Air quality monitoring hot spot report 5
Port Stanvac and O'Sullivans Beach

EPA
South Australia

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July 2004

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GLOSSARY

DOAS	differential optical absorption spectrometry
EPA	South Australian Environment Protection Authority
USEPA	United States Environment Protection Agency
NDIR	non-dispersive infrared
NEPM	National Environment Protection Measure
NPI	National Pollutant Inventory
TEOM	tapered element oscillating microbalance
WHO	World Health Organization
PM_{10}	particles with an effective aerodynamical diameter of ten micrometres and less
µg	millionths of a gram
$\mu g/m^3$	millionths of a gram per cubic metre of air
ppm	parts per million

SUMMARY

Mobil Refining Australia Pty Ltd operated the Port Stanvac Oil Refinery and has managed the site since its closure in July 2003. This was South Australia's only oil refinery, producing the majority of the state's fuels and lube oils. The refinery is located in Lonsdale, an industrial suburb south of Adelaide. Directly adjacent to the southern boundary of the refinery is the residential suburb of O'Sullivans Beach, with residential suburbs predominating southward along the coast.

Under the *Environment Protection Act 1993 (Schedule 1 Part A)* Mobil Refining Australia Pty Ltd was authorised to undertake the following activities of environmental significance on the Port Stanvac Oil Refinery site:

- oil refining
- petroleum storage
- activities producing listed waste
- operating a bulk shipping facility
- dredging; earthworks drainage
- fuel burning (rate of heat release exceeding five megawatts)
- discharges to marine or inland waters.

Hot spot air monitoring commenced at DJ Leane Reserve, O'Sullivans Beach on 6 March 2003, south of the refinery, after complaints about air quality were lodged with the Environment Protection Authority (EPA). Monitoring concluded on 25 August 2003. Monitored parameters included sulfur dioxide, oxides of nitrogen, ozone, carbon monoxide, benzene, toluene, formaldehyde, naphthalene and PM_{10} (particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less).

Additional monitoring data were also collected over this period for sulfur dioxide from the long-term EPA ambient monitoring station at St John's Primary School, also located south of the refinery.

Odour testing was not conducted at either site as part of this study.

No events were measured where pollutant levels were above the National Environment Protection Measure (NEPM) or World Health Organization guidelines.

INTRODUCTION

Monitoring was conducted to evaluate air quality in the residential suburbs south of the Mobil Oil Refinery Pty Ltd. Mobil supplied data to the National Pollutant Inventory (NPI), which estimated the emissions to air from the refinery per year (based on 2001 data) to be sulfur dioxide 710 kg, nitrogen oxides 530,000 kg, carbon monoxide 420,000 kg, total volatile organic compounds 2,600,000 kg (including benzene 3700 kg, toluene 7100 kg) and PM_{10} (particulate matter) 92,000 kg.

The refinery is bounded by the coast to the west, industrial premises to the east and residential suburbs in the south, southeast and northeast.

The hot spot air monitoring was conducted between 6 March and the 25 August 2003 on DJ Leane Reserve, Taralga Road, O'Sullivans Beach, approximately one kilometre from the refinery.

Parameters measured continuously at DJ Leane Reserve included:

- sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), benzene (C_6H_6), toluene (C_7H_8), formaldehyde (CH_2O) and naphthalene ($C_{12}H_8$). These parameters were measured using differential optical absorption spectroscopy (DOAS)
- carbon monoxide (CO), measured using non-dispersive infrared absorption/gas filter correlation
- particulate matter (PM_{10}), measured continuously using a tapered element oscillating microbalance (TEOM)

Data for SO_2 were also collected from the Environment Protection Authority (EPA) ambient monitoring site at St John's Primary School, Winnerah Road, Christies Beach. This site monitored SO_2 emissions during the study period and also since 1992, as the Port Stanvac Oil Refinery was the largest single source of SO_2 in the Adelaide airshed. This site was located approximately 1.8 km south of the refinery (Figure 1).

Meteorological parameters were monitored at a site located two kilometres to the south-east of the hot spot site, Osmund Crescent, Christies Downs; however, technical issues with instrumentation limited the amount of meteorological data available.

Hot spot air quality monitoring

Ambient air quality refers to the quality of the surrounding outdoor air and its background constituents. The EPA conducts an extensive monitoring program around metropolitan Adelaide and major regional centres (EPA 2001). The monitoring sites are strategically placed to determine urban air quality trends and to ensure protection of the general population by evaluating compliance with the national standards (National Environment Protection Council [NEPC] 1998).

Hot spot monitoring is conducted by the EPA to 'fill in the gaps' in the ambient monitoring program. Monitoring is carried out to determine if higher concentrations of air pollutants exist in localised airsheds. A mobile monitoring station is placed adjacent to a point source enabling an assessment of pollutants.

Air quality monitoring does not include the assessment of odour, which is currently measured through a subjective process. Current instrumental measurement technologies typically do not provide an accurate determination of the components of odours at levels discerned by the human nose.

Pollutant information

In the following pages each pollutant is assessed and a summary of its health effects and general sources provided. More detailed information can be obtained from Peach (1997), the NPI, United States Environment Protection Agency (USEPA) IRIS database, the National Environment Protection Measure (NEPM) impact statements and World Health Organization's (WHO) air quality guidelines. Internet links for these sources can be found in the reference list.

SAMPLING SITE

The location of the monitoring sites in relation to the refinery and residential properties is illustrated in Figure 1. The air monitoring sites were situated to provide air quality data representative of the general area, which will include the point source of interest and any pollutants emanating from other nearby sources (that is, slow combustion heaters and vehicle traffic).

The hot spot site utilised a differential optical absorption spectrometry (DOAS) measurement technique on a single path spanning the DJ Leane Reserve between the caravan and a mirror. Instruments for the detection of PM_{10} particles and carbon monoxide were located in the caravan.

The EPA site at St John's Primary School utilises an instrument for the detection of sulfur dioxide.

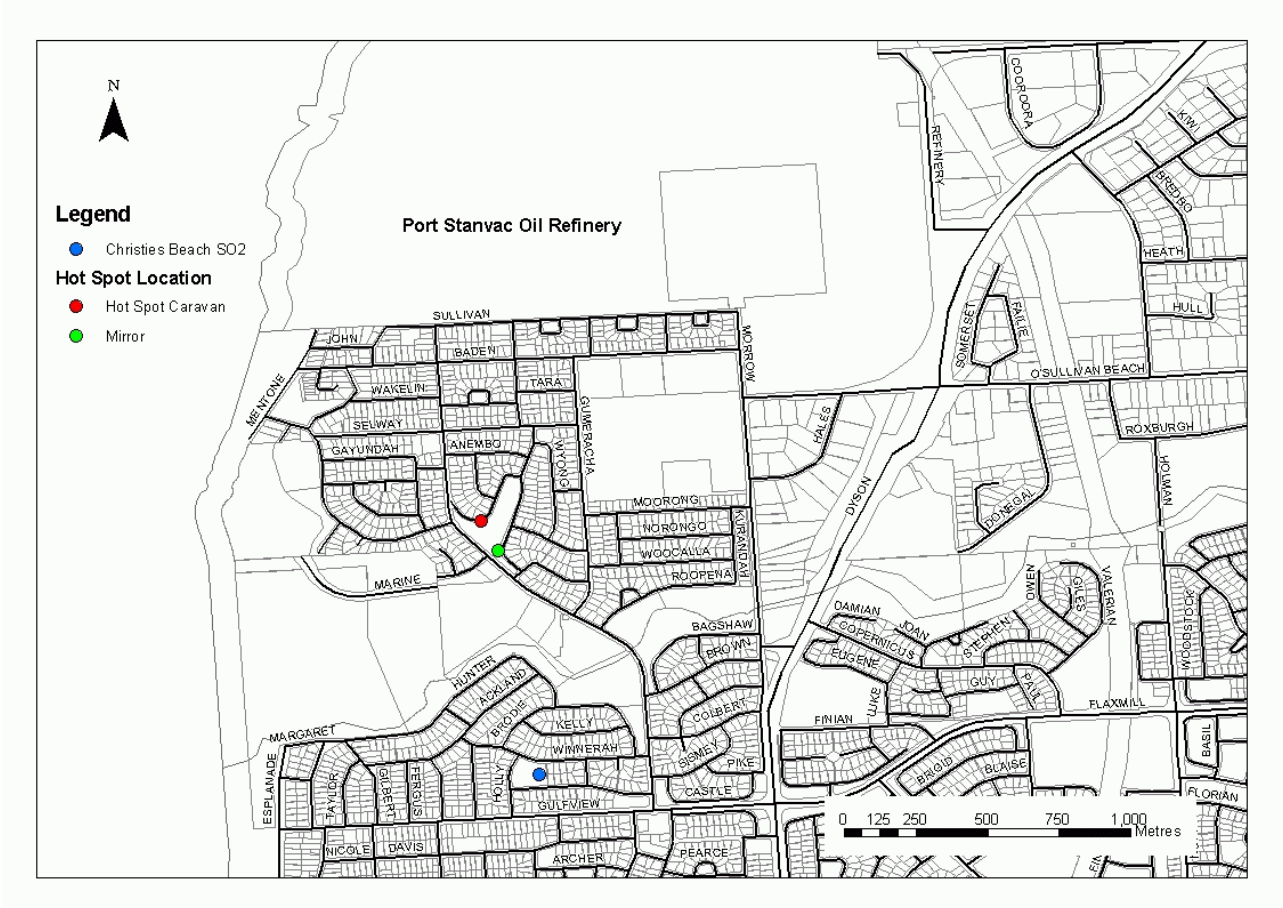

Figure 1 Port Stanvac Oil Refinery and the air monitoring sites

RESULTS

Sulfur dioxide (SO_2)

Health effects

Sulfur dioxide (SO_2) causes constriction of the airways by stimulating nerves in the lining of the nose, throat and airways of the lung. Constriction is particularly likely to occur in those suffering from asthma or other chronic lung disease (NEPC 1998). The NEPM air quality standard for SO_2 is 0.20 ppm measured over a one-hour averaging period. This standard is intended to reduce the exposure of the population, including individuals who may be particularly sensitive to sulfur dioxide, to a level where harmful effects are unlikely to occur. WHO has a 10-minute guideline of 0.175 ppm used in determining the short-term peak events of SO_2 (WHO 2000).

