Government of **Western Australia**
Department of **Water and Environmental Regulation**

Perth Air Emissions Study 2011–2012

Technical report 3: Commercial and Industrial Emissions



Report

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Temporal and spatially allocated emission estimates produced for this study can be made available on request. Please contact **npi@dwer.wa.gov.au** with queries and requests for information.

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Summary

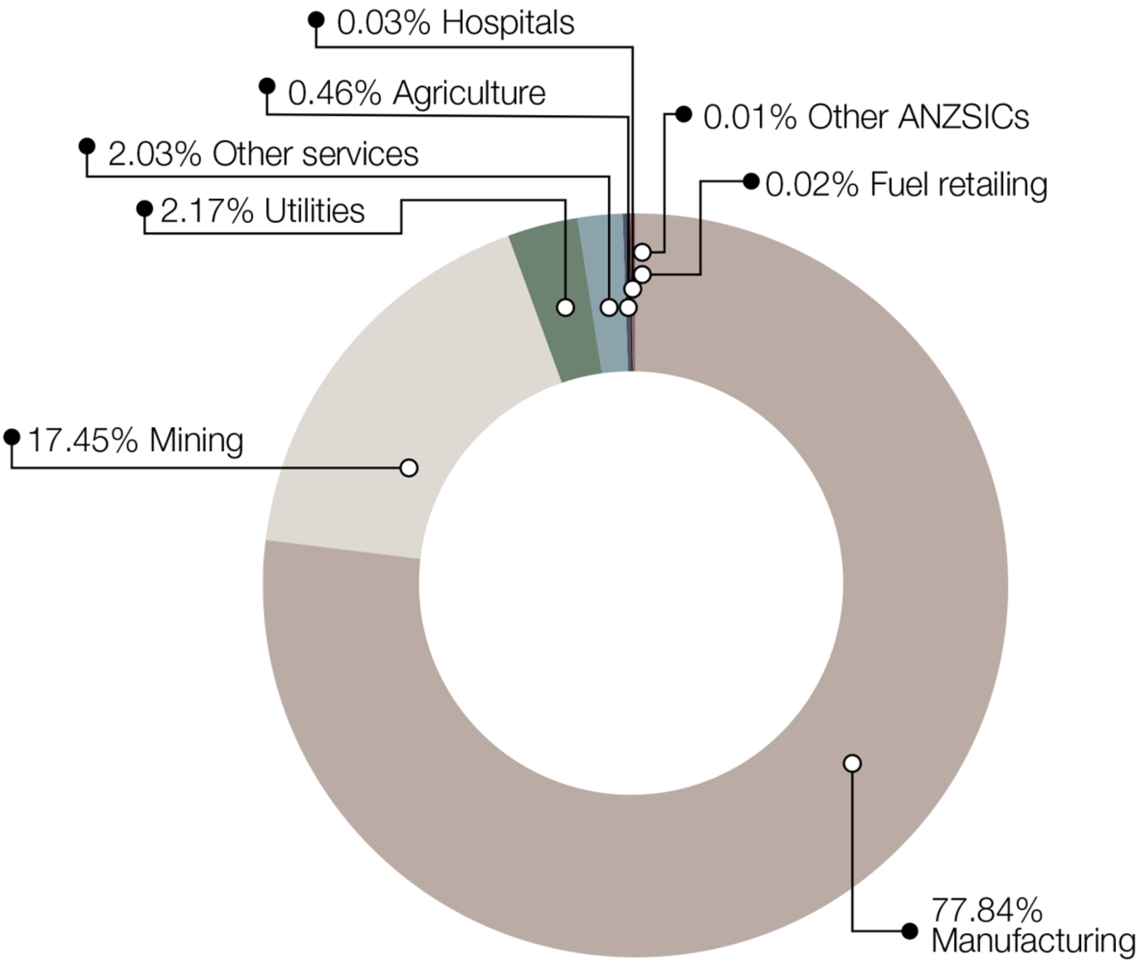
The Department of Water and Environmental Regulation (DWER) has completed an air emissions inventory of Perth for the 2011–12 financial year. The study area was generally consistent with the Australian Bureau of Statistics (ABS) Census Dataset: Greater Capital City Statistical Area – Greater Perth. The inventory estimated emissions for a variety of natural and anthropogenic emission sources.

This report summarises the emissions estimated for commercial and industrial activity.

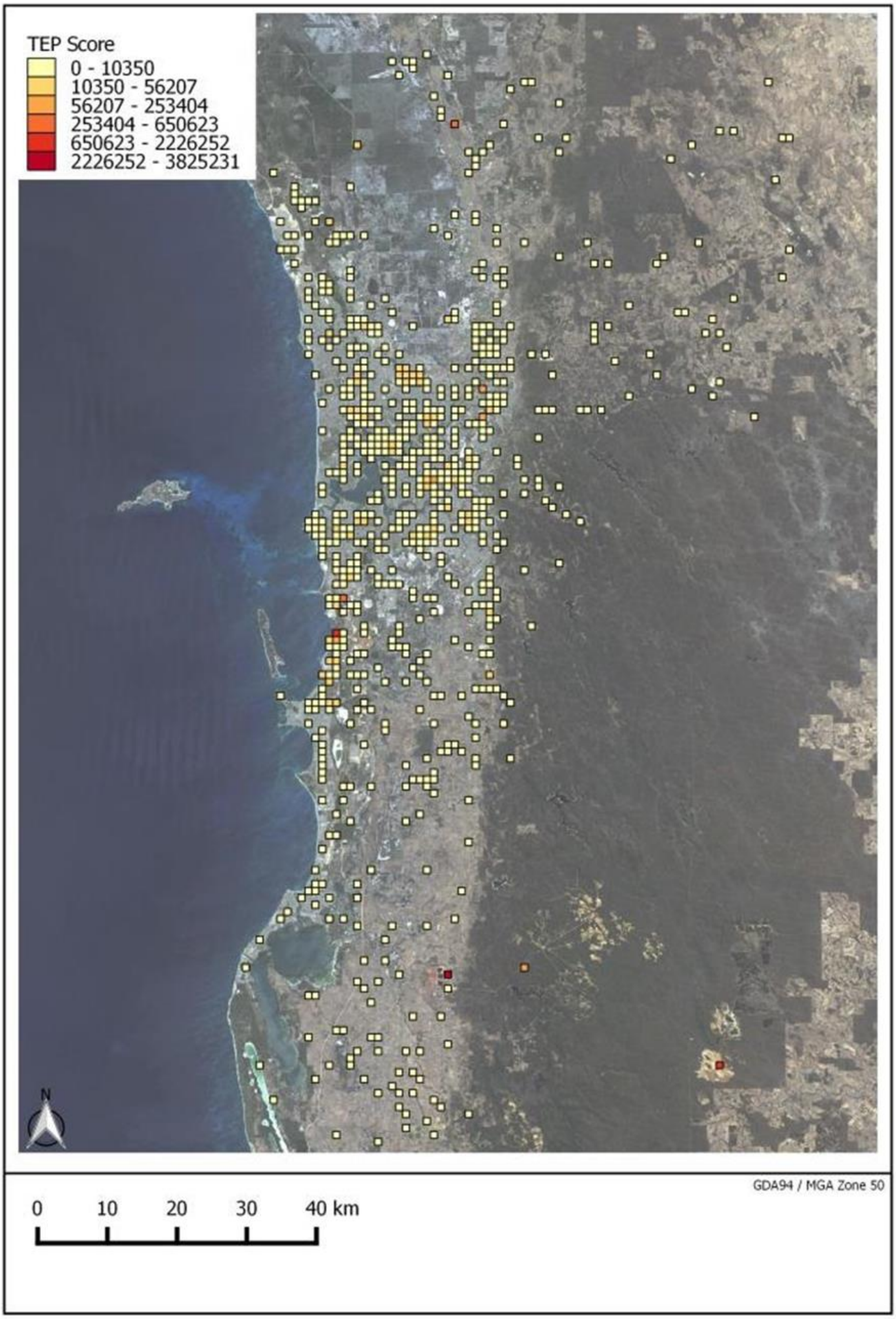
Emissions were estimated using the methodology published in the 2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales (NSW EPA 2012) as a framework for estimates. Methodologies were adapted to incorporate National Pollutant Inventory (NPI) data and to address the availability of local data. In some cases, methods were superseded with more applicable or recently developed methods. Emissions were spatially allocated with respect to registered business locations sourced from the Australian Business Registry (ABR) and other business directories.

Based on a toxic equivalency potential (TEP) scoring system, emission estimates from commercial and industrial sources for the 2011–12 financial year showed that particulate matter ≤ 2.5 µm ($PM_{2.5}$) emissions were the most significant major substance being emitted. Emission estimates of metals such as mercury, lead and cadmium, as well as polychlorinated dioxins and furans were comparatively small, but were found to be significant pollutants due to their high toxicity.

The summary figures show the relative contribution from emission sources to the overall TEP score for commercial and industrial emissions, and the spatial allocation of the TEP score. Manufacturing and mining facilities represented 96 per cent of the emission risk from commercial and industrial sources.



Summary figure – relative TEP contributions from commercial and industrial sources



Summary figure – spatial allocation of commercial and industrial TEP score

1 Introduction

The Department of Water and Environmental Regulation (DWER) has completed an air emissions inventory of Perth for 2011–12.

This technical report presents the emission estimate methods, calculated emissions, and spatial allocation of emissions of commercial and industrial emission sources.

This technical report focuses on emissions estimated as a result of commercial and industrial activities. It is one of six reports prepared for the Perth Air Emissions Study 2011–2012:

1. *Perth Air Emissions Study 2011–2012: Summary of emissions*
2. *Technical report 1: Biogenic and geogenic emissions*
3. *Technical report 2: Domestic emissions*
4. ***Technical report 3: Commercial and industrial emissions***
5. *Technical report 4: On-road vehicle emissions*
6. *Technical report 5: Off-road mobile emissions*

1.1 Inventory scope

This module is defined by the following study parameters:

Year

The data presented by this study represent emissions estimated for the 2011–12 financial year. This time period aligns with Australian Bureau of Statistics (ABS) census data and available datasets.

Where data are not available for 2011–12, data outside the study period have been used as being broadly representative of 2011–12.

Boundaries

This study includes Local Government Areas (LGAs) in the ABS Census Dataset: Greater Capital City Statistical Area – Greater Perth (ABS 2012a). The grid covers an area of 100 kilometres west to east (Rottnest Island to Toodyay) and 160 kilometres north to south (Two Rocks to Waroona). The corner coordinates are presented in Table 1 and the study area is shown in Figure 1.

Table 1 – Study grid corner coordinates

	Easting* (m)	Northing* (m)
North-west	350000	6525000
North-east	450000	6525000
South-west	350000	6365000
South-east	450000	6365000

* Geocentric Datum of Australia 1994 (GDA94 MGA Zone 50).

Figure 1 – Perth Air Emissions Study 2011–2012 boundaries

Spatial allocation

The study used a one kilometre grid to spatially allocate emission estimates. This scale balances the resolution of fine data (roads, individual point sources etc.) and computationally demanding calculations.

Grid coordinates start at the upper left corner, as illustrated in Figure 2.

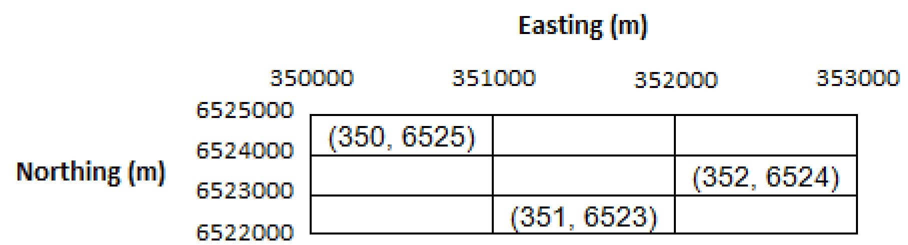


Figure 2 – Grid coordinate system

Emission substances

The substances of interest in this study module are those in the National Environment Protection (Ambient Air Quality) Measure. These include:

- carbon monoxide (CO);
- nitrogen dioxide (NO_2), as a subset of oxides of nitrogen (NO_X);
- particulate matter ≤ 2.5 µm ($PM_{2.5}$);
- particulate matter ≤ 10 µm (PM_{10}); and
- sulfur dioxide (SO_2).

Ozone (O_3), as a proxy for photochemical smog, is a secondary pollutant resulting from the chemical transformation of pollutants in the atmosphere over time, and was not directly considered in this study. Instead, emissions of volatile organic compounds (VOCs) were estimated because these, along with oxides of nitrogen, are considered to be precursors to smog formation.

Other emissions estimated are included in the list of substances of interest to the National Pollutant Inventory (NPI):

- ammonia;
- heavy metals, including lead, cadmium, copper, chromium, nickel, selenium and zinc; and
- organic compounds, including speciated volatiles, polycyclic aromatic hydrocarbons (B[a]Peq), and polychlorinated dioxins and furans (TEQ).

2 Study methodology

This report summarises the emissions from various industry types, defined by the Australian and New Zealand Standard Industrial Classification (ANZSIC) codes (ABS 2006).

Industries were identified using a range of methods, with the Australian Business Registry (ABR) being the primary data source. Directory searches and industry association groups were other sources for business identification.

Identified businesses were contacted and asked to provide activity data via an anonymous survey. The data collected by the survey were used to generate 'generic facility' activity profiles tailored to specific industries. Facilities that reported 2011–12 emissions to the NPI were also included in this report. Non-NPI facility emissions were estimated using relevant industry emission estimation techniques documented in this report.

The methods developed and used were based on readily available data. Any assumptions made to supplement data gaps are documented in the relevant method sections.

2.1 Facility identification

The facilities in this inventory range from major industries with environmental licences that report to the NPI through to small businesses that may cumulatively influence air quality in an area.

The ABR database was used to identify non-NPI commercial and industrial facilities (ABR 2014). The ABR business data used included:

- organisation name;
- business address (actual and postal), including facility coordinates;
- date of registration; and
- business classification (ANZSIC code).

The data were filtered to remove businesses that were not in the study area, were de-registered before July 2011, or were registered after June 2012. Identified businesses were verified by plotting their locations in Google Earth. Businesses registered at a residential address were removed from the database.

The Industry Licensing System (ILS) of the former Department of Environment Regulation (now DWER) was also queried to identify facilities with an environmental licence that did not report to the NPI during 2011–12.

Other facility data verification checks included searching the White Pages directory and industry association webpages, as well as general internet searches. Additional businesses were added to the facility list as a result of these verification searches. This verification method was broadly representative of commercial and industrial activity in the study area for 2011–12.

2.2 Data collection

The emission estimation techniques applied in this study relied on industry activity data. Activity data were sourced through a combination of ABS datasets, published industry association data, and by directly surveying businesses identified by the process described in Section 2.1.

To provide additional facility verification where an appropriate industry aggregate dataset was not available, facilities were surveyed on fuel and energy use, material inputs and production rates. Data requests were limited to only what was required to build generic activity profiles for each industry. An example survey is presented in Appendix A.

Industry types surveyed are presented in Table 2. Industry groups not surveyed were assessed either to have insufficient presence in the study area or an appropriate, publicly available industry aggregate dataset. The average industry response rate was 21 per cent. Some facilities were removed or corrected within the database as they were identified as not operating at the address.

Table 2 – Industry survey response rates

Survey type		Surveys issued	Surveys returned
ANZSIC code	Description		
0900	Non-metallic mineral mining and quarrying	12	7
1170	Bakery product manufacturing	26	5
1212	Beer manufacturing	17	5
1214	Wine and other alcoholic beverage manufacturing	60	17
1610	Printing and printing support services	149	45
1900	Polymer product and rubber product manufacturing	69	15
2000	Non-metallic mineral product manufacturing	49	14
2100	Primary metal and metal product manufacturing	37	5
2200	Fabricated metal product manufacturing	42	9
9412	Automotive body, paint and interior repair	271	29
9531	Laundry and dry-cleaning services	108	26
	Total	**841**	**177**

2.3 Agricultural emissions

Agricultural emission estimates were based on intensive animal farming practices occurring in the study area. Emissions from crop farming have been addressed in the biogenic and geogenic inventory.

Agricultural emissions were estimated for beef and dairy cattle farming, poultry farming and pig farming.

Ammonia is the primary emission from intensive agricultural activities. In addition to its role in atmospheric chemistry, it is also an indicator of odour impacts. While particulates are an emission of interest, emission estimation techniques are only available for cattle and poultry farming emissions.

Emissions from agriculture were estimated and allocated by the following process:

1. Estimating emissions for agricultural activities using state-level activity data
2. Removing emissions reported by NPI facilities from the total emission estimate
3. Dividing the remaining emission estimates equally between identified non-NPI facilities

Emission estimation techniques

Emissions from beef and dairy cattle farming were estimated using the following equation from the NPI Intensive Livestock – Beef Cattle manual (NPI 2007b).

$$E_i = EF_i \times SCU$$

Where:

E_{NH3}	=	Emissions of substance (i)	(kg/yr)
EF_{NH3}	=	Emission factor of substance (i)	(kg/SCU/yr)
SCU	=	Standard Cattle Units (1 SCU = 600kg)	(SCU)

Emissions from poultry farming were estimated using the following equation from the NPI Intensive Livestock – Poultry Raising manual (NPI 2013).

$$E_i = EF_{i,b} \times n_b$$

Where:

E_i	=	Emissions of substance (i)	(kg/yr)
$EF_{i,b}$	=	Emission factor of substance (i) from bird type (b)	(kg/bird/yr)
n_b	=	Population of bird type (n)	(birds)
i	=	Substance	(–)
b	=	Type of bird	(–)

No non-NPI reporting pig farms were identified in the study area. Emissions from pig farming in this study are as reported to the NPI.

Activity data

Beef and dairy cattle emission factors (EF)

Emission factors for beef and dairy cattle were sourced from the NPI Intensive Livestock – Beef Cattle manual (NPI 2007b). PM2.5 and total suspended particles (TSP) emission factors were speciated using the California Air Resources Board PMSIZE database (CARB 2014). Emission factors used are presented in Table 3.

Table 3 – Beef and dairy cattle emission factors

Substance	Emission factor (kg/SCU)
Ammonia (total)	70
Particulate matter ≤ 2.5 µm	1.46
Particulate matter ≤ 10 µm	11.7
Total suspended particulate	24.4

Standard cattle units (SCU)

The beef and dairy cattle population for Western Australia (WA) was derived from the ABS *Agricultural Commodities, Australia, 2011–12* dataset (ABS 2013a). The populations of cattle for ‘Bunbury’, ‘Wheatbelt’ and ‘Outback’ were removed from the total WA population. It was assumed each cow or bull represented a single SCU. The cattle population is presented in Table 4.

Table 4 – Beef and dairy cattle population in study area

	Beef cattle	Dairy cattle
Population	49,090	5,822

Poultry emission factors (EF)

Emission factors for poultry were sourced from the NPI Intensive Livestock – Poultry Raising manual (NPI 2013) and the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA 2012). Emission factors used are presented in Table 5.

Table 5 – Poultry emission factors

Substance	Emission factor (kg/bird)			
	Chicken (meat)	Chicken (eggs)	Turkey	Duck
Ammonia (total)	0.310	0.299	0.354	0.210
Particulate matter ≤ 2.5 µm	0.0039			
Particulate matter ≤ 10 µm	0.017			
Total suspended particulate	0.039			

Number of birds (n)

The poultry population of the study area was derived from the ABS *Agricultural Commodities, Australia, 2011–12* dataset (ABS 2013a) and is presented in Table 6.

Meat chicken population data for WA were only available until 2009. Analysis of the Agricultural Commodities, Australia dataset between 2000 and 2009 shows chicken populations have been mostly stable between five and eight million birds. A conservative value of nine million birds in all of WA was assumed for the study period. To estimate WA's meat chicken population, the same ratio as the egg chicken population to the study area population was applied (44 per cent) in the study area.

The populations of egg chickens for 'Bunbury', 'Wheatbelt' and 'Outback' regions in the ABS dataset were excluded from the WA total to obtain an egg chicken population value for the study area.

No data were available for the population of turkeys and ducks in the study period and no businesses were identified as producers of turkey or duck products.

Table 6 – Poultry population in study area

	Chicken (meat)	Chicken (eggs)	Turkey	Duck
Study area population	3,958,144	610,874	N/A	N/A

Emission estimates

Emissions of key pollutants from agriculture are summarised in Table 7.

Table 7 – Agricultural total emission estimates

Pollutant	Emissions (kg/yr)				
	Beef cattle farming	Dairy cattle farming	Poultry farming	Pig farming	Total
Ammonia (total)	3,436,280	407,562	1,409,676	159,816	5,413,334
Particulate matter ≤ 2.5 µm	71,794	8,515	17,819	–	98,128
Particulate matter ≤ 10 µm	574,350	68,121	77,673	–	720,144
Total suspended particulate	1,196,562	141,919	178,192	–	1,516,672

Spatial allocation

Agricultural emissions were divided between NPI reporting facilities and non-NPI facilities. Emissions from 2011–12 NPI reporting agricultural facilities are presented in Table 8. Emissions from these facilities were spatially allocated according to their recorded facility location in the NPI database.

Table 8 – Agricultural NPI emission estimates

Industry	Pollutant	Emissions (kg/yr)
Poultry farming	Ammonia (total)	1,309,993
Pig farming	Ammonia (total)	159,816

Emissions of particulates from cattle and poultry farms were allocated to NPI facilities based on their reported ammonia emissions.

The number of facilities identified is summarised in Table 9.

Table 9 – Agricultural facilities identified in study area

Industry	NPI facilities	Non-NPI facilities
Beef cattle farming	0	103
Dairy cattle farming	0	7
Poultry farming	45	52
Pig farming	2	0

To allocate emissions to non-NPI facilities, NPI reported emissions were removed from the total estimated emissions for each substance. The remaining emissions were allocated evenly between identified facilities. The emissions profile applied to non-NPI agricultural facilities is summarised in Table 10.

Table 10 – Non-NPI agricultural facility emission profile

Industry	Pollutant	Emissions (kg/yr)
Beef cattle farming	Ammonia (total)	33,362
	Particulate matter ≤ 2.5 µm	11,617
	Particulate matter ≤ 10 µm	5,576
	Total suspended particulate	697
Dairy cattle farming	Ammonia (total)	58,223
	Particulate matter ≤ 2.5 µm	20,274
	Particulate matter ≤ 10 µm	9,732
	Total suspended particulate	1,216
Poultry farming	Ammonia (total)	1,917
	Particulate matter ≤ 2.5 µm	24.2
	Particulate matter ≤ 10 µm	106
	Total suspended particulate	242

The spatial allocation of agricultural ammonia emissions is presented in Figure 3.

Figure 3 – Spatial allocation of agricultural ammonia emissions

2.4 Mining emissions

Mining emission estimates are based on the extraction and handling of ores and basic resources in the study area. Mining emissions have been estimated from:

- metal ore mining (e.g. bauxite, gold, mineral sands); and
- non-metallic mineral mining and quarrying (e.g. sand, clay, gravel, rock).

Particulates are the most common emission to air associated with mining activities, and include trace heavy metals that occur naturally in crustal material. A range of organic compound air emissions are also associated with mining, mostly as a result of fuel storage and combustion onsite (i.e. vehicles and power generation).

