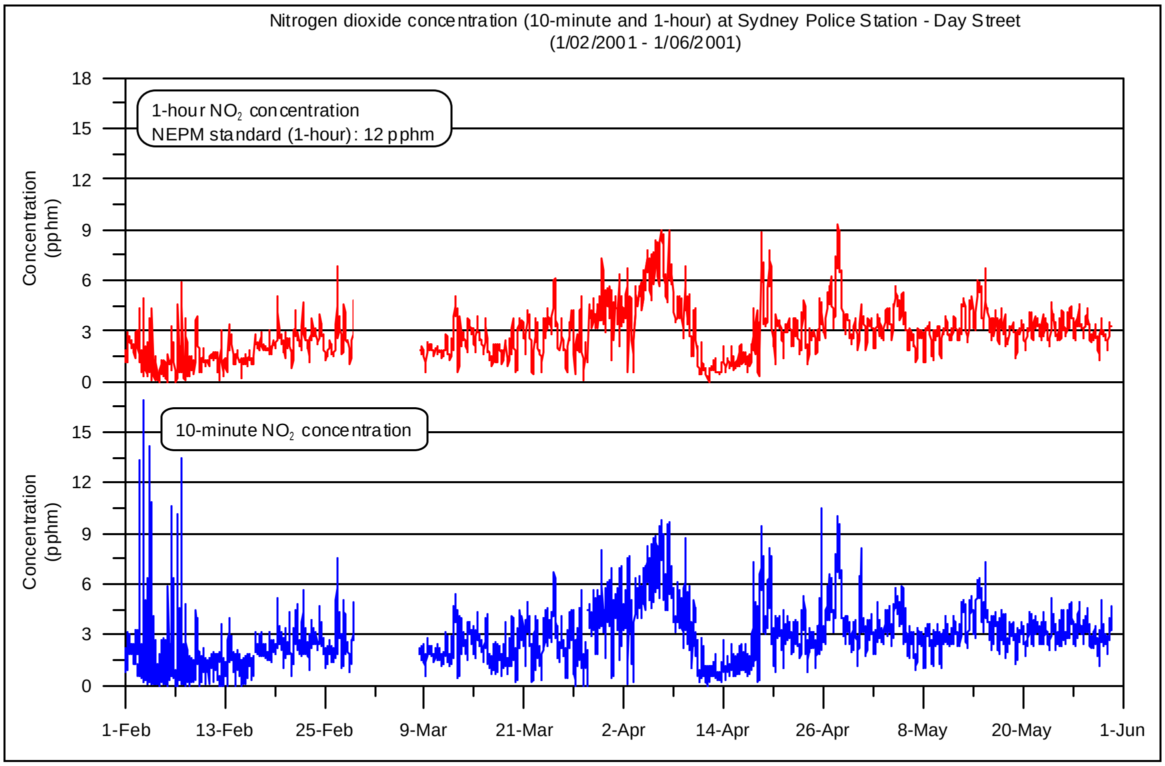

Figure 2: The 1-hour and 10-minute concentration of nitrogen dioxide at Sydney Police Station.

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 February to June are shown in **Figure 2**. A finer resolution of the nitrogen dioxide data captured in **Figure 2** has been presented in **Figure 3** to clearly display the general daily pattern in concentrations. **Figure 3** shows a strong diurnal pattern present in the monitoring data from 30 April to 22 May. The daily pattern shows that concentrations are usually lower during the early morning after which there is a noticeable increase, likely due to increased traffic numbers. The increase in traffic has been assumed to lead to the first peak at mid morning. The concentrations then decrease slightly after midday before returning to peak levels during the evening, remaining higher until the early morning when a significant decrease in concentrations occurs. In the four month reporting period this typical daily cycle in nitrogen dioxide concentrations was regularly interrupted by events where levels remained elevated for extended periods of time.

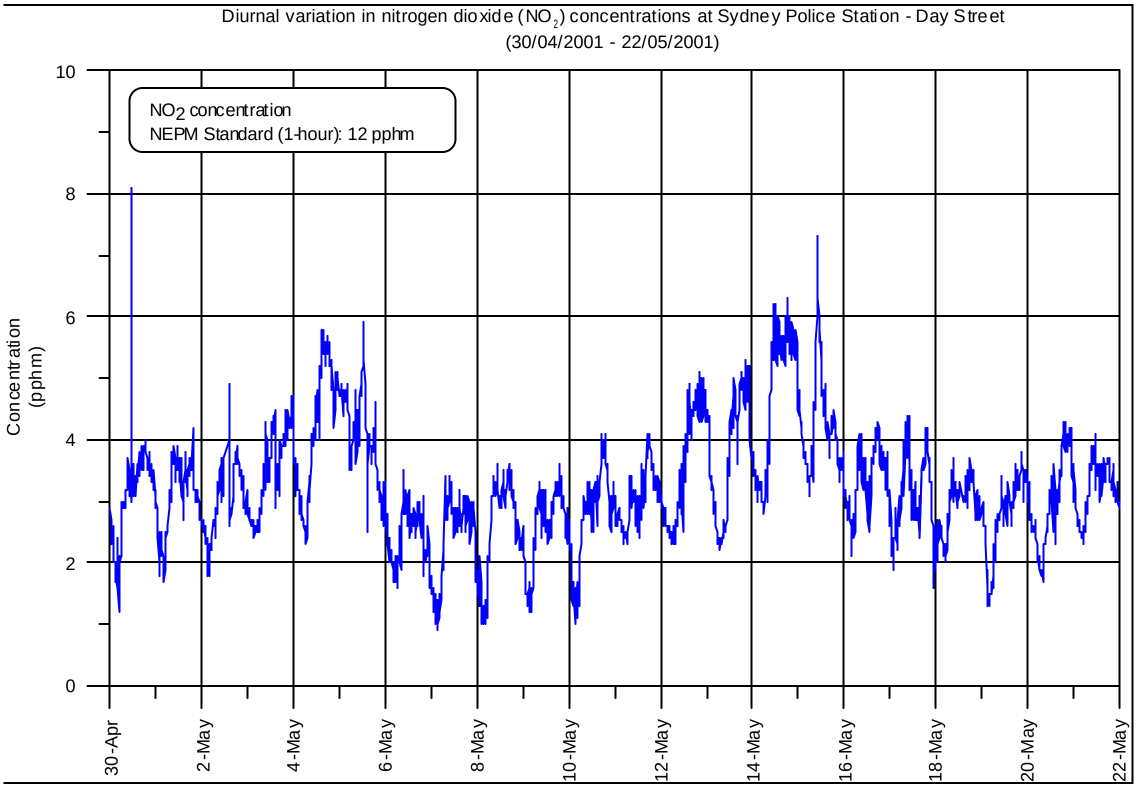

Figure 3: Diurnal variation in nitrogen dioxide concentration at Sydney Police Station.

