NATIONAL POLLUTANT INVENTORY

Perth Airshed Emissions Study 1998/1999

WESTERN AUSTRALIAN
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Revised
November 2003

Erratum for Perth Airshed Emissions Study 1998/1999 - Revised November 2003

This November 2003 Revision incorporates the changes listed below to the original version of the Perth Airshed Emissions Study which was published in October 2000.

A Technical Note is included which outlines specific adjustments to data which appeared in the original document, and to data which will be posted on the NPI Internet site.

Page	Outline of alteration
insert	TECHNICAL NOTE – NOVEMBER 2003, ADJUSTED AGGREGATED EMISSIONS DATA IN PERTH AIRSHED EMISSIONS STUDY 1998/99
iii and p2	NPI internet site address changed.
iv	Some percentage values changed in 'Results'.
v Table 2	• 1,2-Dichloroethane added. • Polychlorinated dioxins and furans removed, (as per July 2001 erratum). • Emission values for 1,2-Dibromoethane, Oxides of Nitrogen, Particulate Matter 10um, Sulphur dioxide revised.
13 Table 2.8	• 1,2-Dichloroethane added. • Polychlorinated dioxins and furans removed (as per July 2001 erratum).
20 Table 2.17	Emission values for Carbon monoxide, Oxides of Nitrogen, Particulate Matter 10um, PAH's, Sulphur dioxide, Total volatile organic compounds revised.
25 Table 3.1	• Sub-threshold and Total emission values revised for Carbon monoxide, Oxides of Nitrogen, Particulate Matter 10um, Polycyclic aromatic hydrocarbons, Sulphur dioxide, Total Volatile Organic Compounds. • Polychlorinated dioxins and furans removed (as per July 2001 erratum). • 1,2-Dichloroethane added; 1,2-Dibromoethane values revised.
27 Table 3.2	• Percentages for Carbon monoxide, Oxides of Nitrogen, Particulate Matter 10um, Polycyclic aromatic hydrocarbons, Sulphur dioxide and Total Volatile Organic Compounds revised. • Polychlorinated dioxins and furans removed (as per July 2001 erratum). • 1,2-Dichloroethane added.
28	Percentage values revised in last paragraph.
29 Figure 3.1	Pie charts revised to align with revised emission values.
B-2 Table B.1	Residual Oil values revised. Refinery Fuel Gas added to Table.
B-12 Table B.12	Emission factor for Polychlorinated dioxins and furans deleted.
B-34 Table B.2.1	New dot point added to NATURAL GAS TURBINE ELECTRIC GENERATOR section.
D-1 Table D.1	• Percentages for Oxides of Nitrogen, Particulate Matter 10um, Sulphur dioxide revised. • 1,2-Dichloroethane added. Percentages for 1,2-Dibromoethane revised. • Polychlorinated dioxins and furans removed (as per July 2001 erratum).
D-3 Table D.2	• Emission values for Carbon monoxide, Oxides of Nitrogen, Particulate Matter 10um, Polycyclic aromatic hydrocarbons, Sulphur dioxide, Total Volatile Organic Compounds revised. • 1,2-Dichloroethane added. Emission value for 1,2-Dibromoethane revised. • Polychlorinated dioxins and furans removed (as per July 2001 erratum).
Appendix E	Deleted from report.

NATIONAL POLLUTANT INVENTORY

TECHNICAL NOTE

NOVEMBER 2003

ADJUSTED AGGREGATED EMISSIONS DATA

in

PERTH AIRSHED EMISSIONS STUDY 1998/1999

1. INTRODUCTION

Aggregate Emissions Data (AED)

Emissions from non-reporting sources are called “aggregated emissions data” (AED), and include mobile, area-based and natural sources such as motor vehicles, domestic solid fuel burning, fuel combustion from commercial activities and wildfires.

This technical note outlines adjustments to aggregated emissions estimates reported:

a) in the *October 2000 “NATIONAL POLLUTANT INVENTORY PERTH AIRSHED EMISSIONS STUDY 1998/1999*”, Western Australian Department of Environmental Protection, and
b) on the NPI internet site (www.npi.gov.au).

A revised version of the October 2000 report (November 2003 Revision) makes corrections in some areas, while still using 1998/99 data references and sources. The November 2003 Revision report will be posted on the Internet at:
www.npi.gov.au/publications/perth-airshed.html.

Additionally, data on the NPI Internet site will be further adjusted to remove emissions from facilities which were non-NPI reporters in 1998/99 but commenced reporting to the NPI in later years. This will allow a better comparison of reported NPI facility emissions against emissions estimated from non-reporting facility sources, for the period 2001/02.

The NPI Perth Airshed Internet data changes have NOT been incorporated in the revised report (November 2003 Revision) on the internet at:
http://www.npi.gov.au/publications/perth-airshed.html.

It is intended that a new NPI Perth Airshed Emissions study will commence in 2004/2005.

It is important to note that the accuracy of aggregated emissions estimates varies with the availability of suitable emissions estimation techniques (EETs). EETs have been sourced from Australia and overseas, and those EETs used for the 1998/99 study were the best available at the time. Many changes have occurred to EETs and to fuel use at various commercial and industrial facilities since the 1998/99 study was published, and a new overall study is to be undertaken in the next two years.

2. NOVEMBER 2003 REVISION

The October 2000 Report presented emission estimates from 19 AED sources located within the Perth Airshed study area. A revision to that report – November 2003 Revision - has been prepared for publication.

The November 2003 Revision corrects some errors in the October 2000 report, and essentially maintains the same basis for the 1998/99 data. Data from one large emitter has been amended, and some minor changes have been made (inclusion of substance 1,2- dichloroethane). An erratum page in the November 2003 Revision details the changes.

The 2001 deletion of erroneous polychlorinated dioxins and furans estimates from the internet data is now reflected in the body of the report, in line with the erratum issued in mid-2001.

3. NPI PERTH AIRSHED INTERNET DATA

A further revision to NPI Perth Airshed data is outlined below. Adjustments to this data are necessary since various stakeholders have expressed interest in making comparisons of the most recent emissions reported to the NPI from facilities in Perth to emissions estimates in Perth from non-facility sources (AED).

NOTE: Such comparisons are subject to the limitations of coverage and accuracy of emissions estimates from NPI facility reports and aggregated sources. AED data does not necessarily represent the particular facility reporting year being examined. For example aggregated data may be from a study completed in 1998/99 and the facility data from 2001/02.

The set of NPI Perth Airshed data which will appear on the NPI Internet database modifies November 2003 Revision data by changing emission estimates for only one of the 19 sources - fuel combustion for 1998/99 sub-threshold facilities. The effects of these changes are summarised in the table below.

Purpose
The basic change in the NPI Perth Airshed Internet data is the removal from the "sub-threshold" group of facilities (or non-NPI reporters) of those which are no longer sub-threshold, since they have become reporting facilities. Emissions have also been removed for a site which would no longer be considered sub-threshold.

These Internet data changes are necessary to prevent double counting and misleading conclusions, if emissions from facilities for 2001/02 are compared with AED emissions that were current for 1998/99.

The procedure is in line with the October 2000 report which noted (page B-1) that the data "*will need to be updated in future years to remove facilities that did not report in the 1998-99 reporting period but do report in future years".*

Specifics
In the 1998/99 work, over 240 facilities' fuel combustion emissions were classified as "sub-threshold" since no NPI report was received from those facilities.

However, based on fuel use, around 40 of these facilities would have been required to report to the NPI, but at the time were not required to, due to lack of published Industry Handbooks, or because reporting was not then compulsory.

Emissions from fuel combustion from the group of around 240 facilities were estimated by the Department using data available at the time, and included in the "fuel combustion sub-threshold" source.

The group of over 40 facilities subsequently reported to the NPI in 2001/02, and their emissions should therefore no longer be considered as "sub-threshold". Emissions estimates from fuel combustion have now been removed for this group of facilities, and are included in the reporting facility section of the database.

Another adjustment removes fuel combustion emissions from a site which did not report to the NPI in 1998/99, and should no longer be considered "sub-threshold". The site is not operational, and if included could lead to incorrect conclusions for 2001/02.

4. INTERNET DATA ADJUSTMENTS

Adjustments to NPI Perth Airshed Internet data relate solely to the aggregated emissions source "Fuel combustion-sub reporting threshold facilities". A comparison of these adjustments appears in the following table.

NPI Substance (kilograms emitted to air)	**Internet data 2001/02 basis**	**Nov 2003 Revision To Study Report**	**Perth Airshed Study Report October 2000 1998/99 basis**
Arsenic and compounds	0.59	198	198
Benzene	5,201	32,800	32,800
Cadmium and compounds	2.73	47.7	47.7
Carbon Monoxide	158,457	2,040,000	1,700,000
Chromium (VI) compounds	0.01	1.39	1.39
Cobalt and compounds	0.35	63.7	63.7
Fluoride compounds	1.33	2,210	2,210
Lead and compounds	1.44	1,300	1,300
Mercury and compounds	0.69	155	155
Nickel and compounds	7.28	4,700	4,700
Oxides of nitrogen	397,852	4,830,000	5,650,000
Particulate matter 10um	33,142	2,400,000	2,200,000
Polycyclic aromatic hydrocarbons (PAH)	22.2	125	128
Sulfur dioxide	58,812	4,090,000	9,740,000
Total Volatile Organic compounds	201,974	660,000	664,000
Toluene	5,074	17,400	17,400
Xylenes	2,121	7,500	7,500

Notes.

1. Polychlorinated dioxin and furan emissions were removed from the October 2000 study and to NPI Perth airshed internet data in 2001 due to an erroneous emission factor in a 1996 US reference source.
2. Substance 1,2 dichloroethane has been included in November 2003 Revision and will appear in NPI Internet data to correct a transcription error in the source "Domestic commercial solvents/aerosols". Emissions of 1-2 dibromoethane have been amended as a result. Refer to erratum in November 2003 Revision document.

5. DISCUSSION

NPI Perth Airshed Internet data compared with October 2000 report

The very large reduction in emissions shown in the Internet data column, compared to the October 2000 column, reflects the fact that many (over 40) facilities' emissions were classified as "sub-threshold" or non-NPI reporters in 1998-99, and their combined emissions were substantial. However, those facilities have subsequently reported to NPI and the estimated emissions of these substances are reported by the facilities themselves. The emissions from facilities that now report to the NPI that did not report to the NPI in 1998-99 should no longer be considered as "sub-threshold".

November 2003 Revision compared with October 2000 report

The differences between the November 2003 Revision column and the October 2000 column are due to corrections to estimates for one facility only, and maintain the original intent and basis for the October 2000 report. The November 2003 Revision of the NPI Perth Airshed Report contains an erratum page outlining differences.

Table of Contents

Appendices

Tables

Figures

Executive Summary

Introduction

The objective of this report is to present the emissions estimates of National Pollutant Inventory (NPI) substances from the Perth airshed for the 1998/ 1999 reporting year. It presents the results and describes the 19 aggregated emission sources as well as emissions from NPI reporting facilities that were located within the study area. Emissions of the 90 substances contained in Table 2 of the National Environment Protection Measure (NEPM) for the NPI (NEPC, 1998) are presented. Estimates for 14 of the sources were made in-house by the Department of Environmental Protection (DEP) and the remainder by an external consultant.

The Perth airshed study area is 87 km (east-west) and 99 km (north-south) comprising a population of 1.3 million people.

Data from this aggregated emissions study became part of the first national NPI database and was loaded onto the internet for public access on 28 January 2000. The Perth airshed study data, along with airshed data from other Australian states and territories, can be viewed at: **http://www.npi.gov.au**

Background

The NPI is a national database of emissions to air, land and water implemented by each Australian State and Territory under the NEPM for the NPI (referred to as the NEPM hereafter). The purpose of the NPI is to:

- Provide information to enhance and facilitate policy formulation and decision making for environmental planning and management.
- Satisfy community needs by providing publicly accessible information on a facility-specific and catchment basis about specific pollutants released to the environment.
- Promote and facilitate waste minimization, cleaner production and energy resource savings programs for industry, government and the community.

As part of the NPI Program, Western Australia (through the DEP) was committed to supplying the national NPI database with estimations of aggregated emissions to air from the Perth airshed for 1998 / 1999. This requirement is stipulated in Schedule C of the NPI Memorandum of Understanding (MOU). The MOU provides the basis for implementation of the NEPM.

Under the NPI MOU States and Territories were not required to report emissions from aggregated sources for which there was no relevant Aggregated Emission Estimation Technique (EET) manuals. No completed aggregated EET manuals were available during 1998/99. However, the WA DEP elected to report emissions using draft versions of the manuals and developed their own methods where necessary.

Air Emission Sources

Emission estimates for the 19 aggregated emission sources calculated for the Perth airshed study area are listed in Table 1. Of these, 14 were estimated in-house by the Air Quality Management Branch of the DEP, with the remaining four sources calculated by Sinclair Knight Merz (SKM). For both completeness and comparative purposes, the emissions generated from all 19 sources are presented and discussed in this report. The detailed methods used by SKM are presented in a separate report entitled “Perth Fugitive Estimations 1998/1999” (SKM 1999).

All emission estimates were based on the 90 substances contained in Table 2 of the NPI NEPM. Estimates were only made for substances in each source category where an emission factor was available.

Table 1: Aggregated Emissions Sources in the Perth Airshed

Commercial shipping/boating and recreational boating[a]	Fuel combustion – sub reporting threshold facilities
Lawn mowing	Cigarettes
Motor vehicle refinishing	Burning / wildfires [a]
Motor vehicles	Cutback bitumen
Service stations	Aeroplanes [a]
Dry cleaning	Gaseous fuel combustion (domestic)
Architectural surface coatings	Railways [a]
Solid fuel burning (domestic)	Biogenics
Natural / town gas leakage	Swimming pools[a]
Domestic/commercial solvents/ aerosols	

[a] Emissions estimated by Sinclair Knight Merz

For comparative purposes emissions from each of the 19 source categories were grouped into five source types. An additional non-aggregated source type – NPI reporting facilities – was included in the comparisons in order to create a more complete picture of emissions occurring in the Perth airshed study area. The six source types and their components are outlined below:

- Motor vehicles - on and off road emissions from cars, trucks, and motorcycles.
- Other mobile - comprised of the following aggregated sources: railways, commercial shipping/boating and recreational boating, and aeroplanes.
- Area-based - comprised of the following aggregated sources: service stations, cigarettes, lawnmowers, domestic/commercial solvents/ aerosols, architectural surface coatings, motor vehicle refinishing, solid fuel burning (domestic), gaseous fuel burning (domestic), cutback bitumen, and dry cleaning.
- Sub-threshold - comprised of the following aggregated source: fuel combustion sub-reporting threshold facilities.
- Natural sources - comprised of the following aggregated sources: burning/ wildfires, and biogenics.
- Reporting facilities - represent emissions from facilities that tripped NPI reporting thresholds and consequently submitted their own NPI report. Not all facilities were required to report in 1998/1999 as the NPI was not yet expanded to include all industry sectors. Facilities not required to report were covered by the Sub-threshold source type. Only those facilities located in the Perth aggregated emissions study area were included in this source type's emissions totals. Note that reporting facilities do not form part of the aggregated emissions study. They have been included for comparative purposes and to portray a more complete picture of emissions in the study area.

Results

Based on these six source types, area-based emissions consistently contributed the greatest percentage of individual volatile organic compound emissions into the Perth airshed. However, motor vehicles were the single largest contributor to emissions in the airshed, contributing 79% of the carbon monoxide, 46% of oxides of nitrogen and over 50% of many of the individual volatile organic compounds. NPI reporting facilities were the largest contributor of sulphur dioxide (60%) with sub-threshold reporting facilities being the second largest emitter of this substance (25%). These percentage contribution results are presented in full in Table 2.

Note that only substances for which emission estimates were made have been reported in this report. In total, estimates were able to be made for 53 of the 90 substances on Table 2 of the NEPM.

Table 2: Emissions from Major Sources (%) in Perth Airshed Study Area

Substance	Motor Vehicles (%)	Other Mobile (%)	Area Based (%)	Sub-threshold (%)	Natural Sources (%)	1998/99 NPI Reporting Facilities[1] (%)
Acetaldehyde	15	<1	85			
Acetone	4	1	93			3
Acrylic acid			100			
Acrylonitrile (2-propenenitrile)			100			
Antimony & compounds		100				
Arsenic & compounds		<1		54		46
Benzene	55	2	31	2	6	4
Beryllium & compounds						100
1,3-Butadiene (vinyl ethylene)	2	8	42		46	2
Cadmium & compounds		1	4	49		46
Carbon disulphide						100
Carbon monoxide	79	1	11	1	6	3
Chlorine			100			
Chloroform (trichloromethane)			100			
Chromium (III) compounds						100
Chromium (VI) compounds		<1	17	1		82
Cobalt & compounds		<1	22	71		7
Copper & compounds		<1	8			92
Cumene (1-methylethylbenzene)			7			93
Cyclohexane			100			<1
Dichloromethane			100			<1
1,2-Dibromoethane			73			27
1,2-Dichloroethane			100			
Ethanol			99			1
Ethylbenzene	93	<1	7			<1
2-Ethoxyethanol acetate			100			
Ethylene glycol (1,2-ethanediol)			100			<1
Ethylene oxide			100			
Fluoride compounds			<1	2		98
Formaldehyde (methyl aldehyde)	27	<1	73			
n-Hexane		<1	98			1
Hydrochloric acid			2			98
Lead & compounds	92	3	1	3		1
Manganese & compounds		1	90			8
Mercury		<1		46		54
Methanol			100			
Methyl ethyl ketone			98			2
Methyl isobutyl ketone			100			
Nickel & compounds		<1	<1	88		12
Oxides of nitrogen	46	6	1	8	14	25
Particulate Matter 10.0 µm	17	2	24	23	19	15
Phenol			100			
Polycyclic aromatic hydrocarbons	<1	1	95	<1		4

[1] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

Table 2: Emissions from Major Sources (%) in Perth Airshed Study Area (Contd)

Substance	Motor Vehicles (%)	Other Mobile (%)	Area Based (%)	Sub-threshold (%)	Natural Sources (%)	1998/99 NPI Reporting Facilities[1] (%)
Selenium & compounds		100				
Styrene (ethenylbenzene)			100			<1
Sulphur dioxide	4	10	<1	25		60
Sulphuric acid						100
Tetrachloroethylene			100			
Total Volatile Organic Compounds	43	1	51	1	2	1
Toluene (methylbenzene)	56	2	36	1	3	3
Trichloroethylene			100			
Xylenes (individual or mixed isomers)	65	2	30	<1	2	1
Zinc and compounds		14	37			49
Summary: Number of Substances Reported	**16**	**27**	**45**	**17**	**8**	**37**
Summary: Percentage of occurrences where the source was the single largest emitter of a substance relative to the number of substances emitted from that source.	**44%**	**7%**	**60%**	**24%**	**13%**	**30%**

[1] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

The greatest number of substances emitted were from the aggregate of the various Area Based emissions (45), followed by the 1998/1999 NPI Reporting Facilities (37) and the aggregate of Other Mobile sources (27). However, on a percentage basis, the aggregate of the Area Based sources were more often than not the single largest contributor of substances emitted from them (60% of substance). Motor Vehicles were consistently the single largest emitter of substances emitted by them (44% of substances).

1 Introduction

This report presents a summary of all 19 aggregated emission sources and their emissions of Table 2 National Pollutant Inventory (NPI) substances that were estimated in the Perth airshed for 1998/1999. Table 2 NPI substances include 90 substances comprised of common products of combustion, metals and volatile organic compounds (VOC's) (Appendix A). A discussion of the methods used to generate the emission estimates is contained in Appendix B to this report. In order to present a complete picture of NPI emissions, emissions from NPI reporting facilities located in the study area are also presented.

Emissions from each of the 19 aggregated emissions source categories have been grouped into five source types in this report for comparative purposes. An additional non-aggregated source type - reporting facilities - was included in the comparisons in order to create a more complete picture of emissions occurring in the Perth airshed study area. The six source types and their components are outlined below:

- Motor vehicles consisting of on and off road emissions from cars, trucks, and motorcycles.
- Other mobile which consists of emissions from railways, commercial shipping/boating and recreational boating, and aeroplanes.
- Area based emissions are those occurring from residential and commercial premises. The source categories studied were service stations, lawnmowers, domestic/commercial solvents/ aerosols, architectural surface coatings, motor vehicle refinishing, solid fuel burning (domestic), gaseous fuel burning (domestic), cutback bitumen, cigarettes, and dry cleaning.
- Sub threshold consists of emissions from industrial facilities that do not trigger NPI reporting thresholds or were not required to report in 1998/ 1999. This category is limited to the following source: fuel combustion - sub reporting threshold facilities.
- Natural sources consists of emissions from burning / wildfires and biogenics.
- 1998 / 1999 NPI reporting facilities represent emissions from facilities that were required to report to the NPI in their own right and were located in the in the Perth study area[1]. Emissions from these facilities do not form part of the aggregated emissions study, but have been included in this report for comparative purposes.

Section 1 sets out the background to the NPI, the aggregated emissions source categories and defines the study area. Section 2 provides the data for each of the emissions categories for the six source types. Section 3 of this report summarises all NPI emissions occurring in the Perth airshed in 1998/1999.

1.1 Background

The NPI is a database designed to provide the community, industry and government with information on the types and amounts of certain substances being emitted to the air, land and water. Australian industrial facilities using more than a specified amount of the substances listed on the NPI reporting list are required to estimate and report emissions of these substances annually as of 1 July 1998. The relevant State and Territory Government environment authorities estimate aggregated emissions from smaller industry, households and everyday activities in certain priority airsheds and water catchments.

The Department of Environmental Protection's (DEP's) requirement to report aggregated emissions to the Commonwealth is defined by section 20 of the National Environmental Protection Measure (NEPM) for the NPI (referred to as the NEPM hereafter) (NEPC, 1998). The Perth airshed was identified as a priority for aggregated emissions estimations in Part 5.3 and Schedule C of the Memorandum of Understanding (MOU). The MOU provides the basis on which the States and Territories implement the NEPM between 27th February 1998 and 30 June 2000. Extracts of relevant sections of the MOU and NEPM are presented in Appendix A.

[1] Not all facilities were required to report in 1998/1999 as the NPI was not yet expanded to include all industry sectors. Facilities not required to report were covered by the Sub-threshold source type.

This inventory, as well as the broader NPI program, serves three main purposes:

- Provide information to enhance and facilitate policy formulation and decision making for environmental planning and management;
- Satisfy community needs by providing publicly accessible information on a facility-specific and catchment basis about specific pollutants released to the environment; and
- Promote and facilitate waste minimization, cleaner production and energy resource savings programs for industry, government and the community.

Data from this aggregated emissions study became part of the first national NPI database and was loaded onto the internet for public access on 28 January 2000. It can be viewed at:

http://www.npi.gov.au

1.2 Aggregated Emission Sources

The DEP was required to estimate emissions of NPI substances from nine core aggregated source categories. Core source categories can be defined as the minimum number of aggregated emission sources from which each jurisdiction has jointly agreed to report on. The decision to include a source category in the 'core' list was made by the NPI Implementation Working Group (IWG) based on:

- significance of emissions from the source to overall emissions;
- relevance to all jurisdictions; and
- the ability of all jurisdictions to estimate emissions from the source.

The IWG consists of each of the State and Territory NPI managers and is coordinated by Environment Australia. These core source categories are listed in Table 1.1.

In addition to the nine core sources, the DEP also provided emissions estimates from a further eight non-core sources (also listed in Table 1.1). These sources were included in the study due to:

- their relevance to the Perth study area;
- availability of an emission estimation technique; and
- the availability of data that was collected for the update of the Perth Photochemical Smog Study.

Table 1.1: Aggregated Emission Source Categories Studied in the Perth Airshed

Core	Non-Core
Commercial shipping/boating and recreational boating[a]	Fuel combustion – sub reporting threshold facilities
Lawn mowing	Cigarettes
Motor vehicle refinishing	Burning / wildfires [a]
Motor vehicles	Cutback bitumen
Service stations	Aeroplanes [a]
Dry cleaning	Gaseous fuel combustion (domestic)
Architectural surface coatings	Railways [a]
Solid fuel burning (domestic)	Biogenics
Domestic/commercial solvents/ aerosols	Swimming pools[a]
	Natural / town gas leakage

[a] Emissions estimated by SKM

All emission estimates were based on the 90 substances contained in Table 2 of the NPI NEPM (Appendix A). Estimates have only been made for substances that are relevant to the emission sources and where an emission factor was available. For example, emissions from drycleaners are only estimated for tetrachloroethylene, toluene, total volatile organic compounds, and xylene, and not for the entire 90 substances in Table 2 of the NPI NEPM.