Sources

Motor vehicles contribute about 20% of the total SO_2 emissions in Adelaide (EPA 2002). Other sources include fossil fuel combustion and industrial processes, such as wood pulping, paper manufacture, petroleum and metal refining and metal smelting, particularly from ores containing sulfide. The Mobil Oil Refinery was the single largest point source for SO_2 in metropolitan Adelaide and the only significant known source of short-term events typically monitored in the southern suburbs.

Monitoring results

DJ Leane Reserve, hot spot monitoring site

One-hour averages for SO_2 (Figure 2) were within the range 0.000 to 0.083 ppm, below the one-hour NEPM air quality standard of 0.20 ppm. Daily averages (Figure 3) ranged between 0.001 and 0.029 ppm, well below the daily NEPM air quality standard of 0.08 ppm.

Ten-minute data (Figure 4) show a very distinct reduction in the SO_2 measured after the refinery closure in July 2003. The ten-minute data ranged from 0.000 to 0.134 ppm, with the high values only lasting for short periods of time. The WHO 10-minute guideline was not exceeded at this site during the monitoring period.

St John's Primary School monitoring site

One-hour averages for SO_2 (Figure 6) were within the range 0.000 to 0.049 ppm, below the one-hour NEPM air quality standard of 0.20 ppm. Daily averages (Figure 7) ranged between 0.000 and 0.010 ppm, well below the NEPM air quality standard of 0.08 ppm (daily average).

Ten-minute data (Figure 5) show a noticeable reduction in measured SO_2 after the major refinery closure in July 2003. The 10-minute data ranged from 0.000 to 0.071 ppm, with the high values again only lasting for short periods of time, well below the WHO ten-minute guideline. One extended event lasted approximately three days, yet only reached a maximum concentration of 0.031ppm.

Figures 4 and 5 show the 10-minute SO_2 monitoring data from both monitoring sites. Similar SO_2 events were measured at each location; however, the St John's Primary School site detected lower levels, probably due to its greater distance from the refinery. A short-term guideline for SO_2 was used to determine if the short-term events were of concern. The WHO 10-minute guideline was not exceeded at either site.

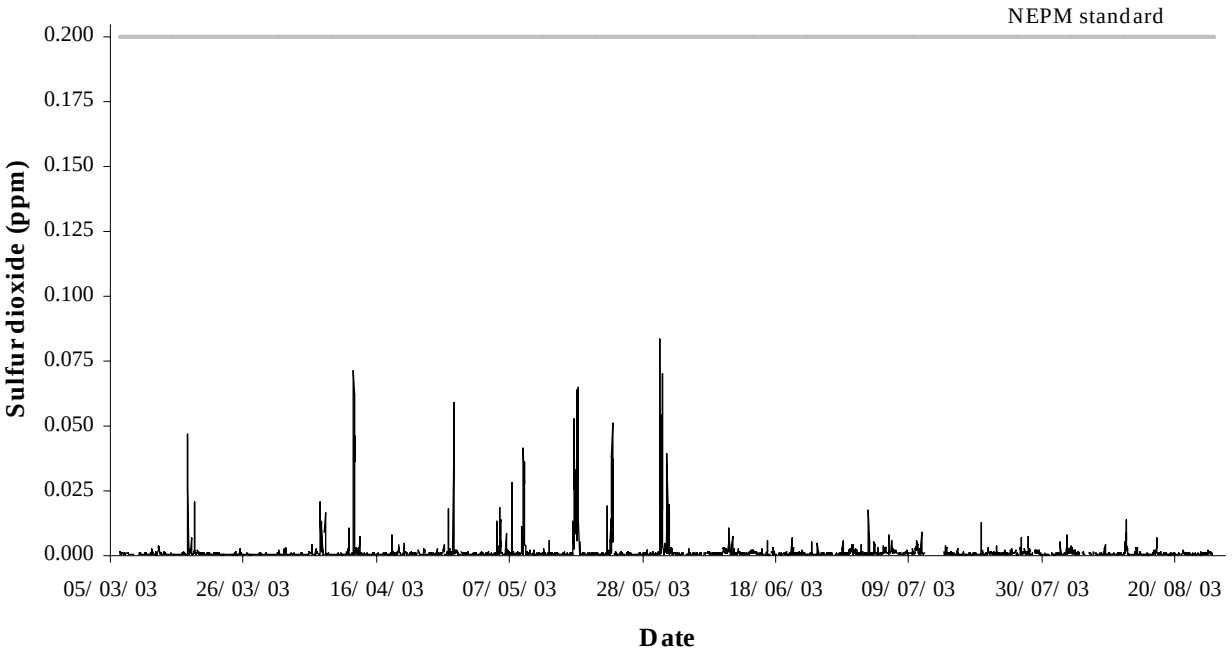

Figure 2 Sulfur dioxide one-hour averages and the NEPM standard at DJ Leane Reserve