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 2: 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 (%)
13/03/01	08:00	45.1	3.9	8.7
30/03/01	09:00	51.4	7.3	14.3
4/04/01	07:00	51.2	5.9	11.5
4/04/01	08:00	55.1	6.6	11.9
9/04/01	07:00	41.7	5.6	13.5
18/04/01	10:00	46.2	1.8	3.9
27/04/01	23:00	41.9	8.5	20.2
28/04/01	00:00	41.1	6.6	16.1
20/05/01	22:00	43.3	4.1	9.4
20/05/01	23:00	41.9	4.0	9.6

Table 2 contains the ten highest 1-hour concentration of NO_x between February and June. Over this period, the proportion of NO and NO_2 in the total oxides of nitrogen was 90.4% and 9.6% 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.

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.

Highest NO_x concentrations are generally dependent on the co-incidence of peak traffic periods and prevailing atmospheric conditions. This co-incidence changes at different times of the year. In summer months, higher NO_x concentrations tend to occur in the morning, in part probably due to daylight savings, as evening peak traffic will be travelling at earlier solar times. In winter, the co-incidence of increased traffic and high atmospheric stability favours peak NO_x concentrations in the evening.

The 10-minute concentrations of total oxides of nitrogen are shown in **Figure 4**. The maximum 10-minute concentration for NO_x was 86.8 pphm, recorded on 25 April.

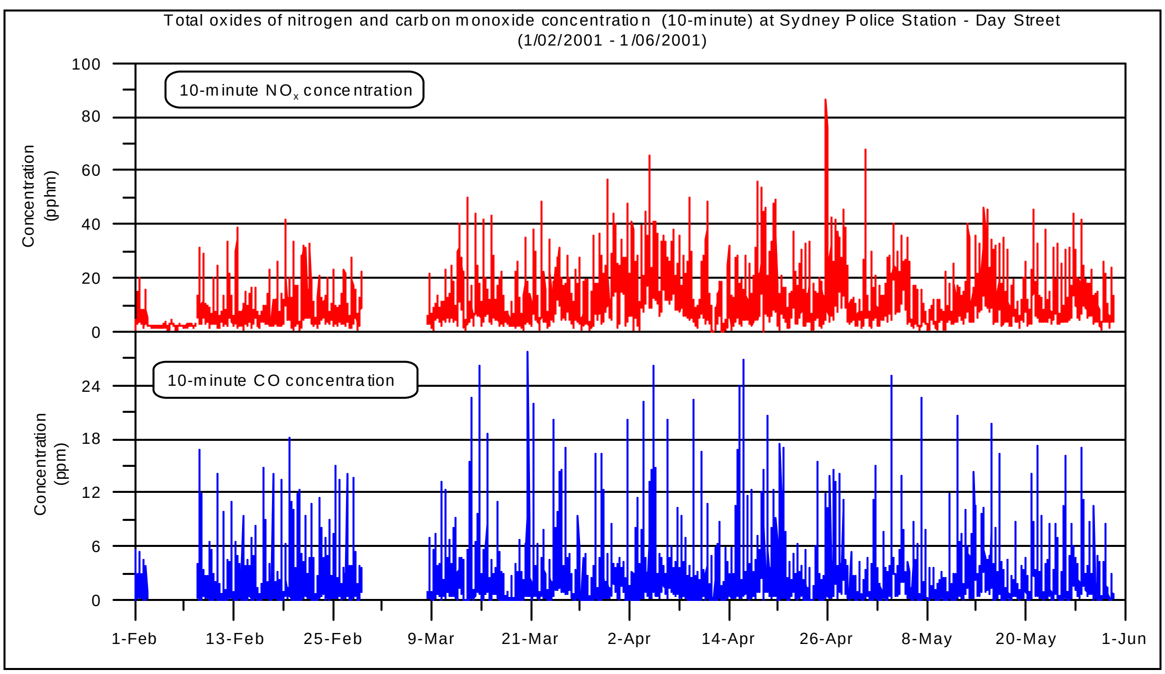

Figure 4: The 10-minute concentrations of carbon monoxide and total oxides of nitrogen at Sydney Police Station.

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 are 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). Concentrations in the middle of the day at the Police Station are lower due to the favourable combination of lower traffic numbers and improved dispersion conditions. The 10-minute concentration of carbon monoxide is shown in **Figure 4**. 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 presented in **Figure 5**, show that throughout the monitoring period levels remained low. The mean carbon monoxide concentration for the four months was 1.4 ppm. The maximum 1-hour and 8-hour CO concentrations were 12.5 ppm and 4.9 ppm, respectively. No readings above the 1-hour or 8-hour carbon monoxide goals were recorded in the four month period.

