

## BENZENE AIR MONITORING IN CORIO 2003-2005

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### SUMMARY

In Geelong (and Victoria generally), motor vehicles are the main source of benzene emissions to air. The Shell refinery in Corio is the largest industrial source of benzene emissions.

Benzene is an aromatic hydrocarbon found in petrol and is used for a range of industrial purposes. Benzene is classified as a human carcinogen. The critical human health effects from long-term exposure to benzene are bone marrow depression and acute myeloid leukaemia.

In recent years new and tighter targets for benzene levels in air have been set in Victoria and nationally.

EPA has been measuring the levels of benzene in air continuously at Geelong Grammar in Corio since December 2002 and for one day each week at Corio, Rosewell and North Shore Primary Schools and Geelong Grammar since August 2004. Average benzene concentrations in Corio were compared to results from previous EPA studies and were found to be similar to levels in Melbourne and lower than concentrations measured beside busy roads (Figure 1). Results indicate that benzene levels in Corio and elsewhere were below the health-based National Investigation Level.

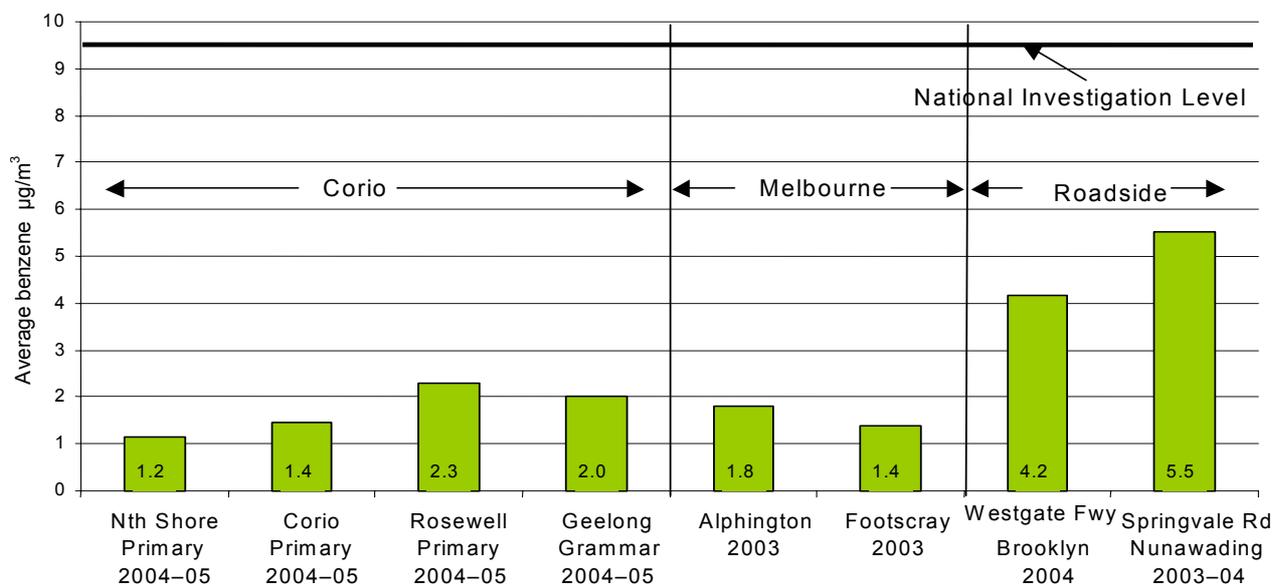


Figure 1: Average benzene concentrations in Corio and Melbourne - EPA canister sampling location and year

Continuous benzene results indicate that while hourly benzene levels were almost always well below the Victorian Intervention Level, two peaks exceeded this level prompting investigation and evaluation. These peaks occurred when the wind was coming from the direction of the refinery.

There is a need to reduce benzene emissions to the maximum extent achievable (even where health based levels are met as occurs in this case) due to its carcinogenic properties.

Accordingly EPA requires Shell to continue to reduce benzene emissions from the refinery. This, along with national cleaner fuel standards, is expected to significantly reduce benzene levels in Corio in coming years.