Emissions from mining in the study area were estimated and allocated by the following process:

1. Identifying mining operations that do not currently report to the NPI
2. Collecting activity data via survey to create a generic activity profile for non-NPI mining facilities
3. Applying relevant emission factors to estimate emissions from non-NPI mining facilities
4. Adding NPI reported emissions to non-NPI estimated emissions to obtain total emission estimates for mining

Emission estimation techniques

The number of facilities identified by the process outlined in Section 2.1 are summarised in Table 11.

Table 11 – Mining facilities identified in study area

Industry	NPI facilities	Non-NPI facilities
Metal ore mining	3	0
Non-metallic mineral mining and quarrying	8	12

Emissions from metal ore mining were reported to the NPI for 2011–12 with no non-NPI metal ore mining facilities identified.

Emissions from non-NPI non-metallic mineral mining and quarrying facilities were estimated using the methods and factors described in the following:

- NPI Mining manual (NPI 2012d);
- NPI Fuel and Organic Liquid Storage manual (NPI 2012b);
- NPI Combustion Engines manual (NPI 2008); and
- NPI Explosives Detonation and Firing Ranges manual (NPI 2012a).

Emission estimates were made using the general equation below.

$$E_i = EF_{i,p} \times A_p \times CF_{i,p}$$

Where:

E_i	=	Emissions of substance (i)	(kg/yr)
$EF_{i,p}$	=	Emission factor for substance (i) from mining process (p)	(–)
A_p	=	Activity of mining process (p)	(–)
$CF_{i,p}$	=	Emission control factor for substance (i) from mining process (p)	(–)
i	=	Substance	(–)
p	=	Mining process	(–)

The emission factors used to simulate mining facilities with no available operational data are summarised in Appendix B. $PM_{2.5}$ emission factors for dust do not exist within the NPI, so PM_{10} estimates were used to estimate $PM_{2.5}$ emissions from dust sources[1].

Particulate emissions were speciated using the 'Earth's Crust' profile from the NPI Mining manual (NPI 2012d) to estimate emissions of trace heavy metals. $PM_{2.5}$ emissions were speciated using the California Air Resources Board PMSIZE database (CARB 2014). The speciation profile applied is reproduced in Appendix C.

Activity data

Industry survey

Fifty-four per cent of non-NPI non-metallic mineral mining and quarrying facilities surveyed provided activity data for emission estimates.

The survey data were averaged to create a generic activity profile, as summarised in Table 12. This activity profile was used to estimate emissions from facilities with no operational data available from which to estimate emissions.

[1] NPI $PM_{2.5}$ data only represents combustion sources. The NPI $PM_{2.5}$ combustion data were subtracted from the NPI PM_{10} combustion and dust data for a NPI PM_{10} dust only estimate. A relevant $PM_{2.5}$ speciation profile was then applied to NPI PM_{10} dust only estimates to obtain NPI $PM_{2.5}$ dust estimates. The $PM_{2.5}$ dust estimates were added to the NPI $PM_{2.5}$ reported values to get total $PM_{2.5}$ estimates.

Table 12 – Non-NPI mining facility activity profile

Industry	Activity	Value	Units
Non-metallic mineral mining and quarrying	Diesel stored/used	771,450	litres/yr
	Front-end loader fuel use	624,874	litres/yr
	Haul truck fuel use	146,576	litres/yr
	Extracted material	1,916,667	tonnes/yr
	Stockpile, pit and laydown area	41.8	ha

The following emission processes were estimated for non-NPI mining facilities:

- excavation;
- trucks dumping mined material;
- screening;
- loading haul trucks for export;
- wheel generated dust;
- wind erosion;
- fuel storage tanks;
- front-end loader fuel consumption; and
- haul truck fuel consumption.

Drilling, blasting and crushing activities, while common for mining operations, did not occur at surveyed facilities so were not included in the generic activity profile.

Based on survey data, 81 per cent of fuel used was assigned to front-end loader operations with the remainder assigned to haul truck operations. All fuel used onsite was considered stored onsite (i.e. no refuelling offsite).

All surveyed facilities used water trucks as emission controls and half used water cannons on stockpiles. The control factors used reflect the survey responses received.

Emission estimates

Emissions of pollutants from mining in the study area are summarised in Table 13.

Table 13 – Mining total emission estimates

Pollutant	Emissions (kg/yr)		
	Metal ore mining	Non-metallic mineral mining and quarrying	Total
Ammonia (total)	162,209	–	162,209
Antimony and compounds	67.6	1.65	69.3

Pollutant	Emissions (kg/yr)		
	Metal ore mining	Non-metallic mineral mining and quarrying	Total
Arsenic and compounds	1,487	12.0	1,499
Benzene	159	3.06	162
Beryllium and compounds	20.6	21.4	42.0
Boron and compounds	2,684	77.7	2,762
Cadmium and compounds	64.2	1.14	65.3
Carbon monoxide	6,953,518	213,577	7,167,095
Chromium (total)	5,390	1,124	6,514
Cobalt and compounds	553	165	718
Copper and compounds	24,474	386	24,860
Cumene (1-methylethylbenzene)	28.3	4.66	33.0
Cyanide	126,279	–	126,279
Cyclohexane	–	1.10	1.10
Ethylbenzene	6.70	1.10	7.80
Fluoride compounds	14,392	7,538	21,930
Formaldehyde	22,041	12,882	34,923
n-Hexane	–	1.59	1.59
Hydrochloric acid	0.23	–	0.23
Lead and compounds	1,369	114	1,483
Manganese and compounds	17,261	7,172	24,433
Mercury and compounds	10.4	0.52	10.9
Nickel and compounds	1,790	612	2,402
Oxides of nitrogen	2,100,977	590,035	2,691,012
Particulate matter ≤ 2.5 µm	4,399,540	1,198,080	5,597,620
Particulate matter ≤ 10 µm	14,938,844	3,958,358	18,897,201
Polychlorinated dioxins and furans (TEQ)	0.000000064	–	0.000000064
Polycyclic aromatic hydrocarbons (B[a]Peq)	46.9	23.5	70.5
Selenium and compounds	37.8	0.41	38.2
Sulfur dioxide	999,938	4,155	1,004,093
Toluene (methylbenzene)	178	2.94	181
Total suspended particulate [2]	–	8,229,663	–
Total volatile organic compounds	1,010,739	67,561	1,078,300
Xylenes (individual or mixed isomers)	916	2.82	919
Zinc and compounds	5,338	1,485	6,823

[2] TSP is not a reportable NPI substance. It is presented in Table 13 due to its use in speciated metal estimates.

Spatial allocation

Emissions from both NPI and non-NPI reporting mining facilities in the study area were spatially allocated according to their recorded facility location in the NPI database or determined during facility verification (Section 2.1).

The spatial allocation of mining PM_{10} emissions is presented in Figure 4.

Mining PM_{10} emissions are dominated by a single facility in the south-west of the study area. The spatial allocation method in this study allocates facility emissions to individual cells, though in reality the mining area is spread out over several square kilometres.

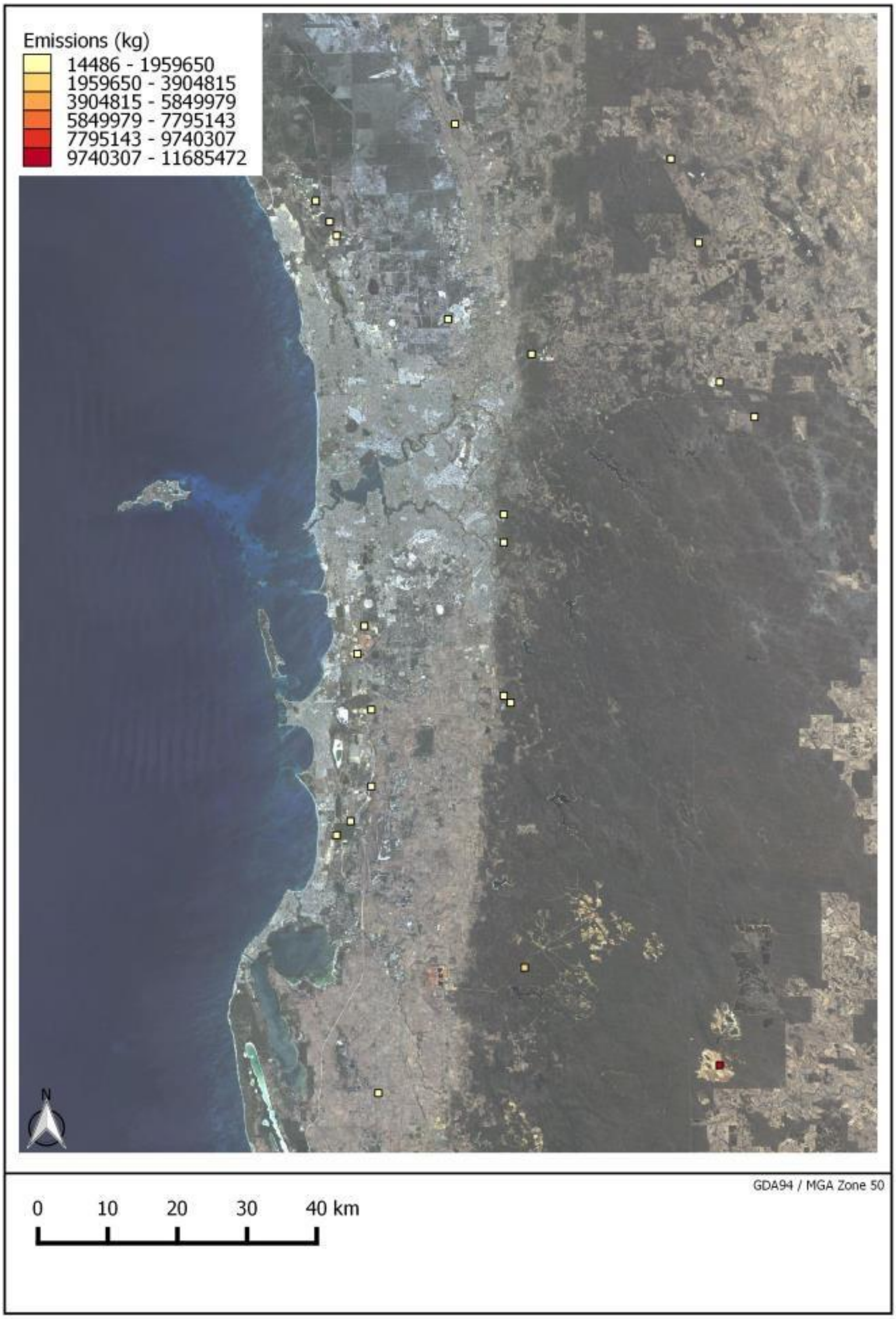


Figure 4 – Spatial allocation of mining PM_{10} emissions

2.5 Manufacturing emissions

Manufacturing emission estimates for this report are based on a diverse range of industries in the study area. Manufacturing emissions have been estimated from:

- food product manufacturing;
- beverage manufacturing;
- wood product manufacturing;
- pulp, paper and converted paper product manufacturing;
- printing and printing support services;
- petroleum and coal product manufacturing;
- basic chemical and chemical product manufacturing;
- polymer product manufacturing;
- non-metallic mineral product manufacturing;
- primary metal and metal product manufacturing;
- fabricated metal product manufacturing;
- transport equipment manufacturing; and
- machinery and equipment manufacturing.

Most industrial operations generate combustion emissions from onsite boilers and generators. Some small industries can have large emissions of specific substances, while larger industries generally have a range of different pollutants unique to their operations.

Emissions from manufacturing were estimated and allocated by the following process:

1. Identifying manufacturing operations in the study area that do not currently report to the NPI
2. Collecting activity data via survey to create generic activity profiles for non-NPI manufacturing facilities
3. Applying relevant emission factors to estimate emissions from non-NPI manufacturing facilities
4. Adding NPI reported emissions to non-NPI estimated emissions to obtain total emission estimates for manufacturing

Emission estimation techniques

The number of manufacturing facilities identified are summarised in Table 14.

Table 14 – Manufacturing facilities identified in study area

<table>
<tr><th>Industry</th><th>NPI facilities</th><th>Non-NPI facilities</th></tr>
<tr><td>Meat and meat product processing</td><td>4</td><td>0</td></tr>
<tr><td>Milk and cream processing</td><td>2</td><td>0</td></tr>
<tr><td>Grain mill and cereal product manufacturing</td><td>3</td><td>0</td></tr>
<tr><td>Bread manufacturing</td><td>2</td><td>27</td></tr>
<tr><td>Potato, corn and other crisp manufacturing</td><td>1</td><td>0</td></tr>
<tr><td>Prepared animal and bird feed manufacturing</td><td>3</td><td>0</td></tr>
<tr><td>Soft drink, cordial and syrup manufacturing</td><td>2</td><td>0</td></tr>
<tr><td>Beer manufacturing</td><td>1</td><td>25</td></tr>
<tr><td>Wine and other alcoholic beverage manufacturing</td><td>3</td><td>61</td></tr>
<tr><td>Wood product manufacturing</td><td>1</td><td>0</td></tr>
<tr><td>Pulp, paper and converted paper product manufacturing</td><td>2</td><td>0</td></tr>
<tr><td>Printing and printing support services</td><td>1</td><td>142</td></tr>
<tr><td>Petroleum and coal product manufacturing</td><td>5</td><td>0</td></tr>
<tr><td>Basic chemical and chemical product manufacturing</td><td>20</td><td>0</td></tr>
<tr><td>Rigid and semi-rigid polymer product manufacturing</td><td>1</td><td rowspan="4">66</td></tr>
<tr><td>Polymer foam product manufacturing</td><td>2</td></tr>
<tr><td>Paint and coatings manufacturing</td><td>2</td></tr>
<tr><td>Other polymer product manufacturing</td><td>8</td></tr>
<tr><td>Clay brick manufacturing</td><td>6</td><td rowspan="6">55</td></tr>
<tr><td>Other ceramic product manufacturing</td><td>3</td></tr>
<tr><td>Cement and lime manufacturing</td><td>4</td></tr>
<tr><td>Plaster product manufacturing</td><td>1</td></tr>
<tr><td>Concrete product manufacturing</td><td>1</td></tr>
<tr><td>Other non-metallic mineral product manufacturing</td><td>1</td></tr>
<tr><td>Iron and steel casting</td><td>4</td><td rowspan="6">38</td></tr>
<tr><td>Alumina production</td><td>2</td></tr>
<tr><td>Copper, silver, lead and zinc smelting and refining</td><td>1</td></tr>
<tr><td>Other basic non-ferrous metal manufacturing</td><td>2</td></tr>
<tr><td>Non-ferrous metal casting</td><td>2</td></tr>
<tr><td>Aluminium rolling, drawing, extruding</td><td>1</td></tr>
<tr><td>Other structural metal product manufacturing</td><td>2</td><td rowspan="3">41</td></tr>
<tr><td>Metal coating and finishing</td><td>7</td></tr>
<tr><td>Other fabricated metal product manufacturing n.e.c.</td><td>2</td></tr>
<tr><td>Transport equipment manufacturing</td><td>3</td><td>0</td></tr>
<tr><td>Other specialised machinery and equipment manufacturing</td><td>1</td><td>0</td></tr>
</table>

Where no non-NPI facilities were identified for a manufacturing industry, it was due to one or more of the following factors:

- no facilities could be identified in the study area;
- all the facilities identified already report to the NPI; and/or
- no unique emission estimation techniques were identified for that industry.

Emissions from manufacturing have been estimated by combining NPI reported data and estimates made to represent non-NPI facilities. Emissions from non-NPI facilities have been estimated using the methods and techniques summarised in Table 15. Emission factors applied have been reproduced in Appendix B.

Table 15 – Manufacturing emission estimation techniques used

Industry	Emission estimation techniques applied	Appendix B reference
Bread manufacturing	NPI Bread Manufacturing manual (NPI 2003) NPI Combustion in Boilers manual (NPI 2011a)	Table 45
Beer manufacturing	NPI Beer and Ready-to-Drink Alcoholic Beverage Manufacturing manual (NPI 2007a) NPI Combustion in Boilers manual (NPI 2011a)	Table 46
Wine and other alcoholic beverage manufacturing	NPI Wine and Spirits Manufacturing manual (NPI 2010)	Table 47
Printing and printing support services	NPI Aggregated Emissions from Printing and Graphic Arts manual (NPI 1999c)	Table 48
Polymer and rubber product manufacturing	NPI Fibreglass Product Manufacturing manual (NPI 1999e)	Table 49
Non-metallic mineral product manufacturing	NPI Combustion Engines manual (NPI 2008) NPI Mining manual (NPI 2012d) USEPA AP42 Chapter 11.12 Concrete Batching (USEPA 2006b)	Table 50
Primary metal and metal product manufacturing	NPI Combustion in Boilers manual (NPI 2011a) NPI Ferrous Foundries manual (NPI 2014) NPI Fugitive Emissions manual (NPI 2012c) NPI Non-Ferrous Foundries manual (NPI 1999f)	Table 51
Fabricated metal product manufacturing	NPI Combustion in Boilers manual (NPI 2011a) NPI Fugitive Emissions manual (NPI 2012c) NPI Structural and Fabricated Metal Product Manufacture manual (NPI 1999g) USEPA AP42 Chapter 12.20 Electroplating (USEPA 1996)	Table 52

Emission estimates for non-NPI facilities were made using the general equation below.

$$E_i = EF_{i,p} \times A_p \times CF_{i,p}$$

Where:

E_i	=	Emissions of substance (i)	(kg/yr)
$EF_{i,p}$	=	Emission factor for substance (i) from manufacturing process (p)	(–)
A_p	=	Activity of manufacturing process (p)	(–)
$CF_{i,p}$	=	Emission control factor for substance (i) from manufacturing process (p)	(–)
i	=	Substance	(–)
p	=	Manufacturing process	(–)

Where appropriate, TSP and VOC emissions from manufacturing were speciated to estimate emissions of trace heavy metals and organic compounds of interest. Index of speciation profiles are summarised in Table 16 and speciation profiles have been reproduced in Appendix C.

Table 16 – Manufacturing emission speciation profiles used

Industry	Emission speciation profile applied	Appendix C reference
Printing and printing support services	USEPA SPECIATE profile 2570 (USEPA 2014)	Table 58
Non-metallic mineral product manufacturing	NPI Mining manual (NPI 2012d) – 'Earth's Crust'	Table 59

Activity data

Industry survey

The response rate for non-NPI manufacturing facilities varied between 14 per cent and 30 per cent, with an average response rate of 24 per cent.

Emissions were estimated for facilities that returned activity data. Averaged activity data were used to create generic activity profiles for manufacturing industries where no operational data were provided.

Bread manufacturing

The following emission sources were estimated for bakeries based on:

- bread leavening (yeast producing ethanol); and
- use of natural gas ovens.

The activity profile in Table 17 was applied to estimate emissions from bakeries with no operational data.

Table 17 – Bread manufacturing facility activity profile

Activity	Value	Units
Bread produced	448	tonnes/yr
Natural gas oven fuel use	395	GJ/yr

No emission control factors were applied for bakeries.

Beer manufacturing

The following emission sources were estimated for breweries:

- bottle filling;
- keg filling; and
- natural gas boiler operation.

The activity profile in Table 18 was applied to estimate emissions from breweries with no operational data.

Table 18 – Beer manufacturing facility activity profile

Activity	Value	Units
Beer produced – small facility	20	kL/yr
Beer produced – medium facility	200	
Beer produced – large facility	20,000	
Natural gas boiler fuel use – small facility	0.4	tonnes/yr
Natural gas boiler fuel use – medium facility	4	
Natural gas boiler fuel use – large facility	400	

Facilities with no operational data were assigned a size (i.e. 'small', 'medium', 'large') based on the facility footprint and its estimated product distribution. Operations with large distribution networks were assumed to have higher production capabilities. 'Small' facilities were assumed to produce only kegs for commercial consumption, with larger facilities assumed to allocate more production to bottling. The container filling process ratio assigned to each facility size is presented in Table 19.

Table 19 – Beer container filling ratios

Facility size	Bottle filling	Keg filling
Small	–	100%
Medium	50%	50%
Large	95%	5%

No emission control factors were applied for beer manufacturing.

Wine and other alcoholic beverage manufacturing

The following emission sources were estimated for wineries and distilleries:

- fermentation;
- pressing and screening (red wines only);
- distilling (spirits only);
- maturation (wooden barrel);
- maturation (steel vessel); and
- bottling.

To estimate emissions from wineries, facility and activity data were sourced from the *Winetitles Industry Directory 2012* (Winetitles 2012).

Where grape crush tonnage data were not available in the Winetitles dataset for an individual facility, a value was applied based on the aerial footprint of that facility and the published grape crush tonnage from similarly sized facilities. Where wine production data were not available, an average value was derived from facilities with similar grape crush tonnage.

All facility production data were proportionally scaled so that total production aligned with the *ABS Vineyards, Australia, 2011–12 and Australian Wine and Grape Industry, 2011–12* datasets (ABS 2012b, 2013b).

Survey data were used to either verify or update individual facility production data, and to develop wooden barrel and steel vessel maturation ratios for red and white wines. For facilities with no operational data, the ratios in Table 20 were applied. Unless survey data indicated a wine facility did not undertake bottling activities, facilities were assumed to bottle all their production.

Table 20 – Wine maturation ratios

	% production
Proportion of white wine production wooden barrel matured	20
Proportion of red/rosé production wooden barrel matured	90

Spirit production volumes were sourced directly from the identified facilities in the study area. It was assumed all spirit maturation was undertaken in wooden barrels.

No emission control factors were applied for wine and other alcoholic beverage manufacturing.

Printing and printing support services

Ink drying was the only emission source estimated for printing facilities.

The activity profile in Table 21 was applied to estimate emissions from printers with no operational data.

Table 21 – Printing facility activity profiles

Industry	Activity	Value	Units
Printing and printing support services	Number of employees	6	(–)
	Total ink used	193	kg/yr
	Amount of VOC-based ink used	97	kg/yr

Emission estimates for printing facilities are based on employee numbers. To estimate emissions, the number of employees at each facility was scaled based on their reported use of VOC-based ink and water-based ink; facilities that used 100 per cent water-based ink were scaled to zero employees. For facilities with no operational data, the generic activity profile employee number was scaled down to three (reported VOC ink use is about half of total reported ink use).

No control factors were applicable for printing and printing support services.

Polymer product and rubber product manufacturing

The following emission sources were estimated for polymer and rubber facilities:

- solvent evaporation;
- manual resin application; and
- gel coat application.

The activity profile in Table 22 was applied to estimate emissions from polymer and rubber product manufacturers with no operational data.

Table 22 – Polymer and rubber product manufacturing facility activity profiles

Industry	Activity	Value	Units
Polymer product and rubber product manufacturing	Solvent usage (acetone)	125	litres/yr
	Fibreglass manual resin application (non-vapour suppressed)	350	kg/yr
	Fibreglass gel coat application	150	

No emission control factors were applied for polymer and rubber product manufacturing.

Non-metallic mineral product manufacturing

While facilities identified for this industry manufacture a range of products, those producing concrete dominate the facility listing. To simplify emission estimates, facilities with no operational data available were simulated as concrete product manufacturers.