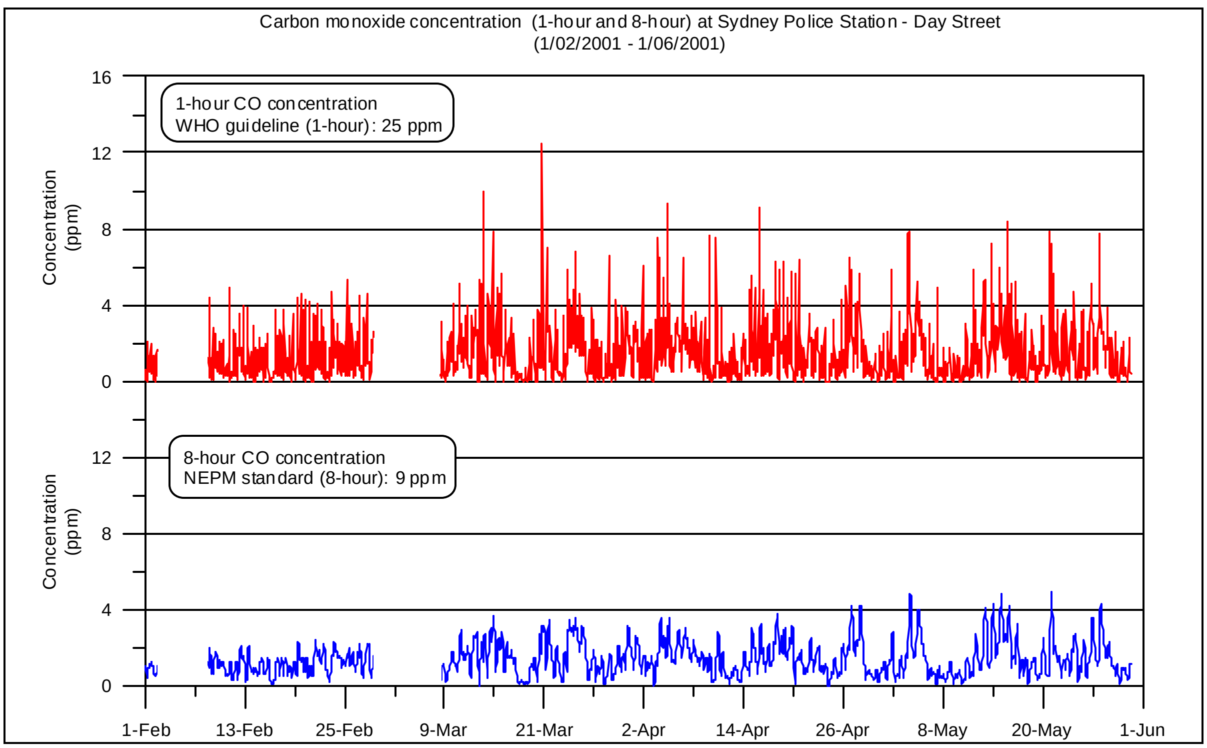

Figure 5: The 1-hour and 8-hour carbon monoxide concentrations at Sydney Police Station.

Like the daily pattern in nitrogen dioxide concentrations shown in **Figure 3**, carbon monoxide concentrations display two peaks that coincide with the times of general morning and evening peak traffic periods.

On closer inspection of the 10-minute carbon monoxide concentrations, a section of which is presented in **Figure 6**, a diurnal pattern shows higher concentrations occurring in the morning and evening. These periods of elevated concentrations in the morning and evening are overlaid by highly variable short term peaks.

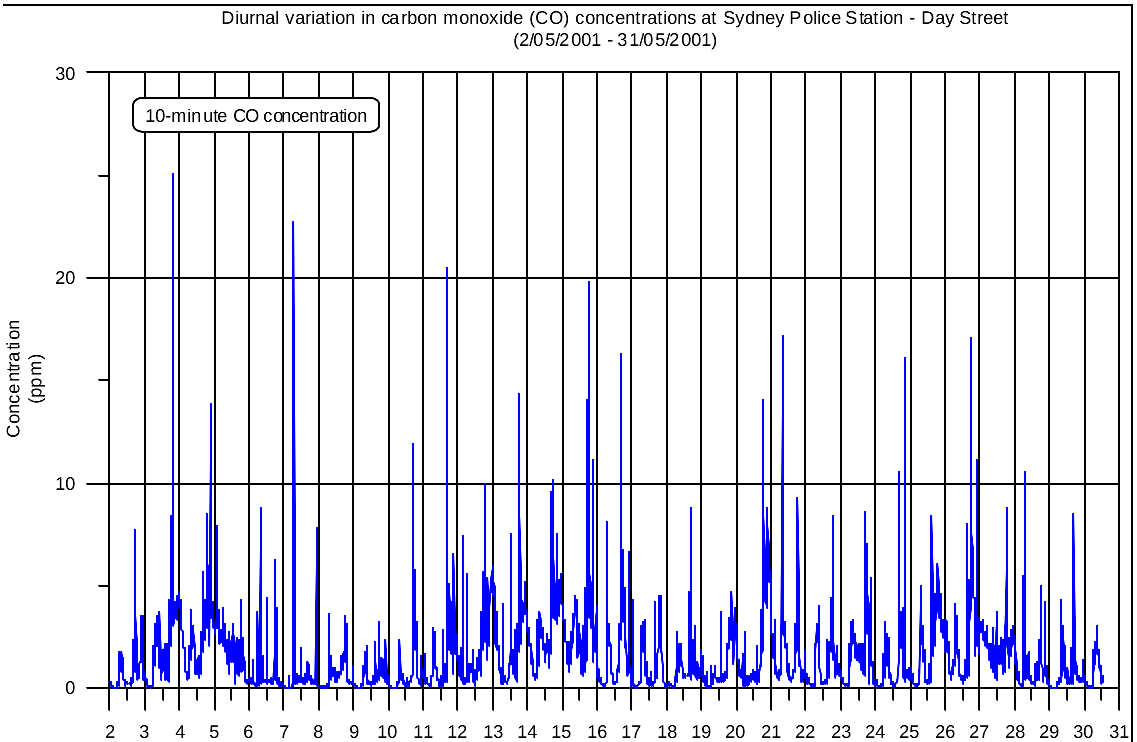

Figure 6: Diurnal variation in carbon monoxide concentrations at Sydney Police Station.

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 four months was 23.6 $\mu g/m^3$. The 10-minute and 24-hour running average PM_{10} concentrations are shown in **Figure 7**. Neither of these averaging periods have associated air quality standards for PM_{10}.