EPA will continue to monitor benzene in Corio until August 2005. Shell's EPA licence requires it to continuously measure benzene levels at 2 locations in Corio into the future.

## OBJECTIVES

The objectives of this study were to measure and assess the significance of benzene levels in air in Corio. Measurements were compared with National and State air quality requirements and with levels previously measured in Melbourne.

## BACKGROUND

In December 2004 the *National Environment Protection (Air Toxics) Measure* was made<sup>1</sup>. This Measure sets monitoring Investigation Levels for concentrations of air toxics. The Investigation Levels

used by the Measure are based on the protection of human health and have been established for use in assessing the significance of the monitored levels of air toxics with respect to protection of human health. Measurements above this level require further investigation and evaluation. The Investigation Level for benzene is  $9.6 \mu\text{g}/\text{m}^3$  (three parts per billion) as an annual average<sup>3</sup>.

The State Environment Protection Policy (Air Quality Management)<sup>2</sup> 2001 provides the basis for EPA's licensing of air discharges from industry. The Policy lists benzene as a class 3 indicator and requires generators of emissions of class 3 indicators to reduce those emissions to the maximum extent achievable. The Policy also provides an Intervention Level for benzene of  $75 \mu\text{g}/\text{m}^3$  as an hourly average. Measurements above these levels provide a trigger for further investigation and evaluation to ensure the requirements of the Policy are met. For benzene this may include longer-term monitoring for comparison with the National annual average health-based level given that the health effects from benzene in air result from long-term rather than hourly exposures.

Motor vehicles are the main source of benzene emissions to air in Geelong (and Victoria)<sup>3</sup>. National cleaner fuel standards require that refineries reduce benzene levels in petrol from around four per cent to less than one per cent from 2006<sup>4</sup>.

The Shell refinery in Corio is the largest industrial source of benzene emissions in Victoria. The company took some steps to reduce its benzene emissions during 2004 and its EPA licence requires that it significantly reduce benzene emissions during 2005–06<sup>5</sup>.

## METHODOLOGY

EPA conducted air monitoring in Corio using two different methods: weekly canister sampling to allow the calculation of average benzene levels for comparison with the annual National Investigation Levels; and continuous sampling to provide hourly benzene levels for comparison with the Victorian Intervention Level.

### Canister sampling method

Canister sampling has been conducted at Corio, Rosewell and North Shore Primary Schools and Geelong Grammar since August 2004. Figure 2 depicts the locations of all monitoring sites. Canister samples are collected each week over a 24-hour period (for practical reasons being morning to morning rather than midnight to midnight as specified in the National Measure).

Samples were collected in stainless steel fused silica-coated canisters and transported to EPA's laboratory for chemical analysis using the technique of gas chromatography with mass spectrometry detection. Analysis was performed using USEPA method TO-15<sup>6</sup>. The detection limit for benzene with the weekly canister method was  $1 \mu\text{g}/\text{m}^3$  and the measurement uncertainty at the levels measured in this study was  $\pm 1 \mu\text{g}/\text{m}^3$ .

Results were compared to National Investigation Levels. The National Measure specifies 12 months of sampling every six days. The Corio results are based on nine months of sampling every week, which is considered sufficient to allow for comparison with National Investigation Levels. The sampling will continue until 12 months of results are collected (August 2005). The results were also compared to

results from benzene air monitoring conducted over the past few years in Melbourne<sup>7,8,9</sup>.

### Continuous monitoring method

Continuous monitoring has been conducted at Geelong Grammar School (close to the canister site) since January 2003 using a UV-visible spectrometer and the technique of differential optical absorption spectrometry (DOAS). The technique involved passing a light beam over a distance of 430 metres from a light source to a receiver. The amount of absorption of light energy at specific wavelengths corresponded to the concentration of the compound. The monitoring equipment was installed at Geelong Grammar approximately 500 metres due east of the north-east corner of the refinery site.