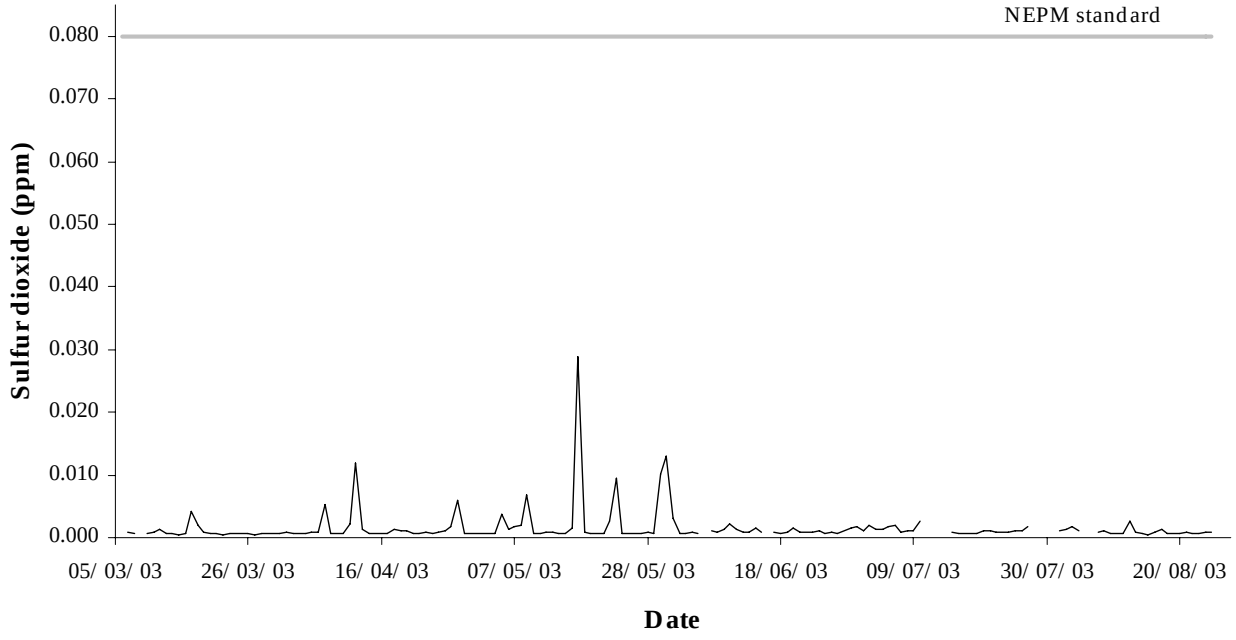

Figure 3 Sulfur dioxide daily averages and the NEPM standard at DJ Leane Reserve

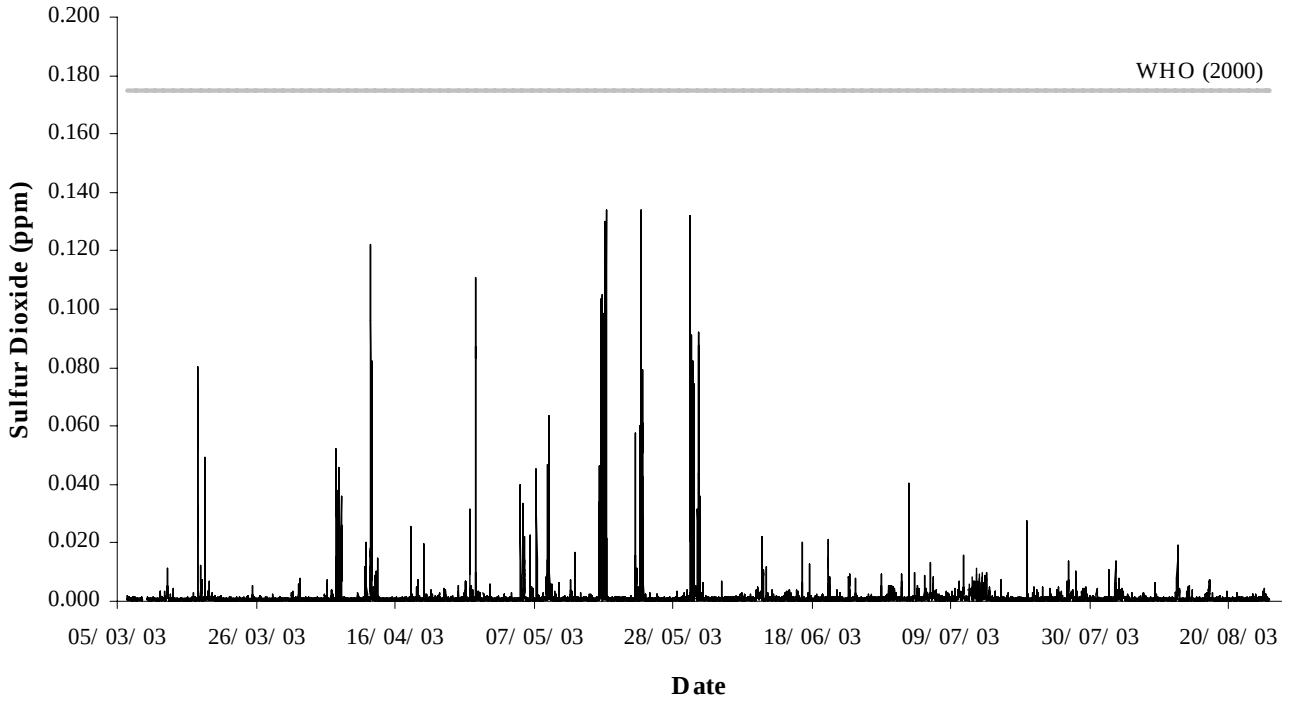

Figure 4 Sulfur dioxide 10-minute averages at DJ Leane Reserve

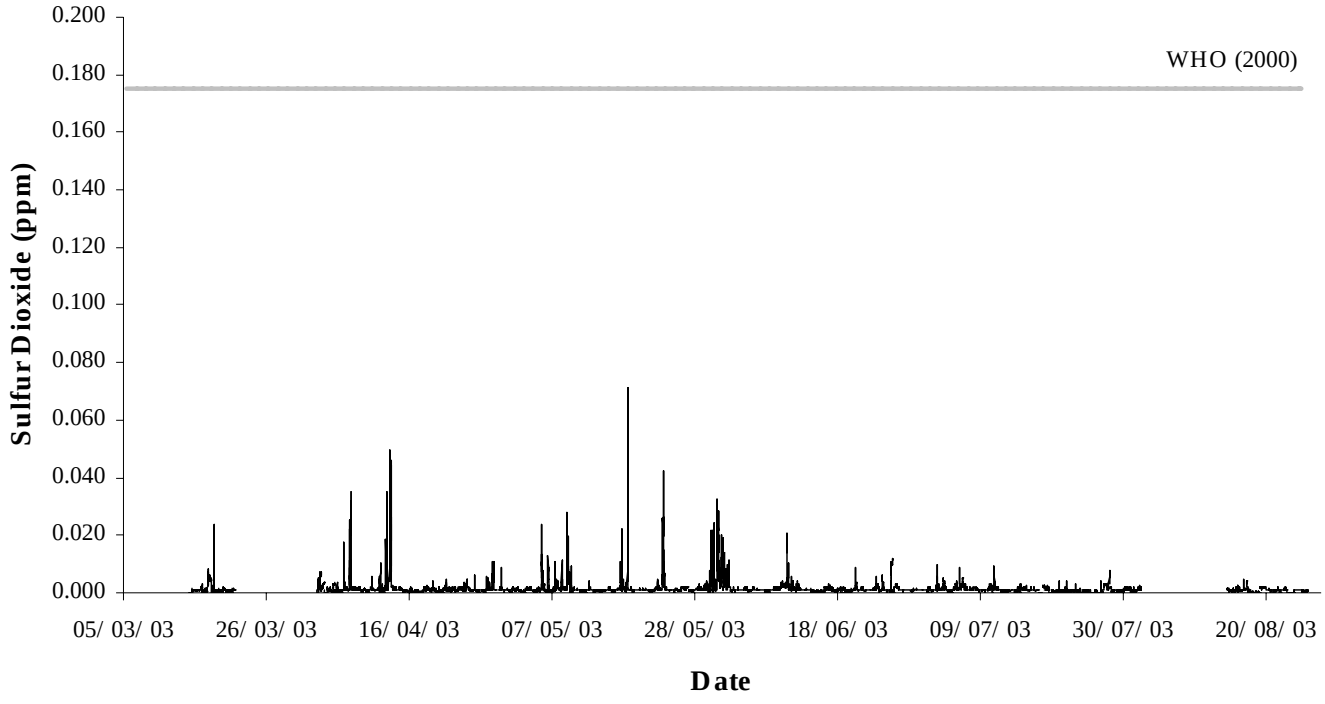

Figure 5 Sulfur dioxide 10-minute averages at St John's Primary School

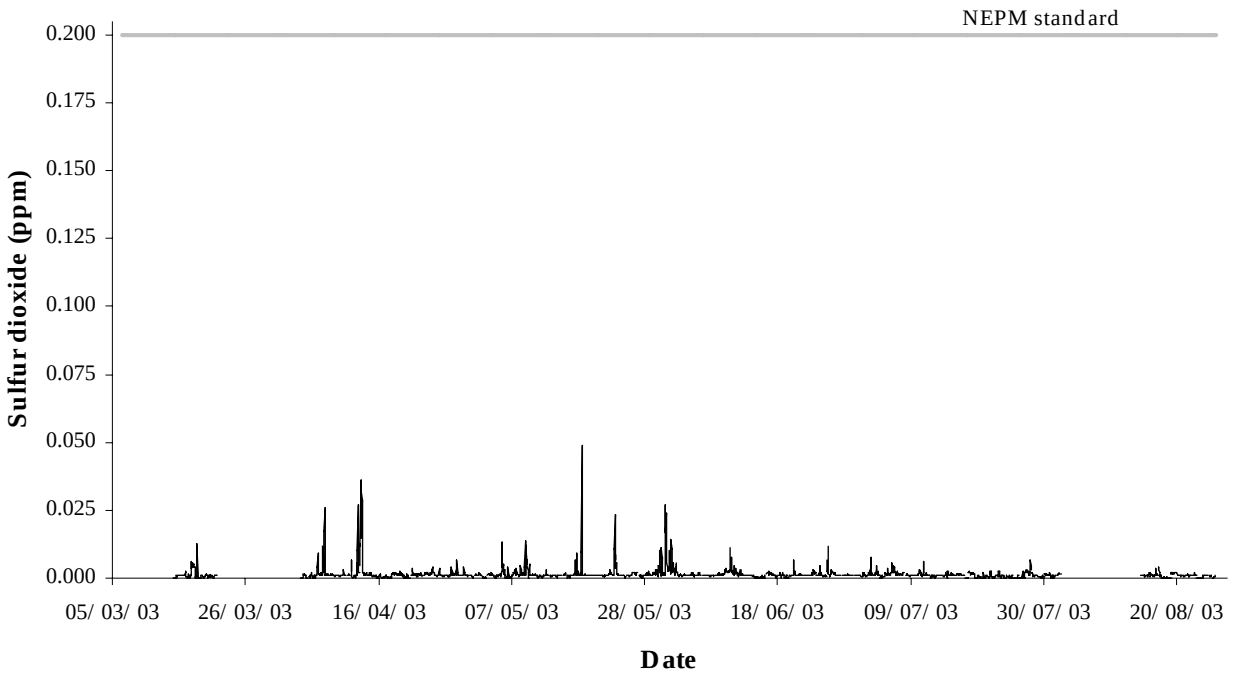

Figure 6 Sulfur dioxide one-hour averages and the NEPM standard at St John's Primary School