1.3 Study Area

The NPI Perth airshed study area is presented in Figure 1.1. The study area is the same as that used by the 1996 Perth Photochemical Smog Study (PPSS), (Western Power and DEP, 1996) and the 1999 update of the Perth Photochemical Smog Study (DEP, in press). This area was originally chosen in 1992 to capture large industries in the Perth area. As the current study was undertaken in conjunction with the update to the PPSS, resource savings were able to be achieved through the use of the same study area whilst also coving the major population centre and emission sources in Western Australia.

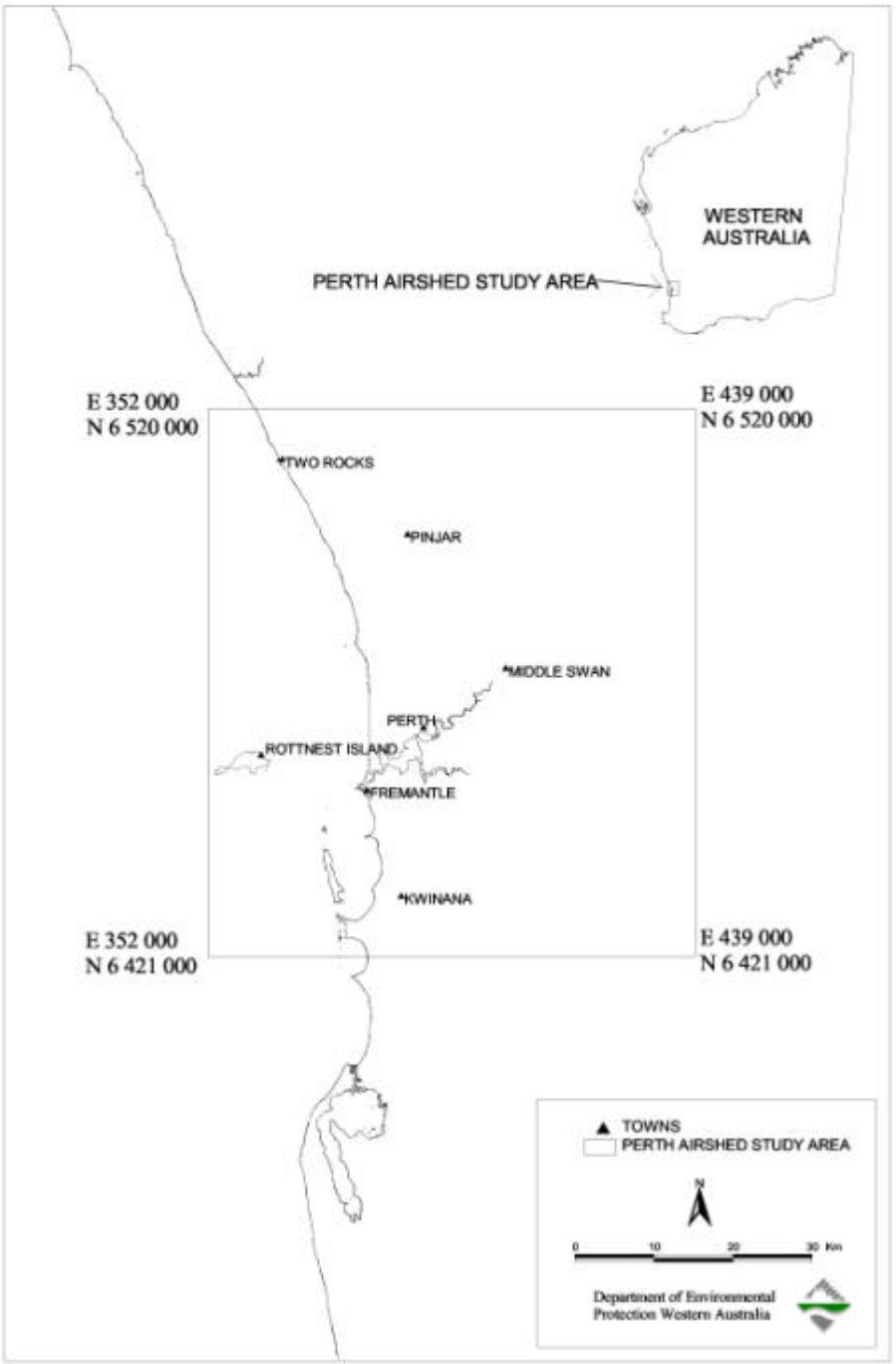


Figure 1.1: NPI Perth Airshed Study Area

2 Emission Sources

2.1 Motor Vehicle Emissions

2.1.1 Motor Vehicles

2.1.1.1 Source Description

The motor vehicle source category refers to emissions from both on and off road vehicles. On-road vehicles were calculated by the DEP and include emissions from the following:

- passenger vehicles;
- light commercial vehicles;
- motor cycles;
- light trucks; and
- heavy duty vehicles (trucks and buses).

As with the Coffey (1999) estimates made for the Kalgoorlie NPI trial, estimates were based on vehicle type, fuel usage, age and kilometers traveled by the vehicle, traffic flow conditions (e.g. average speed and percent idle time), summer/winter average temperatures and fuel composition. A detailed outline of the methods used for this source is provided in a separate report by the DEP entitled “Perth Airshed Emissions Inventory Update” (draft).

Off-road emissions were calculated by Sinclair Knight Merz (SKM) and include mobile combustion sources not covered by other aggregated sources including emissions arising from:

- agricultural usage;
- golf course usage;
- parks and verge mowing/maintenance by councils;
- school ground mowing /maintenance;
- mining/construction; and
- LPG usage.

Emission factors were applied to these activities based on activity type (e.g. mowing, or earth moving), fuel type and quantity, and the length of time in operation. A detailed description of methods used for this source can be found in “Perth Fugitive Studies: Perth Fugitive Estimations 1998/1999” (SKM 1999).

SKM were contracted to estimate emissions from the Perth airshed for both the NPI and the update to the Perth Photochemical Smog Study. This has led to the double counting of some mining/construction activities through their inclusion in both the motor vehicle source category as well as individual NPI reporting facilities. It was not possible to determine the proportion of mining/construction fuel usage that was double reported by NPI facilities and the motor vehicle source category. This issue has been identified and should not occur in future NPI airshed studies.

2.1.1.2 Emissions

Table 2.1 presents a summary of NPI emissions generated by on and off road vehicles in the Perth study area.

Table 2.1: Emissions from On and Off Road Motor Vehicles

Substance	On-Road Emissions (kg)	Off-Road Emissions (kg)	Total Motor Vehicles Emissions (kg)
Carbon monoxide	193,710,000	2,290,000	196,000,000
Oxides of nitrogen	26,040,000	2,060,000	28,100,000
Particulate matter 10.0 µm	1,511,000	139,000	1,650,000
Sulphur dioxide	620,000	109,000	729,000
Total volatile organic compounds	19,300,000	258,000	19,600,000
Acetaldehyde	123,000		123,000
Acetone	30,700		30,700
Benzene	778,100	10,900	789,000
1,3-Butadiene (vinyl ethylene)	0	1,370	1,370
Ethylbenzene	277,000		277,000
Formaldehyde (methyl aldehyde)	277,000		277,000
Lead & compounds	42,556	44	42,600
Polycyclic aromatic hydrocarbons (PAH's)		328	328
Toluene (methylbenzene)	1,558,600	21,400	1,580,000
Xylenes (individual or mixed isomers)	1,450,700	19,300	1,470,000

2.2 Other Mobile Emissions

This grouping of source categories includes emissions from mobile sources other than those covered by the motor vehicle source category. These are:

- railways;
- commercial shipping/boating and recreational boating; and
- aeroplanes.

2.2.1 Railways

2.2.1.1 Source Description

The railway emission category includes emissions from freight and passenger rail operations. Estimates were made for five locomotive operators including Westrail, National Rail, Toll Transport, Specialised Container Transport, and Great Southern Railways. A sixth operator, Tourist Railways, was excluded from the study due to the minor contribution to fuel use and a lack of emission factors for steam locomotives.

Estimates were based on either a fuel consumption or an activity basis for both shunting activities in rail yards as well as travel in the study area (SKM, 1999). For a full description of the Railway source category refer to SKM's report "Perth Fugitive Studies: Perth Fugitive Estimations 1998/1999" (1999).

2.2.1.2 Emissions

A summary of emissions from locomotives on the Perth railways is presented in Table 2.2

Table 2.2: Railway Emissions

Substance	Emissions (kg)
Carbon monoxide	101,000
Oxides of nitrogen	794,000
Particulate matter 10.0 µm	18,700
Sulphur dioxide	34,800
Acetaldehyde	1,010
Antimony & compounds	2.58
Arsenic & compounds	0.056
Benzene	591
1,3-Butadiene (vinyl ethylene)	539
Cadmium & compounds	1.25
Chromium (VI) compounds	0.168
Cobalt & compounds	0.112
Ethylbenzene	20.4
Formaldehyde (methylaldehyde)	3,000
n-Hexane	481
Lead & compounds	0.56
Manganese & compounds	0.430
Mercury	0.466
Nickel & compounds	0.279
Polycyclic aromatic hydrocarbons	253
Selenium & compounds	0.0747
Toluene (methylbenzene)	598
Total volatile organic compounds	34,100
Xylenes (individual or mixed isomers)	95.5
Zinc & compounds	7.47

2.2.2 Commercial Shipping/Boating and Recreational Boating

2.2.2.1 Source Description

The commercial shipping/boating and recreational boating source category covers vessels of a wide range of engine size and fuel type. The following description of the vessels examined by the study is taken from SKM (1999).

Ships

- Commercial cargo ships that berth at the Fremantle Port Authority inner and outer boat harbours at Fremantle and Kwinana.
- Smaller international fishing vessels that berth at Fremantle for refueling and crew changes.
- Naval vessels, including the Royal Australian Navy that berth at Garden Island and the US Navy that berths at Fremantle and in Gage Roads.

Moored Vessels

- Local commercial fishing vessels such as those used within the rock lobster fishing industry that operate out of fishing boat harbour in Fremantle, Hillarys Boat Harbour, Mindarie Keys and Two Rocks Boat Harbour.
- Tug boats that service the Fremantle ports.
- Passenger ferries that operate primarily between the WA mainland and Rottnest Island.
- Pleasure craft that are moored at either moorings or pens. These are larger craft, typically above 8 m which are not easily towed and include larger cabin cruisers and sailing boats with auxiliary engines.

Trailerable Marine Craft

- These include small pleasure craft, (typically less than 8 m) and recreational boats that are launched at any of the ocean or river boat ramps.

For a detailed discussion of the methodology for this source category, refer to SKM (1999).

2.2.2.2 Emissions

A summary of emissions from Commercial Shipping/Boating and Recreational Boating in the Perth waterways is presented in Table 2.3.

Table 2.3: Emissions from Commercial Shipping/Boating and Recreational Boating

Substance	Emissions From Commercial Shipping/Boating and Recreational Boating (kg)
Carbon monoxide	1,660,000
Oxides of nitrogen	2,790,000
Particulate matter 10.0 µm	122,000
Sulphur dioxide	1,620,000
Total volatile organic compounds	448,000
Benzene	21,100
1,3-Butadiene (vinyl ethylene)	2,640
Lead & compounds	290
Polycyclic aromatic hydrocarbons	633
Toluene (methylbenzene)	41,300
Xylenes (individual or mixed isomers)	37,200

2.2.3 Aeroplanes

2.2.3.1 Source Description

Emission estimates were made for the aeroplane source category for three airports within the Perth Study Area: Perth International Airport (includes all domestic flights), Jandakot Airport and the Royal Australian Airforce (RAAF) Pearce Airbase. Estimates only apply to planes when in the landing/take-off (LTO) cycle. The LTO cycle incorporated all normal flight and ground activities including:

- descent/approach and climb out up to a height of 1000 m;
- touchdown and takeoff;
- landing run;
- taxi in and out; and
- start up and idle.

Ground and maintenance operations at airports were not covered by this source category. Estimates for aeroplanes were made by SKM using the USEPA (1992) emission factors. These are the same as those contained in the Draft NPI Emission Estimation Technique Manual for Aggregated Emissions from Aircraft (EA, 1999a), which was not available for use at the time emissions estimates were calculated. The emission factors used are based on the number of LTO movements, time in approach mode, engine type and number of engines. A detailed description of the method used for this source is contained in SKM (1999).

2.2.3.2 Emissions

Table 2.4 presents emission estimates for the LTO cycle for aircraft from the three major airports within the Perth study area (Perth International Airport which includes all domestic flights, Jandakot Airport and the RAAF Pearce Airbase).

Table 2.4: Aircraft Emissions

Substance	Emissions (kg)
Carbon monoxide	1,190,000
Oxides of nitrogen	408,000
Particulate matter 10.0 µm	46,800
Sulphur dioxide	46,800
Acetone	4,230
Benzene	2,630
1,3-Butadiene (vinyl ethylene)	2,330
Lead & compounds	1,270
Toluene (methylbenzene)	730
Xylenes (individual or mixed isomers)	613

2.3 Area-Based Emissions

This category of emission sources is comprised of emissions from domestic and commercial activities. On an individual level, emissions from these sources contribute small amounts of NPI substances, but when combined, they may represent significant proportion of overall emissions to the airshed.

The following sources are discussed under the area-based category:

- solid fuel burning (domestic);
- architectural surface coatings;
- motor vehicle refinishing, solid fuel burning (domestic);
- domestic/commercial solvents/ aerosols;
- service stations;
- lawnmowers;
- dry cleaning.
- cutback bitumen;
- gaseous fuel burning (domestic);
- natural / town gas leakage
- swimming pools; and
- cigarettes.

2.3.1 Solid Fuel Burning (Domestic)

2.3.1.1 Source Description

The “Domestic Solid Fuel Combustion” source category covers aggregate emissions from domestic wood combustion used for heating. Wood is the main solid fuel used in Australia with coal and briquettes used in smaller amounts. The consumption of coal and briquettes was considered to be negligible for the Perth airshed and were therefore not estimated for the purposes of this inventory.

Emission estimates were made for open fireplaces, pot belly stoves and controlled combustion heaters. Emission factors were derived from Draft Aggregated EET Manuals for Domestic Solid Fuel Burning (EA, 1999b; and EA, 1999c) and from Radian Corporation (1997). A detailed description of the methods used to calculate emissions from this source is presented in Section B.2 of Appendix B.

2.3.1.2 Emissions

Table 2.5 presents a summary of NPI emissions occurring due to domestic combustion of wood in open fireplaces, potbelly stoves and controlled combustion heaters in the Perth study area.

Table 2.5: Emissions From Solid Fuel Burning (Domestic)

Substance	Emissions (kg)
Carbon monoxide	21,500,000
Oxides of nitrogen	252,000
Particulate matter 10 µm	2,320,000
Sulphur dioxide	41,900
Total volatile organic compounds	8,660,000
Acetaldehyde	671,000
Acetone	496,000
Benzene	354,000
1,3-Butadiene	18,900
Cadmium	1.66
Chromium (VI)	0.079
Formaldehyde (methyl aldehyde)	722,000
Manganese & compounds	12.3
Methyl ethyl ketone	47,200
Nickel & compounds	1.32
Styrene (ethenylbenzene)	9,170
Toluene	111,000
Total PAHs	132,000
Xylenes	52,500

2.3.2 Architectural Surface Coating

2.3.2.1 Source Description

Architectural surface coating is an area-based source that includes the application of all paints, primers, varnishes, lacquers and thinners to architectural structures for decorative or protective purposes. In general, architectural surface coatings consist of three main components:

- resins, which form the final paint layer after application and drying of the coating;
- pigments, which provide the desired colours and are composed of finely divided organic and inorganic materials; and
- solvents, which act as carriers for the resins and pigments, evaporating during the drying process.

It is common that architectural surface coatings are classified as solvent-based or water-based. Solvent-based coatings typically contain 30% to 70% VOCs by weight while water-based coatings contain approximately 6%. The predominant emissions from the application of architectural surface coatings are primarily VOCs from the coatings themselves and in the solvents used as thinners and for clean up purposes. Generally particulate emissions do not arise when this coating is applied using a brush or roller. Particulate emissions occur when architectural surface coatings are applied using spray equipment, however, emission estimation techniques have not been developed to include this source.

This category specifically excludes automotive refinishing as this is considered as a separate area based source.

Data on paint usage in the study area was obtained by scaling national paint usage data provided by the Australian Paint Manufacturers Federation (APMF) to the population of the study area. Emission factors were derived from the Draft NPI: Area-Based Emissions Estimation Workbook Architectural Surface Coating (EA, 1999d) and NPI Emission Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings (EA,

1999e). A detailed description of the methods used to calculate emissions from this source is presented in Section B.3 of Appendix B.

2.3.2.2 Emissions

A summary of VOC emissions derived from architectural surface coating application in the Perth study area is presented in Table 2.6.

Table 2.6: Architectural Surface Coating Emissions (kg)

Substance	Emissions (kg)
Solvent –based	
Acetone	122,000
Cyclohexane	788,000
Dichloromethane	35,100
Ethanol	22,800
2-Ethoxyethanol acetate	49,500
Ethylene glycol	22,800
n-Hexane	788,000
Methanol	148,000
Methyl ethyl ketone	213,000
Methyl isobutyl ketone	22,800
Toluene	198,000
Total volatile organic compounds	4,450,000
Xylenes (and isomers)	99,000
Water-based	
Benzene	1,910
Dichloromethane (methylene chloride)	35,100
Ethylene glycol	3,190

2.3.3 Motor Vehicle Refinishing

2.3.3.1 Source Description

Motor vehicle refinishing is the repairing of damaged or worn automobiles, light trucks and other vehicles, and refers to any coating applications that occur subsequent to those at the original manufacturer assembly plants. The refinishing process typically consists of four steps: vehicle preparation, primer application, topcoat application and spray equipment cleaning. VOC emissions are generated in each of these steps. Motor vehicle coatings are predominantly applied by a spray gun with the 'over spray' producing suspended particulates. However, refinishing is normally undertaken indoors with emission controls in place, which limits mixing with ambient air.

The same methods used to calculate architectural surface coating emissions (see section 2.3.2.1 above) were used to estimate emissions from motor vehicle refinishing, and relied on the same source data. A detailed description of the methods used to calculate emissions from motor vehicle refinishing is presented in Section B.4 of Appendix B.

2.3.3.2 Emissions

Table 2.7 presents a summary of emissions arising from motor vehicle refinishing activities in the Perth study area.

Table 2.7: Emissions From Motor Vehicle Refinishing

Substance	Emission (kg)
Acetone	59,200
Ethylene Glycol	14,800
Methyl Ethyl Ketone	110,000
Methyl Isobutyl Ketone	16,700
Toluene	310,000
Total volatile organic compounds	1,150,000
Xylene	302,000

2.3.4 Domestic/Commercial Solvent Use

2.3.4.1 Source Description

Emissions from domestic/commercial solvent use emanate from products containing solvents and propellants used in a variety of domestic and commercial applications. Emissions from these products are primarily from the release of volatile organic compounds (VOCs) when they are used. The following group of domestic/commercial products are accounted for by this inventory:

- personal care products;
- household products;
- automotive after market products;
- adhesives and sealants;
- pesticides;
- some coatings; and
- other VOC emitting products.

The method presented in the Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic/Commercial Solvent and Aerosol Use (EA, 1999f) was used to estimate emissions for this source. This method uses a per capita method for distributing emissions across the airshed. A more detailed description of the method used to calculate emissions from this source use is presented in Section B.5 of Appendix B.

This source category does not include emissions from industries such as dry cleaning and asphalt paving as these industries are wholly dependent on the solvent as their means of business (dry cleaning fluid, cutters and fluxes). Emissions from these sources are calculated as separate categories.

2.3.4.2 Emissions

Table 2.8 presents a summary of emissions arising from domestic/commercial solvent use in the Perth study area.

Table 2.8: Emissions from Domestic and Commercial Solvent use

Substance	Emissions (kg)
Acrylic acid	0.002
Benzene	2.81
1,2-Dichloroethane	2.76
Dichloromethane	21,600
Ethylene oxide	8,970
Fluoride and Compounds	8.39
Formaldehyde (methyl aldehyde)	748
n-Hexane	51,300
Hydrochloric acid	1.04
Methanol	414,000
Methyl ethyl ketone	30,100
Methyl isobutyl ketone	4,500
Tetrachloroethylene	16,800
Toluene	255,000
Total volatile organic compounds	4,670,000
Trichloroethylene	289
Xylenes	121,000

2.3.5 Service Stations

2.3.5.1 Source Description

Emissions from service stations are classified within this inventory as those that occur during the retail marketing of petrol, diesel and LPG. This includes the following processes and releases:

- transportation of the fuel to service stations from fuel terminals or depots;
- transfer of the fuel to tanks at the service station from road tankers;
- tank breathing losses at the service station; and
- volatilisation and spillage during refuelling at the bowser.

Emissions were calculated using the Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Service Stations (EA, 1999g) and USEPA (1995) emission factors. Fuel data was obtained from Australian Bureau of Agricultural Recourse Economics (ABARE) on a statewide level and scaled by population to reflect the Perth airshed. A more detailed description of the methods used to calculate emissions from this source is presented in Section B.6 of Appendix B.

This source category does not include emissions occurring during the manufacture of the different fuel types or the transportation of the material in bulk by pipeline or ship to wholesale distributors. It also does not include any emissions resulting from the operation of motor vehicles. All of these emissions are covered by other categories.

2.3.5.2 Emissions

Table 2.9 presents a summary of emissions arising from service stations in the Perth study area.

Table 2.9: Emissions from Service Stations

Substance	Emissions from Fuel (kg)	Emission from tankers (kg)	Total Emission (kg)
Benzene	14,400	225	14,700
Cumene (1-methylethylbenzene)	173	22.9	196
Cyclohexane	1,270		1,270
1,2 - Dibromoethane	9.22		9.23
Ethylbenzene	1,690	281	1,970
n-Hexane	18,700	277	18,900[1]
Lead and compounds	7.64		7.64
Polycyclic aromatic hydrocarbons	277	55.3	332
Toluene	17,400	0	17,400
Total volatile organic compounds	1,530,000	6,720	1,530,000[1]
Xylenes	3,730	1,500	5,220

[1] Numbers may not be additive due to rounding error.

2.3.6 Lawn Mowing

2.3.6.1 Source Description

This source category includes a range of equipment that is used in domestic lawn and garden maintenance including lawn mowers, trimmers/edgers, leaf blowers and other miscellaneous equipment. All of this equipment typically uses internal combustion engines that are either two or four stroke and are fuelled with petrol. Lawn mowers are the main contributor to emissions in this source category due to their number and time in use.

Emissions of concern from lawn and garden engines are combustion products and VOC emissions. Emissions were calculated using emission factors in the Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic Lawn Mowing (EA, 1999h) and are based on hours of operation and equipment type used. As resources were not available to undertake a full domestic survey, data on lawn mower usage was obtained from a survey of local retailers and repairers.

Refer to Section B.7 of Appendix B for a detailed discussion of the methodology used to estimate emissions from this source.

2.3.6.2 Emissions

Table 2.10 presents a summary of NPI emissions that were estimated to have been emitted in the Perth airshed study area through domestic lawn mower usage.

Table 2.10: Emissions from Lawn Mowing

Substance	Emissions (kg)
Carbon monoxide	5,000,000
Oxides of nitrogen	27,000
Particulate matter 10.0 µm	32,700
Sulphur dioxide	7,060
Total volatile organic compounds	1,370,000
Benzene	76,400
1,3-Butadiene (vinyl ethylene)	9,700
Chromium (VI) compounds	19.7
Cobalt & compounds	19.7
Copper & compounds	19.7
Cyclohexane	2,320
Ethylbenzene	17,800
Formaldehyde (methyl aldehyde)	13,900
n-Hexane	5,390
Lead & compounds	491
Manganese & compounds	19.7
Polycyclic aromatic hydrocarbons	4,020
Styrene (ethenylbenzene)	1,360
Toluene (methylbenzene)	128,000
Xylenes (individual or mixed isomers)	94,300
Zinc and compounds	19.7

2.3.7 Dry Cleaning

2.3.7.1 Source Description

The category of dry cleaning refers to commercial operations that use chemicals in place of water for cleaning of garments and other fabric and leather items. Emissions of concern in this source category are the losses of dry cleaning chemicals that are totally comprised of VOCs.

