AGL Loy Yang, Loy Yang B and Energy Australia Yallourn

Latrobe Valley Coal Fired Power Stations Licence Review

Community Summary Report

August 2018

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1. Introduction

1.1 Periodic licence review

The Environment Protection Authority Victoria (EPA) is reviewing the environment licences issued to the brown coal fired power stations in the Latrobe Valley, under the Environment Protection Act (the Act), as part of EPA's periodic licence review process. The brown coal fired power stations that are subject of this review are Loy Yang A, Loy Yang B and Yallourn (collectively, the Power Stations).

EPA has requested that the Power Stations prepare an air quality assessment, which includes air dispersion modelling, to confirm that current performance and licence limits for oxides of nitrogen (NOx), sulfur dioxide (SO_2) and carbon monoxide (CO) continue to meet policy requirements. EPA has also indicated that it intends to review the inclusion of new parameter limits for mercury and the particle fractions of PM_{10} and $PM_{2.5}$ (new parameters additional to the currently licenced total particles) to the power station licences. The air quality assessment must also include consideration of these new parameters.

EPA invited stakeholder feedback on the Power Station licence review process. The operators of the Power Stations have each separately responded to the key issues raised in the stakeholder feedback.

EPA will provide the air quality assessment and responses to stakeholders ahead of a public conference (20B conference)[1].

GHD[2], a professional consultancy firm, has been engaged to prepare an air quality assessment on behalf of the operators of the Power Stations.

The Power Stations operators will participate in the community stakeholder conference being facilitated by EPA (Section 20B of the EPA Act). This will provide an opportunity for EPA and industry to better understand community and stakeholder views which will be further considered as part of the licence review by the EPA.

1.2 Purpose of this report

This report is to provide a summary of the work undertaken by GHD in accordance with the following scope of works:

- A review of Latrobe Valley ambient air quality and power station emissions against relevant State Environment Protection Policies (SEPPs).
- A review of previous modelling work, included a review of the model approach, methodology, background data, meteorology, source emission estimation, receptor locations and conclusions reached.
- A technical assessment of Power Stations' monitoring of the particle fractions of PM_{10}, $PM_{2.5}$ and mercury.
- New air dispersion modelling covering the five year period 2012 – 2017.

This report is subject to, and must be read in conjunction with, the limitations set out in section 11 and the assumptions and qualifications contained throughout the report.

[1] https://www.epa.vic.gov.au/our-work/licences-and-approvals/improving-the-system/licensing-improvement/brown-coal-fired-power-stations-licence-reviews.

[2] GHD Pty Ltd (formerly known as Gutteridge Haskins & Davey) is a multinational technical professional services firm providing engineering, architecture, environmental and construction consulting and management services. https://www.ghd.com/en/index.aspx

2. Regulatory framework – Victoria

2.1 EPA Act

The Environment Protection Act (the Act) creates a legislative framework for the protection of the environment in Victoria. The Act establishes the powers, duties and functions of the EPA which include:

- The administration of the Act and its regulations.
- The making and review of State environment protection policies (SEPPs).
- Issuing works approvals, licences, permits, and pollution abatement notices.
- Implementing National Environment Protection Measures (NEPMs), through the relevant SEPPs.

The Act protects the air environment in three key ways:

- Discharges of wastes into the atmosphere must comply with the relevant SEPPs.
- Creation of a pollution of atmosphere offence.
- The licensing of discharges to the environment from certain premises (scheduled premises[3]) and the creation of licencing offences.

Under the Act certain classes of scheduled premises must not discharge or emit waste to the environment unless they hold a licence. All power stations generating electricity above five megawatts[4] are required to hold an EPA licence under the Act.

Licences issued under the Act contain conditions that are administered by the EPA to control the operation of the premises and manage effects on the environment. These conditions address areas such as waste acceptance and treatment, air emissions, water discharges, land and groundwater, noise and odour.

2.2 National Environment Protection (Ambient Air Quality) Measure

Australia does not have any national air quality emissions standards. Rather, air emissions in Australia are regulated at a State and Territory based level, with regulators in each State and Territory being required to give legislative effect to the requirements of National Environment Protection Measures (NEPMs) made by the National Environment Protection Council.