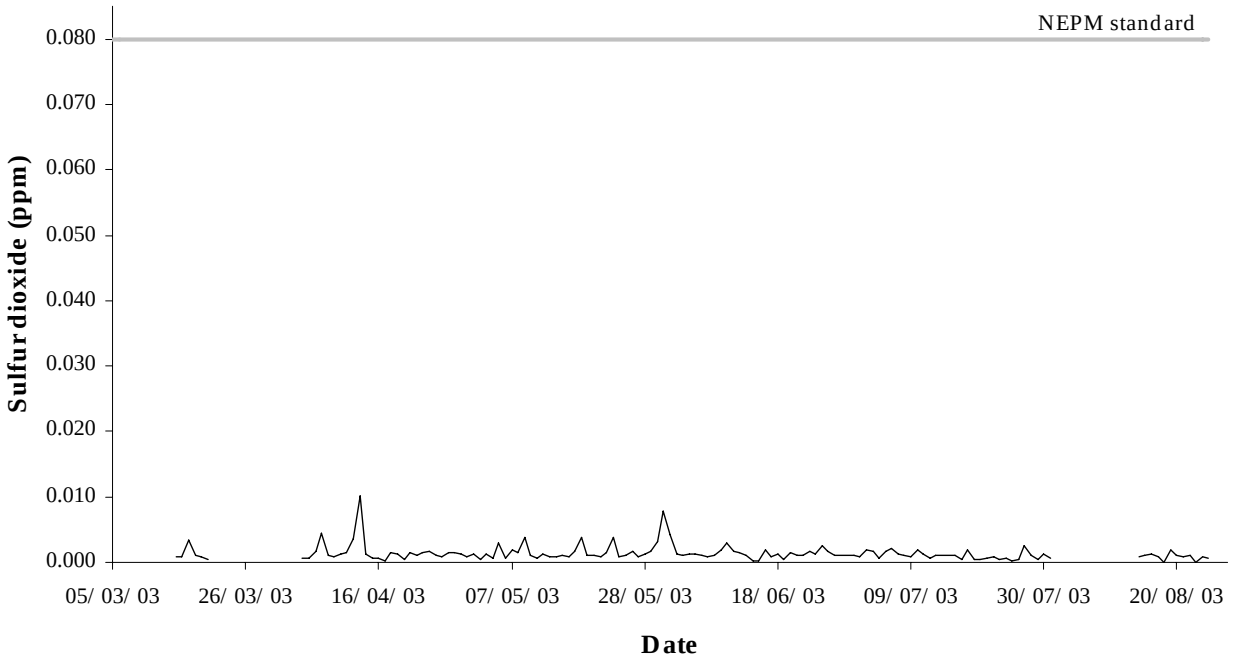

Figure 7 Sulfur dioxide daily averages and the NEPM standard at St John's Primary School

Carbon monoxide (CO)

Health effects

The main threat to health from exposure to carbon monoxide is due to the formation of carboxyhaemoglobin, which substantially reduces the capacity of the blood to carry oxygen around the body, while also blocking important biochemical reactions in cells. People who have an existing disease that affects the delivery of oxygen to the heart or brain, such as coronary artery disease or angina, are likely to be at particular risk. The NEPM air quality standard of 9.0 ppm as a running eight-hour average is intended to limit the exposure of the population, including susceptible individuals (NEPC 1998).

Sources

Carbon monoxide is a gas formed by the incomplete combustion of fuels containing carbon. Currently the main ambient source of carbon monoxide is motor vehicles, in particular those using petrol; in Adelaide this accounts for almost 85% of emissions (EPA 2002).

Industrial sources of carbon monoxide include oil refining, steel plants, foundries and chemical manufacturing facilities, such as the making of lime.

Monitoring results

Eight-hour rolling averages of carbon monoxide (Figure 8) were within the range 0.0 to 1.3 ppm, with an average for the entire sampling period of 0.2 ppm. This is well below the NEPM air quality standard of 9.0 ppm.

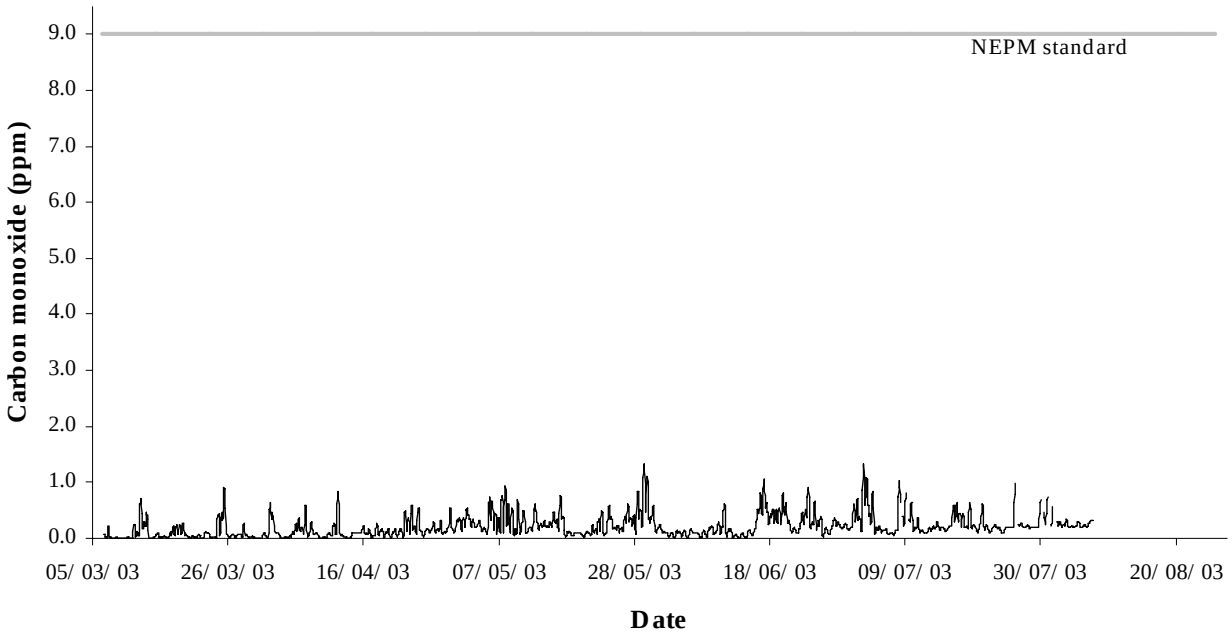

Figure 8 Carbon monoxide eight-hour rolling averages and the NEPM standard at DJ Leane Reserve

Nitrogen dioxide (NO_2)

Health effects

At relatively high concentrations, nitrogen dioxide causes inflammation of the airways. Long-term exposure to nitrogen dioxide may affect lung function and enhance the response to allergens in some individuals. The NEPM short-term air quality standard is 0.12 ppm, measured as an hourly average. There is also a longer-term NEPM standard of 0.03 ppm measured over one year (NEPC 1998).

Sources

All combustion processes in air produce oxides of nitrogen. Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_X (oxides of nitrogen). It is NO_2, which is associated with adverse effects upon human health. Motor vehicles account for approximately 60% of total emissions of NO_X in Adelaide (EPA 2002). Other sources include combustion of fossil fuels, electricity generation and domestic wood burning. NO_X is also a precursor in the production of ozone and photochemical smog.

Monitoring results

One-hour averages for nitrogen dioxide (Figure 9) were within the range 0.000 ppm to 0.037 ppm, which is well within the one-hour NEPM air quality standard of 0.12 ppm. The average concentration for the sampling period was 0.006 ppm. If these values were representative of a whole year, the results would comply with the annual NEPM standard of 0.03 ppm.

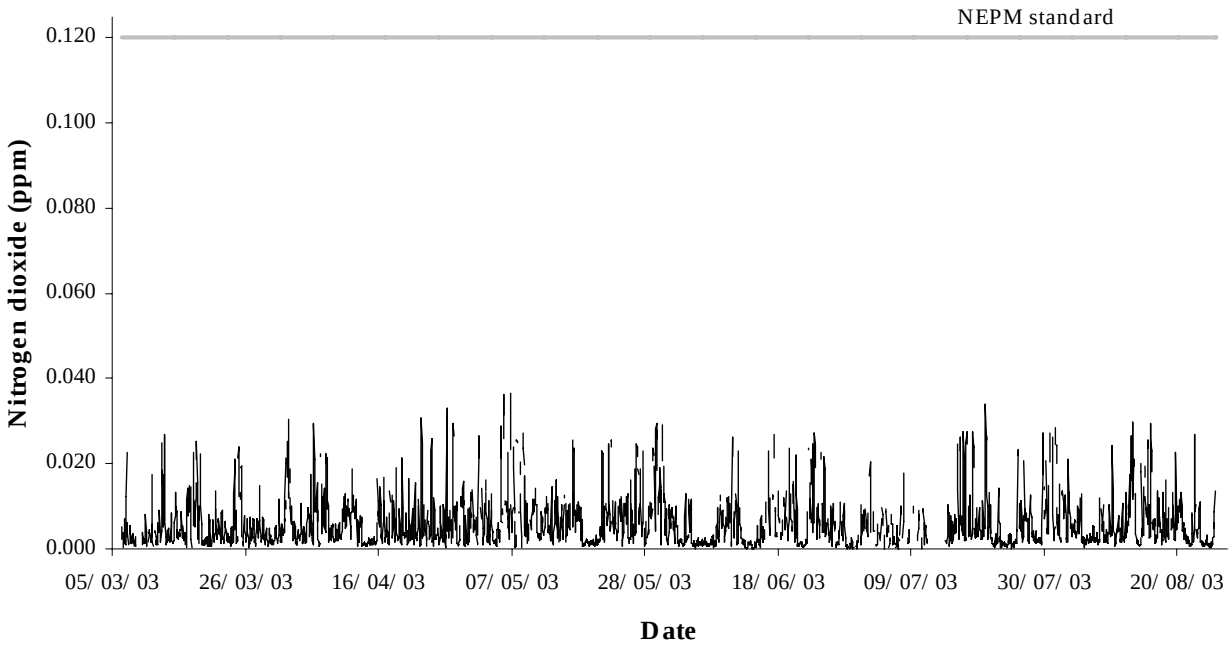

Figure 9 Nitrogen dioxide one-hour averages and the NEPM standard at DJ Leane Reserve

Ozone (O_3)

Health effects

Exposure to elevated concentrations of ozone may cause slight irritation to the eyes and nose. If very high levels of exposure (0.5 to 1 ppm) are experienced over several hours, damage to the airway lining may occur, followed by inflammatory reactions. Minor changes in the airways may occur at lower concentrations, down to about 0.08 ppm. The NEPM air quality standard for ozone is 0.10 ppm as a one-hour average. A rolling four-hour standard at 0.08 ppm has also been set (NEPC 1998).