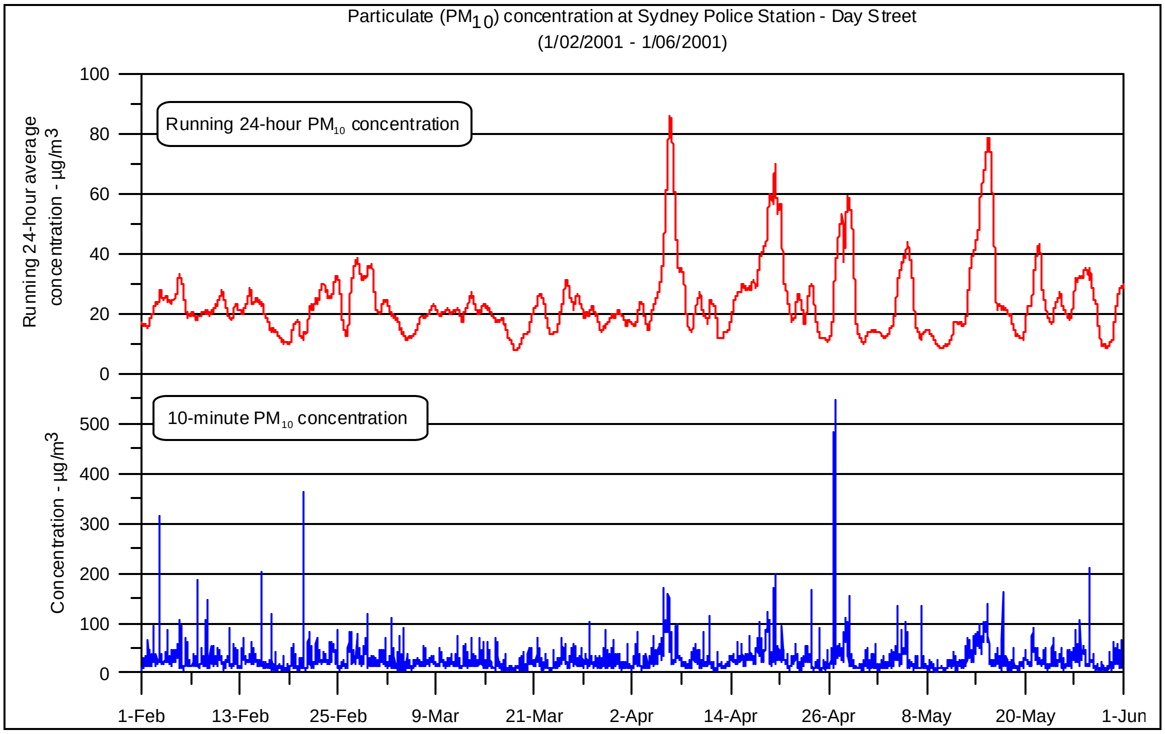

Figure 7: The 10-minute and running 24-hour concentration of PM_{10} at Sydney Police Station.

The PM_{10} concentrations (average and maximum) for three time intervals are shown in **Table 3**. 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 3: The PM_{10} concentrations for three time intervals at the Police Station.

<table>
<tr><th rowspan="2">Measurement Interval</th><th colspan="4">Mean µg/m^3</th><th colspan="4">Maximum µg/m^3</th><th colspan="4">Day of maximum concentration</th></tr>
<tr><th>FEB</th><th>MAR</th><th>APR</th><th>MAY</th><th>FEB</th><th>MAR</th><th>APR</th><th>MAY</th><th>FEB</th><th>MAR</th><th>APR</th><th>MAY</th></tr>
<tr><td>10-minute average</td><td rowspan="3">22.5</td><td rowspan="3">19.0</td><td rowspan="3">28.1</td><td rowspan="3">24.9</td><td>363</td><td>109</td><td>547</td><td>210</td><td>20</td><td>3</td><td>26</td><td>27</td></tr>
<tr><td>24-hour running average</td><td>38.5</td><td>36.6</td><td>85.9</td><td>78.7</td><td>27</td><td>1</td><td>6</td><td>15</td></tr>
<tr><td>Daily average</td><td>36</td><td>31</td><td>69</td><td>67</td><td>27</td><td>25</td><td>7</td><td>15</td></tr>
</table>

The 24-hour average concentrations of PM_{10} at the Police Station are shown in **Figure 8**. Over the four month period at the Police Station, six readings above 50µg/m^3 were recorded.