The following emission sources were estimated for non-metallic mineral product facilities:

- aggregate transfer;
- sand transfer;
- cement unloading;
- cement supplement unloading;
- hopper loading;
- mixer loading;
- miscellaneous diesel and LPG industrial vehicle operation; and
- wind erosion.

The activity profile in Table 23 was applied to estimate emissions from non-metallic mineral product manufacturers with no operational data.

Table 23 – Non-metallic mineral product manufacturing facility activity profiles

Industry	Activity	Value	Units
Non-metallic mineral product manufacturing	Concrete produced	36,000	tonnes/yr
	LPG consumed (misc. engines)	2,771	kg/yr
	Diesel consumed (misc. engines)	5,922	litres/yr
	Stockpile and laydown area	165	m^2

The following control factors were applied to emission sources:

- wind breaks on aggregate and sand transfer (30 per cent reduction);
- cement and cement supplement unloading assumed from silo (98 per cent reduction);
- hopper and mixer loading enclosed with 'boot and chute' (90 per cent reduction); and
- sand and aggregate stockpiles enclosed in three-walled bund (75 per cent reduction).

Primary metal and metal product manufacturing

The following emission sources were estimated for primary metal and metal product manufacturing facilities:

- natural gas furnaces;
- casting metal (iron, zinc and copper);
- casting moulds; and
- welding.

The activity profile in Table 24 was applied to estimate emissions from primary metal and metal product manufacturers. Due to the limited data provided by survey respondents, the generic activity profile was applied to all non-NPI facilities.

Fuel use data were estimated from the 'Basic iron and steel manufacturing' and 'Basic non-ferrous metal manufacturing' data contained in the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA 2012).

The following triggers were used to allocate emissions from casting:

- surveyed facility provided casting data;
- facility was identified as a smelting operation by its ANZSIC code in the ABR database; or
- facility name indicated it was a 'casting' operation.

Table 24 – Primary metal and metal product manufacturing facility activity profiles

Industry	Activity	Value	Units
Primary metal and metal product manufacturing	Natural gas use	349	tonnes/yr
	Iron cast	182	tonnes/yr
	Zinc cast	15	tonnes/yr
	Copper cast	4	tonnes/yr
	Welding rod use	67	kg/yr

No emission control factors were applied for primary metal and metal product manufacturing.

Fabricated metal product manufacturing

The following emission sources were estimated for fabricated metal product manufacturing facilities:

- natural gas furnaces;
- metal cutting;
- welding; and
- electroplating.

The activity profile in Table 25 was applied to estimate emissions from fabricated metal product manufacturers. Due to the limited data provided by survey respondents, the generic activity profile was applied to all non-NPI facilities.

Fuel data were estimated from the 'Fabricated metal product manufacturing', 'Metal coating and finishing' and 'Spring and wire product manufacturing' data contained in the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA 2012).

Cutting activity was estimated based on average surveyed business operational hours, days of the year (12 hours/day, 280 days operational) and three hours of metal cutting each day.

Table 25 – Fabricated metal product manufacturing facility activity profiles

Industry	Activity	Value	Units
Fabricated metal product manufacturing	Natural gas use	27	tonnes/yr
	Cutting metal – mild steel 8 mm	50,400	minutes/yr
	Welding rod use	2,000	kg/yr
	Electroplating – hard chromium	33,600,000	Ampere-hrs/yr
	Electroplating – copper cyanide	3,360,000	
	Electroplating – copper sulfate	3,360,000	
	Electroplating – cadmium cyanide	3,360,000	
	Electroplating – nickel	3,360,000	

Emission factors for electroplating were selected based on the use of fume suppressant emission controls.

Emission estimates

Emissions of pollutants from manufacturing are summarised in Table 26.

Table 26 – Manufacturing total emission estimates

Pollutant	Emissions (kg/yr)													
	Food product manufacturing	Beverage manufacturing	Wood product manufacturing	Pulp, paper and converted paper product manufacturing	Printing and printing support services	Petroleum and coal product manufacturing	Basic chemical and chemical product manufacturing	Polymer product manufacturing	Non-metallic mineral product manufacturing	Primary metal and metal product manufacturing	Fabricated metal product manufacturing	Transport equipment manufacturing	Machinery and equipment manufacturing	Total
Acetaldehyde	0.00026					49.6				48,003				48,053
Acetic acid (ethanoic acid)		13.8					0.0020							13.8
Acetone					3,231	442	3,436	52,656		54,017				113,782
Acrylamide							37.8							37.8
Acrylic acid							206							206
Ammonia (total)	676	7,000				14,524	74,551		104,525	881,447				1,082,723
Aniline										148				148
Antimony and compounds						26.2			2.38×10^{-08}					26.2
Arsenic and compounds	0.11	0.013	0.00025	0.0019		1.35	0.46		49	171	0.024			222
Benzene	0.00030				1,741	4,792	1,339			7,989				15,862
Beryllium and compounds	0.00066	0.000076		0.000011		0.080	0.010		5.47	1.53	0.00013			7.10
Biphenyl (1,1-biphenyl)						0.21								0.21
Boron and compounds									67.6	32.7				100
1,3-Butadiene (vinyl ethylene)	0.000013					386								386
Cadmium and compounds	0.61	0.069		0.010		3.62	2.77		24.2	79.1	314			424
Carbon disulfide						33,639	67.0							33,706
Carbon monoxide	58,733	7,778		4,724	2,034	2,675,362	1,669,661	903	3,518,936	2,179,839	11,095	1,095		10,130,160
Chlorine						2,686	12.5		4,850	134				7,682
Chromium (total)	0.77	0.088	0.00025	0.013		2.64	9.05		110	20,626	1,427			22,175
Cobalt and compounds	0.042	0.0019		0.00076		5.08	0.27		0.47	43.6	0.0091			49.5
Copper and compounds	0.47	0.054	0.00035	0.0079		12.0	15.9		33.6	623	356			1,041
Cumene (1-methylethylbenzene)						66.3	355		21.7	4.70		8.00		456
Cyanide (inorganic)						43.9	3,571			3,578	80.5			7,273
Cyclohexane						8,606	1,137							9,743
1,2-Dibromoethane						2.92								2.92
Dichloromethane								11,907						11,907
Ethanol	49,883	11,081				3,257	304	192		37,616			5,536	107,868
Ethyl acetate		6.12			1,086									1,092
Ethylbenzene					242	1,055	577							1,874
Ethylene glycol (1,2-ethanediol)							47.7							47.7
Fluoride compounds						224	3,998		85,200	961		0.21		90,383

Pollutant	Emissions (kg/yr)													
	Food product manufacturing	Beverage manufacturing	Wood product manufacturing	Pulp, paper and converted paper product manufacturing	Printing and printing support services	Petroleum and coal product manufacturing	Basic chemical and chemical product manufacturing	Polymer product manufacturing	Non-metallic mineral product manufacturing	Primary metal and metal product manufacturing	Fabricated metal product manufacturing	Transport equipment manufacturing	Machinery and equipment manufacturing	Total
Formaldehyde (methyl aldehyde)	11.6					30,583			739	44,177	40.0			75,550
Glutaraldehyde							0.39							0.39
n-Hexane					539	24,316	3,958			10.3				28,823
Hydrochloric acid						9,487	2,564		690,626	713	3,430			706,820
Hydrogen sulfide						22,434				857				23,291
Lead and compounds	0.28	0.031		0.0047		18.9	35.5		164	207	0.056			425
Manganese and compounds	0.20	0.0089		0.0036		36.1	67.7		195	2,344	4,323			6,966
Mercury and compounds	0.14	0.016		0.0024		0.90	0.53		71.3	931	0.029			1,004
Methanol		21				1,715	9,426							11,162
Methyl ethyl ketone					7,154			8.10				0.89		7,163
Methyl isobutyl ketone					1,948									1,948
Methyl methacrylate								1,397						1,397
Nickel and compounds	1.16	0.13		0.020		41.9	6.24		110	1,763	5,065			6,987
Nickel subsulfide										410				410
Nitric acid							137							137
Oxides of nitrogen	52,161	8,425		6,672	2,799	774,628	872,165	1,093	3,713,367	3,707,362	29,126	1,377		9,169,176
Particulate matter ≤ 2.5 µm	4,695	534		168	134	44,814	15,382	74.4	32,864	157,530	1,171	93.0		257,458
Particulate matter ≤ 10 µm	43,171	570		168	146	123,280	78,952	74.4	956,273	1,080,344	13,078	93.2		2,296,148
Phenol						11.7				1,658				1,670
Phosphoric acid							4.90							4.90
Polychlorinated dioxins and furans (TEQ)	2.74×10^{-06}	3.31×10^{-07}		4.62×10^{-08}		6.50×10^{-09}	1.66×10^{-05}		4.88×10^{-04}	1.33×10^{-03}	5.51×10^{-07}			0.0018
Polycyclic aromatic hydrocarbons (B[a]Peq)	0.43	0.040		0.014	0.035	132	2.81	0.0064	73.4	134	0.25	0.0093		342
Selenium and compounds	0.012	43.9		0.00022		0.15			0.0019	159	0.0026			203
Styrene (ethenylbenzene)						17	331	154,010						154,357
Sulfur dioxide	20,483	106		24.9	21.5	4,426,764	141,474	11.1	900,724	50,505	93.6	11.5		5,540,218
Sulfuric acid						0.74	183		8,660	0.00015				8,844
Toluene (methylbenzene)	0.00013				10,125	15,029	13,792	652		11,258			3,072	53,928
Toluene-2,4-diisocyanate								0.60						0.60
Total volatile organic compounds	210,054	11,945		667	90,388	1,731,409	352,970	316,097	90,891	324,144	1,246	1,576	8,608	3,139,996
Xylenes (individual or mixed isomers)	0.000094				1,131	14,137	2,685	151	189	5,740		4.84		24,038
Zinc and compounds	14.9	0.67		0.27		194	73.5		163	497	6,469			7,411

Spatial allocation

Emissions from NPI and non-NPI manufacturing facilities were spatially allocated according to their recorded facility location in the NPI database or determined during facility verification (Section 2.1).

Manufacturing facilities emissions were estimated for 62 different substances, with no pollutant representative of all facilities. While industrial processes produce specific emissions, the spatial allocation of manufacturing facilities presented in Figure 5 below only shows the facility locations represented in this study.

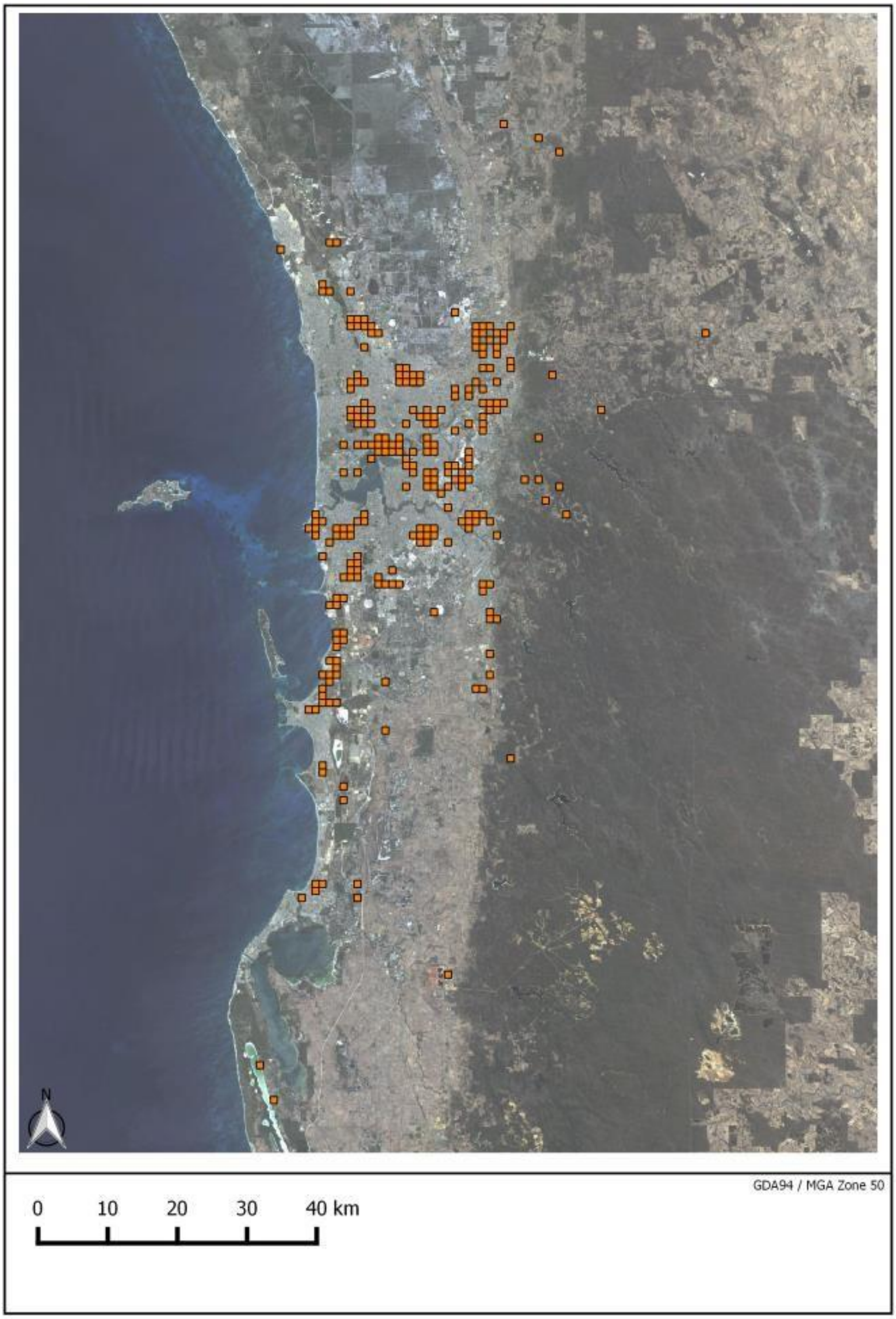


Figure 5 – Spatial allocation of manufacturing emission sources

2.6 Electricity, gas, water and waste services emissions

Facilities in this group include:

- electricity supply;
- gas supply;
- water supply, sewerage and drainage services; and
- waste collection, treatment and disposal services.

All facilities identified in the study area already report to the NPI.

Electricity facility emissions are almost entirely from combustion of fuel. Gas supply emissions are primarily volatile organic compounds. The primary emission from water sewerage facilities is ammonia, although combustion pollutants also are a feature of larger facilities that combust biogas. Waste facilities (i.e. landfills) have a diverse range of emissions as a result of waste decomposition.

Emission estimation techniques

All emissions from electricity, gas, water and waste services facilities were sourced from the NPI database.

Activity data

No activity data were collected or developed for electricity, gas, water and waste services facilities.

Emission estimates

Emissions of pollutants from electricity, gas, water and waste service facilities are summarised in Table 27.

Spatial allocation

Emissions from electricity, gas, water and waste service facilities were spatially allocated according to their recorded facility location in the NPI database.

Electricity, gas, water and waste service facilities emissions were estimated for 52 different substances. While combustion pollutants are common across most facilities, the spatial allocation of electricity, gas, water and waste service facilities presented in Figure 6 below only shows the facility locations represented in this study.

Table 27 – Electricity, gas, water and waste services total emission estimates

Pollutant	Emissions (kg/yr)				
	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Waste collection, treatment and disposal services	Total
Acetone				201	201
Acetonitrile				16.7	16.7
Acrylonitrile (2-propenenitrile)				174	174
Ammonia (total)			268,292		268,292
Antimony and compounds				0.030	0.030
Arsenic and compounds	6.67			0.14	6.81
Benzene	40.2			158	198
Beryllium and compounds	3.55			0.0071	3.55
Boron and compounds				3.87	3.87
Cadmium and compounds	7.49			0.022	7.51
Carbon disulfide				5.78	5.78
Carbon monoxide	1,238,520	2,931	212,048	104,430	1,557,930
Chlorine and compounds			5.00		5.00
Chloroethane (ethyl chloride)				129	129
Chloroform (trichloromethane)				4.28	4.28
Chromium (total)	21.9			4.33	26.2
Copper and compounds	19.5			1.88	21.4
Cumene (1-methylethylbenzene)	30.8			27.0	57.8
Cyclohexane				33.3	33.3
1,2-Dichloroethane				5.72	5.72

Pollutant	Emissions (kg/yr)				
	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Waste collection, treatment and disposal services	Total
Dichloromethane				264	264
Ethanol				5.47	5.47
Ethyl acetate				85.6	85.6
Ethylbenzene	19.6			267	286
Fluoride compounds	20,100			28.6	20,129
Formaldehyde (methyl aldehyde)				792	792
n-Hexane				138	138
Hydrochloric acid	161,000			26.8	161,027
Hydrogen sulfide				571	571
Lead and compounds	25.0			1.55	26.6
Manganese and compounds	46.6			25.3	71.9
Mercury and compounds	16.2			0.020	16.2
Methyl ethyl ketone				264	264
Methyl isobutyl ketone				96.8	96.8
Nickel and compounds	34.6			3.21	37.8
Oxides of nitrogen	5,716,021	11,455	101,524	142,534	5,971,534
Particulate matter ≤ 2.5 µm	174,395	68.0		5,527	179,990
Particulate matter ≤ 10 µm	211,188	68.0		5,869	217,125
Polychlorinated dioxins and furans (TEQ)	0.000088				0.000088
Polycyclic aromatic hydrocarbons (B[a]Peq)	44.9			1.27	46.2
Selenium and compounds				0.17	0.17

Pollutant	Emissions (kg/yr)				
	Electricity supply	Gas supply	Water supply, sewerage and drainage services	Waste collection, treatment and disposal services	Total
Styrene (ethenylbenzene)				22.1	22.1
Sulfur dioxide	3,354,573	18.1	42,786	1,961	3,399,338
Tetrachloroethylene				171	171
Toluene (methylbenzene)	54.4			2,523	2,577
Total volatile organic compounds	100,251	79,390		39,637	219,278
1,1,2-Trichloroethane				10.7	10.7
Trichloroethylene				55.2	55.2
Vinyl chloride monomer				45.0	45.0
Xylenes (individual or mixed isomers)	23.7			506	530
Zinc and compounds	50.2			6.9	57.1

Figure 6 – Spatial allocation of electricity, gas, water and waste emission sources

2.7 Retail trade emissions

The only retail trade emission estimates considered are from fuel retailing.

Emission estimation techniques

Emissions from fuel retailing have been estimated using the method outlined in the *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA 2012). The sources estimated were:

- transfer of fuel from tankers to storage tanks;
- vehicle refuelling;
- fuel spillages; and
- tank breathing losses.

Emissions from the transfer of fuel from tankers to storage tanks were estimated using the following equation (USEPA 2008).

$$\boldsymbol{E_{VOC,FT} = EF_{FT} \times A}$$

Where:

$E_{VOC,FT}$	=	Emissions of volatile organic compounds from fuel transfer	(kg/yr)
EF_{FT}	=	Emission factor for fuel transfer	(mg/litre)
A	=	Amount of fuel dispensed	(litre/yr)

The emission factor for the transfer of fuel from tankers to storage tanks was calculated using the following equation[3] (USEPA 2008).

$$\boldsymbol{EF_{FT} = 12.46 \times \left(\frac{S \times P \times M}{T}\right) \times CF_{FT} \times \left(\frac{1000}{2.20462 \times 3.785412}\right)}$$

Where:

EF_{FT}	=	Emission factor for fuel transfer	(mg/litre)
S	=	Saturation factor (submerged loading: dedicated vapour balance) = 1	(–)[4]
P	=	True vapour pressure of fuel loaded	(psia)
M	=	Molecular weight of vapours	(lb/lb-mole)
T	=	Temperature of bulk fuel loaded	(°R)

[3] The 1000/(2.20462 X 3.785412) factor converts the emission factor from imperial units (lb/1000 gal) to metric units (mg/L)

[4] Saturation factor sourced from Table 5.2-1 AP42 Chapter 5.2 (USEPA 2008)

CF_{FT}	=	Emission control factor for fuel transfer	(–)

The true vapour pressure of the fuel loaded was calculated using the following equation (USEPA 2006a).

$$P = e^{\left(\left(0.7553-\left(\frac{413}{T}\right)\right)\times s^{0.5}\times log(RVP)-\left(1.854-\left(\frac{1042}{T}\right)\right)\times s^{0.5}+\left(\left(\frac{2416}{T}\right)-2.013\right)\times log(RVP)-\left(\frac{8742}{T}\right)+15.64\right)}$$

Where:

P	=	True vapour pressure of fuel loaded	(psia)
T	=	Temperature of bulk fuel loaded	(°R)
s	=	Slope of the ASTM distillation curve at 10% evaporated = 3	(°F/vol%)[5]
RVP	=	Reid vapour pressure	(psi)

The temperature of the fuel loaded was calculated using the following equation (USEPA 2006a).

$$T = T_a + (6 \times \alpha) - 1$$

Where:

T	=	Temperature of bulk liquid loaded	(°R)
T_a	=	Ambient air temperature	(°R)
α	=	Tank paint solar absorptance (white, good condition) = 0.17	(–)[6]

Emissions from the refuelling of vehicles were estimated using the following equation (NPI 1999d).

$$E_{VOC,RV} = EF_{RV} \times A \times 10^{-6} \times CF_{RV}$$

Where:

$E_{VOC,RV}$	=	Emissions of volatile organic compounds from refuelling vehicles	(kg/yr)
EF_{RV}	=	Emission factor for refuelling vehicles	(mg/litre)

[5] Slope value sourced from Table 7.1-4 AP42 Chapter 7.1 (USEPA 2006a)

[6] Tank paint solar absorptance value sourced from Table 7.1-6 AP42 Chapter 7.1 (USEPA 2006a)

A	=	Amount of fuel dispensed	(litres/yr)
CF_{RV}	=	Emission control factor for refuelling vehicles = 1	(–)[7]

The emission factor for refuelling vehicles was calculated using the following equation (NSW EPA 2012).

$$\boldsymbol{EF_{RV} = e^{-1.2798-0.0049\times\Delta T+0.0203\times T_d+0.1315\times RVP} \times \frac{1000}{3.785}}$$

Where:

EF_{RV}	=	Emission factor for refuelling vehicles	(mg/litre)
ΔT	=	Temperature difference between dispensed fuel and fuel on-board vehicle	(°F)
T_d	=	Dispensed fuel temperature	(°F)
RVP	=	Reid vapour pressure	(psi)

The temperature of dispensed fuel and fuel on-board vehicles was calculated using the following equations (USEPA 2006a).

$$\boldsymbol{\Delta T} = |T_v - T_d|$$
$$\boldsymbol{T_v = T_d + (0.418 \times T_d - 16.6)}$$
$$\boldsymbol{T_d = 62 + 0.6 \times (T_a - 62)}$$

Where:

ΔT	=	Temperature difference between dispensed fuel and fuel on-board vehicle	(°F)
T_v	=	Temperature of fuel on-board vehicle	(°F)
T_d	=	Dispensed fuel temperature	(°F)
T_a	=	Ambient air temperature	(°F)

Emissions from fuel spillage were estimated using the following equation (NPI 1999d).