Sources

Ozone at ground level is primarily formed by a series of chemical reactions in air initiated by sunlight. Oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) react to form ozone. VOCs are released from sources such as solvent use, petrol distribution, fossil fuel combustion and the natural environment (plants and decomposition). NOx is emitted from combustion sources and some natural environments. Emissions from motor vehicles alone account for 44% of Adelaide's VOCs and 60% of NO_x (EPA 2002).

The chemical reactions that results in increased levels of O3 do not take place instantaneously, but over several hours, depending on the reactivity of VOCs and meteorological conditions. Ozone measured at a particular location may therefore have arisen from emissions many kilometres away. Maximum concentrations of ozone generally occur downwind of the source areas of the precursor pollutant emissions. Ozone measured at O'Sullivans Beach would not be directly attributed to any one industry, although the data can be used to assist the EPA in examining air quality in the area.

Monitoring results

One-hour averages for ozone (Figure 10) were within the range 0.000 to 0.040 ppm, below the one-hour NEPM air quality standard of 0.10 ppm. Four-hour averages (Figure 11) were within the range 0.002 to 0.036 ppm, which is well below the rolling NEPM air quality standard of 0.08 ppm.

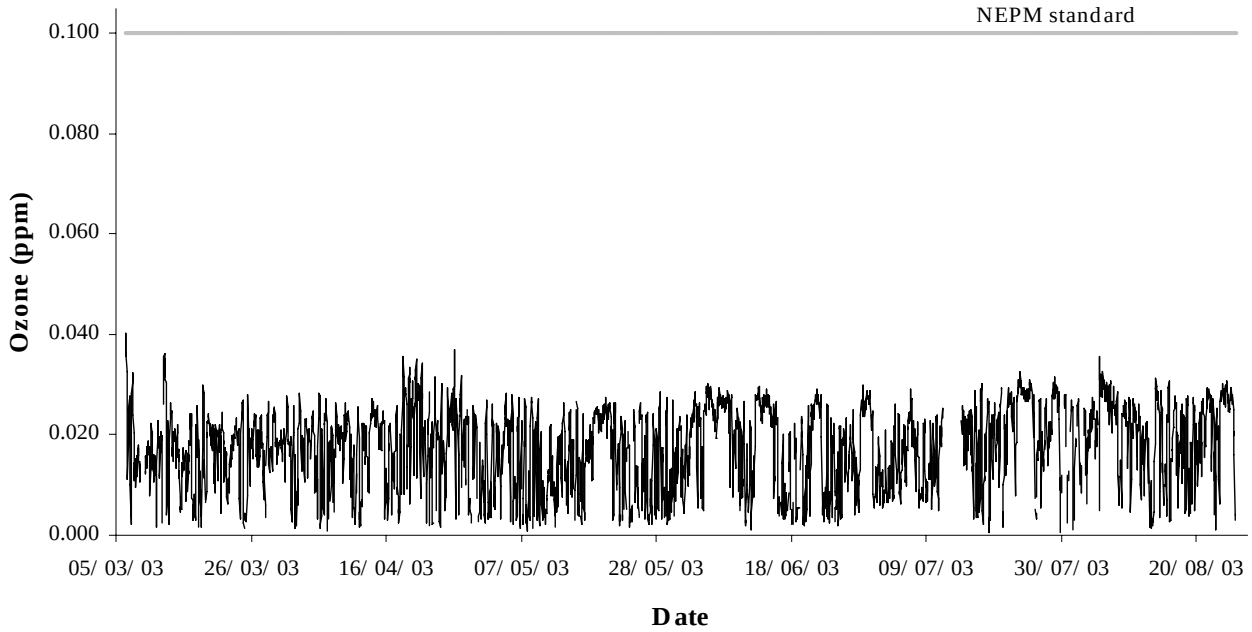

Figure 10 Ozone one-hour averages and the NEPM standard at DJ Leane Reserve

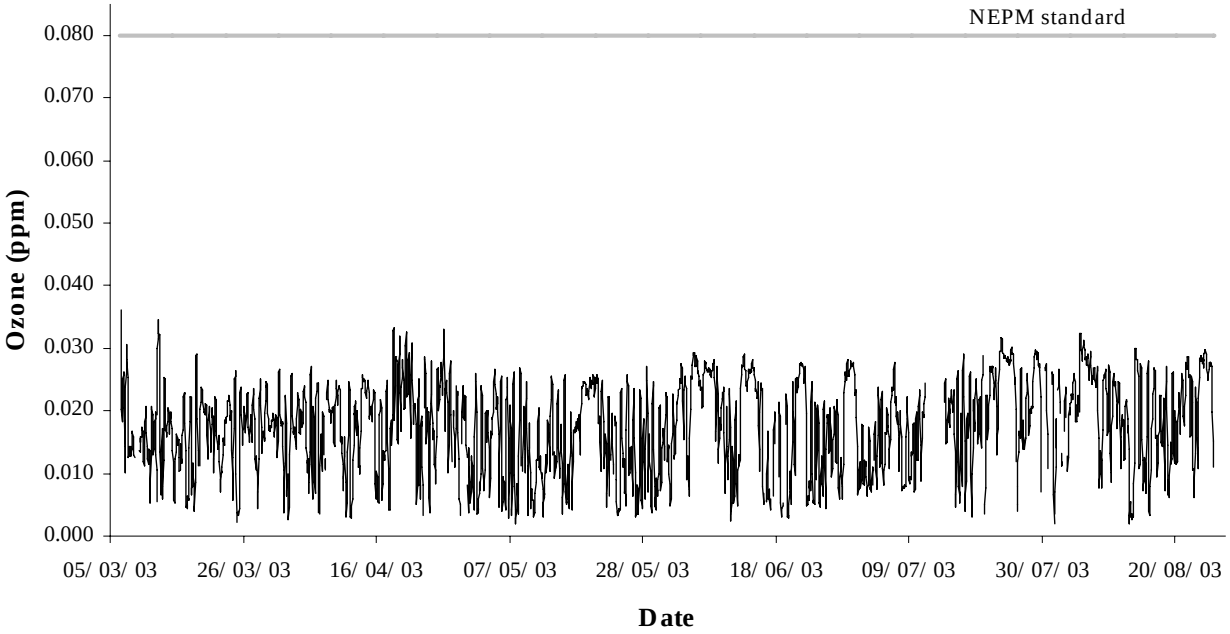

Figure 11 Ozone four-hour averages and the NEPM standard at DJ Leane Reserve

Benzene (C_6H_6)

Health effects

Benzene is a recognised human carcinogen. Studies of industrial workers exposed to high levels of benzene have demonstrated a greater risk of leukaemia, with the degree of risk dependent on the working lifetime exposure. As yet no threshold has been established for benzene exposure (NEPC 2003).

In December 2004 the Air Toxics NEPM was ratified and contains 'investigation limits' for air toxics, which include benzene. The investigation limit is a guide to assessing levels of air toxics. The current investigation limit for benzene is 0.003 ppm as an annual average.

Sources

Benzene is a volatile organic compound. In Adelaide, the main source of benzene is from the combustion and distribution of petrol. Motor vehicles contribute up to 74% of benzene emissions (EPA 2002). Smoke from domestic wood fires and emissions from lawn mowers and from industries, such as foundries, are also significant contributors.

Monitoring results

One-hour averages for benzene (Figure 12) were within the range 0.000 to 0.006 ppm. The average for the entire sampling period for was 0.001 ppm. The investigation limit, which is an annual averaged value, and is not expected to be exceeded if the monitoring data from the five-and-a-half months were indicative of the levels experienced over the year. The average concentration measured is lower than the levels measured in previous hot spot studies, which include Richmond Primary School: 0.009 ppm; Castalloy at Plympton; 0.003 ppm; and Hensley Foundry, Flinders Park: 0.003 ppm.