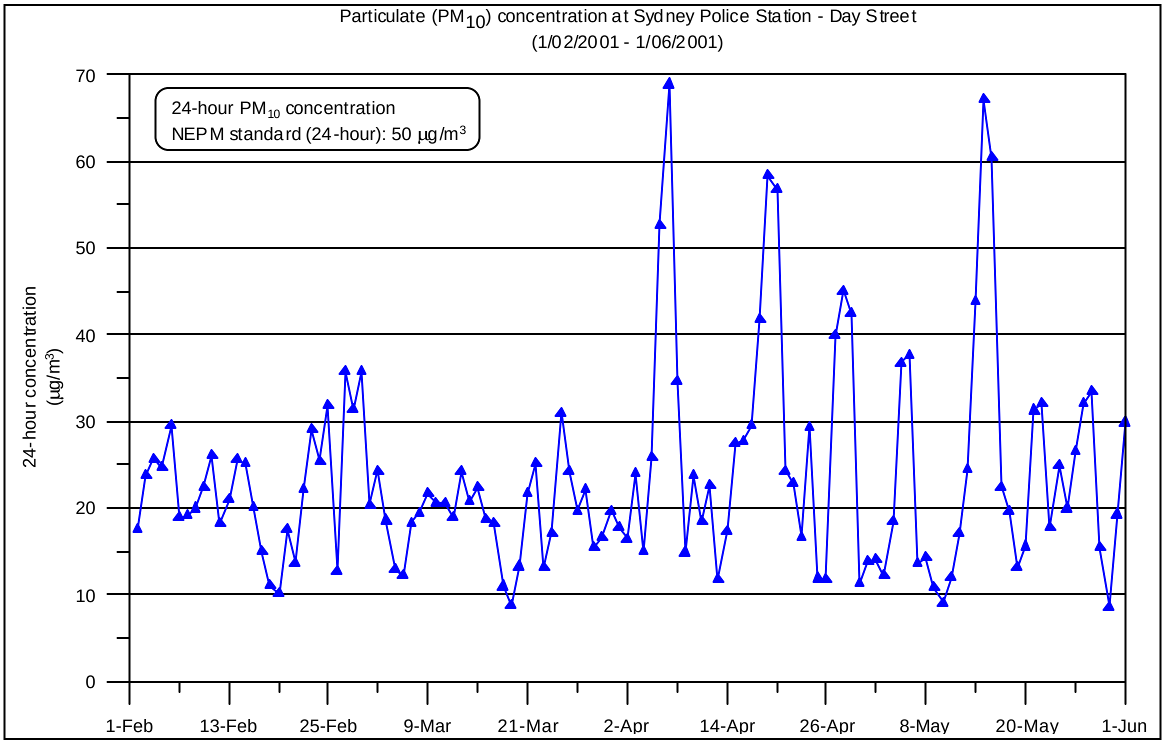

Figure 8: Daily concentration of PM_{10} at Sydney Police Station.

In addition to the daily trends for all concentrations monitored, but particularly for PM_{10}, are episodes when concentrations remain elevated for more than 24 hours. These episodes do not have a regular period and are overlaid on the daily patterns. The daily patterns display generally higher concentrations during the mid-morning and evening peak traffic periods.

Concentrations of all pollutants at the Police Station shown in **Figure 9** display a very high degree of correlation and are therefore likely to be sourced from the same location. The high density of traffic and the proximity of the monitoring station to nearby roadways are the likely source and causes of elevated concentrations measured at the Police Station. The built environment around the monitoring station would further exacerbate the high concentrations that are sometimes measured at monitoring sites close to roadways in the CBD.

In **Figure 9**, the 10-minute particulate matter (PM_{10}) and total oxides of nitrogen (NO_x) concentrations monitored at approximately 8:00 am 13/02/2001 display a sharp increase. While no definite conclusions can be drawn about the source of the elevated concentrations, it is interesting to note that heavy duty diesel vehicles over-whelmingly contribute to PM_{10} and NO_x emissions from roadways.

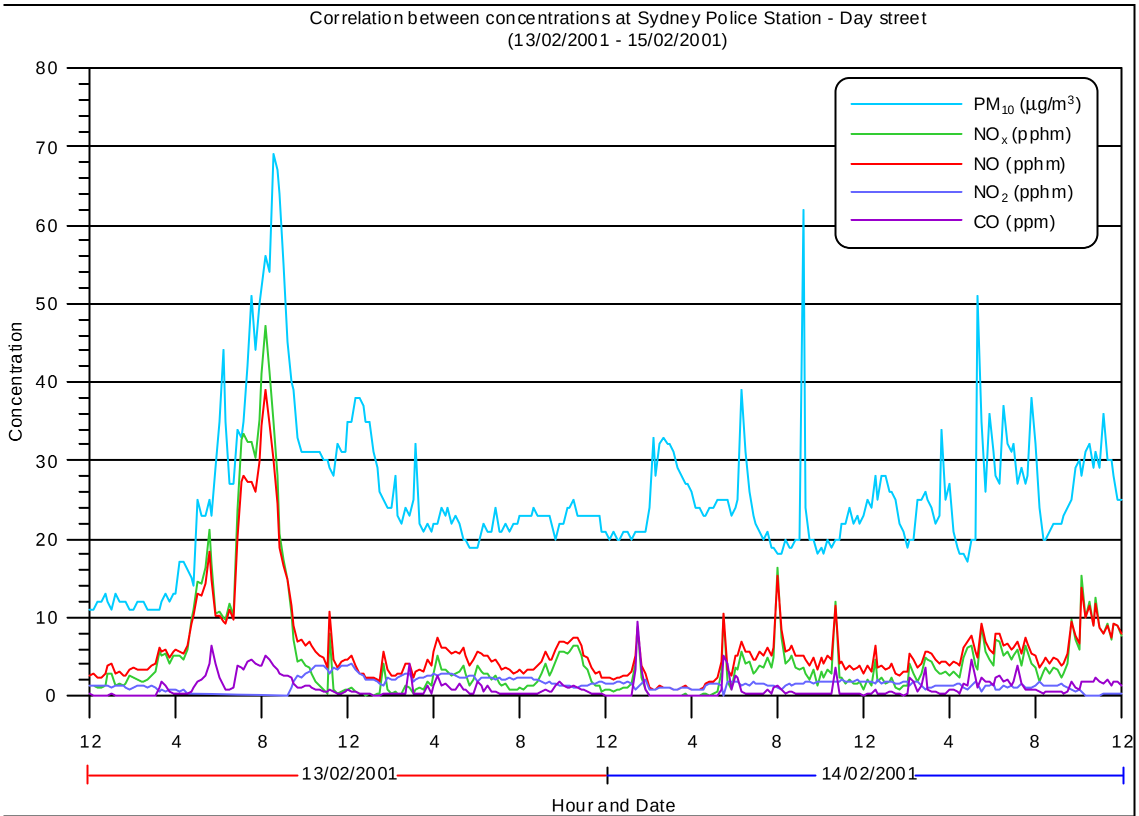

Figure 9: Correlation between 10-minute concentrations at Sydney Police Station

Periods of elevated baseline concentrations of PM_{10}, such as those shown in **Figure 9**, where concentrations do not decline below approximately 20 µg/m^3 are prevalent throughout the monitoring period. This characteristic would be typical of concentrations experienced in an urban street canyon, such as the Police Station site.

4 SYDNEY POLICE STATION - ANNUAL SUMMARY

The annual summary presents the overall results from the year-long monitoring program undertaken by the RTA for the Cross City Tunnel project development process. These results are presented in the form of monthly maximum and average values in graphical format. A finer resolution than one month does not provide extra detail about air quality trends at the monitoring site. In fact, the large amount of data that would be presented from hourly plots would detract from the clear trends displayed in the month plots. The monthly results display a seasonal pattern for CO and PM_{10} with higher concentrations occurring more consistently in cooler months of the year. Nitrogen dioxide concentrations do not display a seasonal trend.