Benzene results for hourly averages from continuous monitoring are considered to be accurate to  $\pm 5 \mu\text{g}/\text{m}^3$ . The instrument was calibrated monthly using a reference gas standard. Concentrations were retrieved from the analyser as five-minute averages and converted to one-hour average concentrations (based on clock hours in accordance with national procedures – using non-clock hours can lead to somewhat higher or lower concentrations). Results associated with instrument light intensity of five per cent or above were considered valid data. These concentrations were compared against the benzene Intervention Level.

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Figure 2: Locations of monitoring sites

The data capture for continuous monitoring was 96, 93 and 81 per cent for 2003, 2004 and 2005 (up to 23 April 05) respectively. It is expected that the pattern of benzene concentrations during times when data was not available would have been similar to the pattern reported below.

## RESULTS

### Canister sampling results

The average benzene levels for the four Corio sites (1.2-2.3 µg/m<sup>3</sup>) are shown in Figure 1. The Corio average levels are below the National Investigation Level of 9.6 µg/m<sup>3</sup> (three parts per billion). The individual results are shown in Appendix 1.

### Continuous sampling results

Nearly 20,000 hours of continuous benzene monitoring data were collected (see graph in Appendix 2).

Ninety nine per cent of the hourly average benzene concentrations measured were less than one third (25 µg/m<sup>3</sup>) of the Victorian Intervention Level. Annual average levels were less than 5 µg/m<sup>3</sup>, consistent with the canister results (the canister method is more sensitive and is preferred for determining averages).

For 29 months of monitoring, benzene levels went above two thirds (50 µg/m<sup>3</sup>) of the Intervention Level for 29 hours (24 hours in 2003, 4 hours in 2004 and 1 hour in 2005). Benzene levels went above the Intervention Level of 75 µg/m<sup>3</sup> on two occasions: 78 µg/m<sup>3</sup> at 12-1am on 26 March 2003 and 84 µg/m<sup>3</sup> at 10-11pm on 26 May 2003.

## DISCUSSION

The average benzene concentrations in Corio (1.2-2.3 µg/m<sup>3</sup>) were similar to average levels measured over 12 months at EPA air monitoring stations in Alphington and Footscray in 2003–2004<sup>7</sup> (1.4-1.8 µg/m<sup>3</sup>) and lower than the average levels measured at the roadside sites (4.2-5.5 µg/m<sup>3</sup>): the corner of Springvale and Whitehorse Roads, Nunawading 2003–2004<sup>8</sup> (6 months); and the Westgate Freeway, Brooklyn 2004<sup>9</sup> (9 months).

Continuous monitoring indicated that most hourly peaks, including the two above the Intervention Level, occurred at light wind speeds, usually with wind directions from the south-west and west. This is consistent with the main local source of benzene being the Shell refinery. There were fewer hourly peaks in 2004 and 2005 than there were in 2003. This is consistent with a reduction in benzene emissions from the refinery over that time. It also may be influenced by weather conditions. A few higher results were measured when the wind was coming from the east to north-east. The sources of these peaks are unknown.

The average results at the four canister sampling sites in Corio were similar. It is expected that the pattern of hourly benzene concentrations at the other sites would be similar to that for Geelong Grammar. Shell monitoring at two locations in Corio into the future will provide further information on this.

Concentrations higher than the Intervention Level do not directly indicate a health issue. They prompt further investigations and evaluation, with a view to ensuring beneficial uses are protected. At Corio the limited number and extent of elevated benzene

levels meant that the annual average benzene concentrations remained below the health based National Investigation Level.

There is however a need for the Shell refinery to reduce levels of benzene to the maximum extent achievable. EPA licensing requirements on the refinery and the program to reduce benzene in petrol, will result in further reduction of benzene in line with Policy requirements.

## CONCLUSIONS

Results indicate that average benzene levels in Corio were below the health-based National Investigation Level of  $9.6 \mu\text{g}/\text{m}^3$ .

Average benzene concentrations in Corio were found to be similar to background levels in Melbourne and lower than concentrations measured beside busy roads.

While benzene levels were mostly well below the Victorian Intervention Level, short-term elevated levels were found, mostly when the wind was blowing from the refinery. Two results were above the Intervention Level.