A number of NEPMs have been made which are relevant to air emissions from the Power Stations including:

- The National Environment Protection (National Pollutant Inventory) Measure (Pollutant Inventory NEPM) which requires operators of large facilities, including the Power Stations, to report on their emissions each year.
- The National Environment Protection (Ambient Air Quality) Measure (NEPM AAQ) which sets a nationally consistent framework for the monitoring and reporting for six common air pollutants: carbon monoxide, nitrogen dioxide, sulfur dioxide, lead, ozone and airborne particles (as PM_{10} and $PM_{2.5}$).

[3] Environment Protection (Scheduled Premises) Regulations 2017
[4] Scheduled Premises, Schedule 1, K01 (power stations): Premises which generate electrical power from the consumption of a fuel at a rated capacity of at least 5 megawatts of electrical power.

- The National Environment Protection (Air Toxics) Measure (Air Toxics NEPM) which establishes 'monitoring investigation levels' for benzene, formaldehyde, benzo(a)pyrene as a marker for Polycyclic Aromatic Hydrocarbons, toluene and xylenes.

It is up to each State and Territory to:

- Set enforceable emissions limits so as to achieve the ambient air quality standards set by the Air Quality NEPM and the investigation levels set by the Air Toxics NEPM.
- Ensure reporting as required by the Pollutant Inventory NEPM.

Table 1 provides the monitoring standards as set out in the NEPM AAQ.

Table 1 NEPM AAQ monitoring standards

Substance	Averaging period	Standard (ppb)	Standard (µg/m^3)
Carbon Monoxide (CO)	8-hour	9000	10440
Nitrogen Dioxide (NO_2)	1-hour Annual	120 30	228 57
Sulfur Dioxide (SO_2)	1-hour 1-Day Annual	200 80 20	523 209 52
Particles as Particulate Matter 10-micron (PM_{10})	1-Day Annual	N/A	50 20
Particles as Particulate Matter 2.5-micron ($PM_{2.5}$)	1-Day Annual	N/A	25 (20 in 2025) 8 (7 in 2025)

Note: Parts per billion (ppb) converted to µg/m^3 using SEPP AQM guidance that gas volumes are expressed at 25ºC and at an absolute pressure of one atmosphere (101.325 kPa).

2.3 State Environment Protection Policies

In Victoria, the requirements of the NEPM AAQ are adopted into the State Environment Protection Policy (Ambient Air Quality) (SEPP AAQ). The SEPP AAQ sets broad air quality objectives and goals for the whole of Victoria by adopting the NEPM AAQ's monitoring and reporting standards. The SEPP AAQ standards do not apply to individual sources but rather to regional air quality.

The State environment protection policy (Air Quality Management) (SEPP AQM) sets the requirements for management of sources of pollution such that the air quality objectives of SEPP AAQ are met, air quality improves and the cleanest air possible is achieved[5]. The SEPP AQM identifies the beneficial uses[6] of the air environment which are to be protected, and defines the air quality indicators[7] which must be managed to ensure that the beneficial uses, inclusive of human health and well-being, are protected.

The air emission limits imposed on each of the Power Station licences are informed by the criteria set by SEPP AQM and the air quality objectives contained by SEPP AAQ.

[5] SEPP AQM Clause 8
[6] SEPP AQM Clause 9
[7] SEPP AQM Part II

In addition:

- Clause 18 of SEPP AQM requires that generators of emissions pursue continuous improvement in their environmental management practices and environmental performance and apply best practice to the management of emissions.
- Clause 19 of SEPP AQM also requires that generators "new or substantially modified source of emissions" must apply best practice to the management of those emissions and, in the case of "Class 3 indicators" must "reduce those emissions to the maximum extent achievable".

Table 2 provides the design (modelling) criteria as set out in SEPP AQM.

Table 2 SEPP AQM design (modelling) criteria

Substance	Averaging period	Standard (ppb)	Standard (µg/m^3)
Carbon Monoxide (CO)	1-hour	25,000	29,000
Nitrogen Dioxide (NO_2)	1-hour	100	190
Sulfur Dioxide (SO_2)	1-hour	170	450
Particles as Particulate Matter 10-micron (PM_{10})	1-Day	N/A	80
Particles as Particulate Matter 2.5-micron ($PM_{2.5}$)	1-Day	N/A	50
Mercury - Inorganic	3-minute	N/A	3.3
TSP* (nuisance dust)	3-minute	N/A	330

*TSP – total suspended particles

The SEPP AQM also establishes the Latrobe Valley Air Quality Control Region (LVAQCR) as shown in Figure 1. An air quality control region is defined as a segment of the air environment which, because of its population size or density, industrialisation, projected development, or meteorological characteristics, has been gazetted as requiring the regional effects of emissions of wastes to the air environment to be considered in formulating control requirements.