It was assumed that 90% of perchloroethylene imported into Western Australia was consumed in the Perth airshed study area. All solvents used for dry cleaning purposes are assumed to escape to the environment. The Dry Cleaners Institute of Australia (1996) outlined that the majority (99.985%) of the perchloroethylene and white spirit used in the dry cleaning process is released to the atmosphere. The remainder (0.015%) is emitted as part of the waste water and hazardous waste (filter and residue). For a more detailed description of this source category refer to Section B.8 of Appendix B.

2.3.7.2 Emissions

Table 2.11 presents a summary of emissions arising from dry cleaning activities in the Perth airshed study area.

Table 2.11: Dry Cleaning Emissions

Substance	Emission (kg)
Tetrachloroethylene	133,000
Toluene	41.9
Total volatile organic compounds	142,000
Xylene	1,530

2.3.8 Cutback Bitumen

2.3.8.1 Source Description

Roads are constructed from gravel, sandstone, limestone and other crushed rocks. To protect these surfaces from excessive deterioration, a bituminous seal is applied. Cutback bitumen is used in tack and seal operations, in priming roadbeds for hot-mix application and for paving operations for pavements up to several centimetres thick.

In preparing cutback bitumen, bitumen is blended or 'cutback' with petroleum solvents such as kerosene ('cutter') or diesel oils ('flux') to reduce the viscosity of the bitumen to enable it to be used for spray sealing operations. Flux oils reduce the viscosity of the bitumen for longer periods and increases the bitumen mixture storage life (Eastern Research Group, Inc. 1998; EPAV, 1996).

VOC emissions from cutback bitumen result from the evaporation of the cutter and flux used to reduce the viscosity of the bitumen. Emissions occur both at the site of application and at the mixing plant. However, the largest source of emissions is from the road surface itself, and will be examined by this area based category source. It is assumed that any emissions produced by a mixing plant will be captured as an industrial point source.

Cutter and flux usage data was speciated using emission factors from the US AP-42 (USEPA, 1985) and Chester (1986). These emission factors have been used by the Perth Photochemical Smog Study, the NSW Metropolitan Air Quality Study and slightly modified for the Dandenong/Port Pirie/Newcastle/Launceston NPI Trial (EPAV, 1996). The suppliers provided information on the types, applications and quantities of bitumen, cutter and flux.

For a detailed discussion of the methods used to estimate emissions from this source, refer to Section B.9 of Appendix B.

2.3.8.2 Emissions

Table 2.12 presents a summary of NPI emissions emanating from cutback bitumen application in the Perth airshed study area.

Table 2.12: Cutback Bitumen Emissions

Substance	Emissions (kg)
Total volatile organic compounds	23,100
Xylene equivalent	4,400

2.3.9 Gaseous fuel burning (domestic)

2.3.9.1 Source Description

Domestic and small business gas combustion includes gas supplied by the reticulated distribution system for cooking, space heating and hot water heating. Natural gas combustion

emissions are therefore limited by the extent of the reticulation system. Emissions from larger businesses are predominantly captured by the NPI reporting facilities.

Emission factors used in this study were derived during the Perth Photochemical Smog Study. They were also used by the Dandenong/Port Pirie/Newcastle/Launceston NPI Trial (EPAV, 1996). A more detailed description of the methods used to estimate emissions from this source is contained in Section B.10 of Appendix B.

2.3.9.2 Emissions

A summary of NPI emissions arising from gaseous fuel burning in the Perth study area is presented in Table 2.13.

Table 2.13: Emissions from Gaseous Fuel Burning

Substance	Emissions (kg)
Carbon monoxide	115,000
Oxides of nitrogen	269,000
Particulate matter 10 µm	32,800
Sulphur dioxide	2,690
Benzene	1,920
Formaldehyde (methyl aldehyde)	3,830
Toluene	1,070
Total volatile organic compounds	21,300

2.3.10 Natural / Town Gas Leakage

2.3.10.1 Source Description

The natural / town gas leakage source category covers emissions of unaccounted for natural gas (UAFG) occurring across the entire Perth gas network. In the Perth airshed, this category is limited to the emissions of natural gas as town gas is not used in the study area.

The leakage of natural gas to air from the gas distribution network is dependent on a number of factors including:

- type and condition of the gas pipeline;
- pressure in the network;
- soil permeability;
- number of service customers; and
- accidental pipe ruptures by contractors and excavation work (third party damage).

According to AlintaGas, the gas distribution network for domestic and commercial / light industrial consumers is relatively new and predominantly constructed from polymer pipe with a corresponding low rate of permeation and gas loss (AlintaGas, MacKenzie, D., personal communication, 1999). Major industry within the Perth airshed is supplied natural gas by high pressure steel piping, which is assumed to be leak free.

Releases of gas from the AlintaGas distribution system contribute to the emission of non-methane organic compounds (total VOC) into the atmosphere. These releases comprise leakage, losses due to pipes being damaged by third parties and purging operations. Leakage is by far the greatest of these sources, constituting about 97% of the total losses (AlintaGas, Bromly, J., personal communication, 2000).

AlintaGas operates some 10,500 km of gas lines constructed of steel, cast iron, polyvinyl chloride (PVC) and polyethylene (PE) piping. The great majority of the leakage comes from the cast iron sections (AlintaGas, Bromly, J., personal communication, 2000).

According to the most recent estimates (Revised AlintaGas Greenhouse Gas Inventory 1999, AlintaGas report GD 00/05, Feb 2000), the gas releases to atmosphere during 1999 was some 8,825,643 standard cubic metres. This equates to approximately 1450 tonnes of total VOC's.

Non-polymer pipes were assumed to emit approximately ten times as much as the polymer pipes in the network. Emissions from the three components (third party damages, leakage's from non-polymer pipes and leakage's from polymer pipes) were all evenly distributed over the network. A full description of the methods used to estimate emissions from this source is contained in section B.11 of Appendix B.

2.3.10.2 Emission

Table 2.14 presents a summary of total VOC emissions emanating from natural gas leakage in the Perth study area.

Table 2.14: Emissions from Natural Gas Leakage.

Substance	Emissions (kg)
Total volatile organic compounds	1,450,000

2.3.11 Swimming Pools

2.3.11.1 Source Description

This source category is limited to the emissions of chlorine from both domestic/private and public swimming pools. No NPI aggregated emissions manuals were available to estimate emissions from this source. The method employed was developed by Sinclair Knight Merz and is documented in SKM (1999).

Data on domestic pools was obtained from the ABS (ABS, 1998) and a brief survey of five municipalities. A survey was undertaken of public pools to determine commercial pool sizes and dosage rates.

2.3.11.2 Emission

Table 2.15 presents a summary of chlorine emissions emanating from private and public swimming pools in the Perth airshed study area.

Table 2.15: Emissions from Swimming Pools.

Substance	Emissions (kg)
Chlorine	714,000

2.3.12 Cigarettes

2.3.12.1 Source Description

A large proportion of the population in Australia smoke cigarettes. When cigarettes are consumed both side stream and main stream smoke are produced. The composition and amount of these smoke streams differ from each other, in addition to variations that occur between brands.

Emission factors for cigarette smoke was obtained from the *1998 Reports on Cigarette Additives and Smoke Constituents* produced by the British Columbia Ministry of Health and Ministry Responsible for Seniors (1999). Quit Victoria (1997) provided cigarette consumption information.

For a detailed description of the methods used to estimate emissions from this source, refer to Section B.13 of Appendix B.

2.3.12.2 Emissions

Table 2.16 presents a summary of NPI emissions emanating from cigarette smoke in the Perth airshed study area.

Table 2.16: Emissions from Cigarettes

Substance	Emissions (kg)
Carbon monoxide	131,000
Oxides of nitrogen	3,910
Acetaldehyde	5,280
Acetone	2,820
Acrylonitrile (2-propenenitrile)	222
Benzene	747
1,3-Butadiene	531
Cadmium & compounds	1.97
Formaldehyde (methyl aldehyde)	1,030
Lead & compounds	0.136
Methyl ethyl ketone	540
Nickel & compounds	0.1
Phenol	834
Styrene (ethenylbenzene)	247
Toluene	1,340

2.4 Sub Threshold Emissions

This category of emission sources is limited to emissions from fuel combustion – sub threshold reporting facilities.

2.4.1 Fuel Combustion – sub reporting threshold facilities

2.4.1.1 Source Description

The source category "Fuel Combustion – sub reporting threshold facilities" relates to emissions from industrial facilities that were below the NPI reporting threshold in the reporting year or were above the threshold but did not report because:

- a relevant NPI handbook had not been published for their industry sector (the NPI does not require facilities to report unless a relevant handbook has been published); or
- the facility elected not to report (there is no penalty imposed on companies not reporting in 1998/1999).

Combustion emissions are generated from equipment such as power plants, boilers, generators, compressors, furnaces and ovens. Emissions were calculated using final and draft NPI Emissions Estimation Technique (EET) manuals developed for reporting facilities. Examples include EET manuals for Combustion in Boilers, Electric Power Generation and Cement Manufacturing.

In addition to combustion emissions, the DEP also included emissions from volatile organic compound (VOC) storage. Whilst VOC emissions do not strictly comply with the source category, they were amalgamated into the source for the following reasons:

- amalgamating of sub-reporting facility combustion emissions with their VOC storage emissions provided an accurate portrait of emissions distributions across the study area; and
- the data transfer protocol between jurisdictions and Environment Australia did not allow for the reporting of emissions from storage tanks on sub reporting facilities.

A detailed description of the methods used to calculate emissions from this source is presented in Section B.1 of Appendix B.

2.4.1.2 Emissions

Table 2.17 presents a summary of the NPI emission estimates made for fuel combustion – sub reporting threshold facilities in the Perth study area.

Table 2.17: Total Emissions from Fuel Combustion –Sub Reporting Threshold Facilities

Substance	Emission (kg)
Carbon monoxide	2,040,000
Particulate matter 10 µm	2,400,000
Oxides of nitrogen	4,830,000
Sulphur dioxide	4,090,000
Total volatile organic compounds	660,000
Arsenic	198
Benzene	32,800
Cadmium	47.7
Chromium (VI)	1.39
Cobalt	63.7
Fluoride	2,210
Lead	1,300
Mercury	155
Nickel & compounds	4,700
PAH's	125
Toluene	17,400
Xylene	7,500

2.5 Natural Source Emissions

2.5.1 Biogenics

2.5.1.1 Source Description

Biogenic emissions have been reported to occur from vegetation and soil microbial activity (Coffey, 1999). Substances emitted include NO_x, isoprene, monoterpene, and VOC's (Cope and Ischtwan, 1995). However, NPI estimates from biogenic sources were limited to oxides of nitrogen emitted from soil microbial activity. Other substances were not reported as they were not on Table 2 (90 substances) of the NEPM and not within the current project scope.

Emissions from soil microbial activity were based on land use type, time and area. A more detailed description of the methods used to estimate emissions from this source category is presented in Section B.13 of Appendix B. It should be noted that no new emissions calculations were made for this source. NPI data presented was generated during the 1996 Perth Photochemical Smog Study (PPSS). A distributed estimate for total VOC's from the PPSS was not available for the current NPI study.

2.5.1.2 Emissions

As emissions are directly related to the study area, larger airsheds can be expected to have larger emissions from biogenic sources than smaller airsheds. Table 2.18, presents the emissions estimated to emanate from the Perth airshed study area.

Table 2.18: Biogenic Emissions

Substance	Emissions (kg)
Oxides of nitrogen	8,400,000

2.5.2 Burning/Wildfires

2.5.2.1 Source Description

The burning/wildfires source category encompasses burning off from forests, agricultural areas and land development sites, together with backyard piles of rubbish in some of the outer suburbs (SKM, 1999).

Emission factors for this source were taken from the USEPA (1995 and 1993) and are based on the area of land burnt and the tonnes of material burnt per hectare. A detailed description of methods used to estimate emissions from this source can be found in SKM (1999).

2.5.2.2 Emissions

A summary of emissions emanating from burning and wildfire activities in the Perth airshed are summarised in Table 2.19.

Table 2.19: Emissions from Burning and Wildfires

Substance	Emissions (kg)
Carbon monoxide	15,200,000
Oxides of nitrogen	316,000
Particulate Matter 10.0 µm	1,870,000
Total volatile organic compounds	1,120,000
Benzene	89,900
1,3-Butadiene (vinyl ethylene)	32,300
Toluene (methylbenzene)	89,100
Xylenes (individual or mixed isomers)	37,900

2.6 Reporting Facility Emissions

This emissions category is comprised of all industrial facilities that submitted a NPI emission report (a NPI Worksheet 3) to the DEP and were located in the study area. It should be noted that under the NPI, reporting facilities are not considered to be an aggregated emissions source, however, they have been included in this report in order to:

- provide a complete emissions inventory for the Perth airshed for 1998/1999; and
- to provide a context for other emissions in the airshed.

2.6.1 1998/1999 NPI Reporting Facilities

2.6.1.1 Source Description

The 1998/1999 NPI Reporting Facilities emissions category is comprised of all those facilities that are located in the Perth airshed study area and reported to the NPI for the NPI reporting period of 1998/1999. It should be noted that not all facilities that trip an NPI threshold were required to report for the 1998/1999 NPI reporting period. This is because industries were not required to report until an NPI Handbook relevant to their activities had been published. For example beer manufacturers were not required to report until the NPI Beer and Malt Manufacturers Handbook was published. Thirty seven facilities reported in the Perth airshed study area in 1998 / 1999.

Of the eventual 80 industry sectors that will be required to report to the NPI, only 23 were required to do so in 1998/1999. Some of these 23 industries that reported, were only required to report for a portion of the 1998/1999 period dependent on when the handbook was published. For example, the Beer and Malt Manufacturers handbook was published in March 1999, requiring Beer and Malt Manufacturers to report for a one month period from 1st June 1999 to 30th June 1999. No attempt has been made to annualise these emissions as some facilities may have only operated for a portion of 1998/1999 and annualising their emissions would be invalid and misleading. Accordingly, the emissions presented below for 1998/1999 NPI Reporting Facilities is not a complete inventory of emissions from this source.

A total of 39 facilities that were located in the study area reported their NPI emissions. Of these 39 facilities, only 3 reported for less than a 12 month period

Facilities located in the study area that did not submit a NPI report in 1998/1999 have been captured and reported by the aggregated emissions source category – “Fuel Combustion – sub threshold reporting facilities” (see Section 2.4 for further explanation).

2.6.1.2 Emissions

Presented in Table 2.20 is a summary of all NPI emissions emanating from 1998/1999 NPI Reporting Facilities. The limitations discussed in Section 2.6.1 above should be considered when viewing these results. Emissions were provided by 39 facilities. Of these 39 facilities, only 3 reported for less than a 12 month period.

Table 2.20: Emissions from 1998/1999 NPI Reporting Facilities in the Perth Airshed

Substance	Number of Facilities Reporting Substance	Emissions[1] (kg)
Carbon monoxide	27	6,350,000
Oxides of Nitrogen	27	15,000,000
Particulate matter 10.0 um	26	1,460,000
Sulphur dioxide	25	9,960,000
Total volatile organic compounds	8	290,000
Acetone	1	19,129
Arsenic & compounds	21	166
Benzene	10	58,700
Beryllium & compounds	1	0.001
1,3-Butadiene (vinyl ethylene)	2	1,625
Cadmium & compounds	19	44
Carbon disulphide	1	2.60
Chromium (III) compounds	1	0.038
Chromium (VI) compounds	18	98.4
Cobalt & compounds	4	6.59
Copper & compounds	1	224
Cumene (1-methylethylbenzene)	3	2,440
Cyclohexane	2	1,300
1,2-Dibromoethane	3	3.37
Dichloromethane	1	15
Ethanol	1	181
Ethylbenzene	4	754
Ethylene glycol (1,2-ethanediol)	1	0.03
Fluoride compounds	18	105,000
Hydrochloric acid	1	66.5
Lead & compounds	23	364
Manganese & compounds	1	3
Mercury & compounds	20	186
Methyl ethyl ketone	3	8,960
n-Hexane	3	13,100
Nickel & compounds	4	614
Nickel carbonyl	10	0
Nickel subsulphide	10	0
Polycyclic aromatic hydrocarbons	16	5,680
Styrene (ethenylbenzene)	1	1
Sulphuric acid	5	453
Toluene (methylbenzene)	12	81,200
Xylenes (individual or mixed isomers)	10	26,900
Zinc and compounds	1	25.9

[1] Emissions from this source are incomplete. Not all NPI reporting facilities were required to report in 1998/1999, whilst some industries were only required to report for a portion of 1998/1999. Emissions are based on NPI reports for 39 facilities.

3 Summary Results

This section contains a summary of all NPI emission estimates that were made for the Perth airshed for 1998/1999. The emission estates only apply to the 90 substances that are contained on Table 2 in the NPI NEPM.

3.1 Results

Table 3.1 contains all 1998/1999 NPI aggregated emissions estimated for the Perth airshed. The percentage breakdown of emissions is presented in Appendix D.

Emissions from each of the source categories were grouped into five source types for comparative purposes. An additional non-aggregated source type - NPI reporting facilities - was included in the comparisons in order to create a more complete picture of emissions occurring in the Perth airshed study area. The six source types and their components are outlined below:

- Motor Vehicles - on and off road emissions from cars, trucks, and motorcycles.
- Other Mobile - comprised of railways, commercial shipping/boating and recreational boating, and aeroplanes.
- Area Based - comprised of service stations, cigarettes, lawnmowers, domestic/commercial solvents/ aerosols, architectural surface coatings, motor vehicle refinishing, solid fuel burning (domestic), gaseous fuel burning (domestic), cutback bitumen, and dry cleaning.
- Sub-threshold - comprised of fuel combustion sub-reporting threshold facilities.
- Natural Sources - comprised of burning / wildfires, and biogenics.
- Reporting Facilities - represent emissions from facilities that tripped NPI reporting thresholds and consequently submitted their own NPI report. Only those facilities located in the in the Perth aggregated emissions study area were included in this source type's emissions totals. Note that reporting facilities do not form part of the aggregated emissions study. They have been included for comparative purposes and to portray a more complete picture of emissions in the study area.

Table 3.2 presents the percentage of the composite emissions that these 6 source types contribute to the Perth airshed study area.

Table 3.1: 1998/1999 Emission Estimates for the Perth NPI Aggregated Emissions Study (reported in kilograms to 3 significant figures)

		Motor Vehicles	Other Mobile			Sub-threshold	Area Based Sources												Natural Sources		1998/99 NPI Reporting Facilities[1]
Substance	**Totals**	Motor Vehicles	Railways	Commercial Shipping/Boating and Recreational Boating	Aeroplanes	Fuel Combustion – sub reporting threshold facilities	Solid fuel burning (domestic)	Architectural Surface Coatings	Motor Vehicle Refinishing	Domestic/Commercial solvents/ aerosols	Service Stations	Lawn Mowing	Dry Cleaning	Cutback Bitumen	Gaseous Fuel Burning	Town Gas Leakage	Swimming Pools	Cigarettes	Biogenics	Burning(fuel red., regen., agric.)/ Wildfires	Reporting Facilities
Acetaldehyde	800,290	123,000	1,010				671,000											5,280			
Acetone	734,050	30,700			4,230		496,000	122,000	59,200									2,820			19,100
Acrylic acid	0.0020									0.002											
Acrylonitrile (2-propenenitrile)	222																	222			
Antimony & compounds	2.58		2.58																		
Arsenic & compounds	364		0.056			198															166
Benzene	1,444,401	789,000	591	21,100	2,630	32,800	354,000	1,910		2.81	14,700	76,400			1,920			747		89,900	58,700
Beryllium & compounds	0.001																				0.001
1,3-Butadiene (vinyl ethylene)	69,935	1,370	539	2,640	2,330		18,900					9,700						531		32,300	1,625
Cadmium & compounds	97		1.25			47.7	1.66											1.97			44
Carbon disulphide	2.6																				2.6
Carbon monoxide	249,287,000	196,000,000	101,000	1,660,000	1,190,000	2,040,000	21,500,000					5,000,000			115,000			131,000		15,200,000	6,350,000
Chlorine	714,000																714,000				
Chloroform (trichloromethane)	588									588											
Chromium (III) compounds	0.038																				0.038
Chromium (VI) compounds	120		0.168			1.39	0.079					19.7									98.4
Cobalt & compounds	90.1		0.112			63.7						19.7									6.59
Copper & compounds	244		0.56									19.7									224
Cumene (1-methylethylbenzene)	2,636										196										2,440
Cyclohexane	792,890							788,000			1,270	2320									1,300
1,2-Dichloroethane	2.76									2.76											
Dichloromethane	56,715							35,100		21,600											15
1,2-Dibromoethane	12.6										9.23										3.37
Ethanol	22,981							22,800													181
Ethylbenzene	298,774	277,000	20.4							1,230	1,970	17,800									754
2-Ethoxyethanol acetate	49,500							49,500													
Ethylene glycol (1,2-ethanediol)	51,700							26,000	14,800	10,900											0.03
Ethylene oxide	8,970									8,970											

Table 3.1: 1998/1999 Emission Estimates for the Perth NPI Aggregated Emissions Study (reported in kilograms to 3 significant figures) (Cont'd)

		Motor Vehicles	Other Mobile			Sub-threshold	Area Based Sources												Natural Sources		1998/99 NPI Reporting Facilities[1]
Substance	Totals	Motor Vehicles	Railways	Commercial Shipping/Boating and Recreational Boating	Aeroplanes	Fuel Combustion – sub reporting threshold facilities	Solid fuel burning (domestic)	Architectural Surface Coatings	Motor Vehicle Refinishing	Domestic/Commercial solvents/ aerosols	Service Stations	Lawn Mowing	Dry Cleaning	Cutback Bitumen	Gaseous Fuel Burning	Town Gas Leakage	Swimming Pools	Cigarettes	Biogenics	Burning(fuel red., regen., agric.)/ Wildfires	Reporting Facilities
Fluoride compounds	107,558					2,210				8.39											105,340
Formaldehyde (methyl aldehyde)	1,021,508	277,000	3,000				722,000			748		13,900			3,830			1030			
n-Hexane	877,171		481					788,000		51,300	18,900	5390									13,100
Hydrochloric acid	67.5									1.04											66.5
Lead & compounds	46,323	42,600	0.56	290	1,270	1,300					7.64	491						0.136			364
Manganese & compounds	35.4		0.43				12.3					19.7									3
Mercury & compounds	340		0.466			155															185
Methanol	562,000							148,000		414,000											
Methyl ethyl ketone	409,800						47,200	213,000	110,000	30,100								540			8,960
Methyl isobutyl ketone	44,000							22,800	16,700	4,500											
Nickel & compounds	5,335		0.279			4,700	1.32					19.7						0.1			614
Oxides of nitrogen	61,189,910	28,100,000	794,000	2,790,000	408,000	4,830,000	252,000					27,000			269,000			3,910	8,400,000	316,000	15,000,000
Particulate Matter 10.0 µm	9,953,000	1,650,000	18,700	122,000	46,800	2,400,000	2,320,000					32,700			32,800					1,870,000	1,460,000
Phenol	834																	834			
Polycyclic aromatic hydrocarbons	143,371	328	253	633		125	132,000				332	4,020									5,680
Selenium & compounds	0.075		0.0747																		
Styrene (ethenylbenzene)	10,778						9,170					1360						247			1
Sulphur dioxide	16,542,250	729,000	34,800	1,620,000	46,800	4,090,000	41,900					7,060			2,690						9,970,000
Sulphuric acid	453																				453
Tetrachloroethylene	149,800									16,800			133,000								
Total Volatile Organic Compounds	45,618,500	19,600,000	34,100	448,000		660,000	8,660,000	4,450,000	1,150,000	4,670,000	1,530,000	1,370,000	142,000	23,100	21,300	1,450,000				1,120,000	290,000
Toluene (methylbenzene)	2,832,180	1,580,000	598	41,300	730	17,400	111,000	198,000	310,000	255,000	17,400	128,000	41.9		1,070			1,340		89,100	81,200
Trichloroethylene	289									289											
Xylenes (individual or mixed isomers)	2,260,159	1,470,000	95.5	37,200	613	7,500	52,500	99,000	302,000	121,000	5,220	94,300	1,530	4,400						37,900	26,900
Zinc and compounds	53.1		7.47									19.7									25.9

[1] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

Table 3.2: Emissions from Major Sources (%) in Perth Airshed Study Area [1]

Substance	Motor Vehicles (%)	Other Mobile (%)	Area Based (%)	Sub-threshold (%)	Natural Sources (%)	1998/99 NPI Reporting Facilities[2] (%)
Acetaldehyde	15	<1	85			
Acetone	4	1	93			3
Acrylic acid			100			
Acrylonitrile (2-propenenitrile)			100			
Antimony & compounds		100				
Arsenic & compounds		<1		54		46
Benzene	55	2	31	2	6	4
Beryllium & compounds						100
1,3-Butadiene (vinyl ethylene)	2	8	42		46	2
Cadmium & compounds		1	4	49		46
Carbon disulphide						100
Carbon monoxide	79	1	11	1	6	3
Chlorine			100			
Chloroform (trichloromethane)			100			
Chromium (III) compounds						100
Chromium (VI) compounds		<1	17	1		82
Cobalt & compounds		<1	22	71		7
Copper & compounds		<1	8			92
Cumene (1-methylethylbenzene)			7			93
Cyclohexane			100			<1
Dichloromethane			100			<1
1,2-Dibromoethane			73			27
1,2-Dichloroethane			100			
Ethanol			99			1
Ethylbenzene	93	<1	7			<1
2-Ethoxyethanol acetate			100			
Ethylene glycol (1,2-ethanediol)			100			<1
Ethylene oxide			100			
Fluoride compounds			<1	2		98
Formaldehyde (methyl aldehyde)	27	<1	73			
n-Hexane		<1	98			1
Hydrochloric acid			2			98
Lead & compounds	92	3	1	3		1
Manganese & compounds		1	90			8
Mercury		<1		46		54
Methanol			100			
Methyl ethyl ketone			98			2
Methyl isobutyl ketone			100			
Nickel & compounds		<1	<1	88		12
Oxides of nitrogen	46	6	1	8	14	25
Particulate Matter =10.0 µm	17	2	24	23	19	15

[1] See Appendix D for the raw data for this table.