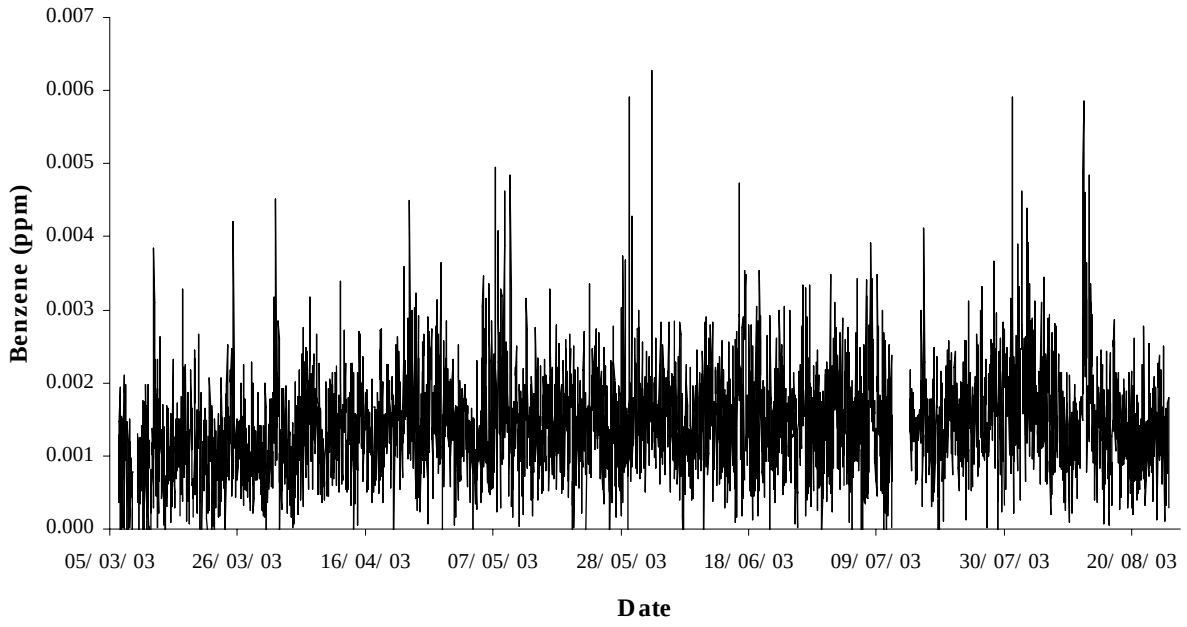

Figure 12 Benzene one-hour averages and the NEPM standard at DJ Leane Reserve

Toluene (C_7H_8)

Health effects

Short-term exposure to toluene can cause respiratory irritation and central nervous depressant effects. High levels (approximately 100 ppm) have been reported to cause irritation to the eyes and nose and also headaches, dizziness and feelings of drunkenness. Long-term exposure can affect eyesight and hearing and cause neurological effects. The NEPM investigation limit for toluene is 1.0 ppm as a daily average (NEPC 2003).

Sources

Toluene is a colourless liquid with a distinctive sweet and pungent smell. Toluene is produced during the refining of crude oil to make fuel. Toluene is emitted by motor vehicles; in Adelaide motor vehicles contribute up to 59% of total emissions (EPA 2002). It is also used in the manufacture of paints, paint thinners, fingernail polish, lacquers, adhesives, rubber, and in some printing and leather tanning processes.

Monitoring results

Daily averages for toluene (Figure 13) were within the range 0.002 ppm to 0.008 ppm. The average for the entire sampling period was 0.003 ppm. The toluene levels detected at the DJ Leane Reserve site were very low and are considered background.

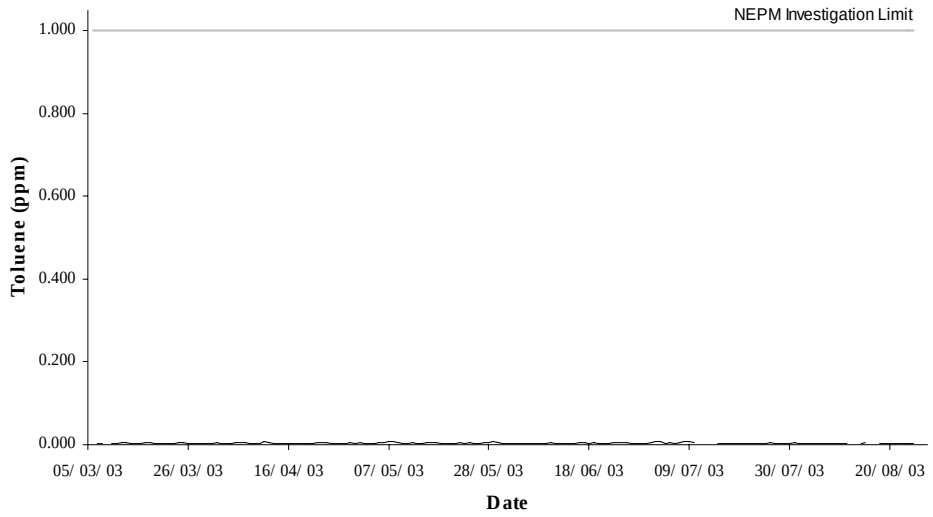

Figure 13 Toluene daily averages and the NEPM investigation limit at DJ Leane Reserve

Formaldehyde (CH_2O)

Health effects

While formaldehyde is not believed to be genotoxic, repeated irritations, which can occur at exposure to concentrations at or above 1.2 ppm, are believed to lead to carcinogenic effects. It has been suggested that if protection is provided against the irritative effects then carcinogenic effects might not occur (NEPC 2003). The NEPM investigation limit is 0.04 ppm as a daily average.

Sources

Formaldehyde is an important industrial chemical used to make building materials, household products and other compounds. It is used in glues, wood products, preservatives, permanent press fabrics, paper product coatings, and certain insulation materials. Formaldehyde can be released into the atmosphere through incomplete combustion of fuel in motor vehicles, cigarette smoking, and burning wood, kerosene and natural gas.

Monitoring results

Daily averages for formaldehyde (Figure 14) were within the range 0.006 to 0.024 ppm. The average measurement for the entire sampling period was 0.013 ppm. The results are less than 50 % of the NEPM investigation limit.

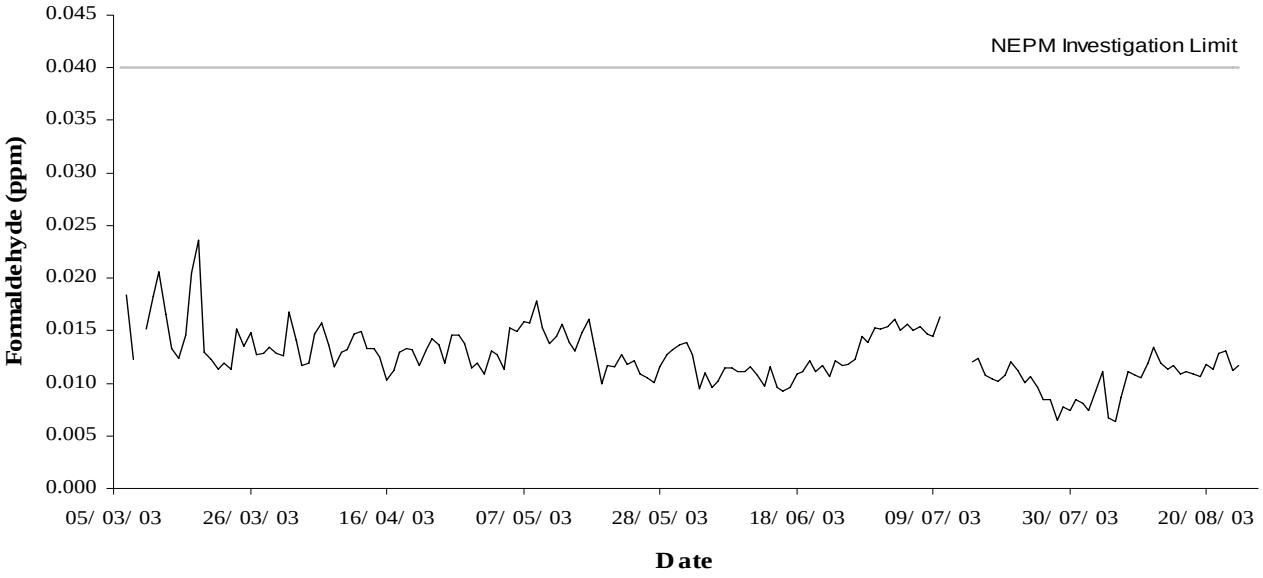

Figure 14 Formaldehyde daily averages and the NEPM investigation limit at DJ Leane Reserve

Naphthalene ($C_{10}H_8$)

Health effects

Currently there are no available health standards for naphthalene in ambient air. Information obtained from the USEPA indicates health effects may vary—from irritation of eyes, skin and the respiratory system, to chronic effects, including cataracts and toxicity within the respiratory tract (both non-cancerous and cancerous effects) (USEPA 2006). This information, however, appears inconclusive, as relevant studies are scarce and, due to the methodology used, may be inadequate. The Department of Human Services had previously advised (EPA 2003) that there are limited ambient air standards for naphthalene. Acceptable ambient air concentrations have been established in the United States, with three states establishing annual average guideline concentrations of 14.3, 50 and 120 $\mu g/m^3$. The most conservative value of 14.3 $\mu g/m^3$ is considerably lower than a cited odour threshold of approximately 1700 $\mu g/m^3$ or 0.3 ppm (Canadian Centre for Occupational Health and Safety [CCOHS] 2006).