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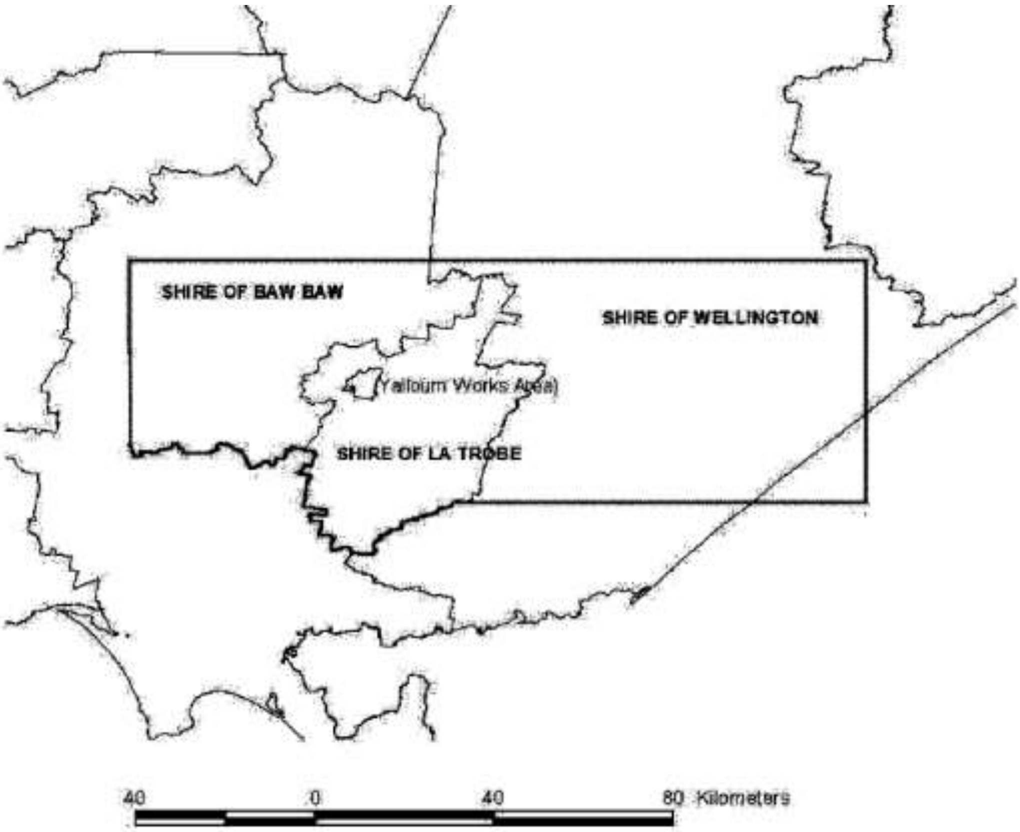


Figure 1 Extract from State environment protection policy (Air Quality Management) – Schedule F

3. Latrobe Valley Air Quality Control Region characteristics

The Latrobe Valley regional air environment is defined as an 'airshed', analogous to a watershed for river systems, due to its significant industrial emissions and terrain influences (topography). The industrial emissions are dominated by facilities such as power generation, pulp and paper manufacturing and other small manufacturing industry. Other emissions can include smoke from burn off activity, bushfires, wood heaters, mining, transport and other natural events. The terrain and topography combine with complex meteorology that affects dispersion and transport of air pollutants.

The Latrobe Valley Air Quality Control Region (LVAQCR) has a number of air quality monitoring and meteorological stations that continuously assess the state of the regional meteorology and air quality. Figure 2 shows the major terrain features of the Latrobe Valley region including the location of the Power Stations, meteorological and air quality monitoring stations.