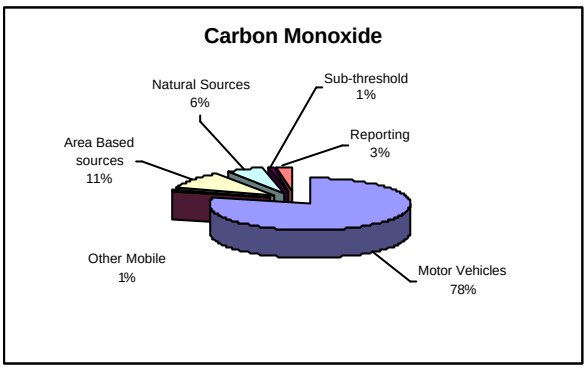
[2] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

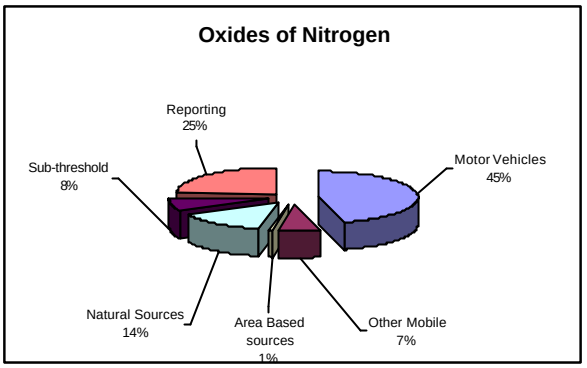
Table 3.2: Emissions from Major Sources (%) in Perth Airshed Study Area [1] (Contd)

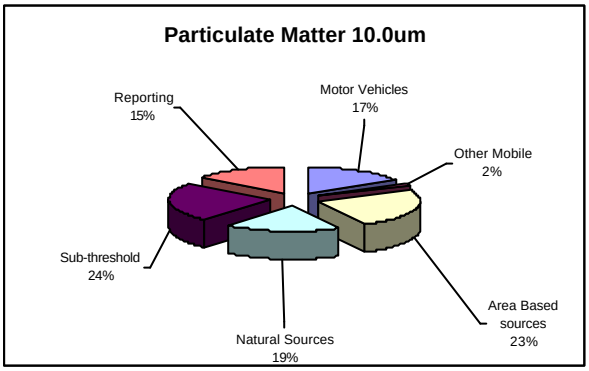
Substance	Motor Vehicles (%)	Other Mobile (%)	Area Based (%)	Sub-threshold (%)	Natural Sources (%)	1998/99 NPI Reporting Facilities [2] (%)
Phenol			100			
Polycyclic aromatic hydrocarbons	<1	1	95	<1		4
Selenium & compounds		100				
Styrene (ethenylbenzene)			100			<1
Sulphur dioxide	4	10	<1	25		60
Sulphuric acid						100
Tetrachloroethylene			100			
Total Volatile Organic Compounds	43	1	51	1	2	1
Toluene (methylbenzene)	56	2	36	1	3	3
Trichloroethylene			100			
Xylenes (individual or mixed isomers)	65	2	30	<1	2	1
Zinc and compounds		14	37			49

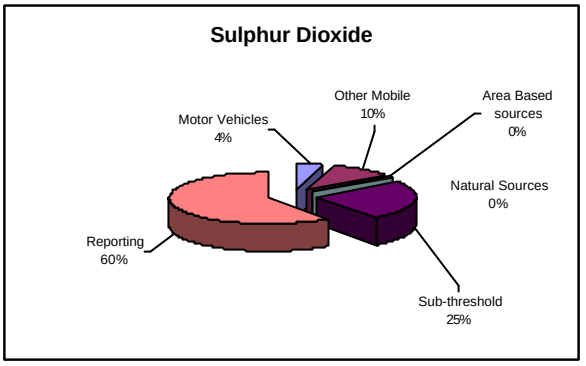
[1] See Appendix D for the raw data for this table.
[2] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

As can be seen by Table 3.2 and Figure 3.1 motor vehicles are a major source of CO, Total VOC's, NO_x and PM_{10}, contributing 79%, 43%, 46% and 17% of these substances respectively. NPI reporting facilities were the greatest source of SO_2, with sub-threshold facilities the next biggest SO_2 source at 25%. What is hidden by this result is that a high percentage of the SO_2 emitted from sub-threshold facilities is coming from facilities that trip NPI reporting thresholds but were not required to report in 1998/1999. Once these facilities start reporting their own emissions, the NPI reporting facilities category can be expected to account for significantly higher SO_2 emissions in the Perth airshed.









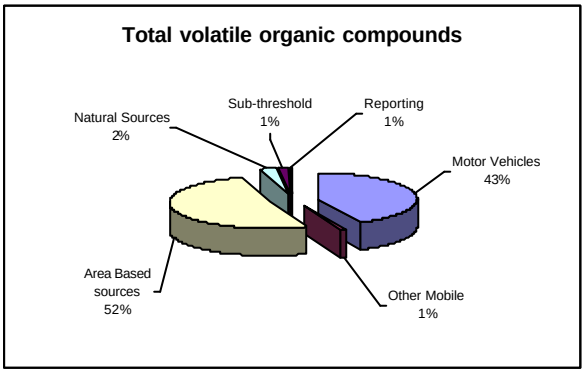


Figure 3.1: Major Emission Points of Criteria Pollutants (CO, NOx, SO2, PM10 and Total VOC) in the Perth Airshed 1998/1999

3.2 Comparability of Results

To check the accuracy of emission estimates made for the NPI Perth airshed, comparisons were made with NPI emission estimates from other Australian airsheds. The airsheds used for comparisons with the Perth data, were:

- Port Phillip Region
- South East Queensland
- Hobart
- Adelaide
- Kalgoorlie
- Sydney Newcastle Wollongong -

Emission estimates made for the Perth airshed were generally within the range of estimates made for other Australian airsheds for the NPI reporting year 1998/1999. Whilst this was an encouraging result in respect to the Perth airshed emissions, it was less encouraging that the range of estimated emissions was so large. The discrepancies were due to a combination of factors including differences in:

- source data;
- emission factors;
- methodologies;
- assumptions made during calculations; and
- consumption habits.

These differences can be broken into two main categories, those associated with the estimation methodologies and those associated with actual emissions differentials. It is not possible to distinguish the latter without knowing the former. There is therefore an urgent need to standardise the methodologies used for future NPI airshed studies in order for the community, industry and regulators to obtain a meaningful understanding of emissions differentials occurring across airsheds.

4 References

ABS., 1998 Australian Bureau of Statistics – Environmental Issues: People's Views and Practices (Cat No. 4602.0).

British Columbia Ministry of Health and Ministry Responsible for Seniors, 1999, "1998 Reports on Cigarette Additives and Smoke Constituents", http://www.aslvin.com/poisons/chemlookup.asp
.

Chester, J.L. 1986, "Flux and cutter Oils and Their Rates of Loss From Sprayed Seals." Pavement and Construction, Vol. 13, Part 4, 163-172.

Coffey Geosciences 1999, "National Pollutant Inventory Kalgoorlie Trial, Aggregated Emissions Study – Final Report". Coffey Geosciences for the Western Australian Department of Environmental Protection, Perth.

Cope, M.C. and Ischtwan, J., 1995, "Perth Photochemical Smog Study, Airshed Modelling Component, Final Report", EPA Victoria,

DEP, Department of Environmental Protection (in press) "Perth Airshed Inventory Update". Department of Environmental Protection, Perth Western Australia.

Drycleaning Institute of Australia, 1996, "Code of Practice for Safe Handling of Perchloroethylene in the Drycleaning Plant", DIA, Melbourne Institute of Textiles, Melbourne.

EA, Environment Australia, 1999a, "Draft NPI Emission Estimation Technique Manual for Aggregated Emissions from Aircraft", Environment Australia, Canberra.

EA, Environment Australia, 1999b, "Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic Solid Fuel Burning", Environment Australia, Canberra.

EA, Environment Australia, 1999c, "Draft NPI: Emission Estimation Technique Workbook Domestic Wood Combustion", Environment Australia, Canberra.

EA, Environment Australia, 1999d, "Draft NPI: Area-Based Emissions Estimation Workbook Architectural Surface Coating", Environment Australia, Canberra.

EA, Environment Australia, 1999e, "NPI Emission Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings", Environment Australia, Canberra.

EA, Environment Australia, 1999f, "Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic/Commercial Solvent and Aerosol Use", Environment Australia, Canberra.

EA, Environment Australia, 1999g, "Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Service Stations", Environment Australia, Canberra.

EA, Environment Australia, 1999h, "Draft NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic Lawn Mowing", Environment Australia, Canberra.

EA, Environment Australia, 1999i, "Draft NPI: Area-Based Emissions Estimation Workbook Domestic/Commercial Solvent and Aerosol Use", Environment Australia, Canberra.

Eastern Research Group, 1998, "EIIP, Vol III, CH 17: Asphalt Paving", USEPA: http://www.epa.gov/ttn/chief/eiip/iii17.pdf.

EPAV, Environmental Protection Authority of Victoria 1996, "Report on the Air Emissions Trials for the National Pollutant Inventory" Australian Government Publishing Service.

NEPC National Environment Protection Council, 1998, "National Environment Protection Measure for the National Pollutant Inventory". National Environment Protection Council.

Quit Victoria, 1999, "Tobacco in Australia: Facts and Issues", Quit Victoria: http://www.quit.org.au.

Radian Corporation, 1997a, "EIIP Vol III, CH 2: Residential Wood Combustion", USEPA: http://www.epa.gov/ttn/chief/eiip/iii02.pdf.

Sinclair Knight Merz 1999, "Perth Fugitive Estimations 1998/1999". Report to the Department of Environmental Protection. Sinklair Knight Merz, Perth, Australia.

USEPA, 1985, "Compilation of Air Pollutant Emission Factors. Stationary Point and Area Sources, Fourth Edition, Volume 1, Chapter 5", United States Environmental Protection Agency.

USEPA, 1992 "Procedures for Emission Inventory Preparation – Vol IV: Mobile Sources". United States Environmental Protection Agency

USEPA, 1993, "VOC/PM Speciation Data System." United States Environmental Protection Agency. (also available via www.epa.gov)

USEPA, 1995, "Compilation of Air Pollutant Emission Factors. Stationary Point and Area Sources, Fifth Edition, Volume 1, Chapter 5", United States Environmental Protection Agency: http://www.epa.gov/ttn/chief/ap42c5.html.

Western Power & Department of Environmental Protection (1996) The Perth Photochemical Smog Study: Perth Western Australia, May 1996.

Appendix A:

Excerpts from NPI NEPM and MOU

Appendix A

Clause 20 from the National Environmental Protection Measure for the National Pollutant Inventory

Estimation of aggregated emissions other than from reporting facilities

20. (1) Jurisdictions shall cooperate to develop, or case to be developed, aggregated emissions data for particular substances specified in the reporting list, in specific regions within their jurisdictions at particular times, as agreed between participating jurisdictions.

(2) The data developed under 20(1) shall be submitted in an agreed format to the Commonwealth on or before the date agreed between participating jurisdictions.

Extract from the Memorandum of Understanding relating to the implementation of the National Pollutant Inventory

5.3. Estimation of Aggregated Emissions Data

5.3.1. Parties agree that aggregated emissions estimations pursuant to clause 20 of the Measure will be carried out in accordance with the following principles:

a) aggregated emissions data should include, where practicable, comprehensive information on emissions of substances from facilities other than reporting facilities and other anthropogenic and, if available, biogenic sources;

b) airsheds and catchments for which aggregated emissions will be estimated will be selected on the basis of priorities for protection of human health and the environment;

c) to the extent possible within the guidance provided by (b) above, airsheds and catchments for which aggregated emissions will be estimated will be selected to provide context for point source data reported under the Measure;

d) aggregated emissions will be estimated using handbooks prepared for the purpose and agreed between parties; no estimation will be carried out unless a relevant handbook has been agreed; handbooks will provide guidance on methodologies for aggregated emission estimations and the reliability of data obtained through the application of those methodologies.

5.3.2. Parties will undertake aggregated emission estimations where resources, as provided for by this Agreement, are available for the purpose.

5.3.3. As baseline data on biogenic sources in Australia are limited, data on biogenic sources will not initially be included in the aggregated data estimations, but parties will work towards its inclusion at a later time.

5.3.4. Schedule C lists priority airsheds and catchments, and timelines for their inclusion in the aggregated emission estimations program. Parties will jointly and annually review Schedule C.

Schedule C of MOU

ESTIMATING AGGREGATED EMISSIONS

This schedule provides the list of priority airsheds and water catchments to be estimated as part of the NPI in 1998/99 and 1999/00. Aggregated emissions for airsheds or water catchments may be from point sources (i.e. those which are specifically exempted, such as service stations or dry cleaning processes, and those which are below the reporting thresholds) or from diffuse sources such as motor vehicles, agricultural operations or stormwater runoff.

The Chief Executive Officers of nominated agencies and Environment Australia will agree on the techniques and handbooks to be used for estimations of aggregated emissions.

List of priority airsheds and water catchments

To be undertaken in 1998/99

Airsheds:
Newcastle, Sydney and Wollongong (update existing inventory)
Perth (update existing inventory)
Port Phillip Region (update existing inventory)
Adelaide (new inventory)
Hobart (new inventory)
Canberra (new inventory)
SE Queensland (new inventory, completed as part of the current integrated trial)
Kalgoorlie (new inventory, completed as part of the current trial)

Water catchments:
Port Phillip Bay
Newcastle, Sydney and Wollongong (including Port Jackson, Hawkesbury-Nepean, Botany Bay, Illawarra and Hunter catchments)
Perth (Swan-Canning catchment)
Adelaide
Hobart (including Derwent)
Canberra (including contributions to Murrumbidgee and Molonglo)
SE Queensland (completed as part of the current integrated trial)
Kalgoorlie (completed as part of the current trial)
Murray-Darling Basin (for N and P only including: Murray, Murrumbidgee and Darling)
Also report all existing 'catchment' information which is consistent with the agreed techniques for estimation of aggregated emissions.

To be undertaken in 1999/00

Airsheds:
Latrobe valley (new inventory)
Launceston (new inventory)
Darwin and Alice Springs (partial inventory)
Pilbara (new inventory)

Water catchments:
Latrobe and Thomson River Basins
Launceston (including the Tamar)
Darwin Harbour
Queensland (2 additional catchments)
NSW (2 additional catchments)
Western Australia (2 additional catchments)

Notes concerning list

1. In those cases where specific airsheds and catchments have not been identified in the list above, it is envisaged that the Commonwealth and the relevant jurisdiction will reach agreement on relative priorities to ensure that the aggregated emissions data estimation undertaken provides the maximum national benefits in delivering the goals of the NPI.
2. Definitions of airshed or water catchment have been left broad intentionally. Definitions will be specified in the aggregated emissions estimation handbooks to be developed.

Appendix A: Table 1 of NPI NEPM

	COLUMN 1 SUBSTANCE	COLUMN 2 CASR No.	COLUMN 3 THRESHOLD CATEGORY	COLUMN 4 THRESHOLD
	Acetaldehyde	75-07-0	1	10 tonnes per year
	Acetic acid (ethanoic acid)	64-19-7	1	10 tonnes per year
	Acetone	67-64-1	1	10 tonnes per year
	Acetonitrile	75-05-8	1	10 tonnes per year
	Acrylamide	79-06-1	1	10 tonnes per year
	Acrylic acid	79-10-7	1	10 tonnes per year
	Acrylonitrile (2-propenenitrile)	107-13-1	1	10 tonnes per year
	Ammonia (total)	N/A	1	10 tonnes per year
	Aniline (benzenamine)	62-53-3	1	10 tonnes per year
	Antimony & compounds	7440-36-0	1	10 tonnes per year
	Arsenic & compounds	7440-38-2	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Benzene	71-43-2	1	10 tonnes per year
	Benzene hexachloro- (HCB)	608-73-1	1	10 tonnes per year
	Beryllium & compounds	7440-41-7	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Biphenyl (1,1-biphenyl)	92-52-4	1	10 tonnes per year
	Boron & compounds	7440-42-8	1	10 tonnes per year
1,3-	Butadiene (vinyl ethylene)	106-99-0	1	10 tonnes per year
	Cadmium & compounds	7440-43-9	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Carbon disulphide	75-15-0	1	10 tonnes per year
	Carbon monoxide	630-08-0	1 2a	10 tonnes per year 400 tonnes per year, or 1 tonne per hour
	Chlorine	7782-50-5	1	10 tonnes per year
	Chlorine dioxide	10049-04-4	1	10 tonnes per year
	Chloroethane (ethyl chloride)	75-00-3	1	10 tonnes per year
	Chloroform (trichloromethane)	67-66-3	1	10 tonnes per year
	Chlorophenols (di, tri, tetra)	N/A	1	10 tonnes per year
	Chromium (III) compounds	7440-47-3	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts

Table 2 (cont.)

	COLUMN 1 SUBSTANCE	COLUMN 2 CASR No.	COLUMN 3 THRESHOLD CATEGORY	COLUMN 4 THRESHOLD
	Chromium (VI) compounds	7440-47-3	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Cobalt & compounds	7440-48-4	1	10 tonnes per year
	Copper & compounds	7440-50-8	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Cumene (1-methylethylbenzene)	98-82-8	1	10 tonnes per year
	Cyanide (inorganic) compounds	N/A	1	10 tonnes per year
	Cyclohexane	110-82-7	1	10 tonnes per year
1,2-	Dibromoethane	106-93-4	1	10 tonnes per year
	Dibutyl phthalate	84-74-2	1	10 tonnes per year
1,2-	Dichloroethane	107-06-2	1	10 tonnes per year
	Dichloromethane	75-09-2	1	10 tonnes per year
	Ethanol	64-17-5	1	10 tonnes per year
2-	Ethoxyethanol	110-80-5	1	10 tonnes per year
2-	Ethoxyethanol acetate	111-15-9	1	10 tonnes per year
	Ethyl acetate	141-78-6	1	10 tonnes per year
	Ethyl butyl ketone	106-35-4	1	10 tonnes per year
	Ethylbenzene	100-41-4	1	10 tonnes per year
	Ethylene glycol (1,2-ethanediol)	107-21-1	1	10 tonnes per year
	Ethylene oxide	72-21-8	1	10 tonnes per year
	Di-(2-Ethylhexyl) phthalate (DEHP)	117-81-7	1	10 tonnes per year
	Fluoride compounds	N/A	1 2a	10 tonnes per year 400 tonnes per year, or 1 tonne per hour
	Formaldehyde (methyl aldehyde)	50-00-0	1	10 tonnes per year
	Glutaraldehyde	111-30-8	1	10 tonnes per year
n-	Hexane	110-54-3	1	10 tonnes per year
	Hydrochloric acid	7647-01-0	1 2a	10 tonnes per year 400 tonnes per year, or 1 tonne per hour
	Hydrogen sulphide	7783-06-4	1	10 tonnes per year
	Lead & compounds	7439-92-1	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts

Table 2 (cont.)

	COLUMN 1 SUBSTANCE	COLUMN 2 CASR No.	COLUMN 3 THRESHOLD CATEGORY	COLUMN 4 THRESHOLD
	Magnesium oxide fume	1309-48-4	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Manganese & compounds	7439-96-5	1	10 tonnes per year
	Mercury & compounds	7439-97-6	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Methanol	67-56-1	1	10 tonnes per year
2-	Methoxyethanol	109-86-4	1	10 tonnes per year
2-	Methoxyethanol acetate	110-49-6	1	10 tonnes per year
	Methyl ethyl ketone	78-93-3	1	10 tonnes per year
	Methyl isobutyl ketone	108-10-1	1	10 tonnes per year
	Methyl methacrylate	80-62-6	1	10 tonnes per year
4,4-	Methylene bis 2,4 aniline (MOCA)	101-14-4	1	10 tonnes per year
	Methylenebis (phenylisocyanate)	101-68-8	1	10 tonnes per year
	Nickel & compounds	7440-02-0	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Nickel carbonyl	13463-39-3	1	10 tonnes per year
			2b	2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Nickel subsulphide	12035-72-2	1 2b	10 tonnes per year 2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Nitric acid	7697-37-2	1	10 tonnes per year
	Organo-tin compounds Oxides of Nitrogen	N/A N/A	1 2a	10 tonnes per year 400 tonnes per year, or 1 tonne per hour
	Particulate Matter 10.0 µm	N/A	2a	400 tonnes per year, or 1 tonne per hour
	Phenol	108-95-2	1	10 tonnes per year
	Phosphoric acid	7664-38-2	1	10 tonnes per year

Table 2 (cont.)

	COLUMN 1 SUBSTANCE	COLUMN 2 CASR No.	COLUMN 3 THRESHOLD CATEGORY	COLUMN 4 THRESHOLD
	Polychlorinated dioxins and furans	N/A	2b	2,000 tonnes per year, or or 60,000 megawatt hours, or rated at 20 megawatts
	Polycyclic aromatic hydrocarbons	N/A	2a	400 tonnes per year, or 1 tonne per hour
	Selenium & compounds	7782-49-2	1	10 tonnes per year
	Styrene (ethenylbenzene)	100-42-5	1	10 tonnes per year
	Sulphur dioxide	7446-09-5	1 2a	10 tonnes per year 400 tonnes per year, or 1 tonne per hour
	Sulphuric acid	7664-93-9	1	10 tonnes per year
1,1,1,2-	Tetrachloroethane	630-20-6	1	10 tonnes per year
	Tetrachloroethylene	127-18-4	1	10 tonnes per year
	Toluene (methylbenzene)	108-88-3	1	10 tonnes per year
	Toluene-2,4-diisocyanate	584-84-9	1	10 tonnes per year
	Total Nitrogen	N/A	3	15 tonnes per year
	Total Phosphorus	N/A	3	3 tonnes per year
	Total Volatile Organic Compounds	N/A	1a 2a	25 tonnes per year, or a design capacity of 25 kilotonnes for bulk storage facilities 400 tonnes per year, or 1 tonne per hour
1,1,2-	Trichloroethane	79-00-5	1	10 tonnes per year
	Trichoroethylene	79-01-6	1	10 tonnes per year
	Vinyl Chloride Monomer	75-01-4	1	10 tonnes per year
	Xylenes (individual or mixed isomers)	1330-20-7	1	10 tonnes per year
	Zinc and compounds	7440-66-6	1	10 tonnes per year

Appendix B:

Detailed Methodology

Contents of Appendix B

B.1 Fuel Combustion – Sub Reporting Threshold Facilities

B.1.1 Methodology

Emissions from Fuel Combustion – sub reporting threshold facilities, were calculated using emission factors. Data used in the calculations was collected using a mail-out questionnaire (Appendix C) sent to 419 facilities. The questionnaire collected data common to both the NPI and an update to Perth Photochemical Smog Study which included information for both reporting and non-reporting facilities. Facilities that reported to the NPI during 1998-1999 have been removed from calculations. However, this database will need to be updated in future years to remove facilities that did not report in the 1998-99 reporting period but do report in future years.