[7] Stage II vapour recovery is not mandatory in WA. It is assumed no fuel retailers have stage II vapour recovery systems.

$$E_{VOC,FS} = EF_{FS} \times A \times 10^{-6}$$

Where:

$E_{VOC,FS}$	=	Emissions of volatile organic compounds from fuel spillage	(kg/yr)
EF_{FS}	=	Emission factor for fuel spillage	(mg/litre)
A	=	Amount of fuel dispensed	(litres/yr)

Emissions from storage tank breathing losses were estimated using the following equation (EEA 2013).

$$E_{VOC,TB} = EF_{TB} \times A \times 10^{-6}$$

Where:

$E_{VOC,TB}$	=	Emissions of volatile organic compounds from tank breathing	(kg/yr)
EF_{TB}	=	Emission factor for tank breathing	(mg/litre)
A	=	Amount of fuel dispensed	(litres/yr)

The emission factor for tank breathing was calculated using the following equation (EEA 2013).

$$EF_{TB} = EF_{TBU} \times RVP \times 10^{(0.000007047 \times RVP + 0.0132) \times T_a + (0.0002311 \times RVP - 0.5236)}$$

Where:

EF_{TB}	=	Emission factor for tank breathing	(g/kL)
EF_{TBU}	=	Emission factor for tank breathing, uncorrected = 3 mg/litre	(g/m^3 throughput/kPa TVP)[8]
T_a	=	Ambient air temperature	(°C)
RVP	=	Reid vapour pressure	(kPa)

The equations above are designed to estimate emissions from petrol fuel. To estimate emissions from diesel fuel at fuel retailing facilities, the emission factors in the equations were adjusted using the following equation (NPI 1999d).

[8] Uncorrected storage tank breathing emission factor sourced from Table 3-9, Activity 050503 (EEA 2013)

$$EF_d = EF_p \times \frac{RVP_d}{RVP_p}$$

Where:

EF_d	=	Emission factors for diesel fuels	(mg/litre)
EF_p	=	Emission factors for petrol fuels	(mg/litre)
RVP_d	=	Reid vapour pressure for diesel	(kPa)
RVP_p	=	Reid vapour pressure for petrol	(kPa)

Emission estimates for autogas handling at fuel retailers were calculated using the following equation (NPI 1999d).

$$E_{VOC} = EF_{LPG} \times A \times 10^{-6}$$

Where:

E_{VOC}	=	Emissions of volatile organic compounds	(kg/yr)
EF_{TB}	=	Emission factor for autogas use = 0.04	(mg/litre)
A	=	Amount of fuel dispensed	(litres/yr)

Volatile organic compound emissions from fuel retailing were speciated using the speciation profile in Appendix C.

Activity data

Fuel dispensed (A)

The volume of fuel distributed by fuel retailers was estimated using Bureau of Resources and Energy Economics Australian Petroleum Statistics data (BREE 2012). A population ratio was used to scale the BREE data to the study area. Population data were sourced from the Australian Bureau of Statistics (ABS 2011a, 2011b, 2011c). Fuel data used for fuel retail emission estimates are presented in Table 28.

Table 28 – Retail fuel dispensed data

Fuel type	Fuel sold – WA 2011–12 (kL)	Fuel sold – study area 2011–12 (kL)
Petrol	1,746,997	1,366,540
Diesel	937,185	733,087
Autogas	146,924	114,927

Ambient air temperature (Ta)

Ambient air temperature data were generated using ‘The Air Pollution Model’ Version 4 (TAPM V4). The model was used to generate gridded meteorology data for the study area. Additional information on meteorology development is provided in the document *Perth Air Emissions Study 2011–2012 – Technical report 1: Biogenic and geogenic emissions*. Ambient temperature used in estimates is the monthly average presented in Table 29.

Reid vapour pressure (RVP)

Petrol RVP data was based on local fuel terminal sampling provided by industry.

A diesel RVP value of 3.5 kPa was considered for calculations as local fuel terminal data was not available (NSW EPA 2012).

Fuel transfer control factor (CFFT)

Service stations in the Perth metropolitan region are required to have a stage I vapour recovery system installed to mitigate emissions from bulk fuel transfers. The control factor applied to emission estimates accounted for:

- a truck vapour collection efficiency of 98.7 per cent (USEPA 2008); and
- a vapour recovery unit control efficiency of 96 per cent (NSW EPA 2012)

Multiplying these efficiencies together gives a fuel transfer control factor of 0.948.

Table 29 – Fuel retailing emission variables

Month	Ambient air temperature T_a (°R)[9]	True vapour pressure P (psia)	Molecular weight of vapours M (lb/lb-mole)[10]
Jul-11	515.5	5.77	65
Aug-11	516.6	6.02	65
Sep-11	516.5	5.66	65
Oct-11	520.7	5.65	66
Nov-11	523.4	5.41	66
Dec-11	528.8	5.99	66
Jan-12	532.9	6.47	66
Feb-12	530.4	6.17	66
Mar-12	529.4	6.07	66
Apr-12	524.4	5.78	66
May-12	520.0	5.57	66
Jun-12	517.5	5.53	65

Table 30 – Calculated emission factors for fuel retailing

Month	Fuel transfer EF_{FT} (mg/litre)		Vehicle refuelling EF_{RV} (mg/litre)		Fuel spillages EF_{FS} (mg/litre)		Tank breathing EF_{TB} (mg/litre)	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
Jul-11	57.0	2.45	1090	46.9	80	3.44	116	5.01
Aug-11	59.4	2.50	1139	48.0	80	3.37	121	5.11
Sep-11	55.8	2.49	1045	46.6	80	3.57	114	5.09
Oct-11	56.1	2.69	985	47.2	80	3.84	114	5.45
Nov-11	53.4	2.79	904	47.2	80	4.18	109	5.68
Dec-11	58.6	3.06	959	50.1	80	4.18	119	6.24
Jan-12	62.8	3.28	1004	52.4	80	4.18	129	6.71
Feb-12	60.2	3.14	976	51.0	80	4.18	123	6.42
Mar-12	59.2	3.09	966	50.5	80	4.18	121	6.32
Apr-12	57.0	2.85	968	48.4	80	4.00	116	5.80
May-12	55.3	2.66	975	46.8	80	3.84	112	5.38
Jun-12	54.5	2.51	1002	46.3	80	3.69	112	5.16

[9] °R (Rankine) is the Kelvin (K) equivalent for the Fahrenheit (°F) scale. °R = °F + 459.6

[10] Molecular weight of vapour data sourced from Table 7.1-2 AP42 Chapter 7.1 (USEPA 2006a). Values based on 'Gasoline RVP 10' and 'Gasoline RVP 11.5' data.

Emission estimates

Emissions of pollutants from fuel retailing are summarised in Table 31.

Table 31 – Fuel retailing total emission estimates

Pollutant	Emissions (kg/yr)
Benzene	13,385
Cumene (1-methylethylbenzene)	2,248
Cyclohexane	858
Ethylbenzene	1,979
n-Hexane	3,775
Toluene (methylbenzene)	33,840
Total volatile organic compounds	1,760,646
Xylenes (individual or mixed isomers)	13,461

Spatial allocation

Emissions were spatially allocated to fuel retailing locations determined during facility identification (Section 2.1). Vehicle activity data were used to allocate emissions to individual facilities. Vehicle kilometres travelled (VKT) data from the document *Perth Air Emissions Study 2011–2012 – Technical report 4: On-road vehicle emissions* were mapped against facility locations. VKTs within a nine square kilometre area around each facility location were used to proportionally allocate total emission estimates for each substance. In the cases where VKT data did not exist near a facility, the 70th percentile of VKT data for all grid cells was applied for proportioning calculations.

The spatial allocation of volatile organic compound emissions from fuel retailing facilities is presented in Figure 7.

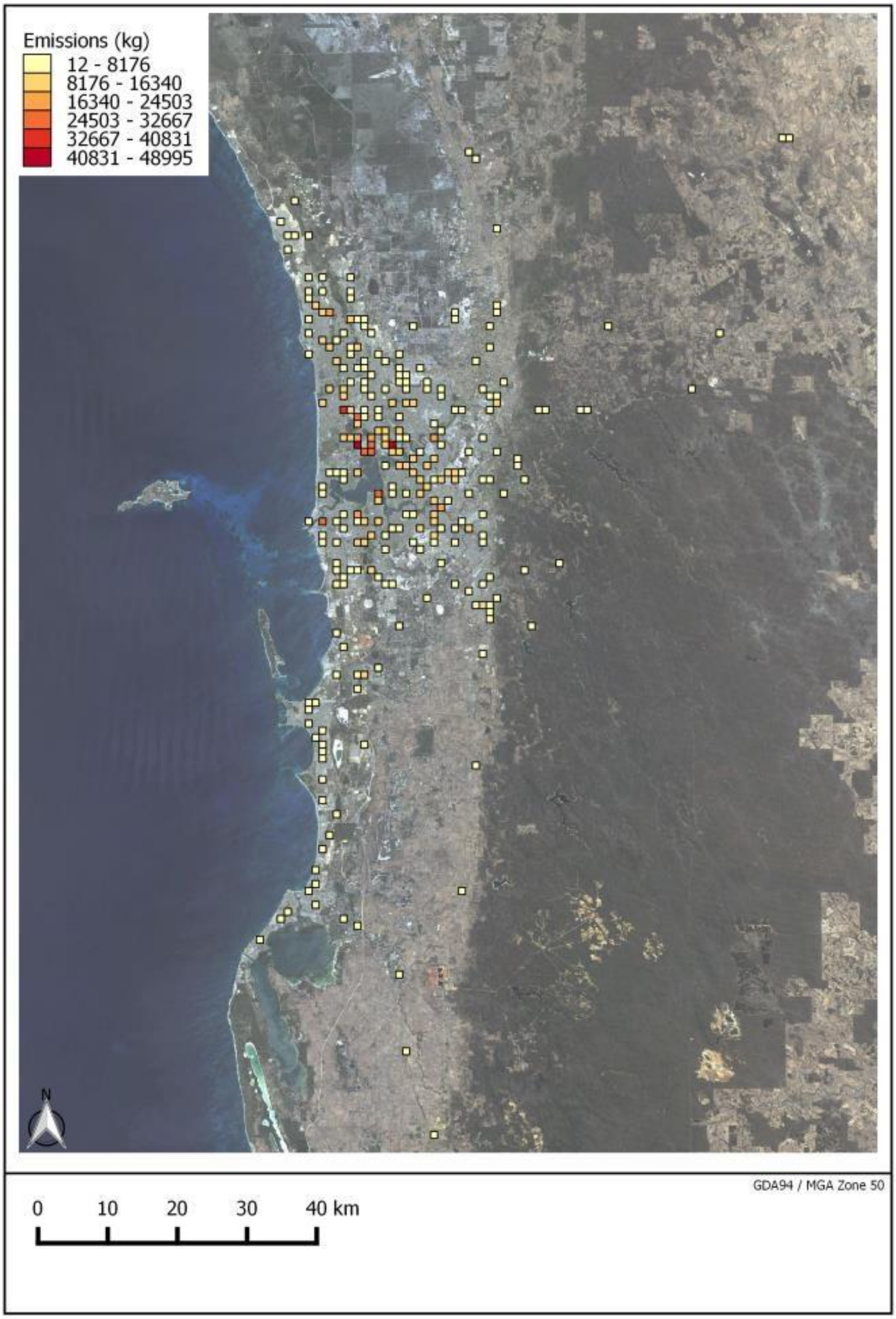


Figure 7 – Spatial allocation of fuel retailing VOC emissions

2.8 Health care and social assistance emissions

Health care and social assistance emission estimates are based on the combustion of fuel at hospital facilities. Most hospitals in the study area use boilers in their operations, with major facilities burning enough fuel each year to trigger reporting of emissions to the NPI.

Emission estimation techniques

The hospitals in Table 32 were identified using the process outlined in Section 2.1.

Table 32 – Hospitals identified in study area

Industry	NPI facilities	Non-NPI facilities
Hospitals	10	12

Emissions from hospital facilities that reported to the NPI for the study period were adopted for this study. Hospital emissions estimates reported to the NPI did not include heavy metals as the reporting thresholds were not met. Emission estimates for heavy metals from NPI reporting facilities were made using the method applied for non-NPI facilities below.

Emissions from non-NPI hospital facilities were estimated using the methods and factors described in the NPI Combustion in Boilers manual (NPI 2011a). Emission estimates were made using the general equation below.

$$E_i = EF_i \times A \times CF$$

Where:

E_i	=	Emissions of substance (i)	(kg/yr)
EF_i	=	Emission factor for substance (i)	(kg/tonne)
A	=	Fuel consumed	(tonne)
CF	=	Emission control factor	(–)
i	=	Substance	(–)

Activity data

Fuel use data were sourced from each non-NPI reporting hospital. Where fuel use data were not available, aerial imagery was used to determine if a boiler was installed. Fuel use for boilers was estimated by plotting fuel use data available against the number of beds for each facility.

Bed data were sourced from the Department of Health website and/or hospital websites. Using a line of best fit on the available data, fuel use was estimated based on bed numbers for facilities with no fuel use data.

Fuel use from non-NPI hospitals was assumed to be 100 per cent natural gas. Emission factors from Table 21 of the NPI Combustion in Boilers manual (NPI 2011a) were used. The emission factors used are presented in Appendix B.

Emission estimates

Emissions of pollutants from hospitals are summarised in Table 33.

Table 33 – Health care total emission estimates

Pollutant	Emissions (kg/yr)
Acetaldehyde	0.028
Arsenic and compounds	0.060
Benzene	1.02
Beryllium and compounds	0.00036
1,3-Butadiene	0.00011
Cadmium and compounds	0.33
Carbon monoxide	26,276
Chromium (total)	0.42
Cobalt and compounds	0.024
Copper and compounds	0.25
Cumene (1-methylethylbenzene)	0.013
Cyclohexane	0.0028
Ethylbenzene	0.0032
Formaldehyde (methyl aldehyde)	0.084
n-Hexane	0.0046
Lead and compounds	0.15
Manganese and compounds	0.11
Mercury and compounds	0.078
Nickel and compounds	0.62
Oxides of nitrogen	44,391
Particulate matter ≤ 2.5 µm	2,475
Particulate matter ≤ 10 µm	2,475
Polychlorinated dioxins and furans (TEQ)	0.0000016
Polycyclic aromatic hydrocarbons (B[a]Peq)	0.19
Selenium and compounds	0.0071
Sulfur dioxide	1,935
Toluene (methylbenzene)	0.29
Total volatile organic compounds	1,883
Xylenes (individual or mixed isomers)	0.21
Zinc and compounds	8.55

Spatial allocation

Emissions from both NPI and non-NPI reporting hospitals were spatially allocated according to their recorded facility location in the NPI database or determined during facility verification (Section 2.1).

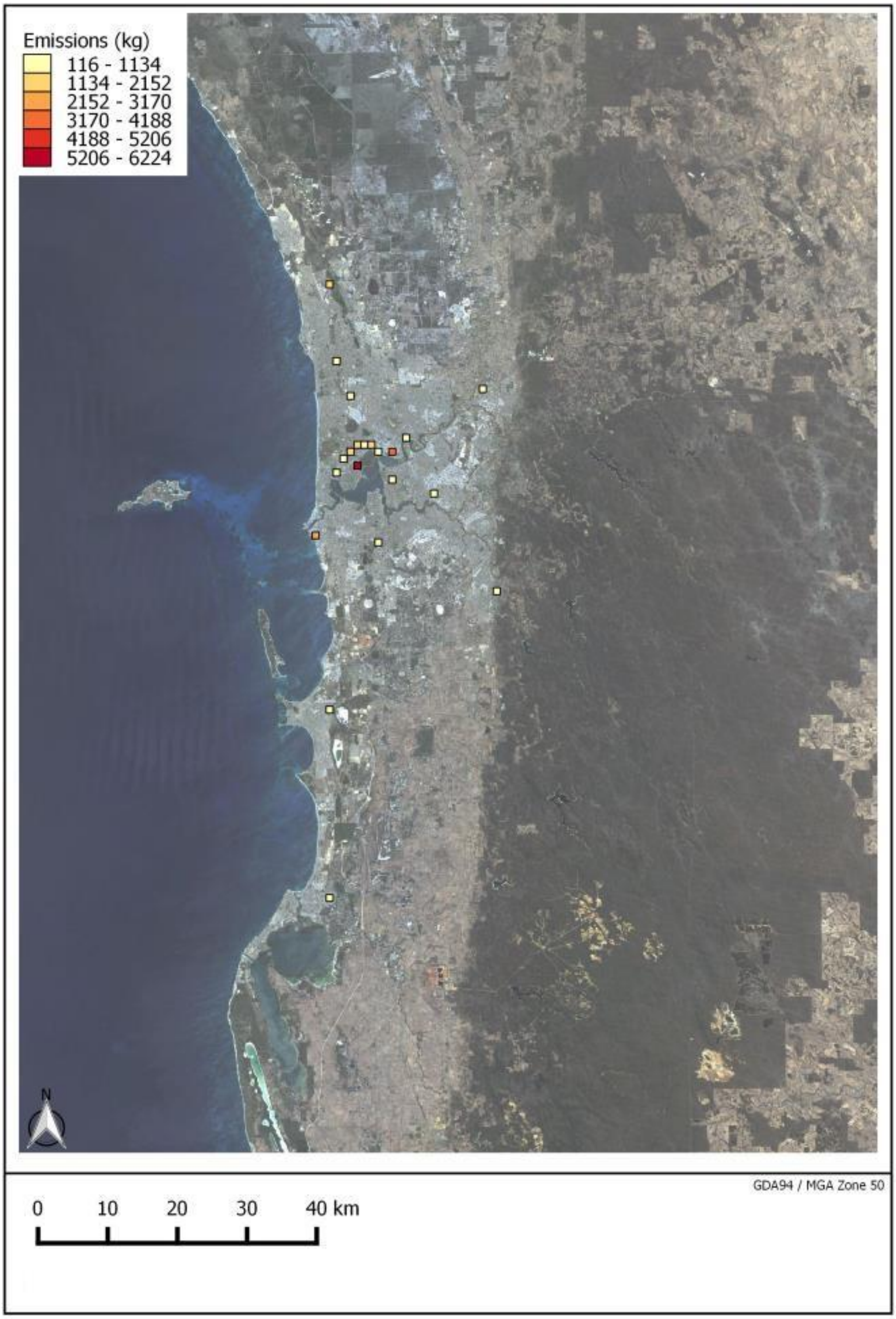


Figure 8 – Spatial allocation of hospital CO emissions

2.9 Services emissions

Services emission estimates apply to industries in the study area that provide a range of personal services for the population. Emissions were estimated from the following industries:

- automotive body, paint and interior repair;
- funeral, crematorium and cemetery services; and
- laundry and dry-cleaning services.

Automotive body, paint and interior repair and laundry and dry-cleaning services produce VOC emissions as a result of paint and solvent use in their processes. Crematorium and laundry and dry-cleaning services produce combustion emissions as a result of natural gas consumption.

Emission estimation techniques

The services facilities in Table 34 were identified using the process outlined in Section 2.1.

Table 34 – Services facilities identified in study area

Industry	NPI facilities	Non-NPI facilities
Automotive body, paint and interior repair	0	271
Funeral, crematorium and cemetery services	1	6
Laundry and dry-cleaning services	1	65

Emissions from services facilities that reported to the NPI for the study period were adopted for this study. Sub-threshold emissions of heavy metals from combustion were estimated using the methods applied for non-NPI facilities.

Emissions from services were estimated by combining NPI reported data and estimates for non-NPI facilities. Emissions from non-NPI facilities were estimated using the methods and techniques summarised in Table 35. Emission factors applied have been reproduced in Appendix B.

Table 35 – Services emission estimation techniques used

Industry	Emission estimation techniques applied	Appendix B reference
Automotive body, paint and interior repair	VOCs from Surface Coatings (ENVIRON 2009) *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales* (NSW EPA 2012)	Table 54
Funeral, crematorium and cemetery services	NPI Crematoria manual (NPI 2011b)	Table 55
Laundry and dry-cleaning services	NPI Combustion in Boilers manual (NPI 2011a)	Table 56

Emissions from non-NPI services facilities were estimated using the general equation below.

$$E_i = EF_{i,p} \times A_p$$

Where:

E_i	=	Emissions of substance (i)	(kg/yr)
$EF_{i,p}$	=	Emission factor for substance (i) from process (p)	(varies)
A_p	=	Activity of process (p)	(varies)
i	=	Substance	(–)
p	=	Process	(–)

Where appropriate, VOC emissions from services were speciated using the profiles summarised in Table 36. Speciation factors applied are presented in Appendix C.

Table 36 – Services emission speciation profiles used

Industry	Emission speciation profile applied	Appendix C reference
Automotive body, paint and interior repair	NPI Aggregated Emissions from Motor Vehicle Refinishing manual (NPI 1999b)	Table 61
Laundry and dry-cleaning services	NPI Aggregated Emissions from Dry Cleaning manual (NPI 1999a)	Table 62

Activity data

Industry survey

The average response rate of identified non-NPI services facilities was 17 per cent.

The data collected were averaged to create generic activity profiles for services industries with no operational data.

Automotive body, paint and interior repair

The emission sources estimated for automotive body, paint and interior repair included paint, coatings, solvent and adhesive use.

The activity profile in Table 37 was used to estimate emissions. No emission control factors were applied for automotive body, paint and interior repair.

Table 37 – Automotive body, paint and interior repair facility activity profile

Activity	Value	Units
1K – Primers	21.9	litres/yr
1K – Lacquers – clear	10.2	
1K – Lacquers – colour	1.17	
1K – Synthetic air dry enamels	6.82	
1K – Thinners	227	
2K – Primers – urethane	133	
2K – Primers – other	131	
2K – Basecoats	181	
2K – Topcoats – clear	190	
2K – Topcoats – colour	101	
2K – Hardeners – isocyanates	100	
2K – Hardeners – other	49.4	
2K – Thinners	264	
2K – Other (e.g. cleaners, enamel)	109	

No emission control factors were applied for automotive body, paint and interior repair.

Funeral, crematorium and cemetery services

Cremation was the only emission source estimated for funeral, crematorium and cemetery services.

To estimate emissions from funeral, crematorium and cemetery services facilities, each identified facility was contacted. Human cremations ranged between 1,500 and 4,500 a year depending on the facility, while animal cremations ranged between 4,000 and 15,000. Animal cremations, on average, were 95 per cent domestic pets and five per cent large animals.

The emission factors for cremation are based on cremation events with an average mass of 90 kilograms. To scale emission factors, average weight data from cremation service providers were used. Scaling factors are presented in Table 38.

Table 38 – Cremation emission factor scaling factors

Cremation type	Average cremation mass (kg)	Weighting factor
Humans	100	1.11
Domestic pets	35	0.39
Large animals	500	5.56

No emission control factors were applied for funeral, crematorium and cemetery services.

Laundry and dry-cleaning services

The following emission sources were estimated for laundry and dry-cleaning services:

- solvent use; and
- natural gas boiler operation.