The pattern of higher concentrations monitored in cooler months is not unexpected. Due to meteorology and the topography of the Sydney Basin, generally higher concentrations of the monitored gases and particulates are experienced in winter months.

The daily trend of two peak concentration periods coinciding with increased traffic numbers in the morning and evening was prevalent for all compounds throughout the year. The times of peak traffic flow also coincide with periods of increased atmospheric stability.

4.1 Nitrogen dioxide

The monthly concentrations of nitrogen dioxide do not display any seasonal variability in maximum concentrations. During the monitoring period, the maximum concentration was 12.2 pphm that resulted in one exceedance of the NEPM goal, taking place in September.

The monthly 1-hour maximum and average concentrations are presented in **Figure 10**. Nitrogen dioxide is the only pollutant that does not display a clear seasonal pattern. The blue line that joins the maximum concentrations has been included to display any seasonal trend. The monthly average concentration remained quite low for the year, displaying little variation. The average concentration for the monitoring period (19/05/00 to 30/05/01) was 2.6 pphm, which was 86% of the annual NEPM goal of 3 pphm.

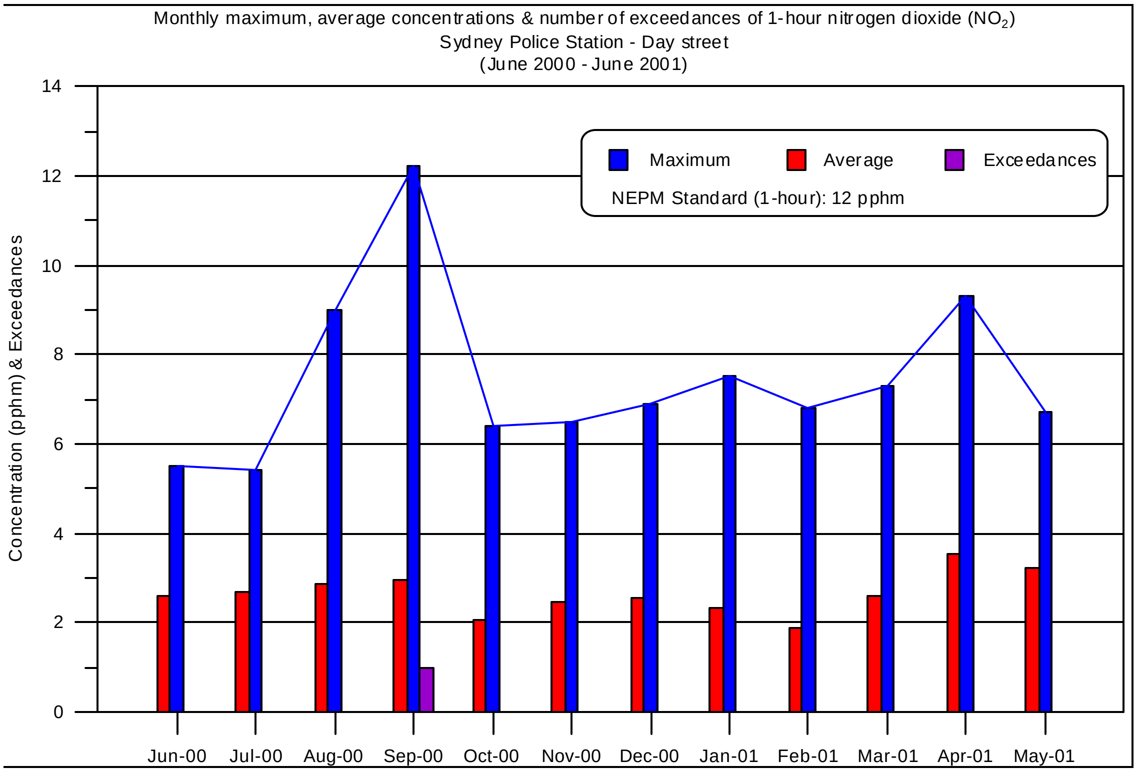

Figure 10: Monthly maximum, average and number of exceedances for NO_2 at Sydney Police Station.

The elevated maximum NO_2 concentrations in August, September and April were the result of isolated events. The vast majority of concentrations in these months remained low, demonstrated by the consistently low monthly averages shown in **Figure 10**.

4.2 Carbon monoxide

The annual maximum 1-hour CO concentration was 29.2 ppm and was one of two exceedances of the WHO guideline, recorded in August. Another exceedance was recorded in June 2000, with a concentration of 26.8 ppm, making a total of three exceedances for the year to June 2001. The monthly maximum and average concentrations are presented in **Figure 11** for 1-hour carbon monoxide concentrations.

The trends in the 1-hour and 8-hour concentrations are very similar. The annual average carbon monoxide concentration at the Police Station was 1.6 ppm. The annual average CO concentration was 6 % of the 1-hour guideline. While the 1-hour maximum concentrations were high in some months, the average monthly CO concentrations remained low throughout the year. The low monthly average concentrations experienced at the Police Station are shown as the red columns in **Figure 11** and **12**.