Results above the hourly Intervention Levels did not lead to an exceedance of the annual average health based National Investigation Level.

There is a requirement for Shell to reduce benzene emissions to the maximum extent achievable. Combined industry licensing and fuel programs should see further reduction in benzene levels.

Future benzene monitoring will show the extent of air quality improvement.

## REFERENCES

1. *National Environment Protection (Air Toxics) Measure* April 2004, National Environment Protection Council.
2. State Environment Protection Policy (Air Quality Management) 2001, Government of Victoria.
3. [www.ephc.gov.au/nepms/air/air\\_toxics.au](http://www.ephc.gov.au/nepms/air/air_toxics.au).
4. [www.deh.gov.au/atmosphere/transport/qualitystandard](http://www.deh.gov.au/atmosphere/transport/qualitystandard).
5. EPA Victoria Licence No. EM30626.
6. United States Environmental Protection Agency Compendium Method TO-15 A Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and analysed by using Gas Chromatography/Mass Spectrometry (GC/MS).
7. Environment Australia (2002) *A Status Report to the Community: Living Cities-Air Toxics Program*.
8. EPA 2004 *Air Monitoring at Nunawading - September 2003 to February 2004*, EPA Publication 948.
9. EPA 2005 *Air Monitoring Alongside the Westgate Freeway in Brooklyn – March to November 2004*, EPA Publication 974.