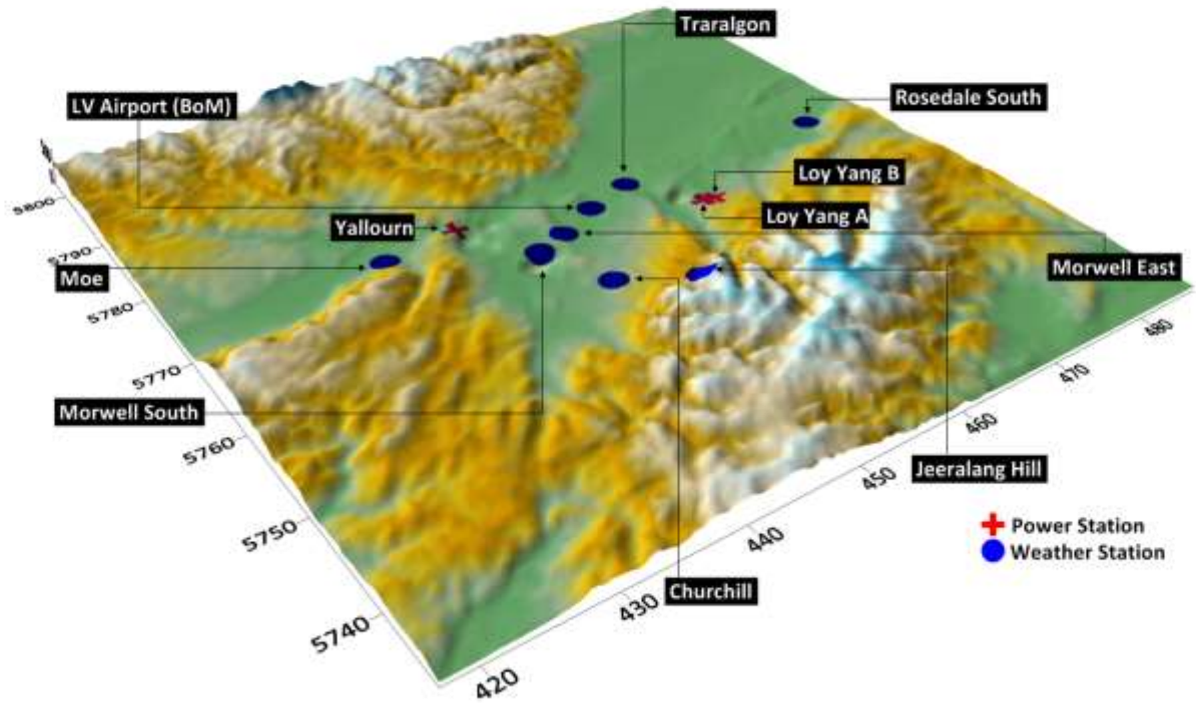


Figure 2 Latrobe Valley terrain with monitoring stations and Power Stations

The Latrobe Valley is an inland geographical region in Gippsland, Victoria. The Latrobe Valley is significant as the centre of Victoria's energy industry, providing the majority of Victoria's electricity to the national electricity market. Power is generated primarily from the burning of brown coal, which is mined locally.

The Earth Resources Regulation[8] section of the Victorian Department of Economic Development, Jobs, Transport and Resources (DEDJTR) provides the following about the lignite resources in Victoria:

- "*Potentially economic brown coal in the Latrobe Valley is 33 billion tonnes*"
- "*In 2013-14, total production in Victoria amounted to 57.8 Mt*"

[8] Victoria's Earth Resources – Coal. http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/coal

- "*Victoria's lignite is typically low in ash, sulphur, heavy metals and nitrogen, making it very low in impurities by world standards*"
- "*However, its high moisture content - which ranges from 48-70 per cent - reduces its effective energy content (average 8.6 MJ/kg on a net wet basis or 26.6 MJ/kg on a gross dry basis)*."

The Latrobe Valley region is largely rural-residential and is well vegetated with undulating terrain that rises over 300 metres in the Strzelecki Ranges to the south from the Latrobe Valley floor. Larger towns in the region and their approximate 2011 populations are: Traralgon (23830), Morwell (14000), Moe (8750), and Churchill (4750) (ABS, 2013).