The activity profile in Table 39 was used to estimate emissions from laundry and dry-cleaning services facilities. All solvent use was assumed to volatilise entirely (i.e. 100 per cent of usage converted to VOC emissions).

Table 39 – Laundry and dry-cleaning services facility activity profile

Activity	Value	Units
Tetrachloroethylene use	811	kg/yr
White spirit and alternate solvents	70	kg/yr
Natural gas use	1.28	tonnes/yr

No emission control factors were applied for laundry and dry-cleaning services.

Emission estimates

Emissions of pollutants from services are summarised in Table 40.

Spatial allocation

Emissions from both NPI and non-NPI reporting services facilities were spatially allocated according to their recorded facility location in the NPI database or determined during facility verification (see Section 2.1).

The spatial allocation of volatile organic compound emissions from services facilities is presented in Figure 9.

Table 40 – Services total emission estimates

Pollutant	Emissions (kg/yr)			
	Automotive body, paint and interior repair	Funeral, crematorium and cemetery services	Laundry and dry-cleaning services	Total
Acetaldehyde		1.80		1.80
Acetone	4,389			4,389
Antimony and compounds		0.42		0.42
Arsenic and compounds		0.41	0.014	0.43
Beryllium and compounds		0.019	0.000087	0.019
Cadmium and compounds		0.15	0.079	0.23
Carbon monoxide		2,998	6,131	9,129
Chromium (total)		0.60	0.10	0.70
Cobalt and compounds		0.024	0.00015	0.024
Copper and compounds		0.38	0.061	0.44
Cyclohexane	462			462
Ethyl acetate	4,867			4,867
Ethylbenzene	480			480
Fluoride compounds		43.8		43.8
Formaldehyde		0.47		0.47
Hydrochloric acid		980		980
Lead and compounds		0.91	0.036	0.95
Manganese and compounds			0.027	0.027
Mercury and compounds		13.8	0.019	13.8
Methyl ethyl ketone	4,854			4,854
Methyl isobutyl ketone	1,307			1,307

Pollutant	Emissions (kg/yr)			
	Automotive body, paint and interior repair	Funeral, crematorium and cemetery services	Laundry and dry-cleaning services	Total
Nickel and compounds		0.53	0.15	0.68
Oxides of nitrogen		15,648	7,205	22,854
Particulate matter ≤ 2.5 µm		1,040	533	1,574
Particulate matter ≤ 10 µm		1,157	534	1,691
Polychlorinated dioxins and furans (TEQ)		0.00015	0.00000036	0.00015
Polycyclic aromatic hydrocarbons (B[a]Peq)		0.78	0.046	0.83
Selenium and compounds		0.60	0.000043	0.60
Sulfur dioxide		2,215	79.5	2,295
Tetrachloroethylene			52,715	52,715
Toluene (methylbenzene)	91,341		22.8	91,364
Total volatile organic compounds	286,522	3,058	57,275	346,855
Xylenes (individual or mixed isomers)	33,805		833	34,638
Zinc and compounds		4.87	0.052	4.92

Figure 9 – Spatial allocation of services VOC emissions

2.10 Other ANZSIC codes emissions

This section addresses commercial and industrial facilities under other ANZSIC codes.

Wholesale trade facilities that report to the NPI have been included in the inventory. Facilities in this grouping include bulk fuel storage and distribution operations. Emissions reported are primarily fugitive emissions from fuel tanks and pipelines, with emissions of VOCs common across all facilities.

Transport, postal and warehousing facilities that report to the NPI have been included in the inventory. No additional facilities (i.e. non-NPI) were identified. Facilities in this grouping are linked to major transport infrastructure (ports and airport) that produce combustion emissions.

Emissions from other ANZSIC code facilities were sourced from the NPI database. No further emission estimates were made for these facilities.

Activity data

No activity data were collected or developed for other ANZSIC code facilities.

Emission estimates

Emissions of pollutants from other ANZSIC code facilities are summarised in Table 41.

Table 41 – Other ANZSIC code total emission estimates

Pollutant	Emissions (kg/yr)		
	Wholesale trade	Transport, postal and warehousing	Total
Acetaldehyde		0.25	0.25
Arsenic and compounds		0.00079	0.00079
Benzene	1,403	12.1	1,415
Beryllium and compounds		0.0000048	0.0000048
1,3-Butadiene (vinyl ethylene)		5.74	5.74
Cadmium and compounds		0.0044	0.0044
Carbon monoxide		29,207	29,207
Chromium (total)		0.0055	0.0055
Cobalt and compounds		0.00032	0.00032
Copper and compounds		0.0034	0.0034
Cumene (1-methylethylbenzene)	132	0.024	132
Cyclohexane	1,541	0.16	1,541
Ethylbenzene	569	0.035	569
Formaldehyde (methyl aldehyde)		105	105
n-Hexane	4,179	0.60	4,180

Pollutant	Emissions (kg/yr)		
	Wholesale trade	Transport, postal and warehousing	Total
Lead and compounds	0.0020	0.0022	0.0042
Manganese and compounds		0.0015	0.0015
Mercury and compounds		0.0010	0.0010
Nickel and compounds		0.0083	0.0083
Oxides of nitrogen		57,624	57,624
Particulate matter ≤ 2.5 µm		4,456	4,456
Particulate matter ≤ 10 µm		4,821	4,821
Polychlorinated dioxins and furans (TEQ)		0.000000020	0.000000020
Polycyclic aromatic hydrocarbons (B[a]Peq)		1.96	1.96
Selenium and compounds		0.000094	0.000094
Styrene (ethenylbenzene)	14.3		14.3
Sulfur dioxide		47.7	47.7
Toluene (methylbenzene)	3,740	0.48	3,740
Total volatile organic compounds	311,731	5,474	317,204
Xylenes (individual or mixed isomers)	3,185	0.24	3,186
Zinc and compounds		0.11	0.11

Spatial allocation

Emissions from other ANZSIC code facilities were spatially allocated according to their recorded facility location in the NPI database.

Other ANZSIC code facilities emissions were estimated for 31 different substances. While they share common pollutants, the main emission processes are different for each facility. The spatial allocation of other ANZSIC code facilities is presented in Figure 10 and only shows the facility locations represented in this study.

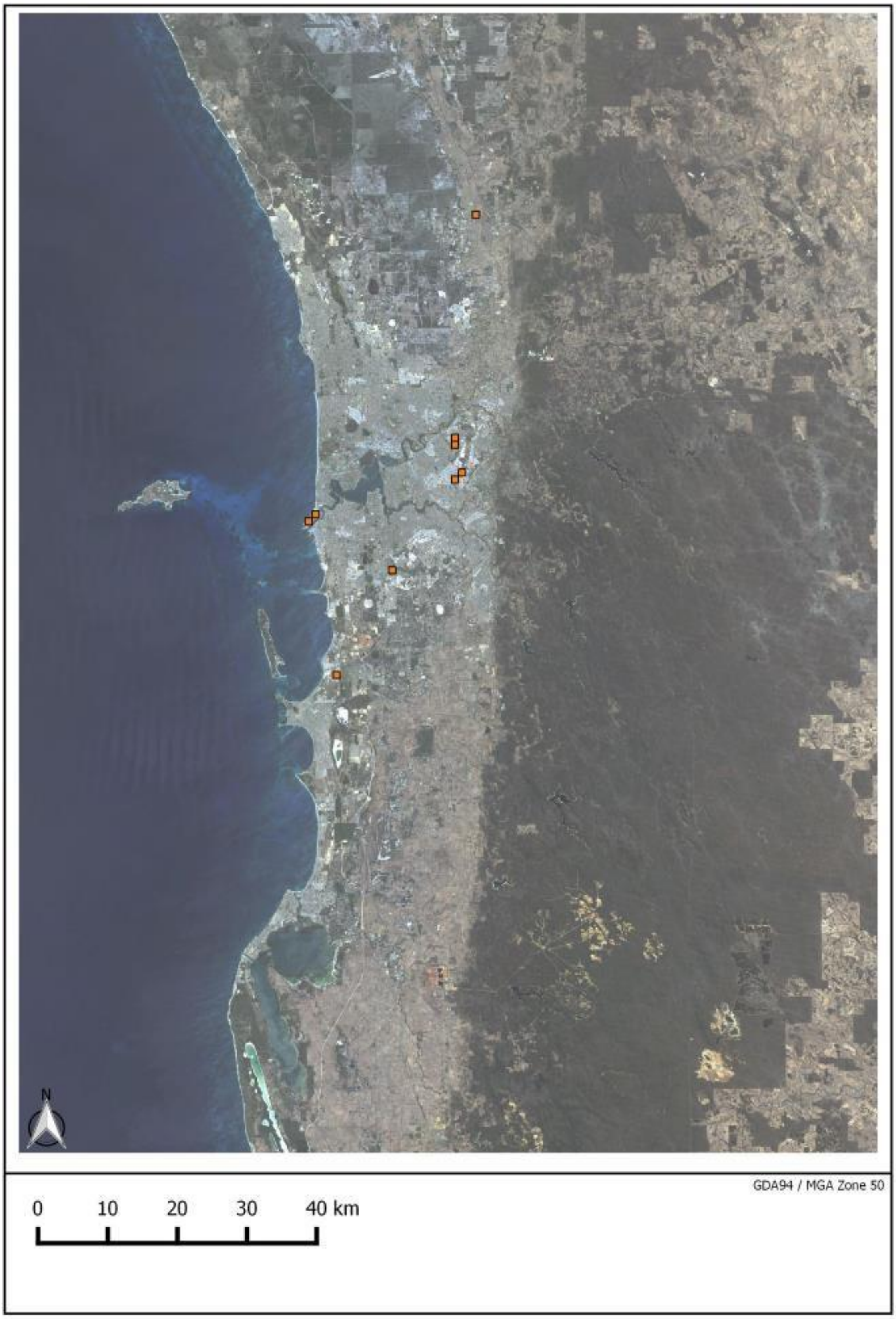


Figure 10 – Spatial allocation of other ANZSIC code emission sources

3 Total emission estimates

This section presents cumulative and comparative emissions estimates, and includes total emissions and NPI reported emissions compared with non-NPI estimated emissions.

To assess the relative risk for all emission estimates, toxic equivalency potential (TEP) scores were calculated. TEP is a technique increasingly being used by Australian and international environment agencies for comparing substances that have varying toxicities. TEP provides a screening-level evaluation of substances according to their effect on human health, and can be calculated in two ways. The ‘non-cancer risk’ score converts emissions to toluene-equivalents and is an assessment of the potential impact of toxins on general human health. The ‘cancer risk’ score converts emissions to benzene-equivalents and is an assessment of the potential impact of carcinogenic toxins[11].

This study assessed TEP using the non-cancer risk score to indicate the more general health risk. TEP is calculated by multiplying the emission estimates for substances by their corresponding non-cancer risk score. A list of NPI substances and their associated risk scores is included in Appendix D.

3.1 Total commercial and industrial emissions

Emission estimates and TEP scores for all commercial and industrial sources are presented in Table 42.

Table 42 – Commercial and industrial emissions estimates: total

Substance	Emissions (tonnes/year)	Toxic equivalency potential (TEP) score
Key pollutants		
Particulate matter ≤ 2.5 µm	6,142	104,409
Oxides of nitrogen	17,957	39,504
Particulate matter ≤ 10 µm	22,140	33,209
Sulfur dioxide	9,948	30,839
Total volatile organic compounds	6,864	6,864
Carbon monoxide	18,920	2,649
Other NPI-listed pollutants		
Mercury and compounds	1.04	5,223,595
Polychlorinated dioxins and furans (TEQ)	0.0000021	1,829,952
Lead and compounds	1.94	1,122,878
Cadmium and compounds	0.50	945,110
Copper and compounds	25.9	337,001

[11] Further information on how TEP is calculated can be found on the Scorecard website at: http://scorecard.goodguide.com/env-releases/def/tep_caltox.html

Substance	Emissions (tonnes/year)	Toxic equivalency potential (TEP) score
Arsenic and compounds	1.73	145,170
Chromium (total)	28.7	89,022
Cyanide (inorganic) compounds	134	77,460
Nickel and compounds	9.43	30,168
Ammonia (total)	6,927	26,321
Manganese and compounds	31.5	24,547
Cobalt and compounds	0.77	23,796
Hydrochloric acid	869	10,426
Tetrachloroethylene	52.9	3,438
Zinc and compounds	14.3	2,718
Formaldehyde (methyl aldehyde)	111	1,782
Beryllium and compounds	0.053	1,265
Hydrogen sulfide	23.9	811
Antimony and compounds	0.10	776
Selenium and compounds	0.24	581
Fluoride compounds	132	477
Acetaldehyde	48.1	447
Benzene	31.0	251
Toluene (methylbenzene)	186	186
Dichloromethane	12.2	85.2
Acrylamide	0.038	75.5
Carbon disulfide	33.7	40.5
Xylenes (individual or mixed isomers)	76.8	20.7
Aniline	0.15	13.5
Acrylic acid	0.21	12.8
Styrene (ethenylbenzene)	154	12.4
Acrylonitrile (2-propenenitrile)	0.17	6.59
Acetone	118	5.92
1,2-Dibromoethane	0.0029	4.38
Vinyl chloride monomer	0.045	3.10
Cumene (1-methylethylbenzene)	2.93	1.20
Methanol	11.2	1.00
1,3-Butadiene (vinyl ethylene)	0.39	0.86
Methyl methacrylate	1.40	0.74
Ethylbenzene	5.20	0.73
Phenol	1.67	0.63
Methyl ethyl ketone	12.3	0.61
Ethyl acetate	6.04	0.54
Acetonitrile	0.017	0.50

Substance	Emissions (tonnes/year)	Toxic equivalency potential (TEP) score
Nitric acid	0.14	0.29
Cyclohexane	12.6	0.25
Methyl isobutyl ketone	3.35	0.10
Phosphoric acid	0.0049	0.078
Chloroform (trichloromethane)	0.0043	0.060
1,1,2-Trichloroethane	0.011	0.052
Trichloroethylene	0.055	0.035
1,2-Dichloroethane	0.0057	0.024
Ethylene glycol (1,2-ethanediol)	0.048	0.012
Chloroethane (ethyl chloride)	0.13	0.0026
Biphenyl (1,1-biphenyl)	0.00021	0.00021
Acetic acid (ethanoic acid)	0.014	N/A
Boron and compounds	2.87	N/A
Chlorine and compounds	7.69	N/A
Ethanol	108	N/A
Glutaraldehyde	0.00039	N/A
n-Hexane	36.9	N/A
Nickel subsulfide	0.41	N/A
Polycyclic aromatic hydrocarbons (B[a]Peq)	0.46	N/A
Sulfuric acid	8.84	N/A
Toluene-2,4-diisocyanate	0.00060	N/A

The relative contributions of commercial and industrial emission sources to key pollutants are summarised in Figure 11 and Table 43. The relative contributions of commercial and industrial emission sources to the overall TEP score are shown in Figure 12.

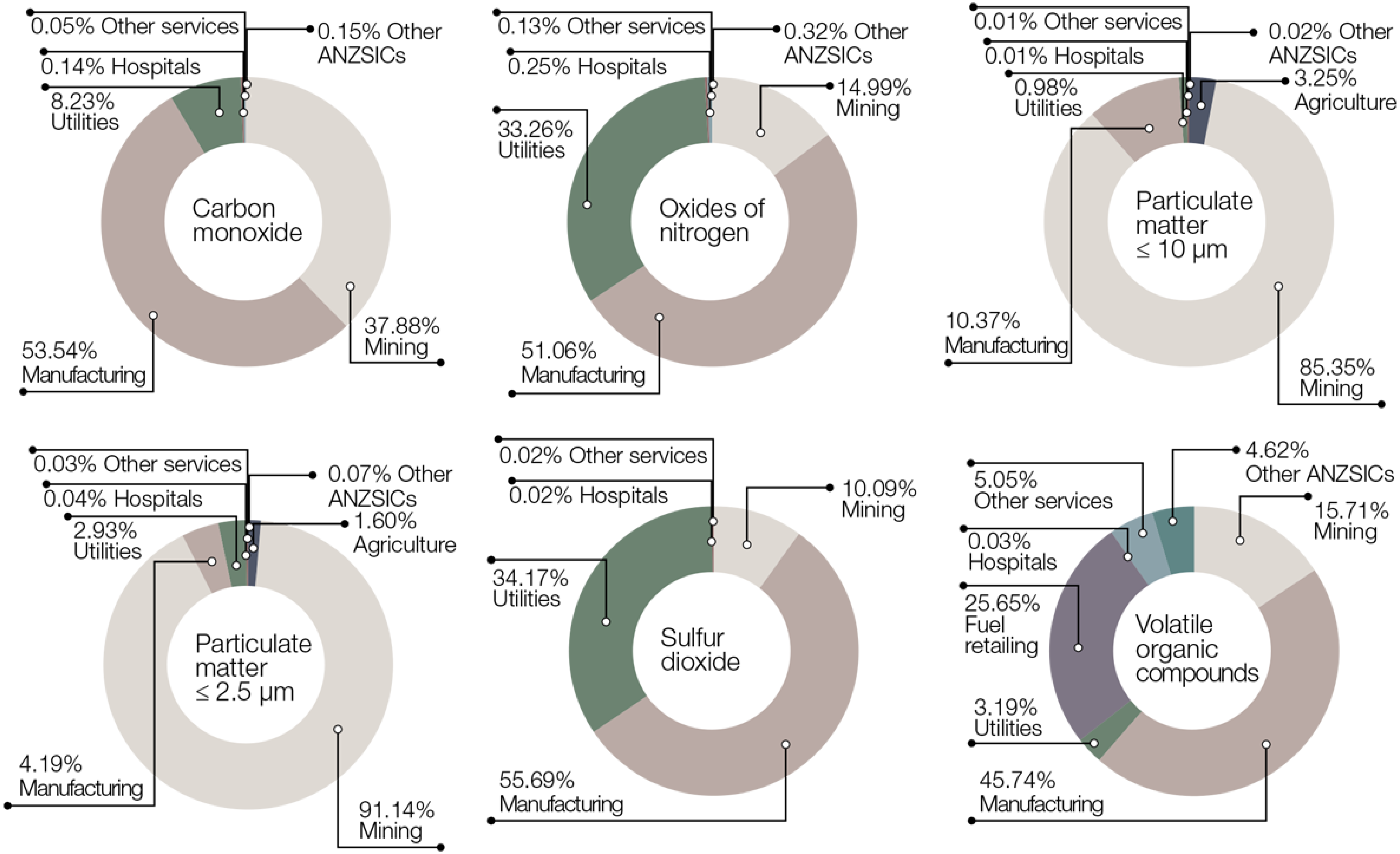


Figure 11 – Commercial and industrial emission estimates: source contributions by mass

Table 43 – Commercial and industrial emissions estimates by source

Substance	Emissions (tonnes/year)								Emissions (tonnes/year)
	Agriculture	Mining	Manufacturing	Utilities	Fuel retailing	Hospitals	Other services	Other ANZSICs	
Key pollutants									
Carbon monoxide		7,167	10,130	1,558		26.3	9.13	29.2	18,920
Oxides of nitrogen		2,691	9,169	5,972		44.4	22.9	57.6	17,957
Particulate matter ≤ 2.5 µm	98.1	5,598	257	180		2.47	1.57	4.46	6,142
Particulate matter ≤ 10 µm	720	18,897	2,296	217		2.48	1.69	4.82	22,140
Sulfur dioxide		1,004	5,540	3,399		1.93	2.29	0.048	9,948
Total volatile organic compounds		1,078	3,140	219	1,761	1.88	347	317	6,864
Other NPI-listed pollutants									
Acetaldehyde			48.1			0.000028	0.0018	0.00025	48.1
Acetic acid (ethanoic acid)			0.014						0.014
Acetone			114	0.20			4.39		118
Acetonitrile				0.017					0.017
Acrylamide			0.038						0.038
Acrylic acid			0.21						0.21
Acrylonitrile (2-propenenitrile)				0.17					0.17
Ammonia (total)	5,413	162	1,083	268					6,927
Aniline			0.15						0.15
Antimony and compounds		0.069	0.026	0.000030			0.00042		0.10
Arsenic and compounds		1.50	0.22	0.0068		0.000060	0.00043	7.92x10^{-07}	1.73
Benzene		0.16	15.9	0.20	13.4	0.0010		1.41	31.0
Beryllium and compounds		0.042	0.0071	0.0036		3.58x10^{-07}	0.000019	4.76x10^{-09}	0.053
Biphenyl (1,1-biphenyl)			0.00021						0.00021
Boron and compounds		2.76	0.10	0.0039					2.87
1,3-Butadiene (vinyl ethylene)			0.39			1.06x10^{-07}		0.0057	0.39

Substance	Emissions (tonnes/year)								Emissions (tonnes/ year)
	Agriculture	Mining	Manufacturing	Utilities	Fuel retailing	Hospitals	Other services	Other ANZSICs	
Cadmium and compounds		0.065	0.42	0.0075		0.00033	0.00023	$4.36x10^{-06}$	0.50
Carbon disulfide			33.7	0.0058					33.7
Chlorine and compounds			7.68	0.0050					7.69
Chloroethane (ethyl chloride)				0.13					0.13
Chloroform (trichloromethane)				0.0043					0.0043
Chromium (total)		6.51	22.2	0.026		0.00042	0.00070	$5.54x10^{-06}$	28.7
Cobalt and compounds		0.72	0.050			0.000024	0.000024	$3.22x10^{-07}$	0.77
Copper and compounds		24.9	1.04	0.021		0.00025	0.00044	$3.37x10^{-06}$	25.9
Cumene (1-methylethylbenzene)		0.033	0.46	0.058	2.25	0.000013		0.13	2.93
Cyanide (inorganic) compounds		126	7.27						134
Cyclohexane		0.0011	9.74	0.033	0.86	$2.76x10^{-06}$	0.46	1.54	12.6
1,2-Dibromoethane			0.0029						0.0029
1,2-Dichloroethane				0.0057					0.0057
Dichloromethane			11.9	0.26					12.2
Ethanol			108	0.0055					108
Ethyl acetate			1.09	0.086			4.87		6.04
Ethylbenzene		0.0078	1.87	0.29	1.98	$3.22x10^{-06}$	0.48	0.57	5.20
Ethylene glycol (1,2-ethanediol)			0.048						0.048
Fluoride compounds		21.9	90.4	20.1			0.044		132
Formaldehyde (methyl aldehyde)		34.9	75.5	0.79		0.000084	0.00047	0.11	111
Glutaraldehyde			0.00039						0.00039
n-Hexane		0.0016	28.8	0.14	3.78	$4.60x10^{-06}$		4.18	36.9
Hydrochloric acid		0.00023	707	161			0.98		869
Hydrogen sulfide			23.3	0.57					23.9
Lead and compounds		1.48	0.43	0.027		0.00015	0.00095	$4.24x10^{-06}$	1.94