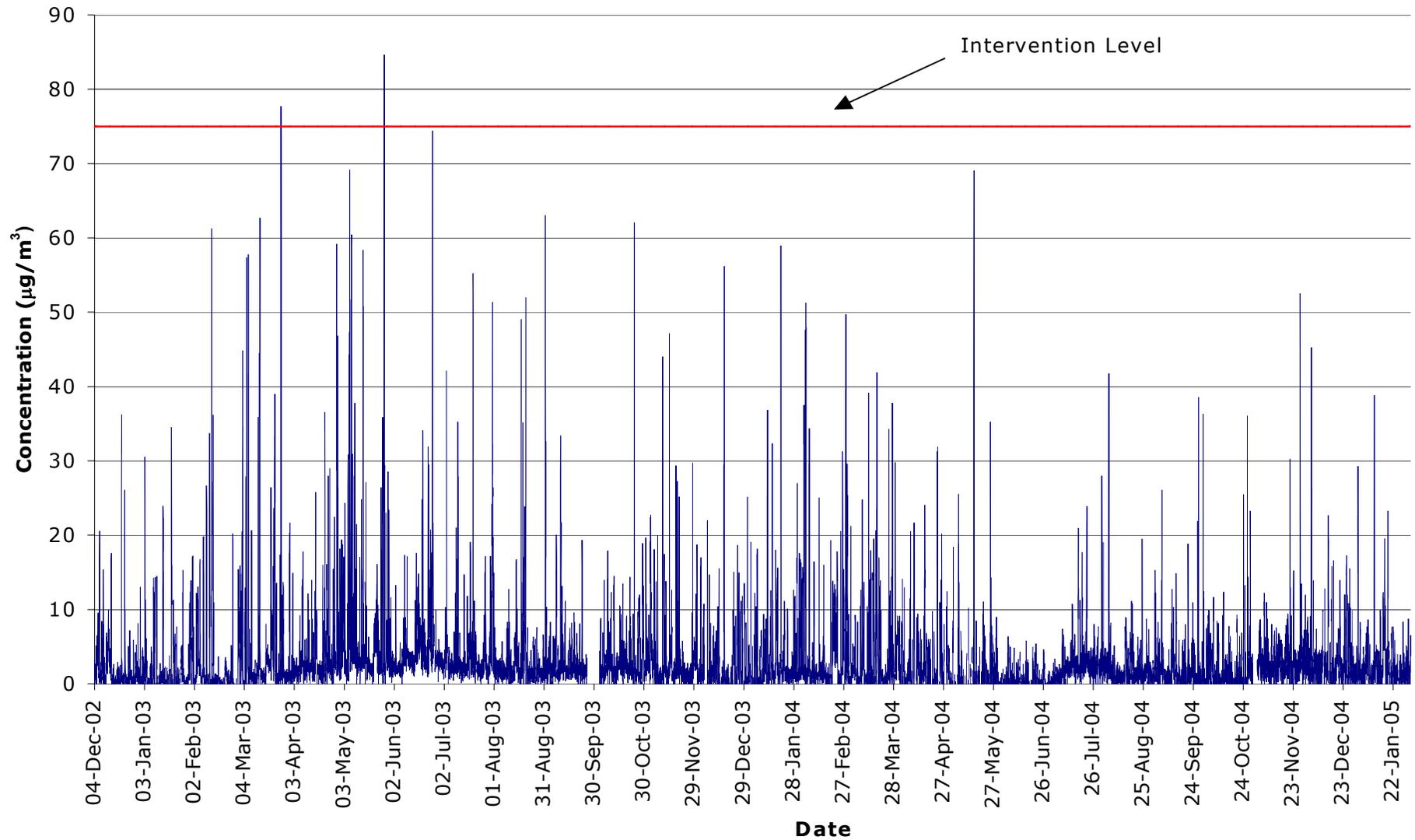
# BENZENE MONITORING IN CORIO 2003–2005

**Appendix 1: 24-hour average benzene concentrations at all school sites 2004–2005 ( $\mu\text{g}/\text{m}^3$ )**

Start Date	North Shore PS	Corio PS	Rosewell PS	Geelong GS
11 Aug 04	<1.0	<1.0	7.7	11.8
17 Aug 04	1.8	2.0	2.4	2.0
26 Aug 04	1.5	1.1	1.0	1.2
31 Aug 04	<1.0	<1.0	1.1	1.5
06 Sep 04	2.5	2.3	1.8	1.1
15 Sep 04	<1.0	<1.0	1.4	<1.0
21 Sep 04	1.8	<1.0	<1.0	<1.0
27 Sep 04	1.9	2.0	4.4	<1.0
08 Oct 04	<1.0	<1.0	<1.0	2.7
12 Oct 04	<1.0	<1.0	<1.0	<1.0
18 Oct 04	<1.0	2.5	3.7	<1.0
28 Oct 04	<1.0	<1.0	<1.0	<1.0
03 Nov 04	<1.0	<1.0	2.3	<1.0
08 Nov 04	<1.0	<1.0	2.0	<1.0
16 Nov 04	<1.0	1.2	1.1	<1.0
24 Nov 04	<1.0	1.3	1.4	<1.0
02 Dec 04	<1.0	1.0	1.0	<1.0
08 Dec 04	<1.0	1.1	3.2	<1.0
14 Dec 04	<1.0	<1.0	<1.0	1.2
21 Dec 04	<1.0	1.4	2.4	<1.0
02 Jan 05	<1.0	1.2	<1.0	<1.0
06 Jan 05	1.1	<1.0	1.4	2.7
13 Jan 05	1.8	1.5	1.2	2.1
19 Jan 05	2.8	1.8	4.2	1.8
24 Jan 05	1.6	2.8	5.6	1.3
05 Feb 05	<1.0	1.1	1.6	5.4
20 Feb 05	1.7	2.5	2.7	1.4
24 Feb 05	1.0	1.7	1.6	7.2
03 Mar 05	2.1	2.6	1.9	3.2
22 Mar 05	<1.0	1.0	3.3	<1.0
31 Mar 05	3.5	2.9	1.1	<1.0
7 Apr 05	0.5	1.5	3.5	0.5
13 Apr 05	1.4	2.8	2.9	1.6
20 Apr 05	1.6	0.5	2.2	1.4
27 Apr 05	4.1	6.4	9.1	13.2
5 May 05	0.5	0.5	0.5	1.4
<b>Average</b>	1.2	1.4	2.3	2.0

\* <1.0 indicates benzene concentration below detection limit. In calculating the average these results are taken as half the detection limit (i.e., 0.5  $\mu\text{g}/\text{m}^3$ ).

# BENZENE MONITORING IN CORIO 2003-2005



Appendix 2: Hourly benzene concentrations at Geelong Grammar 2002-2005