When assessing the effect of emissions from power stations on air quality, it is important to give consideration to the weather, how emissions will behave, and what monitoring needs to be carried out. Variation with wind conditions through the depth of the atmosphere can keep plumes overhead – especially at night – but up and down-drafts can make a plume 'loop' to ground level. Sea breeze influences, peaking in summer months, are complicated in the Latrobe Valley with a Bass Strait breeze from Sale initially but sometimes a stronger breeze from about Western Port can penetrate into the system. The complexity of the LVAQCR was summarised by EPA when devising a monitoring plan for the Latrobe Valley in 2001 (EPA Victoria, 2001, p.22)[9]:

- "*There is considerable variation of wind pattern with season and time of day, and importantly for pollution dispersion with height*".

Figure 3 shows wind-roses prepared from the hourly records of wind speed and wind direction data collected by four of the ambient air monitoring stations at Morwell East, Traralgon, Jeeralang Hill and Rosedale South. These show the observed prevailing speed as colour-coded bars and direction (winds from 16 different direction arcs). It can be seen from the wind roses that the prevailing winds are from the west to the east and on some occasions (summer months mostly) east to west. The southern side of the Latrobe River has some southwest wind dominance due to the Morwell River Valley. Overall, there is limited major north/south components to the wind. A contributing factor to this pattern of winds is the east-west alignment of the Latrobe Valley, which tends to funnel surface winds. Note the variation in pattern depending on a particular location in the Latrobe Valley.

[9] The Ambient Air Quality NEPM Monitoring Plan Victoria. EPA Victoria Publication 763