Sources

Naphthalene is used in mothballs and is produced during coal tar production, wood preserving, tanning and ink and dye production. It is also released from the burning of coal and oil and other industries.

Monitoring results

Thirty-minute averages for naphthalene were within the range 0.1 to 28.2 $\mu g/m^3$. The average for the entire sampling period was 10.3 $\mu g/m^3$. These results are above ambient background levels according to USEPA information; however, the levels were considerably lower than those measured at Castalloy, North Plympton (2001–02), where the maximum measured was 174.5$\mu g/m^3$, with an average of 15.3$\mu g/m^3$.

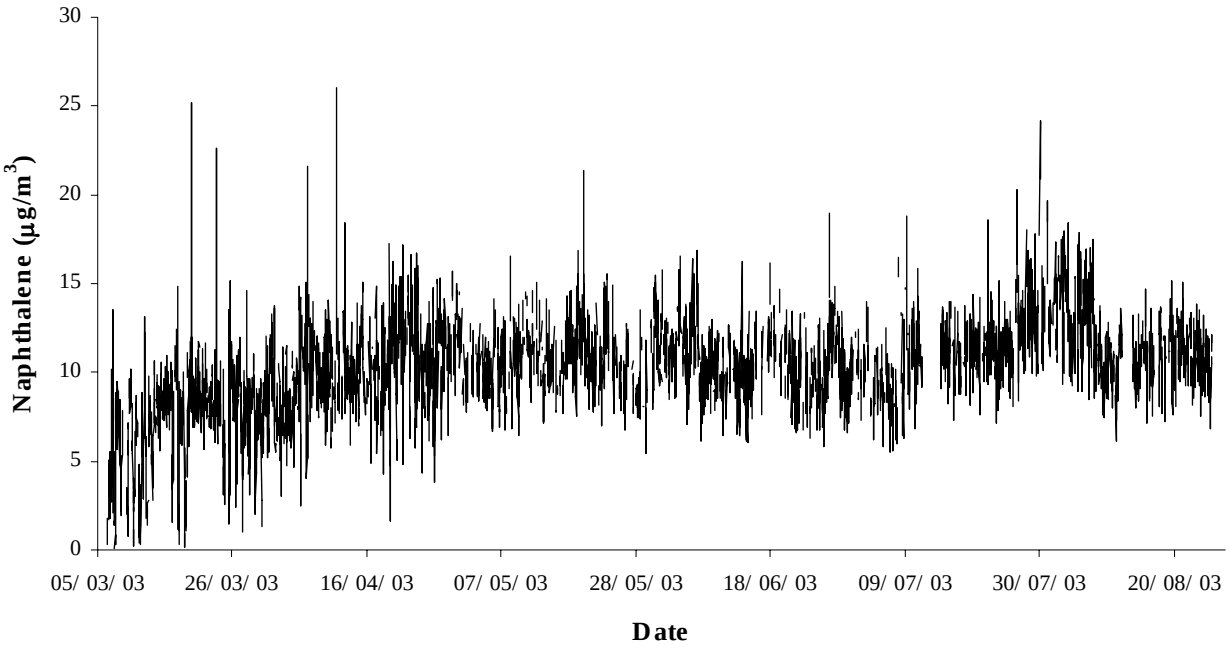

Figure 15 Naphthalene 30-minute averages and at DJ Leane Reserve

Particulate matter (PM_{10})

Health effects

Elevated PM_{10} concentrations are associated with a range of effects on health, including respiratory and cardiovascular difficulties, asthma and mortality (NEPC 1998).

Since the most applicable evidence relates daily average concentrations of particles to effects on health, the PM_{10} NEPM is measured over 24 hours. The NEPM air quality standard is 50 µg/m^3 as a 24-hour average, with a goal of no more than five occasions in a calender year.

Sources

Unlike the individual gaseous pollutants, which are single well-defined substances, particles (PM_{10}) in the atmosphere are composed of a wide range of materials arising from a variety of sources. Concentrations of PM_{10} are comprised of coarse particles, suspended soils and dusts, sea salt, biological particles and particles from construction work. Smaller particles arise from combustion sources and through chemical reactions in the atmosphere to form sulfate and nitrate particles.

The relative contribution of each source type varies from day to day, depending on meteorological conditions and quantities of emissions from mobile and static sources.

Monitoring results

One-day averages for PM_{10} (Figure 16) were within the range 7.0 to 64.6 µg/m^3, with an average for the entire monitoring period of 17.1 µg/m^3. The NEPM air quality standard is 50 µg/m^3. Concentrations of PM_{10} at DJ Leane Reserve exceeded the NEPM standard on one occasion. However, this was due to a regional dust event and was not related to refinery operations. By comparison, the EPA Netley air monitoring site measured a PM_{10} concentration of 128.6 µg/m^3 on the same day. The second highest monitoring result at DJ Leane Reserve was also found to be a regional dust event.

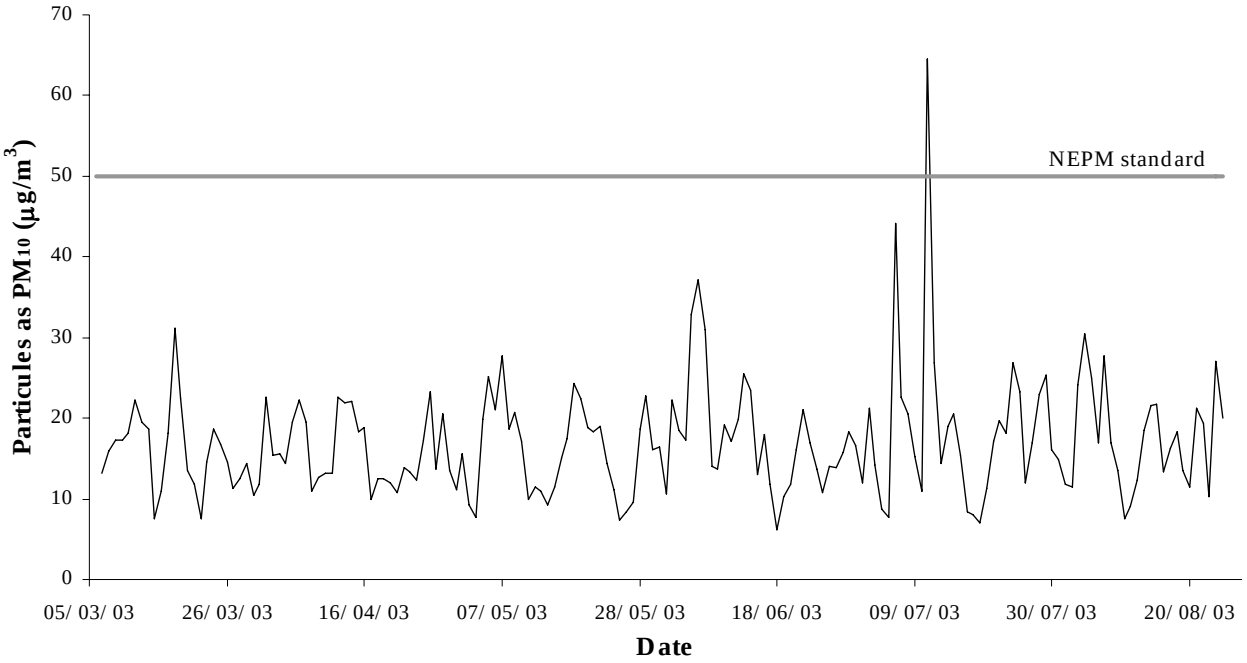

Figure 16 PM_{10} daily averages and the NEPM standard at DJ Leane Reserve

CONCLUSION

Monitoring was conducted over a period of five-and-a-half months at the DJ Leane Reserve, approximately one kilometre south of the Mobil Oil Refinery's southern boundary. Monitoring covered a period from full production to a complete shutdown of the refinery's major operations. Some clean-up operations were still underway when the monitoring program ceased; however, these activities were not expected to have major air quality impacts on the surrounding residential suburbs.

During the same period monitoring was also carried out at the St John's Primary School site, approximately 1.6 km south of the refinery. This was undertaken as part of the Environment Protection Authority's ambient air monitoring program in South Australia.

Monitoring comparisons between the hot spot site and the St John's Primary School site observed the same SO_2 events, although, as expected, the hot spot site observed higher SO_2 peak concentrations. While these events were related, frequently they were time-shifted, probably the result of meteorological conditions. Limited meteorological results showed that a north-north-east wind transports SO_2 from the general direction of the refinery towards the monitoring sites. These events were short in duration and did not exceed the NEPM standards or the WHO (2000) short-term guideline.