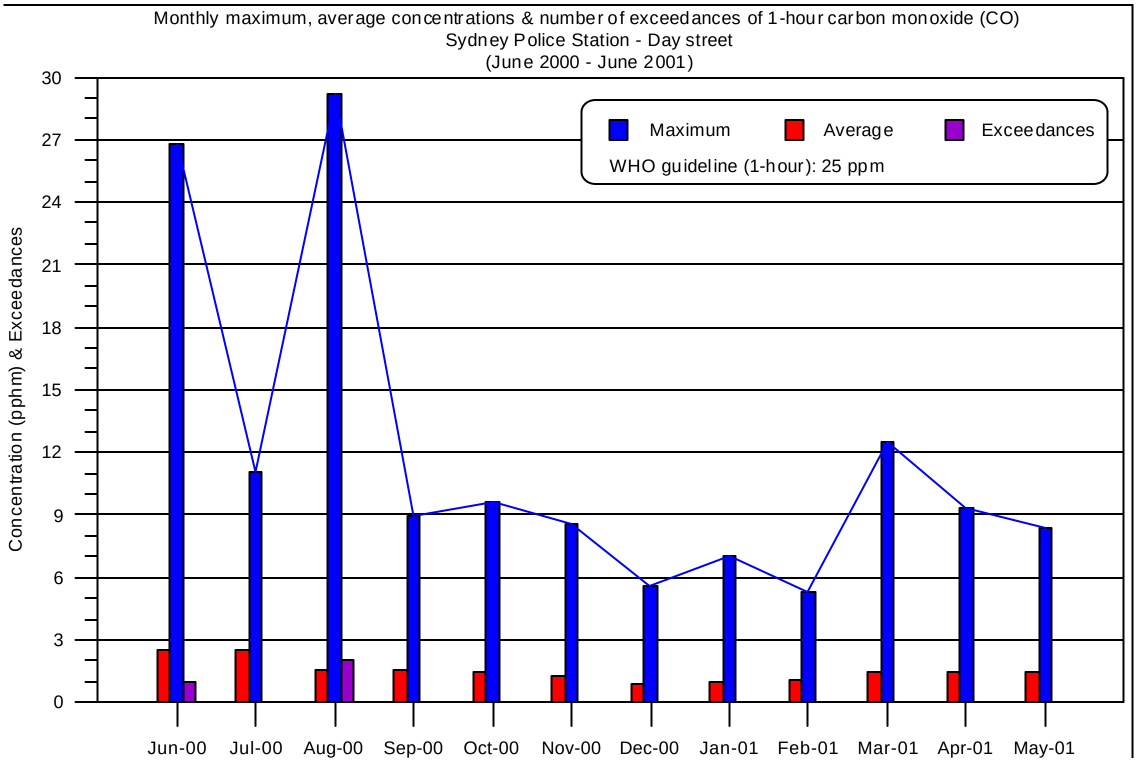

Figure 11: Monthly maximum, average and number of exceedances for 1-hour CO at Sydney Police Station.

Carbon monoxide concentrations at the Police Station display a seasonal trend with maximum concentrations occurring in winter. Meteorological conditions in these months are generally unfavourable with more consistent and intense periods of stability occurring in the evening, overnight and into the mornings. Exceedances of the 1-hour CO guideline that occurred in June and August 2000 were the result of isolated episodes when concentrations remained at noticeably higher levels. These episodes led to 3 exceedances in the 1-hour WHO guideline and 30 exceedances of the running 8-hour NEPM standard in the year to June 2001. During these elevated episodes, CO concentrations were at levels between 25 and 9 ppm. This resulted in a large number of exceedances of the 8-hour standard and only a few exceedances of the 1-hour guideline. These isolated events obscure the annual sinusoidal trend in CO concentrations that occurred at the Police Station.

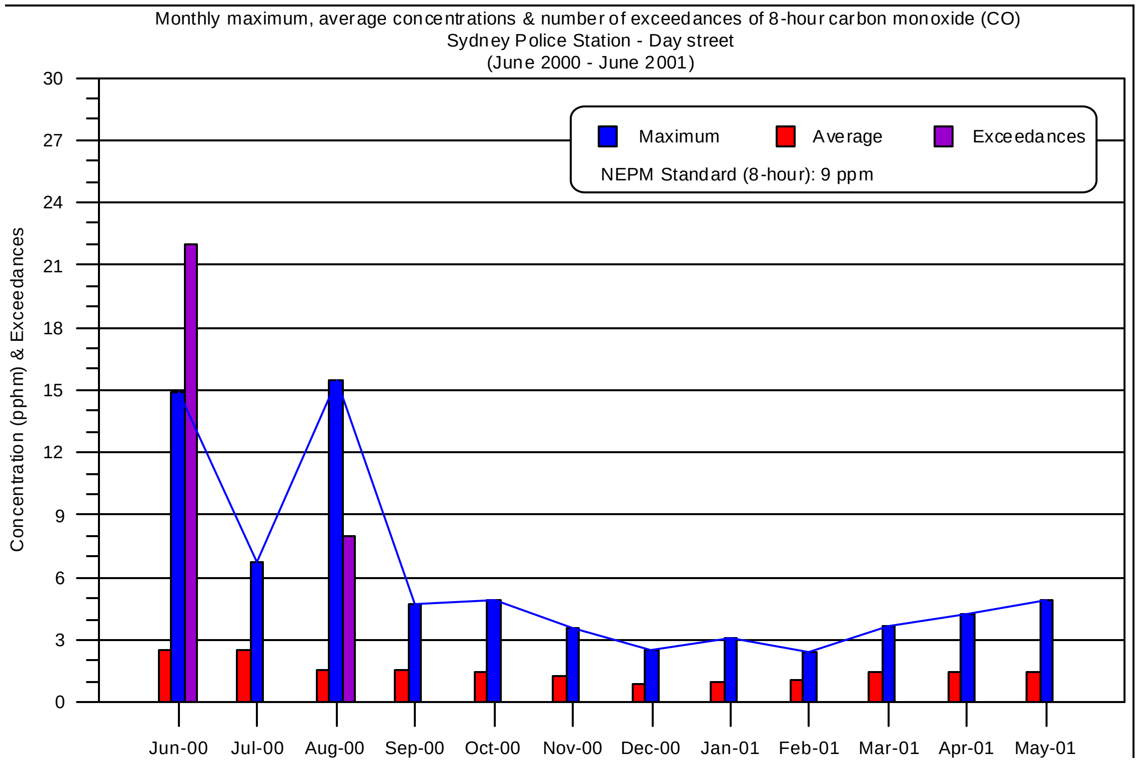

Figure 12: Monthly maximum, average and number of exceedances for 8-hour CO at Sydney Police Station.

While there were a large number of exceedances of the 8hour standard, most of these exceedances were not spread over the reporting period, but occurred over a two day period in early June, where concentrations remained elevated for a period of approximately 20 hours. Otherwise the air quality, with respect to CO at the Police Station was generally good, with the annual average of 1.6 ppm amounting to 17 % of the 8-hour standard.