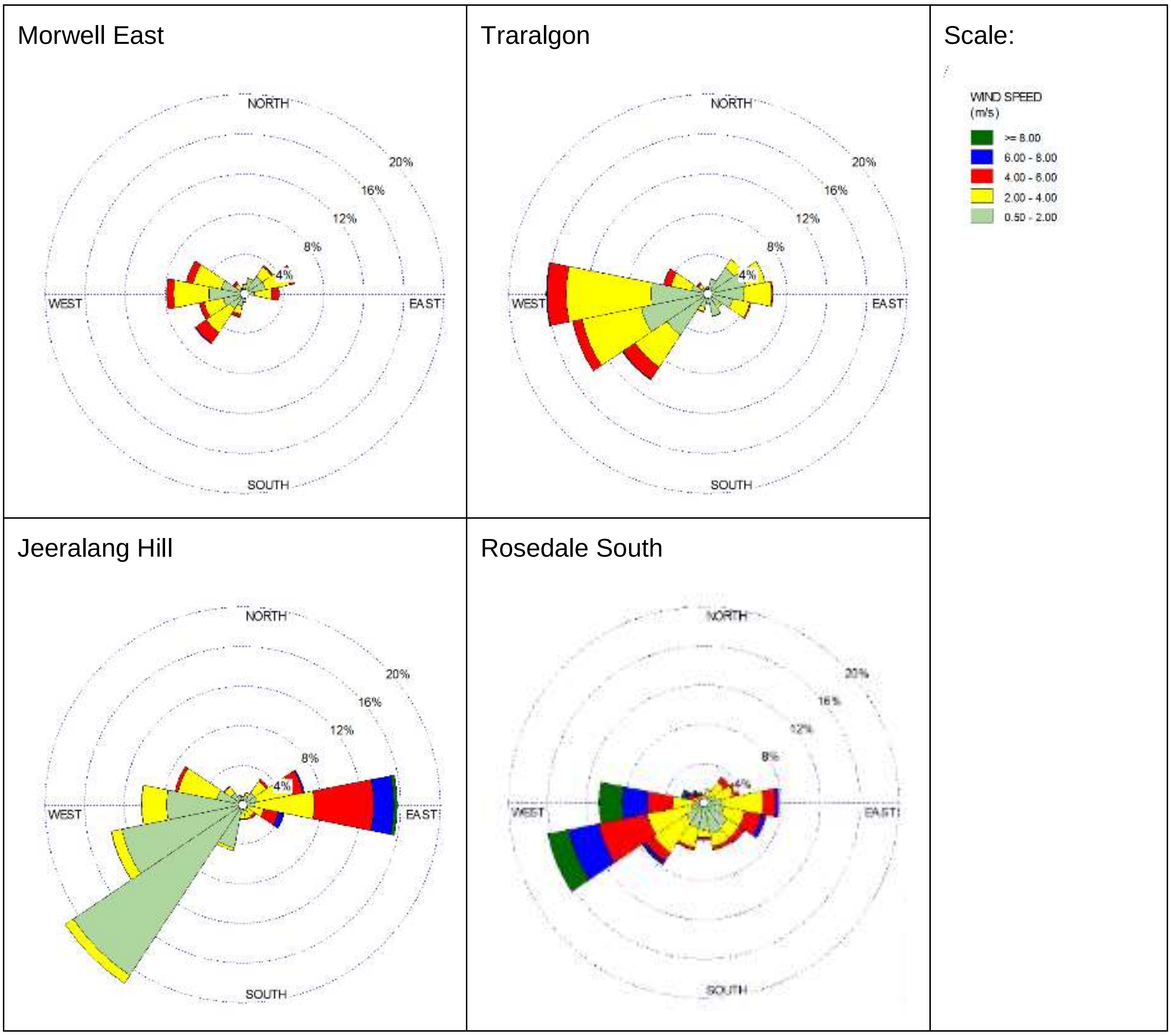


Figure 3 Annual wind roses for Morwell East, Traralgon, Jeeralang Hill and Rosedale South

The wind roses show that the winds at the Morwell East and Traralgon ambient air monitoring stations are generally lower in speed than at the Jeeralang Hill and Rosedale South ambient air monitoring stations.

The weather conditions in the Latrobe Valley have a direct interaction with how emissions from the Power Stations are dispersed as does how winds vary with altitude. The emissions, which are discharged at height from the tall Power Station stacks, are immediately subjected to dispersion and dilution by the wind, and the stronger winds at height results in greater dispersion than would occur at the ground. The difference in speeds for the surface (ground level) and at 250 m in height (about the height of emitted plumes from the Power Stations) can be seen in the wind roses from the Latrobe Valley Airport in Figure 4. Note the predominance of wind speeds greater than 6 metres per second at 250 metres high, compared to the lower surface wind speeds.

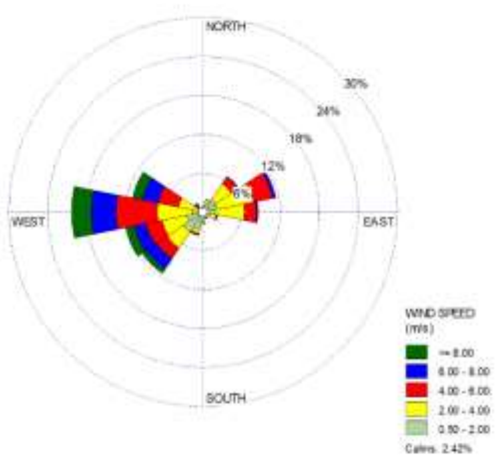
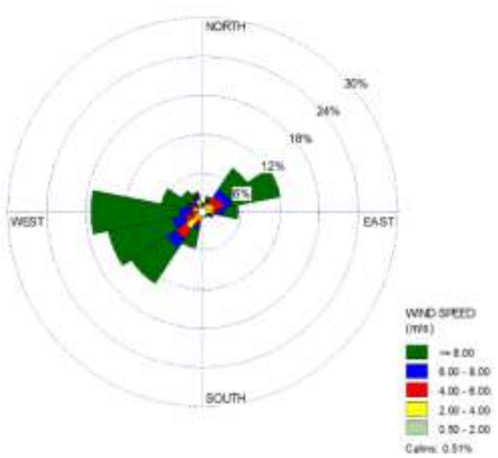
Centrally located Latrobe Valley Airport	
Surface Annual average winds speed = 3.69 m/s  	250 m Annual average winds speed = 9.52 m/s 

Figure 4 Annual wind roses for Latrobe Valley airport – surface and 250 m

4. Latrobe Valley power stations

4.1 General description

The key details of the three brown coal fired Power Stations are:

- AGL Loy Yang operates subject to EPA licence 11149 for a maximum electrical power of 2,200 MW. The power station consists of four units discharging emissions through two discharge points.
- Energy Australia operates subject to EPA licence 10961 for 1,480 MW of installed capacity. The power station consists of four units, discharging through three discharge points.
- Loy Yang B operates subject to EPA licence 3987 for 1,000 MW of installed capacity. The power station consists of two units discharging emissions through one discharge point.