Substance	Emissions (tonnes/year)								Emissions (tonnes/ year)
	Agriculture	Mining	Manufacturing	Utilities	Fuel retailing	Hospitals	Other services	Other ANZSICs	
Manganese and compounds		24.4	6.97	0.072		0.00011	0.000027	1.51×10^{-06}	31.5
Mercury and compounds		0.011	1.00	0.016		0.000078	0.014	1.03×10^{-06}	1.04
Methanol			11.2						11.2
Methyl ethyl ketone			7.16	0.26			4.85		12.3
Methyl isobutyl ketone			1.95	0.10			1.31		3.35
Methyl methacrylate			1.40						1.40
Nickel and compounds		2.40	6.99	0.038		0.00062	0.00068	8.31×10^{-06}	9.43
Nickel subsulfide			0.41						0.41
Nitric acid			0.14						0.14
Phenol			1.67						1.67
Phosphoric acid			0.0049						0.0049
Polychlorinated dioxins and furans (TEQ)		6.39×10^{-11}	1.84×10^{-06}	8.79×10^{-08}		1.63×10^{-09}	1.50×10^{-07}	1.96×10^{-11}	0.0000021
Polycyclic aromatic hydrocarbons (B[a]Peq)		0.070	0.34	0.046		0.00019	0.00083	0.0020	0.46
Selenium and compounds		0.038	0.20	0.00017		7.06×10^{-06}	0.00060	9.39×10^{-08}	0.24
Styrene (ethenylbenzene)			154	0.022				0.014	154
Sulfuric acid			8.84						8.84
Tetrachloroethylene				0.17			52.7		52.9
1,1,2-Trichloroethane				0.011					0.011
Trichloroethylene				0.055					0.055
Toluene (methylbenzene)		0.18	53.9	2.58	33.8	0.00029	91.4	3.74	186
Toluene-2,4-diisocyanate			0.00060						0.00060
Vinyl chloride monomer				0.045					0.045
Xylenes (individual or mixed isomers)		0.92	24.0	0.53	13.5	0.00021	34.6	3.19	76.8
Zinc and compounds		6.82	7.41	0.057		0.0085	0.0049	0.00011	14.3
Total TEP for each source	**23,319**	**1,769,416**	**7,892,410**	**219,943**	**1,908**	**2,702**	**205,661**	**582**	**10,115,941**

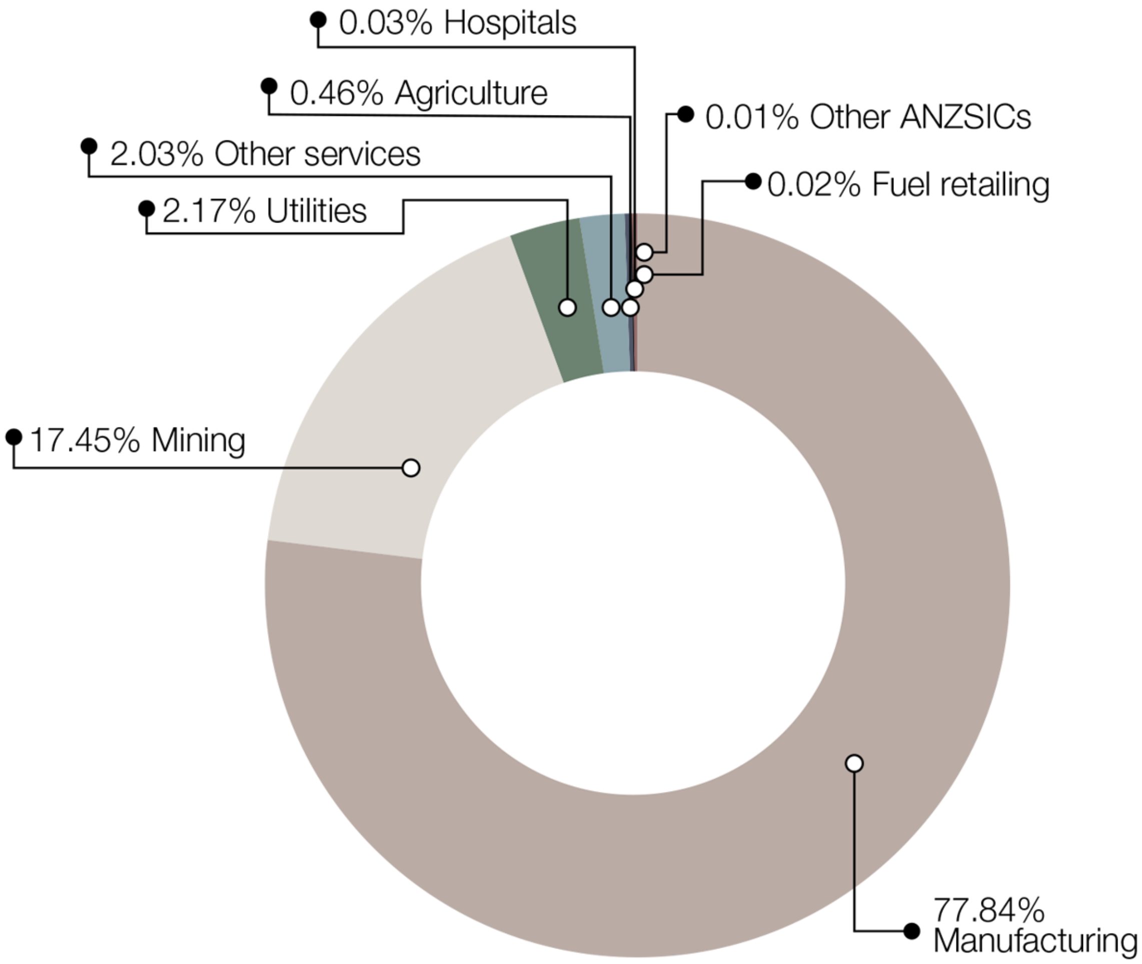


Figure 12 – Relative TEP contributions from commercial and industrial sources

The data show PM_{10} was the greatest substance emitted by mass. $PM_{2.5}$ emissions represented the greatest risk of the key pollutants listed. Emissions of heavy metals, including mercury, lead and cadmium, were substantially less than key pollutant emissions but represented a greater risk due to their high toxicity.

Mining activities were the primary source of particulate (PM_{10} and $PM_{2.5}$) emissions in the study area, with dust emissions making up the bulk of these. Most particulate emission data from mining facilities were sourced from the NPI database, which provided a more representative approach than the 'generic facility' approach applied to non-NPI facilities.

Emissions of heavy metals and polychlorinated dioxins and furans (TEQ) were attributed mainly to manufacturing and mining activities. Mining activities were also the main source of lead, copper and arsenic emissions, which were speciated from dust emissions.

Manufacturing and mining activities dominated the commercial and industrial emissions risk profile, with other commercial and industrial activities only contributing four per cent of total emission risk.

3.2 Spatial allocation summary

Spatial allocation of key pollutant emissions from all commercial and industrial sources is presented from Figure 13 to Figure 18. Emissions of all key pollutants were highest within the Kwinana Industrial Area and at mining operations in the south of the study area.

Spatial allocation of the TEP score for all commercial and industrial sources is presented in Figure 19. Areas with the highest TEP scores were located in the Kwinana Industrial Area and mining operations in the south of the study area which align with the locations of NPI reporting facilities.