Of the 419 questionnaires mailed to facilities, 272 useable responses were obtained (65%). Follow-up calls were made to all facilities that did not return questionnaires. It was determined from this that many of the letters had been sent to the wrong locations, or the questionnaire was not applicable to the site. Discounting these misdirected questionnaires, a high success rate of approximately 95% was achieved. Accordingly, fuel consumption estimates used to estimate emissions for this source are expected to be very accurate.

Accuracy of the estimates is expected to be superior to the data collected in accordance with the NPI EET manual for Aggregated Emissions from Fuel Combustion – sub reporting threshold facilities (EA, 1999a), which relies on generic industry fuel sales data. The current method also allows for more accurate distribution of emissions by specific industry locations (described in Section B.1.1.2).

The mail-out was based on a compilation of three separate DEP mailing lists, which included the original PPSS mailing list, DEP records of licensed facilities in the study area, and early NPI mailing lists. The questionnaire collected data under the following main headings:

- contact details (name, address, AMG/Coordinate location, contact person);
- products manufactured;
- major raw materials used (excluding fuel);
- type and quantity of fuel(s) used;
- equipment each fuel is combusted in;
- type of emission control equipment used on each fuel combustion machinery item; and
- direct monitoring data from stack emissions for the following categories: benzene, NO, NO_2, CO SO_2, particulates and other.

Table B.1 summarises the total quantities of fuel combusted in the study area during 1998-1999 and the equipment type the fuel was combusted in.

Table B.1: Summary of Fuel Consumed in the Perth Study Area by Equipment Types

Combustion Equipment	Fuel Type	Quantity Combusted
Commercial (<3MW)	Natural Gas (m^3)	36,800,000
Industrial Boiler (3-30MW)	Natural Gas (m^3)	106,000,000
Low NO_x Industrial Burner	Natural Gas (m^3)	227,000,000
Electricity Generator Turbine	Natural Gas (m^3)	197,000,000
	Total Natural Gas Combusted	*567,000,000 (m3)*
Electricity Generator Turbine	Refinery Fuel Gas (tonnes)	39,398 (Tonnes)
Commercial Burner (<3MW)	LPG (litres)	2,670,000
Industrial Burner (3-30MW)	LPG (litres)	2,540,000
Small Internal Combustion Engines	LPG (litres)	2,260,000
	Total LPG Combusted	*7,470,000 (litres)*
Small Internal Combustion Engines	Distillate (litres)	5,210,000
Commercial Burner (<3MW)	Distillate (litres)	1,380,000
	Total Distillate Combusted	*6,590,000 (litres)*
Commercial Burner (<3MW)	Residual Oil (litres)	580
Industrial Burner (3-30MW)	Residual Oil (litres)	217,000
	Total Residual Oil Combusted	*217,600 (litres)*
Parallel Fired Boiler	*Coal (Tonnes)*	*28,000 (Tonnes)*
Any Coke Combustion Process[1]	*Coke (Tonnes)*	*22.0 (Tonnes)*
Any Process Using Sawdust	*Smoking Sawdust (Tonnes)*	*47.5 (Tonnes)*
Hydrogen Gas Fired Boiler[1]	*H2 (Tonnes)*	*28.4 (Tonnes)*
Commercial Boiler (<3MW)	*LFG/Biogas (m^3) (60%CH4+40%CO2)*	*81,800,000 (m3)*

[1]No emission factors were available for these sources and hence no emissions were estimated for these fuel types.

Some emission factors used to calculate emissions were based on the quantity of product produced rather than fuel consumed. The total quantities of these products that were produced by the sub-threshold reporting facilities in the study area are summarised in Table B.2.

Table B.2: Quantity of Products Produced by Sub-threshold Reporting Facilities

Product	Fuel Type	Quantity Produced (Tonnes)
Clinker/Cement	Any	570,000
Lime	Coal	721,000
Lime	Natural Gas	48,800
Bricks	Any	0
Glass	Any	77,000

All fuel consumption data was entered into an Excel 97 spreadsheet containing emission factors for the various combustion processes. All data entered into the spreadsheets was double checked to ensure data accuracy. Appendix B.2 contains all combustion processes, the sources of the emission factors and any assumptions made during the data entry and calculation process.

There was significant overlap between substances for which emission estimates were made by Stuart and Carnovale (1994) in the PPSS Update and the current NPI aggregated emissions work (CO, PM10, Benzene, Toluene and Xylene). For consistency, the same emission factor

was used for each of the studies. Emission factors developed for the PPSS update were used in preference to emission factors contained in the NPI Manuals.

Substances not covered by Stuart and Carnovale (1994) were estimated using emission factors in the most relevant NPI manuals available at the time. At the time of spreadsheet development, many NPI EET manuals were in draft form. An outline of which EF's were used and the assumptions behind their use is outlined in Appendix B.2.

Where a facility provided direct monitoring data, this was used in preference to any emissions factor estimate. This is different to the original PPSS which used only emissions factors.

B.1.1.1 Emission Factors

Emission factors used in calculating emissions from fuel combustion sub-threshold facilities are summarised in Table B.3. The complete table containing the sources of the emission factors is presented in Appendix B.2.

Table B.3: Emission Factors for Sub-Threshold Reporting Facilities.

Combustion Equipment	NOx	SO_2	CO	PM10	Total VOC	Benzene	Toluene	Xylene	PAH's	As	Cd	Cr (VI)	Co	Fl	Pb	Hg	Ni
Clinker /Cement (NG fired kg emitted/tonne clinker produced)	2.70E+00	5.00E-03	8.00E-02	3.05E-01	1.05E-02	8.00E-03	1.00E-04	6.50E-06	7.08E-05	6.50E-06	1.10E-06			4.50E-04	3.80E-05		
Production - Lime (Coal fired – kg emitted/tonne lime produced)	1.60E+00	2.70E+00	7.40E-01	1.00E+00	4.43E-02	8.00E-03	4.14E-04	6.50E-06	7.08E-05	6.50E-06	1.10E-06			4.50E-04	3.80E-05		
Production - Lime (NG fired – kg emitted/tonne lime produced)	1.20E-01	6.00E-03	2.30E-01	1.00E+00	4.43E-02	8.00E-03	4.14E-04	6.50E-06	7.08E-05	6.50E-06	1.10E-06			4.50E-04	3.80E-05		
Production – Bricks (kg emitted/tonne bricks produced)	5.75E-02	3.90E-01	2.00E-02	6.50E-02	1.64E-03	3.20E-05	3.24E-05	4.51E-05		1.55E-05				1.40E-01		3.75E-06	
Production – Glass (kg emitted/tonne glass produced)	2.23E+00	1.70E+00	1.00E-01	7.00E-01	7.39E-02	2.11E-03	7.80E-04				1.50E-04				1.20E-02	1.90E-03	5.00E-05
Commercial Burner (kg emitted/m^3 NG burnt)	1.15E-03	1.46E-05	3.20E-04	4.80E-05	1.19E-04	1.07E-05	5.94E-06		1.10E-11	3.20E-09	1.80E-08		1.30E-09		8.00E-09	4.20E-09	3.40E-08
Industrial Burner (kg emitted/m^3 NG burnt)	1.61E-03	1.46E-05	5.60E-04	4.80E-05	4.42E-05	3.98E-06	2.21E-06		1.10E-11	3.20E-09	1.80E-08		1.30E-09		8.00E-09	4.20E-09	3.40E-08
Low NO_x Industrial Burner (kg emitted/m^3 NG burnt)	2.28E-05	1.46E-05	5.60E-04	4.80E-05	4.42E-05	3.98E-06	2.21E-06		1.10E-11	3.20E-09	1.80E-08		1.30E-09		8.00E-09	4.20E-09	3.40E-08
Electricity Generator Turbine (kg emitted/m^3 NG burnt)	4.76E-03	1.37E-07	1.84E-03	2.24E-04	5.58E-04	5.02E-05	2.79E-05			8.07E-08	6.92E-08		1.50E-07		9.61E-07	1.50E-08	2.00E-05
Commercial Burner (kg emitted/litre LPG burnt)	7.55E-04	8.55E-09	2.20E-04	3.00E-05	6.00E-05	2.88E-06	1.44E-06										
Industrial Burner (kg emitted / litre LPG burnt)	1.07E-03	8.55E-09	3.70E-04	3.00E-05	3.00E-05	2.88E-06	1.44E-06										
Small Internal Combustion Engines (kg emitted / litre LPG burnt)	3.10E-03	1.04E-04	2.24E-02		6.30E-04												
Small Internal Combustion Engines (kg emitted / litre diesel burnt)	4.04E-02	4.76E-03	1.22E-02	4.01E-03	3.97E-03	3.53E-04	6.72E-06	4.68E-06	2.76E-06								
Commercial Burner (kg emitted / litre diesel burnt)	1.73E-03	8.50E-03	6.00E-04	2.40E-04	4.00E-05	2.57E-08	7.44E-07	1.31E-08	1.43E-07	6.58E-08	5.03E-08	0.00E+00	0.00E+00		1.51E-07	5.03E-08	5.03E-08
Commercial Burner (kg emitted / litre residual oil burnt)	4.75E-03	1.22E-01	6.00E-04	2.30E-03	1.40E-04	2.57E-08	7.44E-07	1.31E-08	1.43E-07	1.58E-07	4.78E-08	2.98E-08	7.22E-07	4.48E-06	1.81E-07	1.36E-08	1.01E-05
Industrial Burner (kg emitted / litre residual oil burnt)	4.75E-03	1.22E-01	6.00E-04	2.30E-03	3.4E-05	2.57E-08	7.44E-07	1.31E-08	1.43E-07	1.58E-07	4.78E-08	2.98E-08	7.22E-07	4.48E-06	1.81E-07	1.36E-08	1.01E-05
Parallel Fired Boiler (kg emitted/tonne coal burnt)	7.56E+00	1.14E+01	3.00E-01	4.00E+01	4.00E-02		2.25E-03	1.92E-05		5.88E-03	3.80E-04				4.36E-03	1.38E-04	1.00E-02
Smokehouse Sawdust (kg emitted/tonne sawdust burnt)			2.70E+00	1.40E-01	3.60E-01												
Commercial Boiler (kg emitted/m^3 biogas burnt)	1.61E-03	1.46E-05	5.60E-04	4.80E-05	4.42E-05	3.98E-06	2.21E-06		1.10E-11	3.20E-09	1.80E-08		1.30E-09		8.00E-09	4.20E-09	3.40E-08

B.1.1.2 Spatial Distribution

Emissions from sub-threshold facilities were distributed within the study area using the specific location of each facility. AMG coordinates were obtained from the 1999 Perth UBD based on facility addresses provided by questionnaire results. The distribution of sub-threshold faculties across the study area is contained in Appendix B.1.1.

B.2 Solid Fuel Burning (Domestic)

B.2.1 Methodology

Emissions for the domestic solid fuel use were estimated using fuel use data and emissions factors. The Australian Bureau of Statistics Census data collected in 1996 indicates that 21% (102 665) of Perth residences rely on wood combustion as their primary source of heating, and 4.3% (21 022) use wood as a secondary source of home heating. Therefore, 123 687 homes in the Perth airshed utilise wood combustion as a source of heating.

A phone survey on wood heater use was conducted during 1997 for the Perth Woodsmoke Campaign Evaluation. Information collected in the pre-campaign survey indicated that 65% of wood heaters commence their use during May, and 23% are still being operated after September. Results from the survey and information on sales figures and trends compiled by Australian Home Heating Association Inc 40% of the wood heaters in operation are pot belly stoves, 35% are control combustion heaters and 25% are open fireplaces (K. Jenkinson, AHHA, personal communication, 1999).

Average annual consumption figures were derived from a phone survey conducted for a separate interstate study by AGB: Spectrum, a Melbourne based consulting firm. Their report indicated that wood consumption in Perth is 2 t/yr for a home that uses wood as their primary source of heating (Dr. J. Todd, Personal communication, 1999). Homes that use wood combustion as their secondary source of heating were assigned a consumption value of 0.2 t/yr. The literature written by the Forestry Technical Services *Fuelwood Use and Supply in Australia Report to Energy Research and Development Corporation* (FTS, 1989) produced average figures of 2.4 t/yr and 2.6t/yr (low and high estimate) for Western Australia. It is reasonable to assume slightly lower use within Perth than rural areas, due to cost (Dr. J. Todd, Personal communication, 1999).

The estimated consumption of wood for domestic combustion during 1998/1999 was calculated to be 209 534 tonnes. It should be noted that the consumption of wood for domestic combustion is highly dependent on the severity of winter weather and may vary significantly from one year to the next.

The annual consumption above is relatively similar to 175 000 tonnes of firewood available in Perth each year estimated by the Forest Industries Federation (WA) Inc (FIFWA, 1997). Furthermore, personal communication (1999) with K. Womble and J. Clarke (CALM) and G. Allan (DEP) provided an estimate of 171 575 tonnes consumed during last year. Therefore, the consumption value used in the PPSS of 260 000 tonnes appears to be an over estimate in comparison.

B.2.1.1 Emission Factors

Emission factors for domestic wood combustion are divided into 3 categories and are presented in Table B.4. A weighted average of the 3 heater types was determined for the Perth airshed, and is outlined below as *Combined Emissions*. Factors used were the latest available from the USEPA, as limited emission factors exist for Australian appliances and wood types. Particulate emissions have been examined in some detail under Australian conditions and these factors have been used within this inventory. It is noted that emissions from wood combustion in

fireplaces, pot belly stoves and control combustion heaters may vary considerably depending on rate of burn, type and condition of the wood and fuel loading.

Table B.4: Emissions Factors for Domestic Wood Combustion.

Species	Fireplace[a] (kg/tonne)	Pot Belly Stove[a] (kg/tonne)	Control Combustion Heater[a] (kg/tonne)	Combined Emissions (kg/tonne)
CO	126	115	70.4	102
NOx	1.30	1.40	0.91[c]	1.20
PM10	17.3	12.0[b]	5.50[b]	11.1
SO2	0.200	0.20	0.20	0.20
Total VOC	115	26.5	6.00	41.3
Benzene			0.969	0.732
Toluene			0.365	0.26
Cadmium			1.10E-05	1.00E-05
Chromium (total)			5.00E-07	5.00E-07
Manganese			8.50E-05	7.00E-05
Methyl ethyl ketone			0.145	0.031
Nickel			7.00E-06	1.00E-05
Total PAHs			0.365	0.25
Xylenes			0.101	0.093

[a] adapted from (Radian Corporation, 1997)
[b] (EA, 1999b)
[c] (EA, 1999c)

Table B.5: Emissions Factors for Domestic Wood Combustion with Speciated VOC's.

Pollutant	Emission/Dwelling (kg/yr)
CO	44
NOx	0.516
PM10	4.74
SO2	0.0857
Total VOC	1.77E+01
Acetaldehyde	1.37E+00
Acetone	1.02
Benzene	0.725
1,3-Butadiene	0.0386
Cadmium	0.00000339
Chromium (VI)	0.000000161
Formaldehyde	1.48E+00
Manganese	2.51E-05
Methyl ethyl ketone	0.0966
Nickel	2.70E-06
Polycyclic aromatic hydrocarbons	0.100
Styrene	1.88E-02
Toluene	0.227
Xylenes	0.107

B.2.1.2 Spatial Distribution

Emissions from domestic wood combustion were distributed by the proportion of dwellings per grid cell within the Perth airshed. The number and distribution of dwellings in the Perth airshed was derived from 1996 ABS Census information. These figures were scaled to 1999 numbers by applying the population growth rate for each year. The distribution of dwellings by Australian Map Grid (AMG) cell reference is presented in Appendix B.1.2.

B.3 Architectural Surface Coating

B.3.1 Methodology

Emissions from architectural surface coating were calculated using a mass balance technique. The key assumptions required to complete the mass balance are:

- The use of the coatings follows a steady state pattern. That is, there is no stockpiling of coating material by consumers.
- Annual consumption is equal to the total volume of paint produced, plus the volume imported into Australia, less the volume exported overseas.
- All of the VOC contained within a coating will be released to atmosphere during drying of the coated surface.

The volume of architectural surface coatings consumed during 1998/1999 in the Perth Airshed was calculated using data from the Australian Paint Manufactures Federation (APMF). The Metropolitan Air Quality Study (MAQs) report (EPAV, 1997), the NPI EET manual for Aggregated Emissions from Architectural Surface Coatings (EA, 1999d) and the Perth Photochemical Smog Report Area Based Emissions Inventory Final Report (Stuart and Carnovale, 1994) all stated that paint sales data can be obtained for jurisdiction or state areas. However, when the APMF was approached it was indicated that this was not the case and information was collected quarterly on national production, exports and imports of various paint and thinner types. It was suggested that proportioning coating consumption by population figures was relatively accurate (APMF, M. Hambrook, 1999 personal communication).

Calculations indicate that 175 133 kilolitres of architectural surface coating was consumed nationally, during 1998/1999. ABS Population data was referenced (www.abs.gov.au) to estimate Western Australia's architectural surface coating consumption (16 515 kilolitres). The previous PPSS indicated that the consumption of coatings classified as Architectural/Decorative was proportioned by the percentage of WA's population within the airshed region. For industrial and heavy-duty coatings, the Perth airshed consumption was assumed to be 90% of total WA value (Stuart and Carnovale, 1994). When these assumptions were employed, it was estimated that 12 854 kilolitres of architectural surface coating was consumed within the Perth airshed during 1998/1999. More detailed consumption figures are presented in Table B.6 and percentage break-up of the total consumption for the Perth airshed is shown in Figure B.1.

Table B.6: Consumption and estimated VOC emissions from Architectural Surface Coatings and Thinners for 1998/1999.

Coating Type (architectural)	National Annual Consumption (litre)	PA[a] Annual Consumption (litre)	VOCs Density (kg/litre)	VOCs Emitted (kg/yr) PA[a]
Architectural And Decorative Paints, Enamels & Clears				
Solvent Thinned	18,000,000	1,210,000	0.45	546,000
Water Thinned	94,400,000	6,380,000	0.1	638,000
Thinners for Solvent Based	1,320,000	112,000	0.95	106,000
Industrial Paints Enamels & Clears				
Fast Dry alkyl top coats and primers	23,600,000	2,000,000	0.6	1,200,000
Nitrocell Lacquers	1,120,000	95,500	0.6	57,300
Other	6,570,000	557,000	0.6	334,000
Thinners	6,760,000	574,000	0.95	545,000
Heavy Duty Coatings				
Two pack products	5,770,000	490,000	0.4	196,000
Single pack products	1,970,000	167,000	0.4	66,900
Zinc rich products	1,190,000	101,000	0.4	40,300
Thinners	2,180,000	185,000	0.95	176,000
Timber Finishes (Excluding Wood Preservatives)				
Architectural & Decorative	3,630,000	245,000	0.55	135,000
Industrial	7,530,000	639,000	0.55	352,000
Floor Finishes	1,140,000	96,900	0.55	53,300

[a] PA = Perth Airshed study area

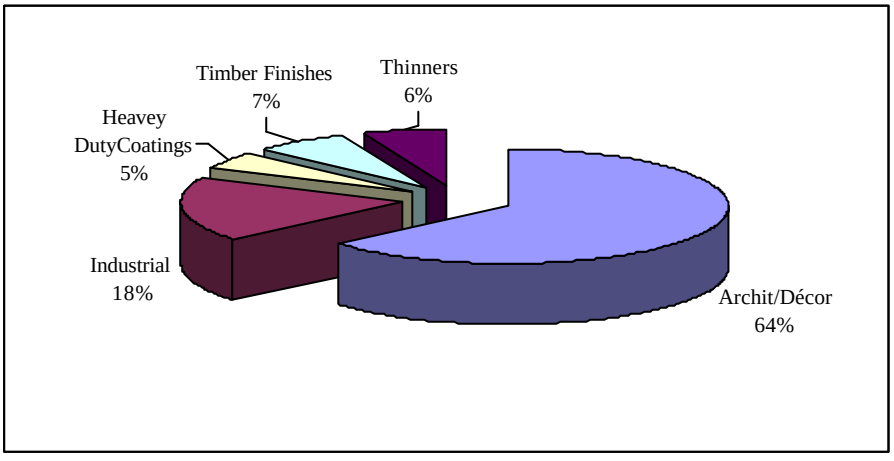


Figure B.1: Percent Consumption of Architectural Surface Coatings and Thinners, Perth Airshed 1998/1999 (by Volume).

B.3.1.1 Emission Factors

To more accurately estimate VOC emissions from architectural surface coatings, consumption data was separated into coating categories and then further into coating types, as shown in Table B.6 above. This detailed speciation is a result of the substantial variation in VOC densities between surface coating types. Consequently, total VOC emissions in the Perth airshed are dependent on the amount used of each product category rather than the total consumption volume for all coatings.

The VOC content of various paint types has been estimated from a detail examination of Australian paints. Information supplied by the APMF has been published within NPI: Area-

Based Emissions Estimation Workbook Architectural Surface Coating (EA, 1999e) as per Table B.7.

Table B.7: Architectural Surface Coating Emission Factors

Substance	Weight Fraction of VOC's
Solvent Based	
Acetone	0.032
Cyclohexane	0.207
2-Ethoxyethanol acetate	0.013
Ethyl alcohol	0.006
Ethylene glycol	0.006
n-Hexane	0.207
Isomers of xylene	0.026
Methyl alcohol	0.039
Methyl ethyl ketone	0.056
Methyl isobutyl ketone	0.006
Toluene	0.052
Water Based	
Benzene	0.003
Dichloromethane (methylene chloride)	0.055
Ethylene glycol	0.005

B.3.1.2 Spatial Distribution

Architectural surface coating emissions were distributed by the proportion of dwellings per grid cell within the Perth airshed. The number and distribution of dwellings in the Perth airshed was derived from 1996 ABS Census information. These figures were scaled to 1999 numbers by applying the population growth rate for each year. The distribution of dwellings by Australian Map Grid (AMG) cell reference is presented in Appendix B.1.2.

B.4 Motor Vehicle Refinishing

B.4.1 Methodology

Emissions from motor vehicle refinishing were calculated using a mass balance technique. Assumptions made for estimating consumption and emissions from this source were taken from the *Architectural Surface Coating* source and are stated in Section B.3.

The volume of automotive coatings consumed during 1998/1999 in the Perth Airshed was calculated using data from the Australian Paint Manufactures Federation (APMF). The APMF collect information on the national production, export and import of various paint and thinner types, on a quarterly basis. It was suggested that proportioning coating consumption by population figures was relatively accurate (APMF, M. Hambrook, 1999 personal communication).

A total of 14,127 kilolitres of automotive coatings and 10,312 kilolitres of automotive thinners were consumed nationally, during 1998/1999. ABS Population data was referenced (www.abs.gov.au) to enable Western Australia's coatings and thinners consumption to be estimated at 1332 kilolitres and 972 kilolitres, respectively. Consumption for the Perth airshed was proportioned by the percentage of WA's population within the airshed region. Perth airshed consumption figures are presented in Table B.9.

Table B.8: Consumption and estimated VOC emissions from Automotive Coatings and Thinners for 1998/1999.