4.3 Particulate Matter (PM_{10})

The Sydney Police station did record some high concentrations over the course of the year. When considering these readings, the circumstances in which the NEPM standard should be applied needs to be taken into account. As discussed in **Section 2**, the NEPM standard for PM_{10} is intended to apply to air quality in large airsheds. Within these large airsheds there are expected to be locations where 24-hour concentrations of PM_{10} would be above and below the 50 $\mu g/m^3$ level. The NEPM standard is not intended to be applied in urban street canyons, such as the Police Station location.

Furthermore, the US EPA cautionary statements discussed in previous reports indicates that air quality at the Police Station with regard to particulate matter would be regarded as good on the majority of occasions.

Figure 13 presents the monthly maximum, average and number of exceedances of PM_{10} at the Police Station site. As with carbon monoxide, particulate matter displays a high degree of seasonality, with maximum concentrations higher in winter months. The reasons for higher concentrations are the same as for CO, more prolonged and intense periods of stability starting in the evening and progressing into the following morning.

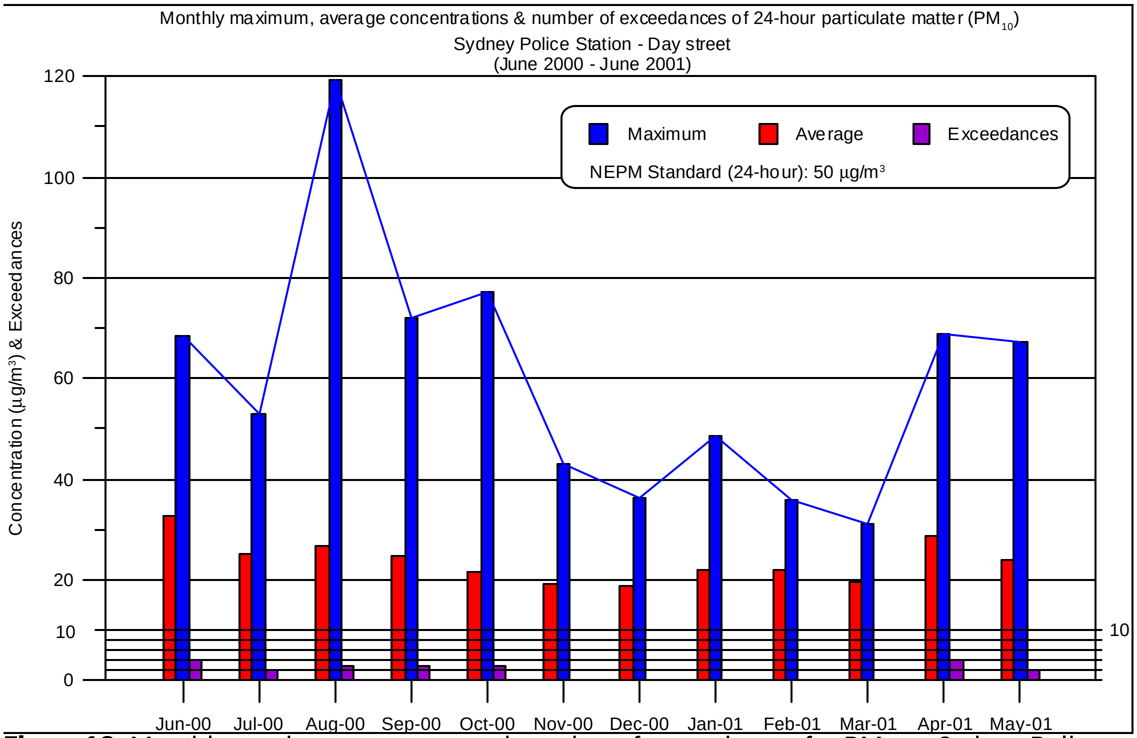

Figure 13: Monthly maximum, average and number of exceedances for PM_{10} at Sydney Police Station.

Concentrations at the monitoring station were relatively high, with the annual average of 23.3 $\mu g/m^3$ being 47 % of the NEPM standard and 78 % of the EPA (long-term) annual reporting goal. There were 21 exceedances of the NEPM standard over the monitoring period, with a maximum of four exceedances per month occurring in June and April. A condition of the NEPM standard is the allowance of five exceedances of 50 $\mu g/m^3$ in a year. An interesting result was that readings above the NEPM standard typically occurred on consecutive days, indicating that PM_{10} concentrations remained at elevated baseline levels for periods of greater than 24 hours. Some of the recorded exceedances, particularly in August, September and October, coincided with bushfires that affected the whole of the Sydney airshed.

5 CONCLUSIONS

Concentrations of pollutants at the Police Station site have a clearly defined daily pattern governed by peak traffic times, which occur in the morning and evening.

For the four months from February to June there were six PM_{10} readings above 50 $\mu g/m^3$. There were no readings measured above any other air quality goals. The progression into cooler months coinciding with some readings above air quality goals is consistent with the increased frequency of poor dispersion conditions throughout the Sydney basin.

The enclosed urban canyon surroundings in which air quality has been monitored for this project means that the NEPM 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.

The only goal/standard for which readings were consistently measured above was the 24-hour standard for PM_{10}. All other pollutants did not regularly have concentrations that were above the relevant goals/standards.

A daily pattern for all pollutants was apparent, with high concentrations in the morning and evening associated with times of increased traffic. There was also a seasonal pattern for total oxides of nitrogen, carbon monoxide and particulate matter. In general, concentrations of these pollutants were higher in winter months. Nitrogen dioxide did not display the seasonal trend, with concentrations remaining relatively constant throughout the year.

When readings above goals were measured, particularly for carbon monoxide and particulate matter, they were the result of prolonged periods of elevated concentrations. While no firm conclusions can be drawn as to why and how these events occurred, a characteristic of urban street canyons are that they have the potential to restrict the movement of air away from the source of emission.

At Sydney Police station these occasions were rare and for the most part air quality at the site could be considered as acceptable, although above levels experienced at most of the EPA monitoring sites throughout Sydney.

6 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)
"The Cross City Tunnel Project Air Quality Monitoring Report for August, September and October, 2000", December 2000.

RTA (2001)
" The Cross City Tunnel Project Air Quality Monitoring Report for November, December and January 2000/01.