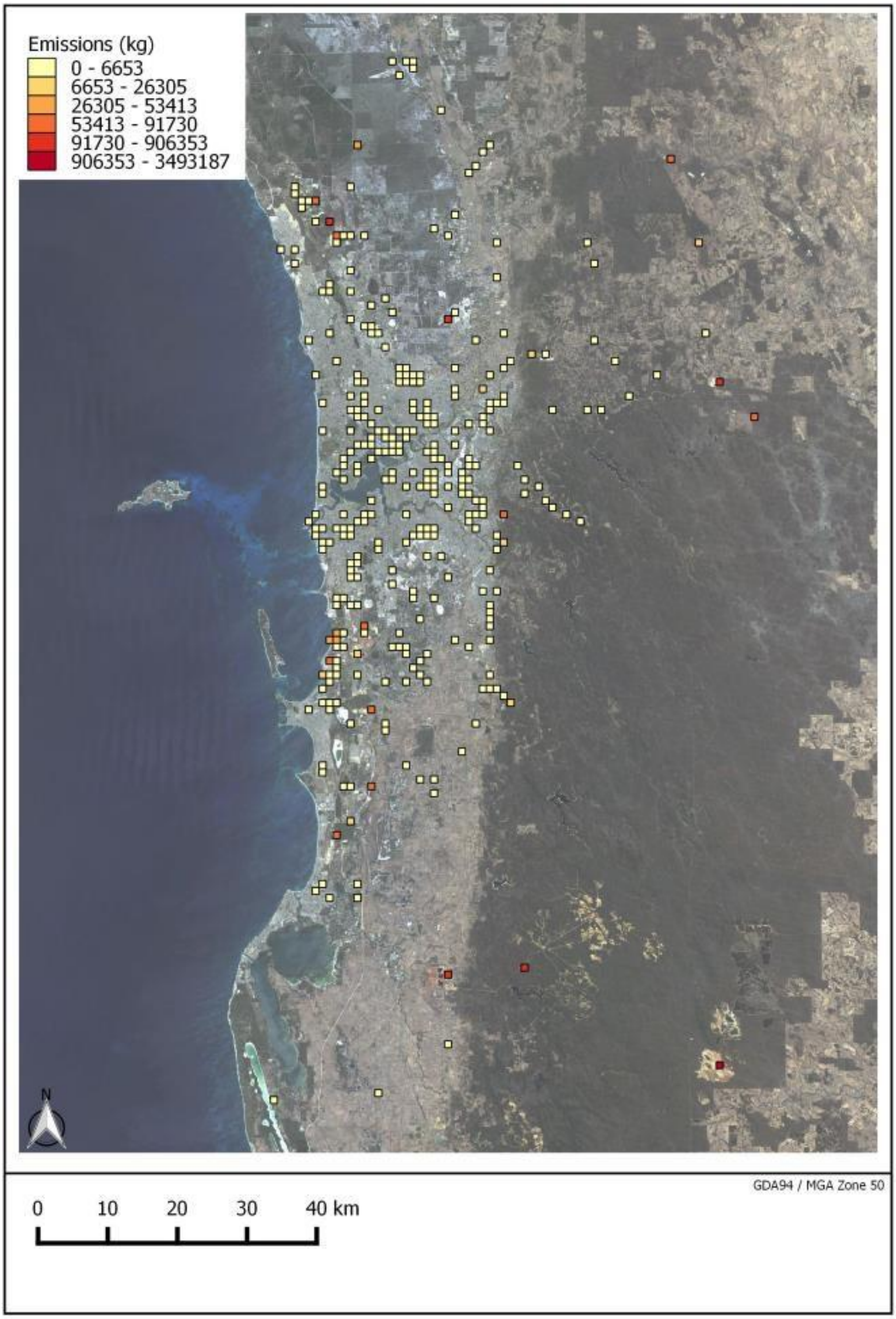


Figure 13 – Spatial allocation of commercial and industrial $PM_{2.5}$ emissions

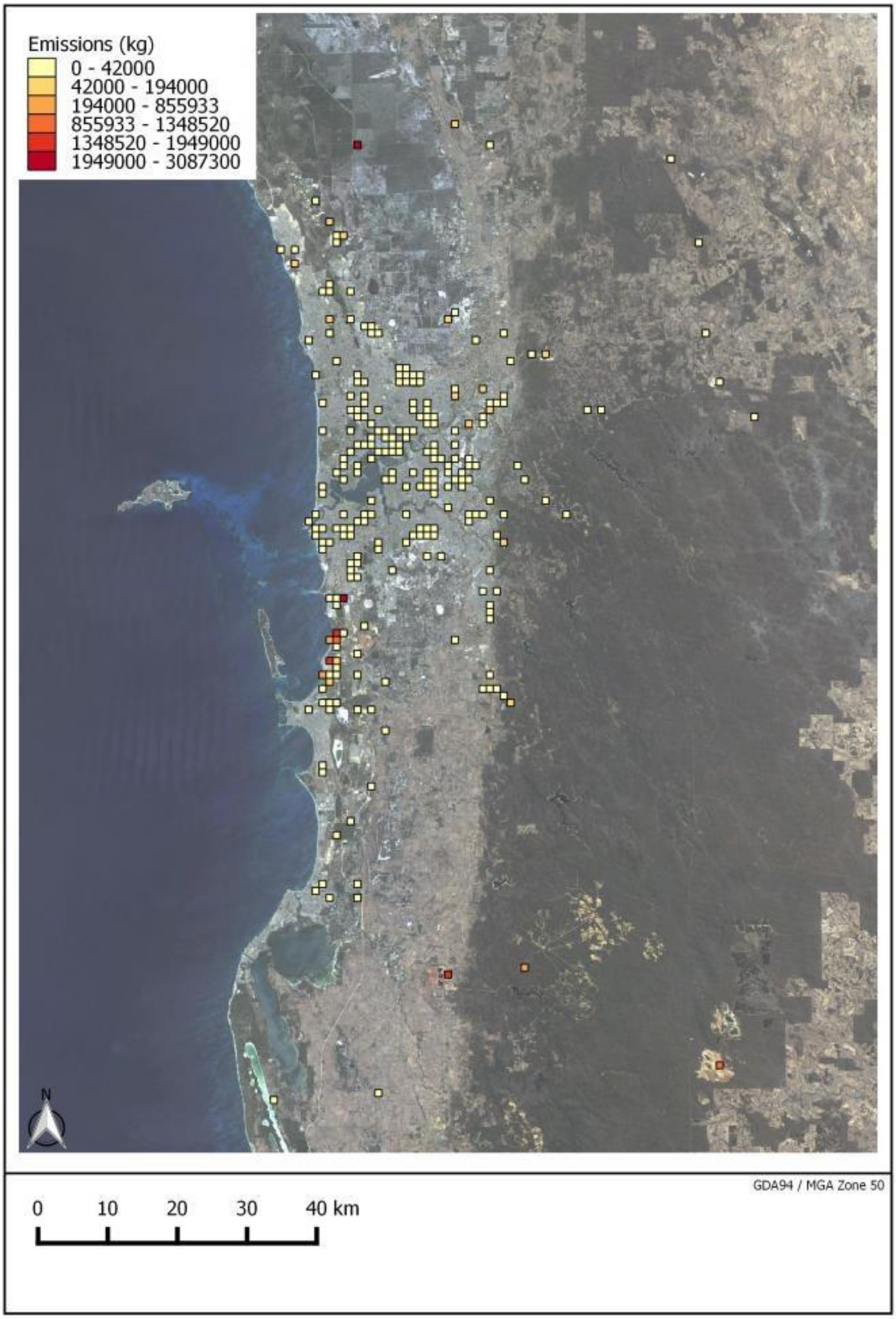


Figure 14 – Spatial allocation of commercial and industrial NO_X emissions

Figure 15 – Spatial allocation of commercial and industrial PM_{10} emissions

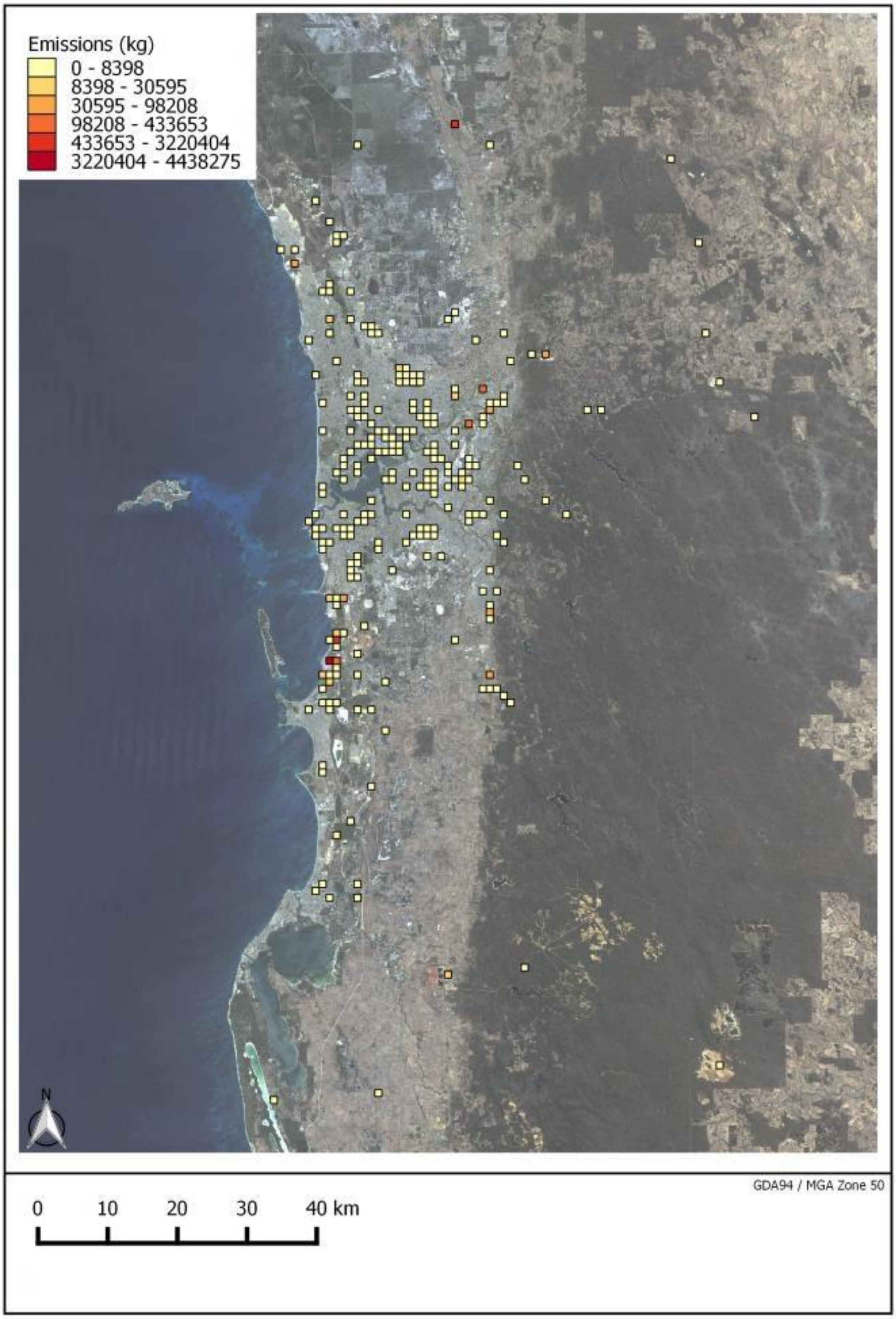


Figure 16 – Spatial allocation of commercial and industrial SO_2 emissions

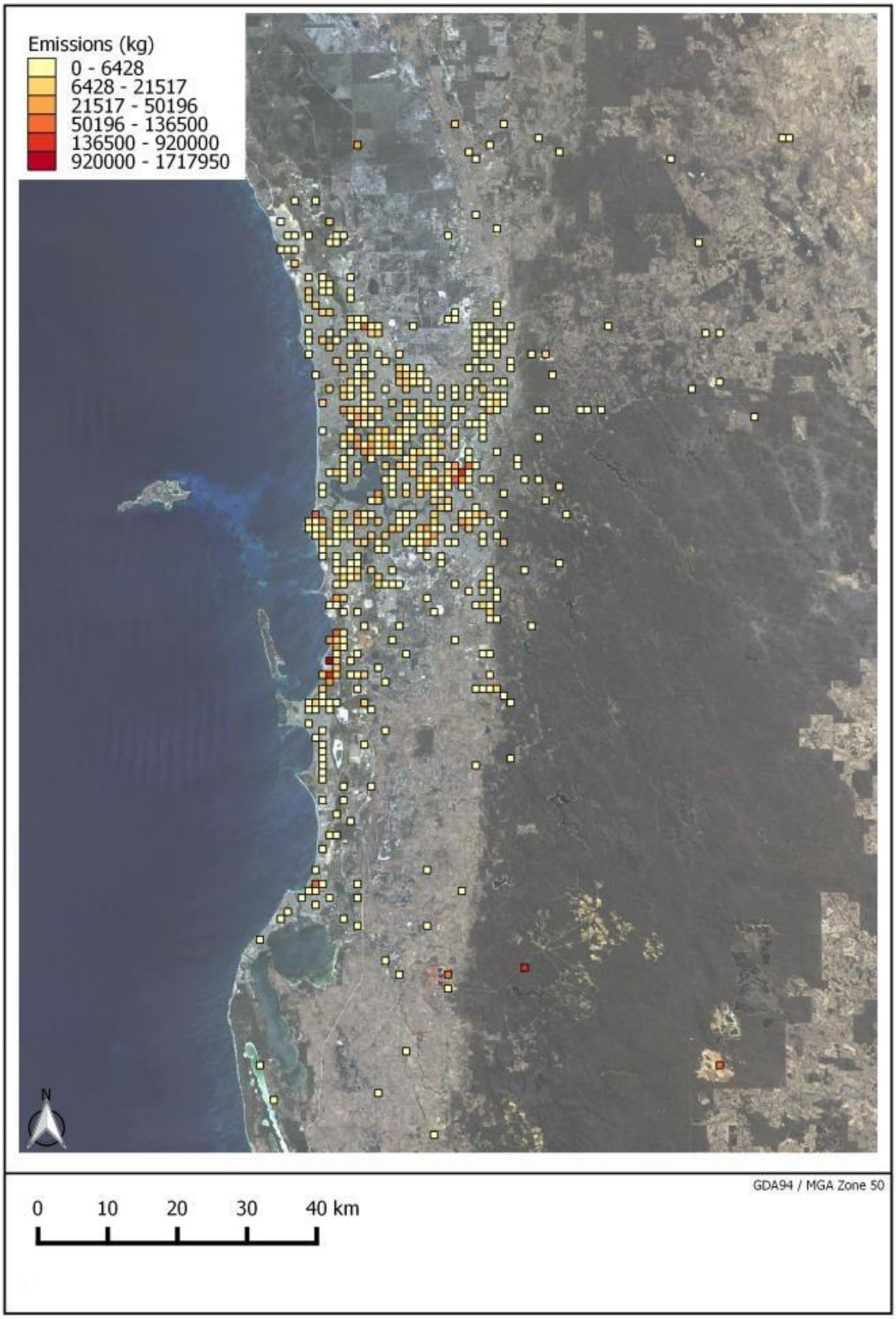


Figure 17 – Spatial allocation of commercial and industrial VOC emissions

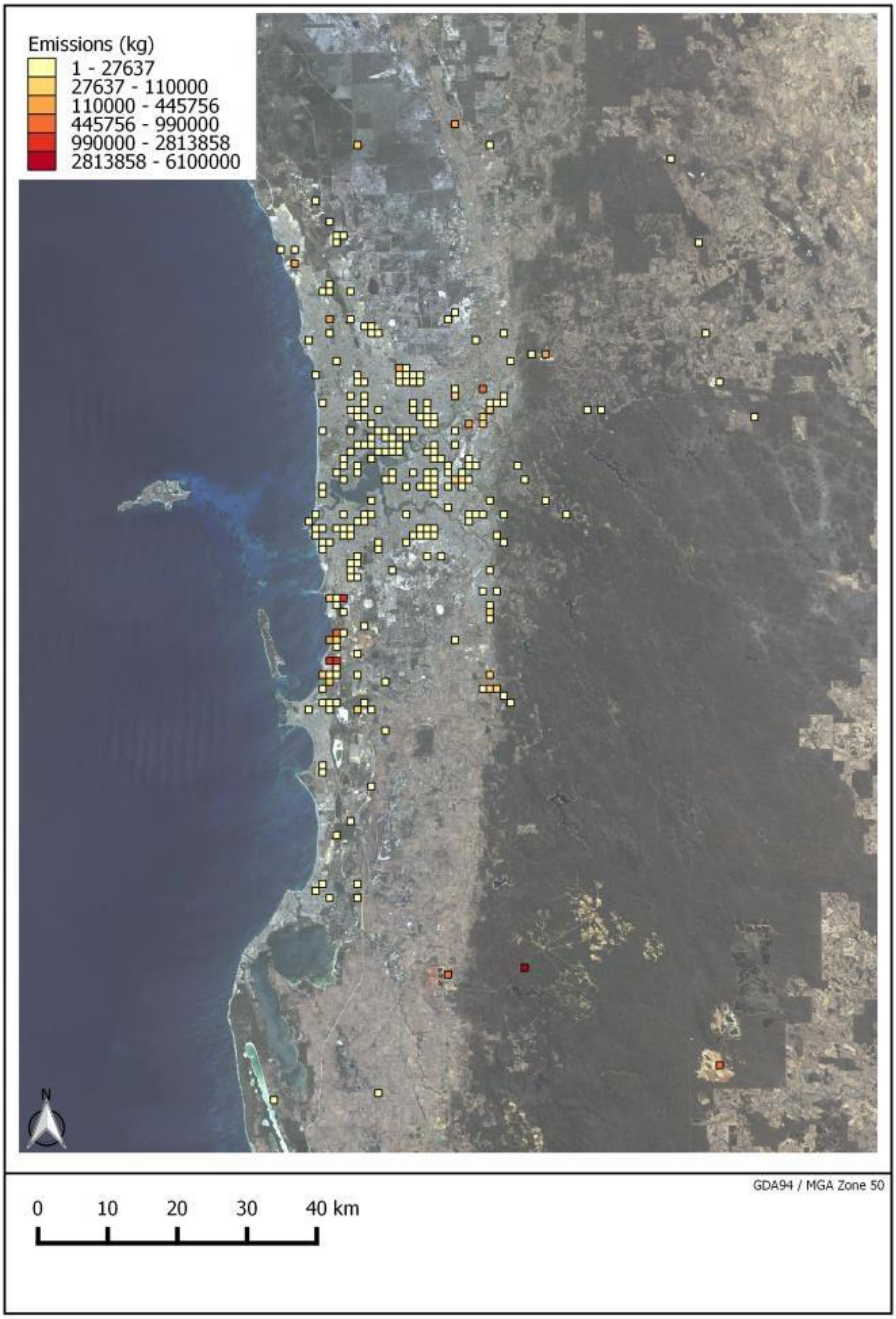


Figure 18 – Spatial allocation of commercial and industrial CO emissions

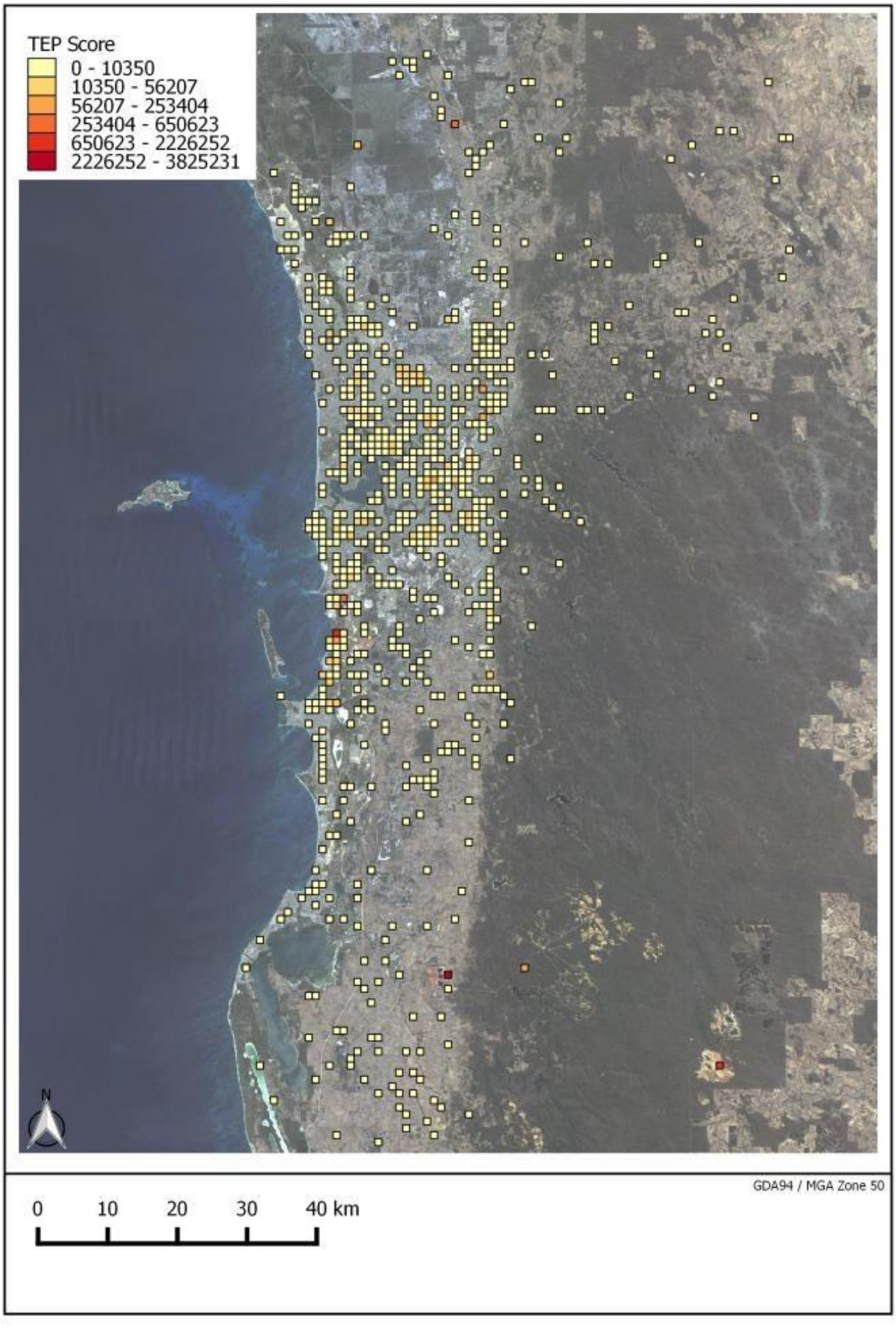


Figure 19 – Spatial allocation of commercial and industrial TEP score

3.3 NPI and non-NPI emissions

The relative TEP contributions from NPI reporting facilities and non-NPI facilities in the study area are shown in Figure 20 below.

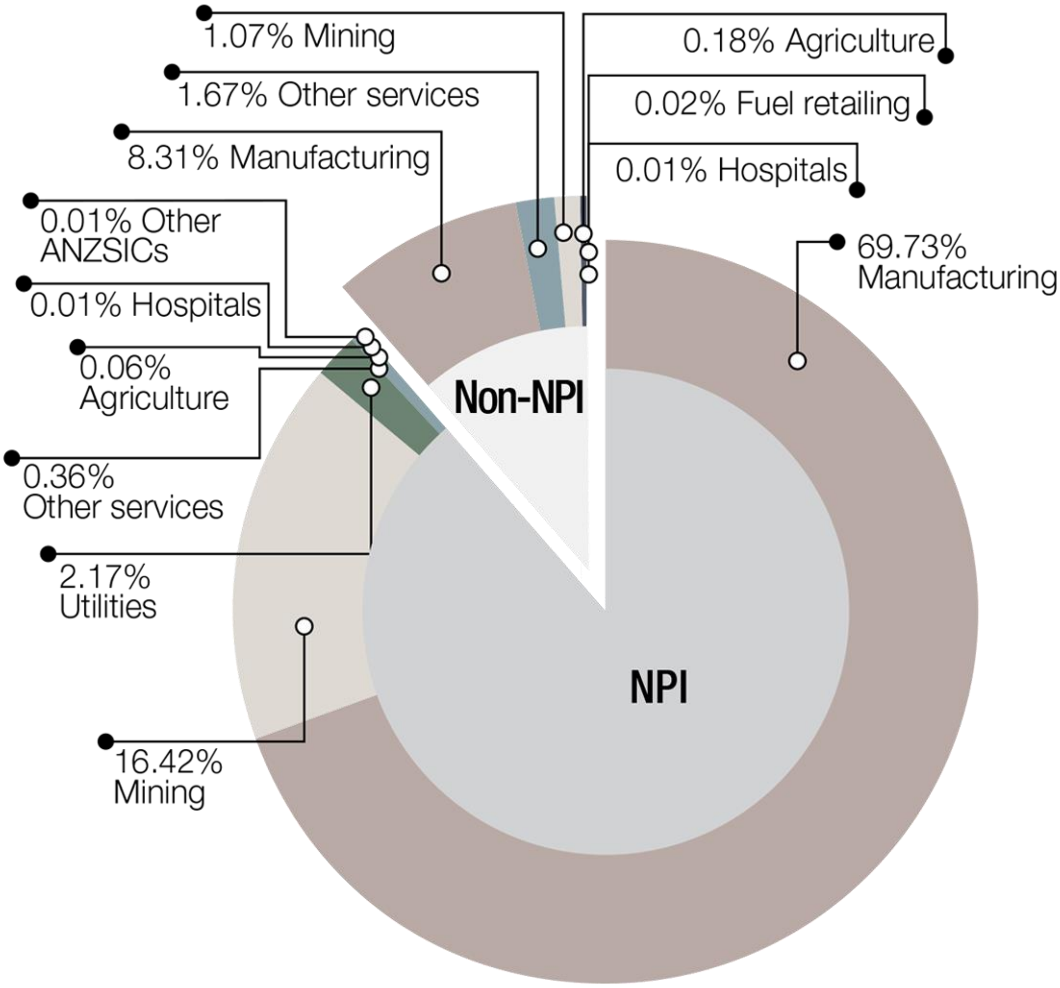


Figure 20 – NPI and non-NPI TEP contributions

The figure shows 89 per cent of commercial and industrial emission risk is captured through NPI reporting. Emissions of significance from NPI facilities in the study area reflect those presented in Table 42.

For non-NPI facilities, 54 per cent of TEP contributions were due to emissions of cadmium. Non-NPI cadmium emissions represented six per cent of the TEP score from all commercial and industrial emissions. Cadmium emissions were mainly a result of fabricated metal product manufacturing (Table 26), specifically electroplating.

While the generic facility profile developed for electroplating operations was based on industry survey data (Table 25) and considered reasonably representative, there was uncertainty as to the number of facilities that produced electroplating emissions. Fabricated metal product manufacturing facilities were assigned electroplating emissions unless individual facility survey data advised otherwise. As a result, it is likely total non-NPI cadmium emissions have been overestimated.

A sensitivity test of halving non-NPI cadmium emissions resulted in the non-NPI TEP contribution dropping from 11 per cent to eight per cent. This variance is not considered significant given the far larger TEP contribution from NPI reporting facilities.

The only other major contributors to non-NPI facility emissions risk were lead from quarrying (8.8 per cent) and metal manufacturing facilities (5.5 per cent), and polychlorinated dioxins and furans (TEQ) from cremation (11.5 per cent).

4 Key considerations

This study has found that:

- Emissions of heavy metals including mercury, lead and cadmium, as well as emissions of polychlorinated dioxins and furans (TEQ), were the most significant emissions risk from commercial and industrial sources due to their high toxicity. Heavy metal emissions are typically based on generic particulate and combustion speciation profiles and will have more uncertainty than specific estimation methods used for key pollutants.
- $PM_{2.5}$ emissions were the most significant of the key pollutants, and are almost entirely generated from mining activities.
- Manufacturing and mining activities dominated the emissions profile for commercial and industrial facilities: they represented 96 per cent of the emissions risk.
- The areas of most emission risk were limited to those where heavy industrial and mining activities occur: the Kwinana Industrial Area and mining operations in the south of the study area.
- NPI reporting facilities produced 88.7 per cent of the emissions risk from commercial and industrial activity in the study area.
- Non-NPI facility emission risk was mostly a result of cadmium emission estimates from electroplating activities. Estimates could be improved with a better understanding of electroplating activity in the study area, while noting that this is unlikely to significantly impact on the emissions risk profile.

This study's outcomes should be viewed in the wider context of other major emission sources (natural, domestic, on-road vehicles, off-road mobile sources) that were also part of the Perth Air Emissions Study 2011–2012.

Appendices

Appendix A — Sample business survey

Questionnaire: *0900 - Non-Metallic Mineral Mining and Quarrying*

We appreciate some of the requested data may not be readily available for your facility. Approximate numbers and your best estimates are entirely acceptable and appreciated.

1. What is your average annual fuel use on your site?

Fuel type	Use on site	How burnt (circle most representative)
Natural gas	[GJ] or [units]	Engines Boiler Turbine
Diesel	L	Engines Boiler
Petrol (incl. E10)	L	Engines Boiler
LPG	L	Engines Boiler

2. What is the average tonnage of material extracted per year at your site (all products)

_________________ *tonnes*

3. Please provide some or all details on your extraction/processing activities below (as applicable)

___________________________ *total tonnes of explosives used in an average year*

___________________________ *average number of blast events in a year*

___________________________ *average area per blast (m^2)*

___________________________ *average number of hole drilled per blast*

___________________________ *% extracted material primary crushed*

___________________________ *% extracted material secondary crushed*

___________________________ *% extracted material tertiary crushed*

4. What is the approximate surface area of:

Your quarries/pits and lay down areas ___________________________ *hectares*

Your product and topsoil stockpiles ___________________________ *hectares*

5. For each vehicle/engine type, please estimate a rough percentage use of your total diesel/petrol burnt on site:

Bulldozers	%	Haul trucks	%
Scrapers	%	Utes and light vehicles	%
Graders	%	Service trucks and other large vehicles	%
Front end loaders	%	Small generators and misc. equipment	%
Excavators	%	Large generators (for power)	%

6. Please indicate with a tick if you operate the following emission controls routinely

Water trucks [ ] Stockpile watering [ ] Water sprays in plant [ ]

Other controls (briefly describe): ____

____

____

7. Typically, what are your operational hours? (mark boxes below as appropriate)

Months of the Year:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
												100%

Days of the Week:

MON	TUES	WED	THUR	FRI	SAT	SUN	Total
							100%

Hours of the Day:

Hour ending	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Weekdays																								
Weekends																								

How many days a year does your facility typically extract/process materials? ____ days

Appendix B – Emission factors

Mining emission factors

Table 44 – Mining facility emissions factors

Process	Substance	Emission factor	Units
Excavation[12]	Total suspended particulate	0.025	kg/ tonne
	Particulate matter ≤ 10 µm	0.012	
Dump trucks[12]	Total suspended particulate	0.012	kg/ tonne
	Particulate matter ≤ 10 µm	0.0043	
Screening[12]	Total suspended particulate	0.08	kg/ tonne
	Particulate matter ≤ 10 µm	0.06	
Loading trucks[13]	Total suspended particulate	0.0022	kg/ tonne
	Particulate matter ≤ 10 µm	0.0010	
Wheel generated dust[14]	Total suspended particulate	0.24	Kg /tonne
	Particulate matter ≤ 10 µm	0.069	
Wind erosion[12]	Total suspended particulate	0.4	kg/ha/ hr
	Particulate matter ≤ 10 µm	0.2	
Fuel storage[15]	Total volatile organic compounds	0.02	kg/ tonne stored
	Benzene	0.00025	
	Cumene	0.00038	
	Cyclohexane	0.00009	
	Ethylbenzene	0.00009	
	n-Hexane	0.00013	
	Toluene (methylbenzene)	0.00024	
	Xylene (individual or mixed isomers)	0.00023	
Front end loaders[16]	Particulate matter ≤ 10 µm	3.56×10^{-3}	kg/litre burnt
	Total volatile organic compounds	5.25×10^{-3}	
	Carbon monoxide	1.20×10^{-2}	
	Formaldehyde	8.71×10^{-4}	
	Oxides of nitrogen	3.89×10^{-2}	
	Particulate matter ≤ 2.5 µm	3.28×10^{-3}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	2.05×10^{-6}	

[12] NPI Mining manual – Version 3.1, Table 2 (page 15) and Table 3 (page 20)

[13] NPI Mining manual – Version 3.1, Section 1.2.2 (page 61)

[14] Emission factors for wheel generated dust are from NSW EPA (2012), Table B-2 and were derived from industry survey data.

[15] NPI Fuel and Organic Liquid Storage manual – Version 3.3, Appendix F.4 Zone 2 Diesel (page 53)

[16] NPI Combustion Engines manual – Version 3.0, Table 31 (page 61)

Process	Substance	Emission factor	Units
	Sulfur dioxide	2.47×10^{-5}	
Haul trucks[17]	Particulate matter ≤ 10 µm	2.09×10^{-3}	kg/litre burnt
	Total volatile organic compounds	1.55×10^{-3}	
	Carbon monoxide	1.46×10^{-2}	
	Formaldehyde	9.15×10^{-4}	
	Oxides of nitrogen	3.38×10^{-2}	
	Particulate matter ≤ 2.5 µm	1.92×10^{-3}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	5.89×10^{-7}	
	Sulfur dioxide	2.40×10^{-5}	

[17] NPI Combustion Engines manual – Version 3.0, Table 33 (page 62)

Manufacturing emission factors

Table 45 – Bread manufacturing emission factors

Process	Substance	Emission factor	Unit
Bread leavening[18]	Ethanol	0.83	kg/tonne bread
	Total volatile organic compounds	0.832	
Natural gas ovens[19]	Carbon monoxide	5.20×10^{-1}	kg/tonne gas
	Oxides of nitrogen	3.68×10^{0}	
	Particulate matter ≤ 10 μm	1.60×10^{-1}	
	Particulate matter ≤ 2.5 μm	1.60×10^{-1}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	1.38×10^{-5}	
	Sulfur dioxide	2.39×10^{-2}	
	Total volatile organic compounds	1.19×10^{-1}	
	Arsenic and compounds	4.33×10^{-6}	
	Beryllium and compounds	2.60×10^{-8}	
	Cadmium and compounds	2.38×10^{-5}	
	Chromium (total)	3.03×10^{-5}	
	Cobalt and compounds	1.76×10^{-6}	
	Copper and compounds	1.84×10^{-5}	
	Lead and compounds	1.08×10^{-5}	
	Manganese and compounds	8.24×10^{-6}	
	Mercury and compounds	5.62×10^{-6}	
	Nickel and compounds	4.54×10^{-5}	
	Selenium and compounds	5.13×10^{-7}	
	Zinc and compounds	6.21×10^{-4}	
	Polychlorinated dioxins and furans (TEQ)	1.07×10^{-10}	

[18] NPI Bread Manufacturing manual – Version 1.1, Table 2 (page 7)

[19] NPI Combustion in Boilers manual – Version 3.6, Table 20 (page 36)

Table 46 – Beer manufacturing emission factors

Process	Substance	Emission factor	Unit
Bottle filling[20]	Ethanol	0.066	kg/kL beer
	Total volatile organic compounds	0.066	
Can filling[20]	Ethanol	0.054	
	Total volatile organic compounds	0.054	
Keg filling[20]	Ethanol	0.0027	
	Total volatile organic compounds	0.0027	
Natural gas boiler[21]	Carbon monoxide	1.82×10^{0}	kg/tonne gas
	Oxides of nitrogen	1.08×10^{0}	
	Particulate matter ≤ 10 μm	1.60×10^{-1}	
	Particulate matter ≤ 2.5 μm	1.60×10^{-1}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	1.38×10^{-5}	
	Sulfur dioxide	2.39×10^{-2}	
	Total volatile organic compounds	1.19×10^{-1}	
	Arsenic and compounds	4.33×10^{-6}	
	Beryllium and compounds	2.60×10^{-8}	
	Cadmium and compounds	2.38×10^{-5}	
	Chromium (total)	3.03×10^{-5}	
	Cobalt and compounds	1.76×10^{-6}	
	Copper and compounds	1.84×10^{-5}	
	Lead and compounds	1.08×10^{-5}	
	Manganese and compounds	8.24×10^{-6}	
	Mercury and compounds	5.62×10^{-6}	
	Nickel and compounds	4.54×10^{-5}	
	Selenium and compounds	5.13×10^{-7}	
	Zinc and compounds	6.21×10^{-4}	
	Polychlorinated dioxins and furans (TEQ)	1.07×10^{-10}	

[20] NPI Beer and Ready-to-Drink Alcoholic Beverage Manufacturing manual – Version 1.2, Appendix B (page 15)

[21] NPI Combustion in Boilers manual – Version 3.6, Table 21 (page 37)

Table 47 – Wine and other alcoholic beverage manufacturing emission factors

Process	Substance	Emission factor	Unit
Fermentation (red/rosé wine)[22]	Ethanol	0.524	kg/kL wine or spirit
	Total volatile organic compounds	0.535	
	Methanol	0.0019	
	Ethyl acetate	0.00038	
	Acetic acid	0.00021	
Fermentation (white wine)[23]	Ethanol	0.274	
	Total volatile organic compounds	0.280	
	Methanol	0.0019	
	Ethyl acetate	0.00038	
	Acetic acid	0.00021	
Fermentation (spirits)[24]	Ethanol	4.3	
	Total volatile organic compounds	4.32	
Pressing and screening[22]	Ethanol	0.0682	
	Total volatile organic compounds	0.0696	
Distillation[24]	Ethanol	0.786	
	Total volatile organic compounds	0.79	
Maturation – wooden barrel (red/rosé wine)[22]	Ethanol	4.4	
	Total volatile organic compounds	4.5	
	Methanol	0.0075	
	Ethyl acetate	0.0026	
	Acetic acid	0.0075	
Maturation – wooden barrel (white wine)[23]	Ethanol	4.1	
	Total volatile organic compounds	4.2	
	Methanol	0.0075	
	Ethyl acetate	0.0026	
	Acetic acid	0.0075	
Maturation – wooden barrel (spirits)[24]	Ethanol	23.7	
	Total volatile organic compounds	23.7	
Maturation – steel vessel[22, 23]	Ethanol	0.10	
	Total volatile organic compounds	0.10	
Bottling[22, 23]	Ethanol	0.012	
	Total volatile organic compounds	0.0122	

[22] NPI Wine and Spirits Manufacturing manual – Version 2.0, Table D1 (page 28)

[23] NPI Wine and Spirits Manufacturing manual – Version 2.0, Table D2 (page 29)

[24] NPI Wine and Spirits Manufacturing manual – Version 2.0, Table D3 (page 30)

Table 48 – Printing and printing support services emission factors

Process	Substance	Emission factor	Unit
Ink drying[25]	Total volatile organic compounds	169	kg/employee/yr

Table 49 – Polymer and rubber product manufacturing emission factors

Process	Substance	Emission factor	Unit
Manual resin application (non-vapour suppressed)[26]	Styrene	0.047	kg/kg resin
Gel coat application (uncontrolled spray)[26, 27]	Styrene	0.323	kg/kg gel
	Methyl methacrylate	0.0405	