Coating Type (architectural)	National Annual Consumption (litre)	PA Annual Consumption (litre)	VOCs Density (g/litre)	VOCs Emitted (kg/yr)PA[a]
Automotive Coatings	14,100,000	954,000	584	557,000
Automotive Thinners	10,300,000	697,000	850	592,000

[a] Perth Airshed

B.4.1.1 Emission Factors

To more accurately estimate VOC emissions from automotive coatings and thinners, distribution data supplied within the Area-Based Emissions Estimation Workbook Motor Vehicle Refinishing (EA, 1999f) was utilised (see Table B.9). This detailed speciation was used to provide an as accurate as possible representation of the VOC density of the coating and thinner data supplied by the APMF. However, it is unclear where this breakdown came from, as it is referenced to the APMF, but when this speciation was requested for 1998/1999 it was not available in so much detail. Consequently, total VOC emissions in the Perth airshed are dependent on the relative proportion used of each product category rather than the total consumption volume for all coatings.

Table B.9: Adapted breakdown of Automotive coating and thinner consumption.

Coating Type	% of total consumption[a]	VOC Density (g/L)	% VOC Density
Primers			
- Lacquers	11%	600	68
- Two Pack	9%	500	42
Basecoat (colour)	12%	700	83
Topcoats			
- Lacquers and clears	23%	650	147
- Synthetic enamels	11%	500	57
- Two Pack	22%	510	111
Hardeners			
- Two Pack	12%	600	75
			Total: 584 (g/L)
Thinners			
- Lacquers and others	77%	830	643
- Two Pack	23%	920	208
			Total: 850 (g/L)

[a.] Adapted from (EA,1999f).

VOC emissions were then speciated in accordance with the emission source (automotive coating or automotive thinner) as described in Table B.12.

Table B.10: VOC Speciation for Automotive Coatings and Thinners.

Species	% Weight	Emissions per Premises (kg)
Automotive Coatings		
Xylene Equivalent	33	422
Toluene Equivalent	29	371
Methyl Ethyl Ketone	17	218
Methyl Isobutyl Ketone	3	38.4
Automotive Thinners		
Toluene Equivalent	25	340
Xylene Equivalent	20	272
Acetone	10	136
Ethylene Glycol Mono Ethyl Ether	2.5	34.0
Methyl Ethyl Ketone	2.5	34.0
Total volatile organic compounds		2,64

B.4.1.2 Spatial Distribution

Automotive refinishing emissions were distributed by dividing the total emissions by the number of automotive premises in the Perth airshed. The number and location of these premises were identified using information from ABS (Business Register (Electronic format), 1999) and the Internet Yellowpages (http://www.yellowpages.com.au/). Four hundred and thirty five premises were identified and allocated to the corresponding grid cell (Appendix B.1.3).

B.5 Domestic/Commercial Solvent Use

B.5.1 Methodology

Consumption of consumer and commercial products was calculated through the use of a per capita emission factor using the population in the study area. The NPI EET Manual for Aggregated Emissions from Domestic/Commercial Solvent and Aerosol Use (EA, 1999g) suggested that this is the preferred method because of the limited amount of research into the composition and use of these types of products in Australia. The United States has, however, performed comprehensive research in this area and the per capita factors are reported to provide emission estimates of medium reliability for Australian conditions. It was assumed that the use of these products in Australia is comparable to that in America. This assumption is made taking into account the history, cultures and sophistication of technologies.

B.5.1.1 Emission Factors

Calculating emissions of VOC's from commercial and consumer products was done by the use of per capita emission factors. The only activity data required was the population number and distribution in the study area. The emission factors used for these calculations (see Table B.14) were referenced from the latest USEPA Emission Inventory Improvement Program (Eastern Research Group, 1996).

Table B.11: Per Capita Domestic/Commercial VOC Emissions Factors [a]

Product Category	(kg VOC/person/year)
Personal Care Products	1.05
Household Products	0.36
Automotive Aftermarket Products	0.62
Adhesives and Sealants	0.26
Pesticides	0.81
Coatings and Related Products	0.43
Miscellaneous Products	0.03
Total For All Products	3.56

[a] Adapted from Eastern Research Group, (1996)

The VOC's were then speciated in accordance with the NPI EET Manual for Domestic/Commercial Solvent and Aerosol Use (EA, 1999g)

Table B.12: Emission Factors for Domestic and Commercial Solvent Use

Domestic and Commercial Solvent use	Emission Factors (kg/person/year)
Acrylic acid	1.79×10^{-9}
Benzene	2.14×10^{-9}
Chloroform	4.49×10^{-4}
1,2-Dichloroethane	2.11×10^{-6}
Dichloromethane	1.65×10^{-2}
Ethyl benzene	9.39×10^{-4}
Ethylene oxide	6.85×10^{-3}
Formaldehyde	5.71×10^{-4}
Glycol ethers	8.32×10^{-3}
n-Hexane	3.91×10^{-2}
Hydrochloric acid	7.94×10^{-7}
Fluoride and Compounds	6.40×10^{-6}
Methanol	3.16×10^{-1}
Methyl ethyl ketone	2.30×10^{-2}
Methyl isobutyl ketone	3.43×10^{-3}
Tetrachloro-ethylene	1.28×10^{-2}
Toluene	1.95×10^{-1}
Total volatile organic compounds [1]	3.56
Trichloro-ethylene	2.20×10^{-4}
Xylenes	9.21×10^{-2}

[1] Reactive VOCs listed on the NPI are counted twice - both as a proportion of total VOCs and as a single substance emission.

B.5.1.2 Spatial Distribution

As outlined above, emissions from domestic/commercial solvent use were distributed by the proportion of the population per grid cell within the Perth airshed. The latest ABS population data from the 1996 census was used, and multiplied by population growth data to estimate the current population. The distribution of the Perth population by Australian Map Grid (AMG) cell reference is presented in Appendix B.1.4.

B.6 Service Stations

B.6.1 Methodology

Fuel consumption in the Perth airshed has been estimated using data from the Australian Mineral Statistics (March 1998; June 1998; September 1998; December 1998; March 1999; June 1999) produced by ABARE. State fuel consumption was scaled according to the relative population, as was done for the PPSS and MAQS. An analysis of the quarterly fuel sales data for WA suggests that there is little seasonal variation, so daily emissions have been assumed to be constant throughout the year. A summary of sales figures is presented in Table B.13.

Table B.13: Summary of Automotive fuel sold in the Perth airshed (1998/1999).

Fuel Type	PA[a] Total (ML/yr)	PA[a] Total (ML/day)
Leaded	263	0.72
Prem Unleaded	32.2	0.09
Reg Unleaded	665	1.82
Total Unleaded Fuel	697	1.91
Auto LPG	65.1	0.18
Auto Diesel	201	0.55

[a] Perth Airshed

B.6.1.1 Emission Factors

Fuel transport tankers, filling of underground tanks at service stations, underground tank breathing and refueling motor vehicles at the bowser are all specific emission sources. Emissions factors derived by the USEPA were implemented for these types of emissions. Use of these factors are considered representative of Perth's practices and equipment, with this approach being consistent with methods used in the PPSS and other Australian inventories.

The vehicle refueling process is the largest emission source per volume of fuel (see Table B.14). Emissions factors associated with filling underground tanks vary significantly depending on the method employed. The *Environmental Protection (Recovery of Vapours from the Transfer of Organic Liquids) Regulations 1995 (Western Australia)* outlines that "a vapour transfer system through which vapours displaced by the transfer of liquids into the tank are returned to the delivery tank being unloaded" needs to be used. This vapour return method of filling tanks is known as vapour balancing and is commonly referred to as Stage 1 vapour control in the US.

Table B.14: Total VOC Emission Factors for Service Stations [a]

Emission Source	Total VOCs Emitted (kg) per ML Throughput
Petrol trucks in transit	
Empty[b]	6.5
Full[b]	0.5
Filling underground petrol tanks (Balanced submerged filling)	40
Underground petrol tank breathing	120
Vehicle refueling (petrol) [c]	1320
Spillage loss (petrol) [c]	80
Diesel (Total)[d]	176
LPG (Total)[d]	0.04

[a] (USEPA, 1995)
[b] Midpoint of typical range provided in AP-42.
[c] Average values used, rather than output of MOBILE 5b

[d] (EA, 1999h)

Total VOC emissions from service station tank and vehicle refueling losses as well as losses from tankers were speciated using the emission factors presented in Table B.15. The data was derived from BP Australia Ltd. and the Draft EET Manual for Aggregated Emissions form Service Stations (EA, 1999h).

Table B.15: Speciation of Emissions from Service Stations

Substance	Speciation (kg/ML of VOC)	Emissions from Tanks and Refueling (kg/yr/SS[c])	Emission from Tankers (kg/yr/SS[c])	Total Emission Factor (kg/yr/SS[c])
Benzene[a]	15.0	31.3	0.486	31.7
Cumene (1 - methylethylbenzene)	0.181	0.375	0.0495	0.425
Cyclohexane	1.32	2.74		2.74
1,2 – Dibromoethane[b]	0.00960	0.0200		0.020
Ethylbenzene	1.76	3.66	0.609	4.27
n - Hexane	19.4	40.4	0.6	41.0
Lead and compounds[b]	0.00796	0.0165		0.0165
Polycyclic aromatic hydrocarbons	0.288	0.599	0.12	0.718
Toluene (methylbenzene)[a]	18.1	37.6		37.6
Xylenes (individual or mixed isomers)[a]	3.88	8.07	3.25	11.3
Total VOCs (LPG: kg/yr)[b]	0.0400	0.00564		0.00564
Total VOCs (Petrol; kg/yr)[b]	1,560	3,240	14.6	3,260
Total VOCs (Diesel; kg/yr)[b]	176	76.7		76.7
Total VOCs (Diesel, LPG and Petrol)[b]	1,740	1,530,000	14.6	3,320

[a] emission factors calculated from information supplied by BP Australia Ltd.
[b] EA 1999h
[c] Service Station

B.6.1.2 Spatial Distribution

Emissions from service stations and fuel distribution were distributed within the airshed with the use of the specific location of each premise. The number and location of these premises were identified using information from the Internet Yellowpages (http://www.yellowpages.com.au/) and ABS (Business Register (Electronic format), 1999). Four hundred and sixty two premises were identified and allocated to the corresponding grid cell. The distribution of service stations in the Perth airshed by Australian Map grid (AMG) cell reference is contained in Appendix B.1.5.

B.7 Lawn Mowing

B.7.1 Methodology

Emissions from lawn and garden equipment in this inventory were estimated using emission factors and the hours of operation of the equipment for domestic use. The resources were not available to conduct an adequate community survey. Therefore, a number of local retailers and repairers were contacted by telephone and asked to provide their views on mower usage in the Perth region (Balcatta Mowers, Cannington Lawnmower & Chainsaw Centre, Metro Mower &

Chainsaw Specialists, Mower City Sales & Service Pty Ltd, Mt Lawley Mower Centre, Greenwood Lawnmower & Chainsaw Centre, personal communication, 1999).

Estimates indicate that 92.5% of dwellings have a lawn or garden where machinery in this category is used. This number is marginally higher than earlier inventories, with the PPSS estimating 90% of dwellings (Stuart and Carnovale, 1994) and Farrington (1988) assuming 80% of total dwellings. The retailers estimated that approximately 72.5% of dwellings owned their own equipment and the other 20% used contractors and lawn mowing companies

The average time taken to mow a lawn or use domestic garden equipment (petrol machinery) varied from 45 minutes to 1 hour, with an average running time of 46 minutes. During the summer period domestic garden equipment is used 3 times a month. Over the winter period the frequency of use is reduced to once a month. The average equipment use (hours/dwelling) is shown in Table B.16. The retailers surveyed believed that the current proportions of two and four stroke mowers in Perth to be 44.6% and 50.4%, respectively. The other 5% is made up of electric and push mowers.

Table B.16: Domestic garden equipment use (hours/dwelling) during 1998 / 1999.

	Weekdays	Weekend	Total Week	Annually
Summer (hr/dwelling)	0.118	0.428	0.546	14.2
Winter (hr/dwelling)	0.038	0.139	0.177	4.61

B.7.1.1 Emission Factors

Emission factors used to determine the aggregated emissions from domestic lawn mowing are provided in Table B.17. Composite emission factors have been calculated from data on two and four stroke mowers, weighted according to the ratio of mowers in the Perth airshed.

Table B.17: Emission factors for domestic lawn mowing and garden equipment use. [a]

NPI Substance	2 Stroke (kg/hr)	4 stroke (kg/hr)	Weighted Average[b] of 2 and 4 stroke (kg/hr)	Emissions per Dwelling (kg/yr)
CO	7.31×10^{-1}	4.89×10^{-1}	5.72×10^{-1}	1.02×10^{1}
NOx	1.45×10^{-3}	4.85×10^{-3}	3.09×10^{-3}	5.52×10^{-2}
PM10	7.80×10^{-3}	5.15×10^{-4}	3.74×10^{-3}	6.68×10^{-2}
SO2	1.02×10^{-3}	7.01×10^{-4}	8.08×10^{-4}	1.44×10^{-2}
Total volatile organic compounds	3.04×10^{-1}	4.11×10^{-2}	1.56×10^{-1}	2.79
Benzene	1.70×10^{-2}	2.30×10^{-3}	8.74×10^{-3}	1.56×10^{-1}
1,3-Butadiene	2.16×10^{-3}	2.92×10^{-4}	1.11×10^{-3}	1.98×10^{-2}
Chromium (VI) compounds	4.70×10^{-3}	3.10×10^{-4}	2.25×10^{-3}	4.02×10^{-2}
Cobalt and compounds	4.70×10^{-3}	3.10×10^{-4}	2.25×10^{-3}	4.02×10^{-2}
Copper and compounds	4.70×10^{-6}	3.10×10^{-7}	2.25×10^{-6}	4.02×10^{-5}
Cyclohexane	5.17×10^{-4}	7.00×10^{-5}	2.66×10^{-4}	4.75×10^{-3}
Ethylbenzene	3.96×10^{-3}	5.34×10^{-4}	2.04×10^{-3}	3.64×10^{-2}
Formaldehyde	2.80×10^{-3}	6.80×10^{-4}	1.59×10^{-3}	2.84×10^{-2}
n-Hexane	5.48×10^{-4}	7.40×10^{-4}	6.17×10^{-4}	1.10×10^{-2}
Lead	7.52×10^{-5}	4.51×10^{-5}	5.63×10^{-5}	1.01×10^{-3}
Manganese and Compounds	4.70×10^{-6}	3.10×10^{-7}	2.25×10^{-6}	4.02×10^{-5}
Nickel and Compounds	4.70×10^{-6}	3.10×10^{-7}	2.25×10^{-6}	4.02×10^{-5}
PAH	8.95×10^{-4}	1.21×10^{-4}	4.60×10^{-4}	8.22×10^{-3}
Styrene	3.04×10^{-4}	4.10×10^{-5}	1.56×10^{-4}	2.79×10^{-3}
Toluene	2.86×10^{-2}	3.87×10^{-3}	1.47×10^{-2}	2.63×10^{-1}
Xylenes	2.10×10^{-2}	2.83×10^{-3}	1.08×10^{-2}	1.93×10^{-1}

Zinc and Compounds	4.70 X 10^{-6}	3.10 X 10^{-7}	2.25 X 10^{-6}	4.02 X 10^{-5}

[a] EA, (1999i)
[b] Based on the percentage of 2-stroke and 4-stroke usage found in the Perth airshed (44.6% 2-stroke, 50.4% 4-stroke)

B.7.1.2 Spatial Distribution

Domestic lawn mower and garden equipment use emissions were distributed by the proportion of dwellings per grid cell within the Perth airshed. The number and distribution of dwellings in the Perth airshed was derived from 1996 ABS Census information. These figures were scaled to 1999 numbers by applying the population growth rate for each year (Appendix B.1.4).

B.8 Dry Cleaning

In 1998 / 1999 it was estimated that approximately 133.2 tonnes of perchloroethylene and 8.4 tonnes of white spirit was consumed in the Perth region (ORICA, A. Bradley; Drytech Industries, V. Chelose; West Fuel, B. Scott; Drycleaning Supplies, Carina, personal communication, 1999). It was assumed that 90% of the perchloroethylene imported into Western Australia was consumed in the Perth Airshed.

B.8.1.1 Emission Factors

All solvents employed for dry cleaning purposes are assumed to escape to the surrounding environment. The Drycleaning Institute of Australia (1996) outlined that the majority (99.985%) of the perchloroethylene and white spirit used in the dry cleaning process is released into the atmosphere. The remainder (0.015%) is emitted as part of the waste water and hazardous waste (filter and residue).

Table B.18: Speciation of White Spirit.

Substances	% Weight of White Spirit
Toluene	0.5
Xylene	18.3

B.8.1.2 Spatial Distribution

Dry cleaning emissions as a result of perchloroethylene use were distributed by dividing the total emissions by the number of full time dry cleaning employees in the Perth airshed (382). Initially, the location of each premise was identified using information from ABS (Business Register (Electronic format), 1999) and the Internet Yellowpages (http://www.yellowpages.com.au/). One hundred and nine premises were identified and allocated to the corresponding grid cell. Each premise apart from those identified by the Textile Rental and Laundry Association (W.A.) were allocated 3 full time employees. Those specifically identified were allocated 10 full time employees (See Appendix B.1.6).

Emissions from the use of white spirits has been distributed using sales data supplied by V. Chelose, Drytech Industries; B. Scott, West Fuel; Carina, Drycleaning Supplies (personal communication, 1999). Due to the relatively small number of premises that use this dry cleaning chemical relatively accurate spatial distributions were achieved.

B.9 Cutback Bitumen

B.9.1 Methodology

According to local bituminous products suppliers between 1% and 5% of the total cutback bitumen used in Western Australia was consumed in the Perth airshed. Suppliers indicated that

water based emulsions and “hot mix” bitumen seal coats are normally used for road works within the metropolitan area (CSR Ltd, Mr. K. Manning; Boral Ltd, Mr. R. Evans; Pioneer Pty Ltd, Mr. P. Stringer; Hotmix Pty Ltd/Bitumen Emulsions, Mr. K. Box, personal communication, 1999). Processes associated with emulsion and “hot mix” are relatively low emitters of VOC’s and are not considered by this source category.

With additional information on the amount of bitumen, cutter and flux sold to the bituminous suppliers and a range of ‘typical’ mixture compositions, annual estimates were developed (BP, Mr. R. Allister; Shell, Ms. S. Jarvis, personal communication, 1999). Estimates indicate that 31.2 tonnes of kerosene (cutter) and 7.2 tonnes of distillate (flux) were consumed in the Perth airshed during 1998 / 1999 for cutback bitumen applications.

B.9.1.1 Emission Factors

The two major variables affecting the quantity of VOC’s emitted and the time over which emissions occur are the type and quantity of diluent (cutter and flux) used. It is assumed that medium cure cutback bitumen emission factors provide an accurate estimate of VOC emissions. The preparation of cutback bitumen involves heating the standard grade bitumen followed by the addition of the dilutent (cutter and/or flux). The mixture is then mixed thoroughly, which causes relatively high emission rates during the preparation and spraying stages. Approximately 65% of the cutter and 40% of the flux is released to the atmosphere, with the remainder bound within the bitumen substrate. Approximately 50% of the emissions occur in the first week, but continue for several months. Xylene is estimated to be 19% by weight of the total VOC’s emitted.

These emission factors are adapted from AP-42 (USEPA, 1985) document and an Australian study by J. L. Chester (1986). These emission factors have been utilised by the PPSS, MAQS and slightly modified for the Dandenong/Port Pirie/Newcastle/Launceston NPI Trial (EPAV, 1996).

B.9.1.2 Spatial Distribution

Emissions from cutback bitumen within the Perth airshed were proportioned using the road classification ‘residential’ as described by Main Roads Western Australia. This road classification was considered a better proxy for spatial distribution than population data, which was used in the MAQS (EPAV, 1997), PPSS (Stuart and Carnovale, 1994) and Port Pirie, Newcastle, Dandenong and Launceston NPI Trial (EPAV, 1996).

B.10 Gaseous fuel burning (domestic)

B.10.1 Methodology

AlintaGas provided temporal consumption data. This information will not be published within this document as the data was stated to be commercially confidential and accepted in confidence by the DEP.

B.10.1.1 Emission Factors

Emission factors derived during the PPSS were used for this study (Table B.23 and Table B.24). These emission factors were also used by the Dandenong/Port Pirie/Newcastle/Launceston NPI Trial (EPAV, 1996).

Table B.19: Emission Factors Gaseous Fuel Burning.

Substance	Emission Factors (kg/million m^3)
CO	640
NOx	1500
PM10	182.8
SO2	15
Total VOC	118.8

Individual VOC's were speciated according to the percentages in Table B.24.

Table B.20: VOC Speciated Emissions factors for Gaseous Fuel Burning.

Substance	Emission Factors (% of Total VOC)
Benzene	9
Toluene	5

B.10.1.2 Spatial Distribution

Previous inventories (EPAV, 1996; EPAV 1997; Stuart and Carnovale, 1994) used relative population data to distribute similar sources. This inventory used a map of the metropolitan gas distribution network, supplied by AlintaGas, to proportion the emissions from domestic and small business natural gas combustion (Appendix B.1.7). This method was assumed to be more accurate as it outlined the actual extent of the network system.

B.11 Natural / Town Gas Leakage

B.11.1 Methodology

The leakage of natural gas to air from the gas distribution network is dependent on a number of factors including:

- type and condition of the gas pipeline;
- pressure in the network;
- soil permeability;
- number of service customers; and
- accidental pipe ruptures by contractors and excavation work (third party damage).

According to AlintaGas, the gas distribution network for domestic and commercial / light industrial consumers is relatively new and predominantly constructed from polymer pipe with a corresponding low rate of permeation and gas loss (AlintaGas, MacKenzie, D., personal communication, 1999). Major industry within the Perth airshed is supplied natural gas by high pressure steel piping, which is assumed to be leak free.

The amount of natural gas that is lost from the network is defined as unaccounted for gas (UAFG). UAFG consists of line losses and metering inaccuracies. The polymer piping accounts for approximately 90% of the Perth distribution network, with the remaining 10% consisting mainly of steel and cast iron pipe (Stuart and Carnovale, 1994). The gas meters ‘run slow’ over time, and are replaced at specific intervals. However, meter errors still account for approximately 50% of the UAFG in the Perth region (AlintaGas, Bromly, J., personal communication, 2000).

Therefore, approximately 50% of the UAFG is lost from the gas distribution network to the surrounding environment. Leakages from the pipe network accounts for approximately 97% of the actual loss. Third party damage and purging of the gas lines accounts for 2% and 1% respectively of the remaining UAFG losses to the environment (AlintaGas, Bromly, J., personal communication, 2000).

B.11.1.1 Emission Factors

AlintaGas estimated their actual gas losses over their entire 10,500km gas network as being 8,825,643 standard cubic meters. The methane and other non volatile components were then removed from this quantity before conversion to kilograms as per table .

Table B.21: Typical Analysis of AlintaGas's Gas and Quantification of Total VOC's Based on 8,825,643 m^3 (at STP) Gas Loss

Substance	**Typical Analysis** (%mol)	**Quantity** (m^3)	**Quantity** (tonnes)	**VOC's** (kilograms)
Nitrogen	2.47	217993		
Carbon Dioxide	2.2	194164		
Methane	84.68	7473554	5071	
Ethane	6.84	603674	768	767873
Propane	2.82	248883	464	464167
Butanes	0.93	82078	202	201748
Higher Alkanes	0.06	5295	17	16945
Total	100.00	8825643		1450734

(Source: AlintaGas, Bromly, J., personal communication, 2000)

It has been assumed that all natural gas lost from the gas distribution network will enter the atmosphere. It is understood that some gas lost underground may be partially or completely absorbed by the soil and consumed by bacterial action. However, there were not any reliable estimates of the significance of such a process for the Perth network, so it was assumed negligible. Emissions of total VOC's were based on the non-methane component of the gas.

B.11.1.2 Spatial Distribution

Natural gas emissions from third party damage were proportioned into the grid cell based on the extent of the gas distribution network (see Appendix B.1.8.). AlintaGas provided a map showing the extent of the gas distribution network. It was assumed that third party damage occurs evenly throughout the distribution network. Natural gas emissions from leakages were also distributed using the gas distribution network. However, it was assumed that non-polymer pipes released approximately 10 times more gas than polymer pipes.

B.12 Cigarettes

B.12.1 Methodology

There appears to be little work that considers the consumption of cigarettes in some detail. *Tobacco in Australia: Facts and Issues* (Quit Victoria, 1999) provides research, information and statistics on smoking and cigarette consumption for the Australian population. Information from this document was used to estimate cigarette consumption for the Perth airshed.