PM_{10} particulate matter exceeded the NEPM standard on one occasion. This was due to a dust storm event that was also measured in other suburbs of Adelaide and was not associated with the refinery.

All other parameters measured did not exceed the relevant NEPM standards or other health-based guidelines currently used for comparison.

REFERENCES

Canadian Centre for Occupational Health and Safety (CCOHS) 2006, website, viewed 17 April 2007, <www.intox.org/databank/documents/chemical/naphthal/cie361.htm>.

National Environment Protection Council (NEPC) 1998, *National environment protection measure, and impact statement, for ambient air quality, 26 June 1998*, NEPC, viewed 17 April 2007, Adelaide, <www.ephc.gov.au>.

—— 2003, *Impact statement for the national environment protection (air toxics) measure,* NEPC, viewed 17 April 2007, Adelaide, <http://www.ephc.gov.au/pdf/Air_Toxics/Air_Toxics_IS.pdf>.

National Pollutant Inventory 2002, *National Database of Pollutant Emissions,* NPI, viewed 17 April 2007, <www.npi.gov.au>.

Peach, H 1997, *Air quality and human health*, Australia: State of the environment technical paper series (The atmosphere), Department of the Environment, viewed 17 April 2007, Canberra, <www.ea.gov.au/soe/techpapers/series1/pubs/human.pdf>.

Peer Review Committee 2001, *Technical paper no. 5: Data collection and handling*, National Environment Protection Council, Canberra.

South Australian Environment Protection Authority (EPA) 2001, *South Australian Air Monitoring Plan*, EPA, viewed 17 April 2007, Adelaide, <http://www.epa.sa.gov.au/pdfs/airnepm.pdf>.

——2002, *South Australian NPI summary report: Adelaide and regional airsheds air emissions study 1998–99*, EPA, viewed 17 April 2007, Adelaide, <www.epa.sa.gov.au/pdfs/npi_air.pdf>.

—— 2003, *Air quality monitoring hot spot report, no. 4*, EPA, viewed 17 April 2007, Adelaide <www.epa.sa.gov.au/pdfs/aq_castalloy.pdf>.

United States Environment Protection Agency, IRIS: Integrated Risk Information System 2007, website, viewed 17 April 2007, <www.epa.gov/iris/index.html>.

World Health Organization WHO 2000, *Guidelines for air quality*, WHO, viewed 17 April 2007, Geneva, <www.euro.who.int/air/activities/20050222_2>.

APPENDIX 1 SAMPLING METHODS

Differential optical absorption spectrometry (DOAS)

Gaseous compounds such as ozone, nitrogen dioxide, sulfur dioxide and hydrocarbons were measured using the OPSIS (DOAS) analyser. The system utilises the light-absorbing properties of gaseous species to determine concentrations along a designated path. A beam of light is projected across a path where the pollutants in the path absorb light at particular wavelengths. A comparison is made between the absorption of light at a wavelength specific to the compound of interest and a known absorption property consistent with the background spectra. The concentration of the gaseous species is then determined. The almost simultaneous measurement of many pollutants is possible using this technique.

Tapered element oscillating microbalance (TEOM)

The TEOM mass-measurement system was used for the continuous measurement of particulate mass (PM_{10}) concentrations. It relies on the instrument drawing air through a filter at a constant flow rate and temperature, and then measures, continuously, the filter's weight to calculate the mass concentration. Mass is determined from the measured change in frequency at which the element attached to the filter is oscillating.

The TEOM is an instrument that measures PM_{10} as an equivalent aerodynamic diameter (EAD) using a standard impacting mechanism to separate particles **(**Australian Standard method: AS 3580.9.8-2001).

Non-dispersive infrared/Gas correlation (NDIR)

Carbon monoxide is measured using a non-dispersive infrared (NDIR) analyser, of the gas filter correlation type. A pre-filtered air sample is drawn through a sample cell. Infrared radiation is passed through the sample cell and a carbon monoxide-free reference cell. The detector measures the infrared light absorbed by carbon monoxide in the sample cell. By comparing the light intensity received by the detector through the cell with the light intensity through the reference cell, the concentration of carbon monoxide is determined (Australian Standard method: AS 3580.7.1-1992).

Ultraviolet (UV) fluorescence

Sulfur dioxide is measured using an UV fluorescence analyser. A pre-filtered air sample is drawn through a sample cell. The sample is irradiated by UV light (at 214 nm), which is absorbed by SO_2 within the sample. The excited SO_2 molecules then release UV light that is proportional to the concentration of SO_2. This light is measured and the concentration of sulfur dioxide present in the sample is thus determined (Australian Standard method: AS 3580.4.1–1992).

APPENDIX 2 SITE META DATA

Meta data: DJ Leane Reserve, O'Sullivans Beach (continuous sampling site)

Site information (Meta data)	
Site name	DJ Leane Reserve, O'Sullivans Beach
Site details	
Street address	Taralga Rd, O'Sullivans Beach
Date established	06/03/03
Date terminated	25/08/03
Siting guidelines (AS 2922–1987) exceptions	A tree within 10 m of the station
Description of surrounding land use	Residential and industrial 1 km north
Description of nearby emission sources	Oil refinery, sewage treatment, motor vehicles, small industry
Map coordinates	
Datum	GDA 94
Projection	AMG Zone 54
Easting	270038.1
Northing	6110554.3

Notes on data validation and assessment

Zero, span, calibration equation parameters & quality assurance procedures

CO: Zero corrections: (maximum adjustment is +0.6 ppm, minimum –0.1 ppm due to instrument zero stability)

OPSIS parameters: (SO_2 6/3/03–25/8/03 –3 $\mu g/m^3$) (NO_2 6/3/03–25/8/03 +34 $\mu g/m^3$) (O_3 6/3/03–25/8/03 +27 $\mu g/m^3$) (FOR 6/3/03-25/8/03 –90 $\mu g/m^3$) (TOL 6/3/03–25/8/03 +26 $\mu g/m^3$) (BEN 6/3/03-25/8/03 –6 $\mu g/m^3$) (NAP 6/3/03–25/8/03 +42 $\mu g/m^3$)

Data return OPSIS parameters SO_2 – 94%; NO_2 – 86%; O_3 – 94%; FOR – 94%; TOL – 91%; BEN – 96%; NAP – 66%

Note: Data return varies due to parameter measured (wavelength of light used)

Data validated and checked in accordance with the National Environment Protection (Ambient Air Quality) Measure (Peer Review Committee 2001).

Notes of time and nature of events that may influence data validation or interpretation

Box placed over OPSIS transceiver (8–9 March 2003), dust storm resulting in loss of light path (11–14 July 2003), CO instrument technical malfunction on 7 August 2003.

Pollutants measured		
NO, NO_2, SO_2, O_3, benzene, toluene, formaldehyde, naphthalene	Particulate matter (PM_{10})	Carbon monoxide (CO)

Instrument types					
Make	OPSIS	Make	RP	Make	Thermo electron
Model	ER130 & AR500	Model	TEOM PM_{10}	Model	NDIR analyser
Serial number	E672	Serial number	140AB221849807	Serial number	48–16574–162
Deviation of detection	1–15 $\mu g/m^3$ dependant on path length and parameter	Minimum detection level	N/A	Minimum detection level	0.05 ppm or 2%
Units	$\mu g/m^3$ (converted to ppm where applicable)	Units	$\mu g/m^3$	Units	ppm
Measurement cycle	10 minutes	Sampling rate	10 minutes	Sampling rate	20 seconds
Logging interval of raw data	10 minutes	Logging interval of raw data	10 minutes	Logging interval of raw data	10 minutes
Data return	See notes section	Data return	99%	Data return	88%
Clock adjustment	Period ending	Clock adjustment	Period ending	Clock adjustment	Period ending

Meta data: St John's Primary School, Christies Beach (continuous sampling site)

Site information (Meta data)		**Notes on data validation and assessment**
Site Name	Saint John's Primary School, Christies Beach	**Zero, span, calibration equation parameters & quality assurance procedures** Zero corrections: (SO_2 +0.001 ppm)
Site details		
Street address	Winnerah Rd, Christies Beach	
Date established	1992	
Date terminated	December 2004	
Siting guidelines (AS 2922–1987) exceptions	Adjacent a building, sampling point at 2.5 m	
Description of surrounding land use	Residential and industrial 1.8 km north	
Description of nearby emission sources	Oil refinery, sewage treatment, motor vehicles, small industry	Data validated and checked in accordance with the National Environment Protection (Ambient Air Quality) Measure (Peer Review Committee 2001).
Map coordinates		
Datum	GDA 94	**Notes of time and nature of events that may influence data validation or interpretation**
Projection	AMG Zone 54	Logger malfunction resulted in loss of SO_2 data (1/8/03–15/8/03)
Easting	270245	
Northing	6109682.5	
Pollutants measured		
Sulfur Dioxide (SO_2)		

Instrument types			
Make	Monitor labs		
Model	ML9850B		
Serial number	792B–314		
Minimum detection level	0.0005 ppm		
Units	ppm		
Sampling rate	20 seconds		
Logging interval of raw data	2 minutes		
Data return	80%		
Clock adjustment	Period ending		