Table 50 – Non-metallic mineral product manufacturing emission factors

Process	Substance	Emission factor	Unit
Concrete batching – aggregate transfer[28]	Particulate matter ≤ 10 µm	1.70×10^{-3}	kg/tonne produced
Concrete batching – sand transfer[28]	Particulate matter ≤ 10 µm	5.10×10^{-4}	
Concrete batching – cement unloading[28]	Particulate matter ≤ 10 µm	2.40×10^{-1}	
	Arsenic and compounds	8.38×10^{-7}	
	Beryllium and compounds	8.97×10^{-9}	
	Cadmium and compounds	1.17×10^{-7}	
	Chromium (total)	1.26×10^{-7}	
	Lead and compounds	3.68×10^{-7}	
	Manganese and compounds	1.01×10^{-4}	
	Nickel and compounds	8.83×10^{-6}	
Concrete batching – cement supplement[28]	Particulate matter ≤ 10 µm	6.50×10^{-1}	
	Arsenic and compounds	5.02×10^{-7}	
	Beryllium and compounds	4.52×10^{-8}	
	Cadmium and compounds	9.92×10^{-9}	

25 NPI Aggregated Emissions from Printing and Graphic Arts manual – Version 1.0, Table 3 (page 14)

26 NPI Fibreglass Product Manufacturing manual – Table 3, 35% styrene content (page 15)

27 NPI Fibreglass Product Manufacturing manual – Table 4, 6% MMA content (page 15)

28 USEPA AP42 Chapter 11.12 Concrete Batching (USEPA 2006b), Table 11.12-1 (page 4) for PM_{10} and Table 11.12-7 (page 11) for metals

Process	Substance	Emission factor	Unit
	Chromium (total)	6.10×10^{-7}	
	Lead and compounds	2.60×10^{-7}	
	Manganese and compounds	1.28×10^{-7}	
	Nickel and compounds	1.14×10^{-6}	
	Selenium and compounds	3.62×10^{-8}	
Concrete batching – hopper loading[28]	Particulate matter ≤ 10 µm	1.30×10^{-3}	
Concrete batching – mixer loading[28]	Particulate matter ≤ 10 µm	7.80×10^{-2}	
	Arsenic and compounds	4.19×10^{-6}	
	Cadmium and compounds	5.92×10^{-9}	
	Chromium (total)	7.11×10^{-7}	
	Lead and compounds	1.91×10^{-7}	
	Manganese and compounds	3.06×10^{-5}	
	Nickel and compounds	1.64×10^{-6}	
Miscellaneous LPG industrial vehicle exhaust[29]	Carbon monoxide	3.00×10^{-1}	kg/kg LPG
	Oxides of nitrogen	1.50×10^{-2}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	9.40×10^{-10}	
	Total volatile organic compounds	3.27×10^{-2}	
Miscellaneous diesel industrial vehicle exhaust[30]	Carbon monoxide	1.85×10^{-2}	kg/litre diesel
	Formaldehyde	8.16×10^{-4}	
	Oxides of nitrogen	4.44×10^{-2}	
	Particulate matter ≤ 10 µm	3.63×10^{-3}	
	Particulate matter ≤ 2.5 µm	3.33×10^{-3}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	1.65×10^{-6}	
	Sulfur dioxide	2.39×10^{-5}	
	Total volatile organic compounds	4.05×10^{-3}	
Wind erosion[31]	Total suspended particulate	0.4	kg/ha/hr
	Particulate matter ≤ 10 µm	0.2	

[29] NPI Combustion Engines manual – Version 3.0, Table 41 (page 68)

[30] NPI Combustion Engines manual – Version 3.0, Table 35 (page 63)

[31] NPI Mining manual – Version 3.1, Table 2 (page 15)

Table 51 – Primary metal and metal product manufacturing emission factors

Process	Substance	Emission factor	Unit
Natural gas furnace[32]	Carbon monoxide	1.82×10^{0}	kg/tonne gas
	Oxides of nitrogen	1.08×10^{0}	
	Particulate matter ≤ 10 μm	1.60×10^{-1}	
	Particulate matter ≤ 2.5 μm	1.60×10^{-1}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	1.38×10^{-5}	
	Sulfur dioxide	2.39×10^{-2}	
	Total volatile organic compounds	1.19×10^{-1}	
	Arsenic and compounds	4.33×10^{-6}	
	Beryllium and compounds	2.60×10^{-8}	
	Cadmium and compounds	2.38×10^{-5}	
	Chromium (total)	3.03×10^{-5}	
	Cobalt and compounds	1.76×10^{-6}	
	Copper and compounds	1.84×10^{-5}	
	Lead and compounds	1.08×10^{-5}	
	Manganese and compounds	8.24×10^{-6}	
	Mercury and compounds	5.62×10^{-6}	
	Nickel and compounds	4.54×10^{-5}	
	Selenium and compounds	5.13×10^{-7}	
	Zinc and compounds	6.21×10^{-4}	
	Polychlorinated dioxins and furans (TEQ)	1.07×10^{-10}	
Casting metal (iron)[33]	Particulate matter ≤ 10 μm	22.9	kg/tonne metal cast
	Carbon monoxide	73	
	Lead and compounds	0.05	
Casting metal (zinc)[34]	Particulate matter ≤ 10 μm	12.9	
	Sulfur dioxide	0.01	
	Oxides of nitrogen	0.96	
	Aniline	0.90	
	Methylene(B)4-phenylisocyanate	0.00042	
Casting metal (copper)[34]	Particulate matter ≤ 10 μm	19.1	
	Sulfur dioxide	0.25	
	Copper and compounds	0.0075	
	n-Hexane	0.23	
	Trimethylfluorosilane	1.34	
	Benzene	0.46	

[32] NPI Combustion in Boilers manual – Version 3.6, Table 21 (page 37)

[33] NPI Ferrous Foundries manual – Version 2.0, Table 4, Table 5 (page 7) and Table 7 (page 8)

[34] NPI Non-Ferrous Foundries – Version 1.0, Table 1 (page 7), Table 3 (page 8) and Table 5 (page 10)

Process	Substance	Emission factor	Unit
	Toluene (methylbenzene)	0.12	
Casting moulds[35]	Ammonia (total)	3.17	kg/tonne resin in sand mould
	Hydrogen sulfide	0.33	
	Oxides of nitrogen	0.32	
	Sulfur dioxide	2.27	
	Benzene	3.60	
	Formaldehyde	0.071	
	Cyanide (inorganic) compounds	1.62	
	Xylenes (individual or mixed isomers)	1.09	
	Phenol	0.75	
	Toluene (methylbenzene)	1.33	
	Total volatile organic compounds	6.22	
Welding[36]	Particulate matter ≤ 10 µm	81.6	kg/tonne welding rods
	Chromium (total)	1.39	
	Manganese and compounds	23.2	
	Nickel and compounds	1.71	

[35] NPI Ferrous Foundries manual – Version 2.0, Table 9 (page 10), Table 10 and Table 11 (page 11). Emission factors used are average of emission factors for all binder types.

[36] NPI Fugitive Emissions manual – Version 2.0, Table 7 (page 29) and Table 8 (page 30). 14Mn-4Cr factors used.

Table 52 – Fabricated metal product manufacturing emission factors

Process	Substance	Emission factor	Unit
Natural gas furnace[37]	Carbon monoxide	1.82×10^{0}	kg/ tonnes gas
	Oxides of nitrogen	1.08×10^{0}	
	Particulate matter ≤ 10 µm	1.60×10^{-1}	
	Particulate matter ≤ 2.5 µm	1.60×10^{-1}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	1.38×10^{-5}	
	Sulfur dioxide	2.39×10^{-2}	
	Total volatile organic compounds	1.19×10^{-1}	
	Arsenic and compounds	4.33×10^{-6}	
	Beryllium and compounds	2.60×10^{-8}	
	Cadmium and compounds	2.38×10^{-5}	
	Chromium (total)	3.03×10^{-5}	
	Cobalt and compounds	1.76×10^{-6}	
	Copper and compounds	1.84×10^{-5}	
	Lead and compounds	1.08×10^{-5}	
	Manganese and compounds	8.24×10^{-6}	
	Mercury and compounds	5.62×10^{-6}	
	Nickel and compounds	4.54×10^{-5}	
	Selenium and compounds	5.13×10^{-7}	
	Zinc and compounds	6.21×10^{-4}	
	Polychlorinated dioxins and furans (TEQ)	1.07×10^{-10}	
Metal cutting – mild steel 8mm[38]	Oxides of nitrogen	6.6	g/min
	Copper and compounds	0.16	
	Manganese and compounds	1.38	
Welding[39]	Particulate matter ≤ 10 µm	81.6	kg/ tonnes welding rods
	Chromium (total)	1.39	
	Manganese and compounds	23.2	
	Nickel and compounds	1.71	
Electroplating – hard chromium[40]	Particulate matter ≤ 10 µm	2.2032	mg/A-hr
	Chromium (total)	1.0368	
Electroplating – (copper cyanide,	Cadmium and compounds	2.592	
	Copper and compounds	0.52488	
	Nickel and compounds	40.824	

[37] NPI Combustion in Boilers manual – Version 3.6, Table 21 (page 37)

[38] NPI Structural & Fabricated Metal Product Manufacture manual – Table 4 (page 15)

[39] NPI Fugitive Emissions manual – Version 2.0, Table 7 (page 29) and Table 8 (page 30). 14Mn-4Cr factors used.

[40] USEPA AP-42 Chapter 12 Section 20 Electroplating – Table 12.20-1 (page 15) and Table 12.20-4 (page 17)

copper sulfate, cadmium cyanide, and nickel)	Cyanide (copper cyanide)	0.017496	
	Cyanide (cadmium cyanide)	0.648	

Health care and social assistance emission factors

Table 53 – Hospital manufacturing emission factors

Process	Substance	Emission factor	Unit
Natural gas boiler[41]	Carbon monoxide	$1.82x10^{0}$	kg/tonnes gas
	Oxides of nitrogen	$1.08x10^{0}$	
	Particulate matter ≤ 10 µm	$1.60x10^{-1}$	
	Particulate matter ≤ 2.5 µm	$1.60x10^{-1}$	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	$1.38x10^{-5}$	
	Sulfur dioxide	$2.39x10^{-2}$	
	Total volatile organic compounds	$1.19x10^{-1}$	
	Arsenic and compounds	$4.33x10^{-6}$	
	Beryllium and compounds	$2.60x10^{-8}$	
	Cadmium and compounds	$2.38x10^{-5}$	
	Chromium (total)	$3.03x10^{-5}$	
	Cobalt and compounds	$1.76x10^{-6}$	
	Copper and compounds	$1.84x10^{-5}$	
	Lead and compounds	$1.08x10^{-5}$	
	Manganese and compounds	$8.24x10^{-6}$	
	Mercury and compounds	$5.62x10^{-6}$	
	Nickel and compounds	$4.54x10^{-5}$	
	Selenium and compounds	$5.13x10^{-7}$	
	Zinc and compounds	$6.21x10^{-4}$	
	Polychlorinated dioxins and furans (TEQ)	$1.07x10^{-10}$	

[41] NPI Combustion in Boilers manual – Version 3.6, Table 21 (page 37)

Services emission factors

Table 54 – Automotive body, paint and interior repair emission factors

Process[42] [43]	Substance	Emission factor	Unit
1K - Primers	Total volatile organic compounds	0.732	kg/litre used
1K – Lacquers – Clear	Total volatile organic compounds	0.738	
1K – Lacquers – Colour	Total volatile organic compounds	0.759	
1K – Synthetic air dry enamels	Total volatile organic compounds	0.631	
1K – Thinners	Total volatile organic compounds	0.855	
2K – Primers – Urethane	Total volatile organic compounds	0.587	
2K – Primers – Other	Total volatile organic compounds	0.697	
2K – Basecoats	Total volatile organic compounds	0.771	
2K – Topcoats – Clear	Total volatile organic compounds	0.587	
2K – Topcoats – Colour	Total volatile organic compounds	0.571	
2K – Hardeners – Isocyanates	Total volatile organic compounds	0.489	
2K – Hardeners – Other	Total volatile organic compounds	0.721	
2K – Thinners	Total volatile organic compounds	0.735	
2K – Other (e.g. cleaners, enamel)	Total volatile organic compounds	0.713	

[42] VOCs from Surface Coatings – Assessment of the Categorisation, VOC Content and Sales Volumes of Coating Products Sold in Australia, Table 31, page 122 (ENVIRON 2009)

[43] *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales*, Table 3-25 page 47 (NSW EPA 2012)

Table 55 – Funeral, crematorium and cemetery services emission factors

Process	Substance	Emission factor	Unit
Cremation[44]	Acetaldehyde	5.90×10^{-5}	kg/ cremation
	Antimony and compounds	1.37×10^{-5}	
	Arsenic and compounds	1.36×10^{-5}	
	Beryllium and compounds	6.21×10^{-7}	
	Cadmium and compounds	5.03×10^{-6}	
	Carbon monoxide	1.00×10^{-1}	
	Chromium (III) compounds	1.36×10^{-5}	
	Chromium (VI) compounds	6.12×10^{-6}	
	Cobalt and compounds	7.94×10^{-7}	
	Copper and compounds	1.24×10^{-5}	
	Fluoride compounds	1.46×10^{-3}	
	Formaldehyde	1.54×10^{-5}	
	Hydrochloric acid	3.27×10^{-2}	
	Lead and compounds	3.00×10^{-5}	
	Mercury and compounds	1.55×10^{-3}	
	Nickel and compounds	1.73×10^{-5}	
	Oxides of nitrogen	5.22×10^{-1}	
	Particulate matter ≤ 10 µm	3.86×10^{-2}	
	Particulate matter ≤ 2.5 µm	3.47×10^{-2}	
	Polychlorinated dioxins and furans (TEQ)	4.90×10^{-9}	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	2.60×10^{-5}	
	Selenium and compounds	1.98×10^{-5}	
	Sulfur dioxide	7.39×10^{-2}	
	Total volatile organic compounds	1.02×10^{-1}	
	Zinc and compounds	1.60×10^{-4}	

[44] NPI Crematoria – Version 1.0, Appendix B (page 17)

Table 56 – Laundry and dry-cleaning services emission factors

Process	Substance	Emission factor	Unit
Natural gas boiler[45]	Arsenic and compounds	$4.33x10^{-6}$	kg/tonne gas
	Beryllium and compounds	$2.60x10^{-8}$	
	Cadmium and compounds	$2.38x10^{-5}$	
	Carbon monoxide	$1.82x10^{0}$	
	Chromium (total)	$3.03x10^{-5}$	
	Cobalt and compounds	$1.76x10^{-6}$	
	Copper and compounds	$1.84x10^{-5}$	
	Lead and compounds	$1.08x10^{-5}$	
	Manganese and compounds	$8.24x10^{-6}$	
	Mercury and compounds	$5.62x10^{-6}$	
	Nickel and compounds	$4.54x10^{-5}$	
	Oxides of nitrogen	$1.08x10^{0}$	
	Particulate matter ≤ 10 µm	$1.60x10^{-1}$	
	Particulate matter ≤ 2.5 µm	$1.60x10^{-1}$	
	Polychlorinated dioxins and furans (TEQ)	$1.07x10^{-10}$	
	Polycyclic aromatic hydrocarbons (B[a]Peq)	$1.38x10^{-5}$	
	Selenium and compounds	$5.13x10^{-7}$	
	Sulfur dioxide	$2.39x10^{-2}$	
	Total volatile organic compounds	$1.19x10^{-1}$	
	Zinc and compounds	$6.21x10^{-4}$	

[45] NPI Combustion in Boilers manual – Version 3.6, Table 21 (page 37)

Appendix C – Speciation profiles

Mining speciation factors

Table 57 – Mining dust speciation profiles

Substance	Speciation (mg/kg TSP)[46]
Antimony and compounds	0.2
Arsenic and compounds	1.5
Beryllium and compounds	2.6
Boron and compounds	10
Cadmium and compounds	0.11
Chromium (total) compounds	100
Cobalt and compounds	20
Copper and compounds	50
Fluoride compounds	950
Lead and compounds	14
Manganese and compounds	950
Mercury and compounds	0.05
Nickel and compounds	80
Selenium and compounds	0.05
Zinc and compounds	190
Substance	**Speciation (kg/kg PM_{10})[47]**
Particulate matter ≤ 2.5 µm	0.29

[46] NPI Mining manual – Version 3.1, Table 9 (page 65) – Earth's Crust

[47] PMSIZE profile 90006 (CARB 2014)

Manufacturing speciation factors

Table 58 – Printing VOC speciation profiles

Substance	Speciation (% VOC)[48]
Acetone	3.6
Benzene	1.94
Ethyl acetate	1.21
Ethylbenzene	0.27
Methyl ethyl ketone (2-butanone)	7.97
Methyl isobutyl ketone	2.17

Table 59 – Non-metallic mineral product manufacturing TSP speciation profiles

Substance	Speciation (% TSP)[49]
Antimony and compounds	0.2
Arsenic and compounds	1.5
Beryllium and compounds	2.6
Boron and compounds	10
Cadmium and compounds	0.11
Chromium (total) compounds	100
Cobalt and compounds	20
Copper and compounds	50
Fluoride compounds	950
Lead and compounds	14
Manganese and compounds	950
Mercury and compounds	0.05
Nickel and compounds	80
Selenium and compounds	0.05
Zinc and compounds	190

[48] USEPA SPECIATE profile 2570 (USEPA 2014)

[49] NPI Mining manual – Version 3.1, Table 9 (page 65) – Earth's Crust

Fuel retailing speciation factors

Table 60 – Fuel retailing VOC speciation profiles

Substance	Speciation (kg/kg VOC)[50]	
	Petrol	Diesel
Benzene	0.0078	–
Cumene (1-methylethylbenzene)	–	0.0504
Cyclohexane	0.0005	–
Ethylbenzene	0.0010	0.0059
n-Hexane	0.0022	–
Toluene (methylbenzene)	0.0190	0.0277
Xylenes (individual or mixed isomers)	0.0055	0.0902

Services speciation factors

Table 61 – Automotive body, paint and interior repair VOC speciation profiles

Substance	Speciation (kg/kg VOC)[51]					
	Paint	Enamel	Lacquer	Primer	Thinner	Adhesive
Acetone	0.0127	0.0557	–	–	–	0.142
Cyclohexane	0.0052	0.0227	–	–	–	–
Ethyl acetate	0.0204	0.0896	–	–	–	0.133
Ethylbenzene	0.0054	0.0236	–	–	–	–
Methyl ethyl ketone	0.0054	0.0236	–	–	0.025	0.053
Methyl isobutyl ketone	0.0036	0.0157	–	–	–	0.043
Toluene (methylbenzene)	0.3787	0.159	0.4459	0.4431	0.25	0.203
Xylenes (individual or mixed isomers)	0.0817	0.2309	0.0418	0.0268	0.20	–

[50] 2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in New South Wales – Commercial Emissions, Tables 3-7 and 3-8 (NSW EPA 2012)

[51] NPI Aggregated Emissions from Motor Vehicle Refinishing manual – Table 4 (page 10)

Table 62 – Laundry and dry-cleaning services VOC speciation profile

Substance	Speciation (kg/kg VOC)[52]	
	PERC	White spirit
Tetrachloroethylene	1	–
Toluene (methylbenzene)	–	0.005
Xylenes (individual or mixed isomers)	–	0.183

[52] NPI Aggregated Emissions from Dry Cleaning manual – Table 4 (page 12)

Appendix D — Toxic equivalency potential score

Table 63 – NPI substance TEP rating

Substance	Non-cancer risk score (TEP)[1]
Acetaldehyde	9.3
Acetic acid (ethanoic acid)	N/A
Acetone	0.05
Acetonitrile	30
Acrolein	1,600
Acrylamide	2,000
Acrylic acid	62
Acrylonitrile (2-propenenitrile)	38
Ammonia (total)	3.8
Aniline (benzenamine)	91
Antimony and compounds	8,100
Arsenic and compounds	84,000
Benzene	8.1
Benzene hexachloro- (HCB)	21,000
Beryllium and compounds	24,000
Biphenyl (1,1-biphenyl)	0.98
Boron and compounds	N/A
Butadiene (vinyl ethylene)	2.2
Cadmium and compounds	1,900,000
Carbon disulfide	1.2
Carbon monoxide	0.14
Chlorine and compounds	N/A
Chlorine dioxide	N/A
Chloroethane (ethyl chloride)	0.02
Chloroform (trichloromethane)	14
Chlorophenols (di, tri, tetra)	51
Chromium (III) compounds	N/A
Chromium (VI) compounds	3,100
Cobalt and compounds	31,000
Copper and compounds	13,000

Substance	Non-cancer risk score (TEP)[1]
Cumene (1-methylethylbenzene)	0.41
Cyanide (inorganic) compounds	580
Cyclohexane	0.02
Dibromoethane	1,500
Dibutyl phthalate	11
Dichloroethane	4.2
Dichloromethane	7
Ethanol	N/A
Ethoxyethanol	N/A
Ethoxyethanol acetate	N/A
Ethyl acetate	0.09
Ethyl butyl ketone	N/A
Ethylbenzene	0.14
Ethylene glycol (1,2-ethanediol)	0.25
Ethylene oxide	56
Di-(2-Ethylhexyl) phthalate (DEHP)	33
Fluoride compounds	3.6
Formaldehyde (methyl aldehyde)	16
Glutaraldehyde	N/A
Hexane	N/A
Hydrochloric acid	12
Hydrogen sulfide	34
Lead and compounds	580,000
Magnesium oxide fume	N/A
Manganese and compounds	780
Mercury and compounds	5,000,000
Methanol	0.09
Methoxyethanol	N/A
Methoxyethanol acetate	N/A
Methyl ethyl ketone	0.05
Methyl isobutyl ketone	0.03
Methyl methacrylate	0.53
Methylene-bis(2-chloroaniline) (MOCA)	N/A

Substance	Non-cancer risk score (TEP)[1]
Methylene bis (phenylisocyanate)	N/A
Nickel and compounds	3,200
Nickel carbonyl	N/A
Nickel subsulfide	N/A
Nitric acid	2.1
Organo-tin compounds	N/A
Oxides of nitrogen	2.2
Particulate matter ≤ 2.5 µm	17
Particulate matter ≤ 10 µm	1.5
Phenol	0.38
Phosphoric acid	16
Polychlorinated biphenyls	2,000,000
Polychlorinated dioxins and furans (TEQ)	880,000,000,000
Polycyclic aromatic hydrocarbons (B[a]Peq)	N/A
Selenium and compounds	2,400
Styrene (ethenylbenzene)	0.08
Sulfur dioxide	3.1
Sulfuric acid	N/A
Tetrachloroethane	56
Tetrachloroethylene	65
Toluene (methylbenzene)	1
Toluene-2,4-diisocyanate	N/A
Total nitrogen	N/A
Total phosphorus	N/A
Total volatile organic compounds	1
Trichloroethane	4.9
Trichloroethylene	0.63
Vinyl chloride monomer	69
Xylenes (individual or mixed isomers)	0.27
Zinc and compounds	190

[1] based on toluene equivalent

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