The estimated total consumption of cigarettes consumed per person (over the age of 15) annually was 1825 grams. The average cigarette weight was assumed to be 0.712 grams. Therefore, an estimated 2563 cigarettes are consumed annually per person over the age of 15. The Integrated Regional Database complied by the ABS (1998) was used to determine that 78.9% of the population are over the age of 15 years. With population of 1.31 million people in the Perth airshed, it was estimated that 2650 million cigarettes are consumed annually.

B.12.1.1 Emission Factors

The British Columbia Ministry of Health and Ministry Responsible for Seniors (1999) *1998 Reports on Cigarette Additives and Smoke Constituents* provided emission factors for 11 of the most popular cigarettes in Canada. It was assumed that the composition of the cigarettes in Canada is comparable to those in Australia. Emission factors used to determine emissions from this source are summarised in Table B.22.

Table B.22 Summary of Emission factors for cigarette consumption.

Substance	µg/cigarette
CO	56060
NOx	1475.7
1,3-Butadiene	226.5
Acetone	1204.5
Benzene	318.5
Cadmium & compounds	0.84
Lead & compounds	0.06
Methyl ethyl ketone	230.3
Toluene	572.1

B.12.1.2 Spatial Distribution

Emissions from cigarettes within the Perth airshed were proportioned using population data. Environment Australia provided this data for NPI reporting. The latest ABS population data from the 1996 census was used and multiplied by the population growth data to estimate the current population. The distribution of the population throughout the study area is presented in Appendix B.1.4.

B.13 Biogenics

B.13.1 Methodology

Due to resource limitations, emissions from biogenic sources were not calculated during the current study. The results presented (8,400 tonnes of NOx) were taken directly from estimates made during the 1996 Perth Photochemical Smog Study.

Emissions were estimated using factors generated by (Cope and Ischtwan, 1995) and input into the DEP's emissions calculations. Input variables included land use type, time and area. As emissions are directly related to the study area, emissions occur on a diurnal profile peaking at mid-day and falling to zero during the night (Rye, personnal communication 2000).

B.13.1.1 Emission Factors

Emission factors used in the original study were generated by Cope and Ischtwan (1995). The final emission factors used after considering the variables land use type, time and area, are presented in Table B.23.

Table B.23: Biogenic Emission Factors

Landuse Type	Emission Factor (ng of Nitrogen/m^2/second)
Agricultural	20
Rangeland	10
Various Forests	2

B.13.1.2 Spatial Distribution

Biogenic emissions estimated during the PPSS were evenly distributed over all land surfaces in the study area.

B.14 References

ABARE, “Australian Mineral Statistics; March Quarter 1998; June Quarter 1998; September 1998; December 1998; March Quarter 1999; June Quarter 1999”, Canberra.

ABS, 1996 “Business register”, Microsoft Excel file, Commonwealth of Australia.

ABS, 1998, “IRDB 98 Integrated Regional Database”, CD ROM, Commonwealth of Australia.

British Columbia Ministry of Health and Ministry Responsible for Seniors, 1999, “1998 Reports on Cigarette Additives and Smoke Constituents”, http://www.aslvin.com/poisons/chemlookup.asp
.
Chester, L. 1986,

Cope, M.C. and Ischtwan, J., 1995, “Perth Photochemical Smog Study, Airshed Modeling Component, Final Report”, EPA Victoria,

Drycleaning Institute of Australia, 1996, “Code of Practice for Safe Handling of Perchloroethylene in the Drycleaning Plant”, DIA, Melbourne Institute of Textiles, Melbourne.

EA, Environment Australia, 1999a, “NPI Emission Estimation Technique Manual for Aggregated Emissions from Fuel Combustion – sub reporting threshold facilities” Environment Australia, Canberra.

EA, Environment Australia, 1999b, “NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic Solid Fuel Burning”, Environment Australia, Canberra.

EA, Environment Australia, 1999c, “NPI: Emission Estimation Technique Workbook Domestic Wood Combustion”, Environment Australia, Canberra.

EA, Environment Australia, 1999d, “NPI Emission Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings”, Environment Australia, Canberra.

EA, Environment Australia, 1999e, “NPI: Area-Based Emissions Estimation Workbook Architectural Surface Coating”, Environment Australia, Canberra.

EA, Environment Australia, 1999f, “NPI: Area-Based Emissions Estimation Workbook Motor Vehicle Refinishing”, Environment Australia, Canberra.

EA, Environment Australia, 1999g, “NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic/Commercial Solvent and Aerosol Use”, Environment Australia, Canberra.

EA, Environment Australia, 1999h, “NPI: Emission Estimation Technique Manual for Aggregated Emissions from Service Stations”, Environment Australia, Canberra.

EA, Environment Australia, 1999i, “NPI: Emission Estimation Technique Manual for Aggregated Emissions from Domestic Lawn Mowing”, Environment Australia, Canberra.

EA, Environment Australia, 1999j, “NPI Emission Estimation Technique Manual for Cement Manufacture”, Environment Australia, Canberra.

EA, Environment Australia, 1999k, “NPI Emission Estimation Technique Manual for Lime and Dolomite Manufacturing”, Environment Australia, Canberra.

EA, Environment Australia, 1999l, "NPI Emission Estimation Technique Manual for Bricks, Ceramics, and Clay Product Manufacturing", Environment Australia, Canberra.

EA, Environment Australia, 1999m, "NPI Emission Estimation Technique Manual for Glass and Glass Fibre Manufacturing", Environment Australia, Canberra.

EA, Environment Australia, 1999n, "NPI Emission Estimation Technique Manual for Combustion in Boilers", Environment Australia, Canberra.

EA, Environment Australia, 1999o, "NPI Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation", Environment Australia, Canberra.

EA, Environment Australia, 1999p, "NPI Emission Estimation Technique Manual for Petroleum Refining", Environment Australia, Canberra.

EA, Environment Australia, 1999q, "NPI Emission Estimation Technique Manual for Combustion Engines", Environment Australia, Canberra.

Eastern Research Group, 1996, "EIIP, Vol III, CH 5: Consumer and Commercial Solvent Use", USEPA: http://www.epa.gov/ttn/chief/eiip/iii05.pdf.

Environment Australia, 1999e, "NPI: Area-Based Emissions Estimation Workbook Motor Vehicle Refinishing", Environment Australia, Canberra.

Environmental Protection (Recovery of Vapours from the Transfer of Organic Liquids) Regulations 1995 (Western Australia)

EPAV, Environmental Protection Authority of Victoria (1996)" Report on the Air Emissions Trials for the National Pollutant Inventory" Australian Government Publishing Service.

EPAV, Environmental Protection Authority of Victoria (1997)"Metropolitan Air Quality Study: Air Emissions Inventory" by Carnovale, F., Tilly, K., Stuart, A., Carvelho, C., Summers, M., and Erikson, P.. for the NSW EPA. Australian Government Publishing Service.

Farrington, V., 1988, "Air Emission Inventories (1985) for the Australian Capital Cities", Australian Environmental Council Report No. 22.

FIFWA, 1997, "Submission by the Forest Industries Federation of Western Australia to Select Committee on Perth's Air Quality Discussion Paper 1 – Smoke Emission from Homes" Submission 116 to the Report of the Select Committee on Perth's Air Quality, Forest Industries Federation (WA) Inc.

FTS, 1989, "Fuelwood Use and Supply in Australia" Report to Energy Research and Development Corporation, Project No. 28.

James, B. (1995), "Perth Photochemical Smog Study: Motor Vehicle Emissions Inventory". Transport Report 358, December 1995. Transport Department of Western Australia.

Quit Victoria, 1999, "Tobacco in Australia: Facts and Issues", Quit Victoria: http://www.quit.org.au.

Radian Corporation, 1997a "EIIP Vol III, CH 2: Residential Wood Combustion", USEPA: http://www.epa.gov/ttn/chief/eiip/iii02.pdf.

Stuart, A. and Carnovale, F. (1994) "Perth Photochmical Smog Study: Area Based Emissions Inventory." Environmental Protection Authority of Victoria.

UBD, (1999). "UBD Perth 1999; 41st Edition Street Directory". Universal Press Pty Ltd.

USEPA, 1985, “Compilation of Air Pollutant Emission Factors. Stationary Point and Area Sources, Fourth Edition, Volume 1, Chapter 5”, United States Environmental Protection Agency:

USEPA, 1995, “Compilation of Air Pollutant Emission Factors. Stationary Point and Area Sources, Fifth Edition, Volume 1, Chapter 5”, United States Environmental Protection Agency: http://www.epa.gov/ttn/chief/ap42c5.html.

Yellow Pages http://www.yellowpages.com.au Downloaded 1999.

Appendix B.1.1: Distribution of Sub Reporting Facilities In the Study Area

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517																													
6514																													
6511																	1												
6508																													
6505									1																				
6502											1																		
6499																													
6496												1																	
6493																													
6490											1	1																	
6487																			1										
6484											1		3																
6481													2																1
6478															2						1								
6475												1	1	1	7			1	1										
6472												5	1	1	3	6		1	1										
6469												1	5	4		5		1	1										
6466											1	2	8	13	2	4	1												
6463											2	1	2			8	13	4											
6460													1	1	2	8	5												
6457											1		1		1		4	1											
6454											4	7			2	13			1										
6451											4	2	2		1			1											
6448											2	5	2	1	1	1													
6445											4	1		1			1		1										
6442												2																	
6439												2																	
6436									1		9	2																	
6433											10				1														
6430											2																		
6427																													
6424																													

Appendix B.1.2: Number of Dwellings per Grid Cell in the Perth Study Area.

Number of Dwellings 488879

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520				2	10	10	10	2						1	1	1	1	9	19	13	10	10	9						
6517					238	63	10	9	9	9	9	10	10	10	10	10	10	18	19	10	10	10	9						
6514					261	88	10	10	10	10	10	10	10	10	10	10	10	15	16	10	10	10	8						
6511						130	396	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4						
6508						48	160	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	4			2	6	9	6
6505							4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	7	5	5	10	10	10	10
6502								9	10	10	10	10	10	10	10	10	10	10	10	10	22	16	10	10	10	10	10	10	10
6499								4	621	10	10	10	10	10	10	10	10	16	220	121	38	25	10	10	10	10	10	10	10
6496								177	3012	312	38	56	10	10	10	10	10	19	88	83	38	20	10	10	10	10	10	10	10
6493									320	521	213	215	67	71	10	10	10	16	38	38	22	10	10	10	10	10	12	15	14
6490									77	3054	1338	299	139	77	10	10	17	45	61	64	22	10	10	12	22	23	21	19	19
6487									2	4066	3564	3053	360	144	13	10	55	195	167	94	36	10	10	21	38	31	19	19	19
6484										4175	5557	2340	240	195	21	20	68	93	134	102	35	10	10	18	28	19	19	95	19
6481										2808	5569	5890	1757	1432	301	42	50	101	281	123	10	11	14	20	33	23	35	50	19
6478										1018	6311	5454	6510	5596	4516	586	129	277	259	102	56	32	60	89	94	76	86	46	22
6475										494	4405	3353	6322	4285	3361	4012	2121	609	2292	1687	65	83	546	410	526	113	198	38	19
6472										22	9090	4688	9246	7333	6871	5013	3438	1333	2491	2870	665	312	621	561	272	25		2	15
6469											3979	4387	7793	7618	9971	2988	1276	572	402	813	933	302	120	135					
6466											1233	4879	6604	5447	2862	4519	1393	1954	2170	1085	77	31	13	1					
6463										10	4736	5991	1326	6107	8205	5994	868	1625	1582	2462	188	29	29	22	3				
6460		15	57	130						211	5353	1896	1659	6681	5660	3609	2893	484	1399	2359	366	23	27	23	17	2			
6457	10	11	12	175						231	4676	6758	5523	4346	5004	4753	2749	1412	313	36	81	33	19	19	19	18	3		
6454										1138	7252	5210	5352	6253	5006	2486	6362	3945	864	62	29	20	19	19	19	19	13		
6451										46	4027	5423	1899	2642	650	992	2850	4577	683	111	107	14	14	12	13	12	10		
6448								129			1763	2949	3024	567	120	169	156	2188	2612	799	1015	18	13	10	10	10	8		
6445								15		8	423	653	551	782	113	83	96	3501	3673	169	40	19	19	15	10	10	8		
6442											75	237	185	237	122	105	133	1355	1650	22	19	19	19	19	17	11	8	3	
6439											21	108	40	101	124	102	105	243	202	28	28	22	19	19	19	19	15	10	1
6436											48	545	519	125	74	49	48	224	659	10	12	23	20	19	19	19	19	19	10
6433											78	1770	2873	170	75	41	40	94	21	10	10	21	25	19	12				
6430									324	1867	1145	444	285	58	28	19	19	174	35	10	10	19	27	20	2				
6427									1438	5160	4200	138	38	38	25	19	19	217	38	10	8	1							
6424										938	3128	146	38	36	17	17	19	65	67	118	34								

Appendix B.1.3: Distribution of Motor Vehicle Refinishes in Perth Airshed

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517																													
6514																													
6511							1																						
6508																													
6505																													
6502																													
6499																													
6496									1																				
6493																													
6490																													
6487																													
6484													7																
6481													17																
6478															3														
6475												5	3		12														
6472											25	15			18	24		12	4				2						
6469											5	10	2	1	5	13	1				1								
6466												4	8	9	11	18													
6463												3			5	10	8	2											
6460													1	1		13	8				3								
6457										3	4	10				1	7	25											
6454										5	11			7				4											
6451										14	2																		
6448											9	4																	
6445																	14												
6442											1				1		3												
6439											3																		
6436																	1	1											
6433											2			1															
6430										11																			
6427																													
6424																													

Appendix B.1.4: Distribution of Perth Population by AMG Cell

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520				10	38	38	38	19	10	10	10	10	10	10	10	10		19	48	29	19	19	19	10	10	10	10	10	10
6517					572	162	38	29	19	19	19	19	19	19	19	19	19	48	48	19	19	19	19	10	10	10	10	10	10
6514					591	210	38	38	19	19	19	19	19	19	19	19	19	38	38	19	19	19	19	10	10	10	10	10	10
6511						315	1097	38	19	19	19	19	19	19	19	19	19	19	19	19	19	19	10	10	10	10	10	10	10
6508						124	429	38	19	19	19	19	19	19	19	19	19	19	19	19	19	19	10	10	10	19	29	38	29
6505							19	38	29	19	19	19	19	19	19	19	19	19	19	19	19	19	19	10	19	38	38	38	38
6502								38	29	19	19	19	19	19	19	19	19	19	19	29	67	48	19	19	19	38	38	38	38
6499								10	1860	29	19	19	19	19	29	29	29	48	601	372	124	76	19	19	19	38	38	38	38
6496								439	9042	992	114	172	19	19	29	29	29	48	448	267	124	57	19	19	19	19	29	38	29
6493									954	1679	687	687	200	210	29	29	29	48	95	95	57	19	19	19	19	19	29	48	48
6490									191	9853	4282	858	439	229	29	29	48	134	172	181	57	19	19	29	57	67	57	57	57
6487										12952	10711	8365	1125	439	38	29	162	591	496	286	95	19	19	57	114	95	57	57	57
6484										12618	16128	7811	744	572	67	67	200	277	391	286	95	19	19	48	86	57	57	248	57
6481										8594	16281	18150	5332	4254	1001	143	172	334	820	362	19	29	38	57	105	67	105	143	57
6478										2737	19581	15928	18808	17111	14440	1831	410	877	877	343	153	105	200	286	286	219	267	134	57
6475										1116	11436	9376	15775	12723	10034	12332	6304	1612	6619	4988	172	238	1698	1221	1602	334	610	105	48
6472										57	19648	11541	18656	16414	16710	13963	8536	3519	6219	8050	1850	887	1745	1545	801	76			38
6469											10778	10158	17235	18112	20716	6648	3176	1679	1221	2442	2709	887	334	353					
6466											3376	11655	15194	15814	6667	10873	3529	5847	6562	3043	219	86	38						
6463										19	11655	16548	3319	13076	17712	13668	2213	4864	4569	6676	525	76	76	57	10				
6460		48	181	401						458	12590	5608	4073	14125	13610	8565	7583	1507	4139	7220	1106	67	76	67	48	10			
6457	29	38	38	534						553	11035	15775	13515	11245	13343	13038	7611	4101	887	105	277	114	57	57	57	57	10		
6454										3081	16643	13296	17273	18494	15480	7354	18761	10587	2528	191	76	57	57	57	57	57	38		
6451										95	9786	14040	5866	9004	2165	3605	9376	13038	1736	343	324	38	38	29	29	29	29		
6448								391			5007	8851	8689	1841	448	773	429	6428	7268	2327	3071	57	38	19	19	19	19		
6445								48		19	1164	1946	1602	2318	362	238	277	10549	10015	477	105	57	57	38	19	19	19		
6442								48			200	668	563	706	372	324	401	4168	4292	57	48	48	48	57	48	29	19	10	
6439								57			57	305	124	324	401	343	343	763	668	95	95	67	48	48	48	48	38	19	
6436								57	19		134	1269	1278	458	277	153	153	715	2051	29	38	76	57	48	48	48	48	48	29
6433								10	10		162	4607	8307	849	343	124	124	286	67	29	29	67	76	48	29				
6430									906	4225	2919	1393	887	172	76	48	48	496	95	29	29	67	86	57	10				
6427									3548	13048	12246	467	124	124	67	48	48	620	105	29	29	10	10	10					
6424										2623	9652	467	124	114	48	48	48	172	172	315	105	10	10	10	10				

Appendix B.1.5:Distribution of Service Stations in Perth Airshed by AMG Cell

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517						1																							
6514																													
6511								1																					
6508																													
6505									1																				
6502																													
6499																													
6496									4										2										
6493									1		1																		
6490										2																			
6487										3	5	2							2										
6484										3	3	1	4		1				1					1					
6481											2	3	2	1				1					1						
6478										2	2	2	5	5	3	1		3											
6475											3	2	7	5	4	4		2	2						1	1		1	
6472											5	9	7	2	8	7	4	3	6		1	1	3		2				
6469												1	6		13	4	2			1									
6466												10	11	8	3	8		3											
6463											3	7		6	12	6	3			5									
6460											4	1	4	5		3	3	1	1	2									
6457											5	3	6	3	4	4	2	2	2			1							
6454											9	7	3	1	4	2	5	8	3										
6451											4	3	3	2	2	2		1	1			1							
6448												7	2	1	1		1	2	4		2	1							
6445															2	1	1	3	2										
6442											1						2	2											
6439												1				1			2		1								
6436											1			1					3										
6433											3	4	3																
6430										2	1							1											
6427									3	2	2								1										
6424											3	1																	

Appendix B.1.6: Distribution of Dry Cleaning Premises in Perth Airshed Weighted by Employee Number.

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517																													
6514																													
6511																													
6508																													
6505																													
6502																													
6499																													
6496																													
6493																													
6490										3	6																		
6487												6																	
6484												6																	
6481											3		3																
6478											3	6		3															
6475													6	6	3														
6472											3	6	3		9			12					3						
6469											3	6	9	6	9														
6466												6	42	16		23				3									
6463											9	6			6	3		3											
6460											9	3	3	3		3	3			3									
6457										3	3	6		3		3													
6454										3		3	12		6		9	3											
6451												3	10		3														
6448													3					6											
6445														3	3				3										
6442														6	3														
6439																													
6436																													
6433												3	3																
6430																													
6427											9																		
6424											3																		

Appendix B.1.7: Distribution of Gas Consumption in the Perth Airshed (as a proportion of total gas used)

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517																													
6514																													
6511																													
6508																													
6505																													
6502																													
6499								7.00E-04	4.48E-03																				
6496								7.00E-04	9.80E-03	2.24E-03		7.00E-04																	
6493									1.40E-03	2.24E-03	2.80E-03	2.80E-03																	
6490									2.24E-03	1.05E-02	5.60E-03	2.31E-03																	
6487									7.00E-04	9.80E-03	8.40E-03	8.66E-03	1.44E-03					2.31E-03											
6484										8.96E-03	1.12E-02	6.72E-03	2.89E-03	1.44E-03			4.62E-03												
6481										6.72E-03	1.12E-02	9.33E-03	4.62E-03	4.62E-03	2.31E-03				2.31E-03										
6478										2.80E-03	1.12E-02	1.12E-02	1.15E-02	8.66E-03	1.01E-02	1.28E-03			3.85E-03	7.21E-04									
6475										1.87E-03	1.12E-02	1.06E-02	1.15E-02	1.15E-02	1.08E-02	1.08E-02	4.62E-03	1.92E-03	2.31E-03	4.62E-03									
6472										5.60E-04	1.12E-02	1.12E-02	1.12E-02	1.15E-02	1.15E-02	1.15E-02	4.62E-03	4.62E-03	6.59E-03	6.59E-03									
6469											1.12E-02	6.72E-03	9.80E-03	1.12E-02	1.15E-02	1.08E-02	4.62E-03	1.92E-03	2.31E-03	2.31E-03									
6466											1.06E-02	1.12E-02	8.71E-03	9.95E-03	7.07E-03	8.34E-03	3.53E-03	4.62E-03	6.92E-03	1.84E-03									
6463											1.06E-02	1.12E-02	2.24E-03	6.06E-03	7.18E-03	8.83E-03	6.63E-03	4.62E-03	4.62E-03	1.72E-03									
6460										7.00E-04	6.72E-03	5.60E-03	2.80E-03	6.32E-03	1.01E-02	1.01E-02	8.83E-03	3.53E-03	1.77E-03	3.58E-04									
6457										2.02E-03	7.22E-03	8.84E-03	7.22E-03	7.58E-03	7.58E-03	7.58E-03	6.63E-03	3.53E-03	7.36E-04										
6454										3.37E-03	1.01E-02	1.01E-02	1.01E-02	1.01E-02	9.47E-03	7.58E-03	7.73E-03	7.73E-03	3.53E-03										
6451										5.05E-04	9.47E-03	9.54E-03	4.04E-03	4.04E-03	4.04E-03	7.58E-03	5.30E-03	7.73E-03	3.53E-03										
6448											7.07E-03	7.07E-03	6.06E-03	4.04E-03	5.05E-04	1.47E-03		3.31E-03	6.63E-03	4.91E-04									
6445											2.02E-03	4.04E-03	3.37E-03	6.06E-03	6.32E-04	4.91E-04	5.52E-04	5.89E-03	8.34E-03	1.77E-03									
6442											5.61E-04	2.02E-03			5.05E-04	4.42E-04	5.52E-04	2.21E-03	5.52E-03										
6439												6.32E-04							1.10E-04										
6436											5.05E-04	5.61E-04	5.05E-04					5.85E-04	5.85E-04										
6433											1.68E-03	4.04E-03	7.58E-03	6.32E-04				3.51E-04	9.76E-05										
6430									6.32E-04	3.37E-03	4.04E-03	2.53E-03	3.37E-03																
6427									3.37E-03	8.98E-03	8.98E-03	5.05E-04																	

6424										3.37E-03	7.58E-03	2.53E-03																	

Appendix B.1.8: Gas Leakages in the Perth Airshed

AMG	352	355	358	361	364	367	370	373	376	379	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436
6520																													
6517																													
6514																													
6511																													
6508																													
6505																													
6502																													
6499								0.06	0.40																				
6496								0.06	0.88	0.20		0.06																	
6493									0.13	0.20	0.25	0.25																	
6490									0.20	0.94	0.50	0.20																	
6487									0.06	0.88	0.75	0.75	0.13					0.20											
6484										0.80	1.00	0.60	0.25	0.13			0.40												
6481										0.60	1.00	0.83	0.40	0.40	0.20				0.20										
6478										0.25	1.00	1.00	1.00	0.75	0.88	0.11			0.33	0.06									
6475										0.17	1.00	0.94	1.00	1.00	0.94	0.94	0.40	0.17	0.20	0.40									
6472										0.05	1.00	1.00	1.00	1.00	1.00	1.00	0.40	0.40	0.57	0.57									
6469											1.00	0.60	0.88	1.00	1.00	0.94	0.40	0.17	0.20	0.20									
6466											0.94	1.00	0.78	0.89	0.80	0.94	0.40	0.40	0.60	0.43									
6463											9.44	10.00	0.20	0.60	0.81	1.00	0.75	0.40	0.40	0.40									
6460										0.63	6.00	5.00	0.25	0.63	1.00	1.00	1.00	0.40	0.20	0.08									
6457										2.00	7.14	8.75	0.71	0.75	0.75	0.75	0.75	0.40	0.08										
6454										3.33	10.00	10.00	1.00	1.00	0.94	0.75	0.88	0.88	0.40										
6451										0.50	9.38	9.44	0.40	0.40	0.40	0.75	0.60	0.88	0.40										
6448											7.00	7.00	0.60	0.40	0.05	0.17		0.38	0.75	0.06									
6445											0.20	0.40	0.33	0.60	0.06	0.06	0.06	0.67	0.94	0.20									
6442											0.06	0.20			0.05	0.05	0.06	0.25	0.63										
6439												0.06						0.00	0.06										
6436											0.05	0.06	0.05					0.33	0.33										
6433											0.17	0.40	0.75	0.06				0.20	0.06										
6430									0.06	0.33	0.40	0.25	0.33																
6427									0.33	0.89	0.89	0.05																	

6424										0.33	0.75	0.25															

Appendix B.2

Table B.2.1: Source Documents and Assumptions Used In Estimating Combustion Emissions from Sub-Threshold Reporting Facilities

Combustion Process Description	Source for Emission Factors	Assumptions and Conversions Made When Entering Data
CLINKER /CEMENT (NG) – Emissions from calcination in natural gas fired kilns.	• All EF's based on kg substances emitted per tonne of clinker produced. • EF's for NOx, SO2 and CO from Table 3: Gas precalciner kilns, in the Cement Manufacturing EET Manual. Metal EF's from Table 4, and individual VOC emissions from Table 5 of the same manual (EA, 1999j). • PM_{10} emission factor is the sum of emission factors for limestone crushing with a fabric filter, wet process kiln with an electrostatic precipitator, clinker processing with a fabric filter and finished cement grinding with an electrostatic precipitator.	The only facilities engaged in calcination were Alcoa (which submitted their own NPI facility report) and Cockburn Cement (included in this spreadsheet).
PRODUCTION – LIME (coal) Emissions associated with lime production in coal fired operations.	• All EF's based on kg emitted per tonne of lime produced. • EF's for NOx, SO2 and CO from Table 5: Coal fired rotary kiln, in the Lime and Dolomite Manufacturing EET Manual. Metal EF's from Table 7, and individual VOC emissions from Table 8 of the same manual (EA, 1999k). • PM_{10} EF of 1 kg/tonne of product used as a rough guide based on Section 11.17 of the 1996 USEPA AP-42. Most PM_{10} emissions are derived from fugitive/non-combustion sources.	The quantity of coal burnt was not entered into the spreadsheet, as this emission factor was based on the quantity of lime produced.
PRODUCTION – LIME (NG) Emissions associated with lime production in coal fired operations.	• All EF's based on kg emitted per tonne of lime produced. • EF's for NOx, SO2 and CO from Table 5: Natural Gas fired parallel flow regenerative kiln with fabric filter, in the Lime and Dolomite Manufacturing EET Manual (this kiln type was chosen as it was the only natural gas kiln with emission factors for all three substances). Metal EF's from Table 7, and individual VOC emissions from Table 8 of the same manual (EA, 1999k). • PM_{10} EF of 1 kg/tonne of product was used as a rough guide based on Section 11.17 of the 1996 USEPA AP-42. Most PM_{10} emissions are derived from fugitive/non-combustion sources.	The quantity of natural gas burnt was not entered into the spreadsheet, as this emission factor was based on the quantity of lime produced.
PRODUCTION – BRICKS Emissions associated with brick production in natural gas fired kilns.	• All EF's based on kg emitted per tonne of bricks produced. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • EF's for remaining substances are based on Tables 9 and 10 for natural gas fired kilns, in the EET Manual for Bricks, Ceramic and Clay Product Manufacturing (EA, 1999l).	All brick producing facilities in the study were above the reporting threshold and have submitted their own facility reports for the NPI.

Table B.2.1: Source Documents and Assumptions Used In Estimating Combustion Emissions from Sub-Threshold Reporting Facilities (contd)

Combustion Process Description	Source for Emission Factors	Assumptions and Conversions Made When Entering Data
PRODUCTION – GLASS Emissions associated with glass production.	• EF's based on kg emitted per tonne of glass products produced. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NOx is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 4 and 5 of the EET manual for Glass and Glass Fibre Manufacturing (EA, 1999m).	All glass producing facilities in the study were above the reporting threshold and have submitted their own facility reports for the NPI.
NATURAL GAS BOILER – COMERCIAL Domestic boiler used in small industries for heating and cooking (< 3MW).	• All EF's based on kg emitted per cubic metre (m^3) of natural gas consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NOx is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 27 and 28 of the EET Manual for Combustion in Boilers (EA, 1999n).	Natural gas entered in cubic metres. The following conversion factors were used: • 1 energy unit = 3.6MJ • $1m^3$ = 0.84kg • 1MJ = 40.507 m3
NATURAL GAS BOILER – INDUSTRIAL Industrial boiler used in hospitals, hotels, large industries (3-30 MW).	• All EF's based on kg emitted per cubic metre (m^3) of natural gas consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NOx is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 27 and 28 of the EET Manual for Combustion in Boilers (EA, 1999n).	Natural gas entered in cubic metres. The following conversion factors were used: • 1 energy unit = 3.6MJ • $1m^3$ = 0.84kg • 1MJ = 40.507 m^3
NATURAL GAS - LOW NOx INDUSTRIAL BURNER Used in metal foundry furnaces, and similar processes but includes any burner/furnace/oven type equipment running on natural gas.	• All EF's based on kg emitted per cubic metre (m^3) of natural gas consumed. • NPI EET manuals did not contain generic EF's for burners. All relevant burners were industry specific and were based on the mass of product produced. Given DEP resource limitations, it was not possible to estimate emissions for every industry type in the study. Consequently, the best matched EF's chosen were those for industrial boilers. Following studies should abandon this methodology and use industry specific EF's where possible. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 27 and 28 of the EET Manual for Combustion in Boilers (EA, 1999n).	Natural gas entered in cubic metres. The following conversion factors were used: • 1 energy unit = 3.6MJ • $1m^3$ = 0.84kg • 1MJ = 40.507 m^3

Table B.2.1: Source Documents and Assumptions Used In Estimating Combustion Emissions from Sub-Threshold Reporting Facilities (contd)

Combustion Process Description	Source for Emission Factors	Assumptions and Conversions Made When Entering Data
NATURAL GAS TURBINE ELECTRIC GENERATOR Any turbine used for electricity generation.	• All EF's based on kg emitted per cubic metre (m^3) of natural gas consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 18, 19 and 21 of the EET Manual for Fossil Fuel Electric Power Generation (EA, 1999o). • EF's for refinery fuel gas combustion assumed to be identical to those for natural gas combustion.	Natural gas entered in cubic metres. The following conversion factors were used: • 1 energy unit = 3.6MJ • $1m^3$ = 0.84kg • 1MJ = 40.507 m^3
LPG BURNER COMMERCIAL Any burners (<3MW) running on LPG.	• All EF's based on kg emitted per litre of LPG consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NOx is a the sum of the NO and NO_2, emission factors provided by the PPSS. • Remaining EF's based on Table 29, Industrial Boilers of the EET Manual for Combustion in Boilers (EA, 1999n).	LPG entered in litres. The following conversion factors were used: • 1 kg = 50MJ • 1 kg = 1.98 Litres
LPG BURNER INDUSTRIAL Any burners (3-30MW) running on LPG.	• All EF's based on kg emitted per litre of LPG consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Table 29, Industrial Boilers in the EET Manual for Combustion in Boilers (EA, 1999n).	LPG entered in litres. The following conversion factors were used: • 1 kg = 50MJ • 1 kg = 1.98 Litres
LPG ENGINE Generally refers to smaller internal combustion engines such as forklifts.	• All EF's based on kg emitted per litre of LPG consumed. • EF's are based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • VOC profile for LPG engine was based on 'LPG burner commercial,' as described above (EA, 1999n).	LPG entered in litres. The following conversion factors were used: • 1 kg = 50MJ • 1 kg = 1.98 Litres
DIESEL ENGINE Industrial sized combustion engines running on diesel, but can include smaller internal combustion engines.	• All EF's based on kg emitted per litre of diesel/distillate consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Table 5 in the EET Manual for Combustion Engines (EA, 1999q).	Diesel entered in litres. The following conversion factors were used: • 1 kg = 45.5 MJ • 1 L = 0.85 kg

Table B.2.1: Source Documents and Assumptions Used In Estimating Combustion Emissions from Sub-Threshold Reporting Facilities (contd)

Combustion Process Description	Source for Emission Factors	Assumptions and Conversions Made When Entering Data
DISTILLATE BURNER COMMERCIAL Any diesel fired burner/furnace/oven equipment rated at <3MW.	• All EF's based on kg emitted per litre of diesel/distillate consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • NPI EET manuals did not contain generic EF's for burners. All relevant burner EF's burners were industry specific and required the mass of product .produced as an input. Given DEP resource limitations, it was not possible to estimate emissions for every industry type in the study. Consequently, the best matched EF's chosen were those for industrial boilers. Where possible, ensuing studies should abandon this methodology and use industry specific EF's • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • Remaining EF's based on Tables 33 and 34 of the EET Manual for Combustion in Boilers (EA, 1999n).	Diesel entered in litres. The following conversion factors were used: • 1 kg = 45.5 MJ • 1 L = 0.85 kg
RESIDUAL BURNER – COMMERCIAL Any residual oil fired Burner/furnace/oven equipment rated at <3MW.	• All EF's based on kg emitted per litre of residual oil(s) consumed. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NPI EET manuals did not contain generic EF's for burners. All relevant burner EF's burners were industry specific and required the mass of product produced as an input. Given DEP resource limitations, it was not possible to estimate emissions for every industry type in the study. Consequently, the best matched EF's chosen were those for industrial boilers. Where possible, ensuing studies should abandon this methodology and use industry specific EF's. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 33 and 34 of the EET Manual for Combustion in Boilers (EA, 1999n).	Residual oil entered in litres. The following conversion factors were used: • 1 kg = 45.5 MJ • 1 L = 0.85 kg

Table B.2.1: Source Documents and Assumptions Used In Estimating Combustion Emissions from Sub-Threshold Reporting Facilities (contd)

Combustion Process Description	Source for Emission Factors	Assumptions and Conversions Made When Entering Data
RESIDUAL BURNER INDUSTRIAL Any residual oil fired burner/furnace/oven equipment rated at <3-30MW.	• NOx is a the sum of the NO and NO_2, emission factors provided by the PPSS • NPI EET manuals did not contain generic EF's for burners. All relevant burner EF's burners were industry specific and required the mass of product produced as an input. Given DEP resource limitations, it was not possible to estimate emissions for every industry type in the study. Consequently, the best matched EF's chosen were those for industrial boilers. Where possible, ensuing studies should abandon this methodology and use industry specific EF's. • EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • Remaining EF's based on Tables 33 and 34 of the EET Manual for Combustion in Boilers (EA, 1999n).	Residual oil entered in litres. The following conversion factors were used: • 1 kg = 45.5 MJ • 1 L = 0.85 kg
PULVERISED COAL - PARALLEL BOILER coal powered burners for power stations.	• EF's for: CO, PM_{10}, Total VOC, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • EF's from Tables 12-16 for Sub-Bituminous Coal in the EET Manual for Combustion in Boilers for PC-fired, dry bottom, wall fired, sub-bituminous, Pre-NSPS boiler (EA, 1999n).	Data entered in tonnes
COKE Any process using coke as a fuel or a catalyst e.g. fluidised bed reactor.	• EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS.	Data entered in tonnes
SMOKEHOUSE SAWDUST Any process using sawdust i.e. smoking meat products.	• EF's based on PPSS • $NO_x$is the sum of the NO and NO_2 emission factors provided by the PPSS	Data entered in tonnes
H2 FIRED BOILER Any boiler using hydrogen.	• No EF's found. Only one facility burnt Hydrogen (28 tonnes)	
LFG BURNER Any boiler/burner using biogas i.e. landfill gas for raising steam or brick kiln burners.	• EF's for: CO, PM_{10}, Total VOC, Benzene, Toluene and Xylene based on PPSS. • NO_x is the sum of the NO and NO_2 emission factors provided by the PPSS. • LFG burner emissions were assumed to be the same as those for Natural Gas Industrial burner as was assumed for the PPSS.	LFG burner emissions are based on natural gas emission factors Data entered as cubic metres. Conversion factors used for natural gas (methane) of:1 m^3 = 40.507 MJ. However, as LFG is only 60% methane, only 60% of the actual LFG consumed was entered into the spreadsheet.

Appendix C:

NPI Reporting Facilities

Appendix C

1998/1999 NPI Reporting Facilities located in the Perth airshed study area:

Facility Name	Reporting Period	Duration
• ACI Glass Packaging	1 July 98 – 30 June 99	1 year
• Akzo Nobel Pty Ltd	1 July 98 – 30 June 99	1 year
• Alcoa World Alumina Australia - Kwinana Alumina Refinery	1 July 98 – 30 June 99	1 year
• Amcor Fibre Packaging Spearwood Mill	1 July 98 – 30 June 99	1 year
• Associated Corrosion Control Pty Ltd	1 July 98 – 30 June 99	1 year
• Beenyup Wastewater Treatment Plant	1 July 98 – 30 June 99	1 year
• BP Fremantle Bunkering Service	1 July 98 – 30 June 99	1 year
• BP North Fremantle Terminal	1 July 98 – 30 June 99	1 year
• BP Oil Australia – Kewdale Terminal	1 July 98 – 30 June 99	1 year
• BP Refinery, Kwinana	1 July 98 – 30 June 99	1 year
• Bristile Guardians Pty Ltd	1 July 98 – 30 June 99	1 year
• Buttercup Bakery (Quality Bakers Australia Limited)	1 July 98 – 30 June 99	1 year
• Caltex Australia Limited - Fremantle Terminal	1 July 98 – 30 June 99	1 year
• Chemical Formulators	1 July 98 – 30 June 99	1 year
• Coogee Chemicals Pty Ltd	1 July 98 – 30 June 99	1 year
• Cooper & Dysart P/L	1 July 98 – 30 June 99	1 year
• DFC Ceramics	1 July 98 – 30 June 99	1 year
• George Weston Foods - Tip Top Bakeries Canning Vale	1 July 98 – 30 June 99	1 year
• Joe White Maltings	1 July 98 – 30 June 99	1 year
• Kwinana Power Station	1 July 98 – 30 June 99	1 year
• Matilda Bay Brewing Co	1 July 98 – 30 June 99	1 year
• Metro Brick – Armadale	1 July 98 – 30 June 99	1 year
• Metro Brick – Bellevue	1 July 98 – 30 June 99	1 year
• Metro Brick – Byford	1 July 98 – 30 June 99	1 year
• Metro Brick – Malaga	1 July 98 – 30 June 99	1 year
• Midland Brick Co	1 July 98 – 30 June 99	1 year
• Mobil Oil - Perth Airport	1 July 98 – 30 June 99	1 year
• Nufarm Coogee – Kwinana Chlor-alkali Plant	1 July 98 – 30 June 99	1 year
• Nufarm Limited	1 July 98 – 30 June 99	1 year
• Pinjar Gas Turbine Station	1 July 98 – 30 June 99	1 year
• Point Peron Wastewater Treatment Plant	1 July 98 – 30 June 99	1 year
• Shell Company of Australia Ltd	1 July 98 – 30 June 99	1 year
• *Stephenson & Ward Incinerator Co Pty Ltd*	*1 May98 – 30 June 99*	*3 months*
• Subiaco Wastewater Treatment Plant	1 July 98 – 30 June 99	1 year
• *Talloman*	*1 June 98 – 30 June 98*	*1 month*
• *Tiwest Cogeneration Facility*	*7 Mar 98 – 30 June 99*	*3.75 months*
• Wesfarmers LPG Pty Ltd	1 July 98 – 30 June 99	1 year
• Western Australian Specialty Alloys (W.A.S.A)	1 May 98 – 30 April 99	1 year
• Woodman Point Wastewater Treatment Plant	1 July 98 – 30 June 99	1 year

*Note: Due to the early stage of the NEPM development, only 23 out of the 80 industry sectors were required to report in 1998 /1999, and some of these were only required to report for a partial year. Only 3 facilities in the study area reported for less than a 12 month period.

Appendix D:

Summary Emissions Data

Table D.1: 1998/1999 Emission Estimates for the Perth NPI Aggregated Emissions Study (%)

	Motor Vehicles	Other Mobile			Sub-threshold	Area Based Sources												Natural Sources		1998/99 NPI Reporting Facilities[1]
Substance	Motor Vehicles	Railways	Commercial Shipping/Boating and Recreational Boating	Aeroplanes	Fuel Combustion – sub reporting threshold facilities	Solid fuel burning (domestic)	Architectural Surface Coatings	Motor Vehicle Refinishing	Domestic/Commercial solvents/ aerosols	Service Stations	Lawn Mowing	Dry Cleaning	Cutback Bitumen	Gaseous Fuel Burning	Natural / Town Gas Leakage	Swimming Pools	Cigarettes	Biogenics	Burning(fuel red., regen., agric.)/ Wildfires	Reporting Facilities
Acetaldehyde	15	<1				84											<1			
Acetone	4			<1		68	17	8									<1			3
Acrylic acid									100											
Acrylonitrile (2-propenenitrile)																	100			
Antimony & compounds		100																		
Arsenic & compounds		<1			54															46
Benzene	55	<1	1	<1	2	25	<1		<1	1	5			<1			<1		6	4
Beryllium & compounds																				100
1,3-Butadiene (vinyl ethylene)	2	<1	4	3		27					14						<1		46	2
Cadmium & compounds		1			49	2											2			46
Carbon disulphide																				100
Carbon monoxide	79	<1	<1	<1	<1	9					2			<1			<1		6	3
Chlorine																100				
Chloroform (trichloromethane)									100											
Chromium (III) compounds																				100
Chromium (VI) compounds		<1			1	<1					16									82
Cobalt & compounds		<1			71						22									7
Copper & compounds		<1									8									92
Cumene (1-methylethylbenzene)										7										93
Cyclohexane							99			<1	<1									<1
1,2-Dichloroethane									100											
Dichloromethane							62		38											<1
1,2-Dibromoethane										73										27
Ethanol							99													<1
Ethylbenzene	93	<1							<1	<1	6									<1
2-Ethoxyethanol acetate							100													
Ethylene glycol (1,2-ethanediol)							50	29	21											<1

[1] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

Table D.1: 1998/1999 Emission Estimates for the Perth NPI Aggregated Emissions Study (%) (contd)

	Motor Vehicles	Other Mobile			Sub-threshold	Area Based Sources														Natural Sources		1998/99 NPI Reporting Facilities[1]
Substance	Motor Vehicles	Railways	Commercial Shipping/Boating and Recreational Boating	Aeroplanes	Fuel Combustion – sub reporting threshold facilities	Solid fuel burning (domestic)	Architectural Surface Coatings	Motor Vehicle Refinishing	Domestic/Commercial solvents/ aerosols	Service Stations	Lawn Mowing	Dry Cleaning	Cutback Bitumen	Gaseous Fuel Burning	Natural/ Town Gas Leakage	Swimming Pools	Cigarettes	Biogenics	Burning(fuel red., regen., agric.)/ Wildfires	Reporting Facilities
Ethylene oxide									100												
Fluoride compounds					2				<1												98
Formaldehyde (methyl aldehyde)	27	<1				71			<1		1			<1			<1				
n-Hexane		<1					90		6	2	<1										1
Hydrochloric acid									2												98
Lead & compounds	92	<1	<1	3	3					<1	1						<1				<1
Manganese & compounds		1				35					56										8
Mercury & compounds		<1			46																54
Methanol							26		74												
Methyl ethyl ketone						12	52	27	7								<1				2
Methyl isobutyl ketone							52	38	10												
Nickel & compounds		<1			88	<1					<1						<1				12
Oxides of nitrogen	46	1	5	<1	8	<1					<1			<1			<1	14	<1		25
Particulate Matter 10.0um	17	<1	1	<1	24	24					<1			<1					19		15
Phenol																	100				
Polycyclic aromatic hydrocarbons	<1	<1	<1		<1	92				<1	3										4
Selenium & compounds		100																			
Styrene (ethenylbenzene)						85					13						2				<1
Sulphur dioxide	4	<1	10	<1	25	<1					<1			<1							60
Sulphuric acid																					100
Tetrachloroethylene									11			89									
Total Volatile Organic Compounds	43	<1	<1		1	19	10	3	10	3	3	<1	<1	<1	3				2		<1
Toluene (methylbenzene)	56	<1	1	<1	<1	4	7	11	9	<1	5	<1		<1			<1		3		3
Trichloroethylene									100												
Xylenes (individual or mixed isomers)	65	<1	2	<1	<1	2	4	13	5	<1	4	<1	<1						2		1
Zinc and compounds		14									37										49

[1] Emissions from this source are incomplete as not all NPI reporting facilities were required to report in 1998/1999, and some industry sectors were only required to report for a portion of 1998/1999.

Table D.2: Summary of NPI Aggregated Emissions in the Perth Airshed

Substance	Motor Vehicles	Other Mobile	Area Based Sources	Natural Sources	Sub-threshold	1998/99 NPI Reporting Facilities1
Acetaldehyde	123,000	1,010	676,280			
Acetone	30,700	4,230	680,020			19,100
Acrylic acid						
Acrylonitrile (2-propenenitrile)			222			
Antimony & compounds		2.58				
Arsenic & compounds		0.06			198	166
Benzene	789,000	24,321	449,680	89,900	32,800	58,700
Beryllium & compounds						0.0001
1,3-Butadiene (vinyl ethylene)	1,370	5,509	29,131	32,300		1,625
Cadmium & compounds		1.25	3.63		47.7	44.
Carbon disulphide						2.60
Carbon monoxide	196,000,000	2,951,000	26,746,000	15,200,000	2,040,000	6,350,000
Chlorine			714,000			
Chloroform (trichloromethane)			588			
Chromium (III) compounds						0.04
Chromium (VI) compounds		0.17	19.8		1.39	98.4
Cobalt & compounds		0.11	19.7		63.7	6.59
Copper & compounds		0.56	19.7			224
Cumene (1-methylethylbenzene)			196			2,440
Cyclohexane			791,590			1,300
1,2-Dichloroethane			2.76			
Dichloromethane			56,700			15
1,2-Dibromoethane			9.2			3.37
Ethanol			22,800			181
Ethylbenzene	277,000	20.4	21,000			754
2-Ethoxyethanol acetate			49,500			
Ethylene glycol (1,2-ethanediol)			51,700			0.03
Ethylene oxide			8,970			
Fluoride compounds			8.39		2,210	105,340
Formaldehyde (methyl aldehyde)	277,000	3,000	741,508			
n-Hexane		481	863,590			13,100
Hydrochloric acid			1.04			66.5
Lead & compounds	42,600	1,561	499		1,300	364
Manganese & compounds		0.43	32			3
Mercury		0.47			155	185
Methanol			562,000			
Methyl ethyl ketone			400,840			8,960
Methyl isobutyl ketone			44,000			
Nickel & compounds		0.28	21.1		4,700	614
Oxides of nitrogen	28,100,000	3,992,000	551,910	8,716,000	4,830,000	15,000,000
Particulate Matter 10 um	1,650,000	187,500	2,385,500	1,870,000	2,400,000	1,460,000
Phenol			834			
Polycyclic aromatic hydrocarbons	328	886	136,352		125	5,680
Selenium & compounds		0.07				

Substance	Motor Vehicles	Other Mobile	Area Based Sources	Natural Sources	Sub-threshold	1998/99 NPI Reporting Facilities1
Styrene (ethenylbenzene)			10,777			1
Sulphur dioxide	729,000	1,701,600	51,650		4,090,000	9,970,000
Sulphuric acid						453
Tetrachloroethylene			149,800			
Total Volatile Organic Compounds	19,600,000	482,100	23,466,400	1,120,000	660,000	290,000
Toluene (methylbenzene)	1,580,000	42,628	1,021,852	89,100	17,400	81,200
Trichloroethylene			289			
Xylenes (individual or mixed isomers)	1,470,000	37,909	679,950	37,900	7,500	26,900
Zinc and compounds		7.47	19.7			25.9