While each Power Station is of a different age, size and number of units, they have common characteristics. As shown in Figure 5 brown coal is combusted inside a boiler that heats water into steam. The steam is delivered to a turbine connected to an electrical generator.

Burning brown coal in the boiler generates boiler flue gas. The boiler flue gases pass through electrostatic dust precipitators (ESPs) before being emitted to the atmosphere from a stack. The ESPs remove solid particles (fly ash) from the flue gas stream which are then transferred to ash ponds.

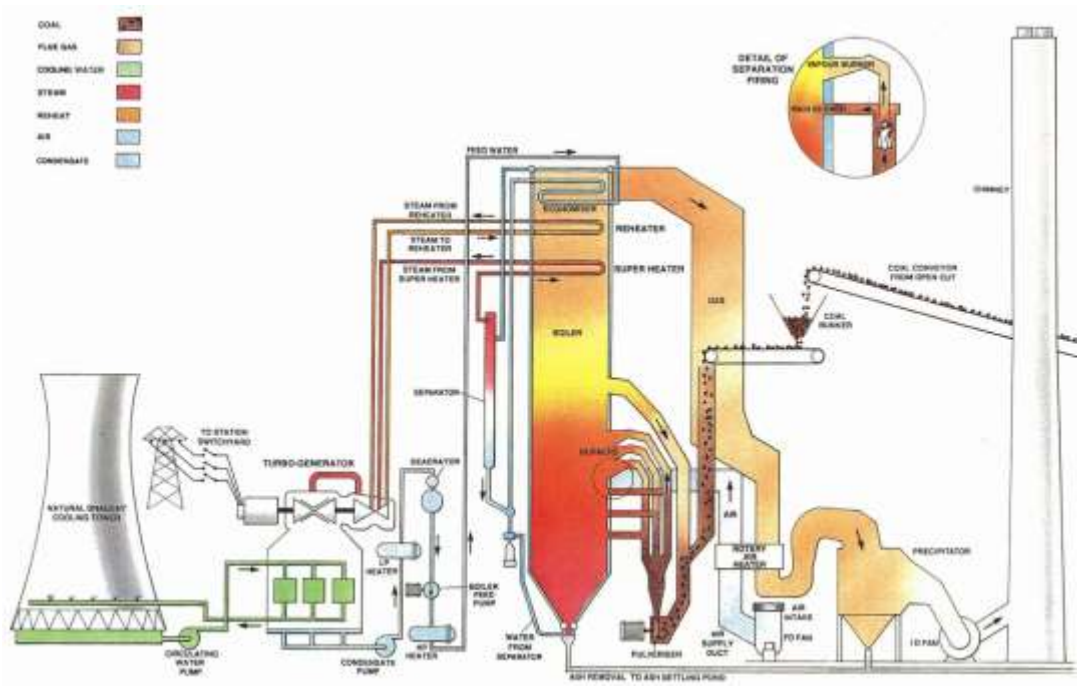


Figure 5 A typical Latrobe Valley coal fired power station schematic

4.2 Annual Performance Statement (APS)

Licence holders must submit an APS by 30 September every year outlining their level of compliance with their licence conditions. These licences and performance statements are publicly available on the EPA website.

- https://www.epa.vic.gov.au/our-work/licences-and-approvals/search-licence

As outlined in Table 3, all three Power Stations are EPA accredited licence holders and as a result have developed accredited environmental management systems.

Table 3 Power Stations Environment Management Systems (EMS)

Issue	Loy Yang A	Loy Yang B	Yallourn
Implement Environment Management System (EMS)	Environmental management system (EMS) accreditation by Environmental Auditor	Environmental management system (EMS) accreditation to ISO:14001	Environmental management system (EMS) accreditation to ISO:14001
EPA Accredited Licence Holder	✓	✓	✓

5. Power station licence monitoring regime

5.1 By each facility

As required by the respective EPA licences and EPA publication 1321.2, Licence Assessment Guidelines, the operators of the three Power Stations have each developed a risk based environmental monitoring program in order to demonstrate compliance with their licence conditions. Details of the monitoring regimes currently in place at each of the Power Stations are provided in Table 4.

Table 4 Source air monitoring program

Parameter	Loy Yang A[10]	Loy Yang B[11]	Yallourn[12]
Flue gas flow	CEMS plus annual stack test	CEMS plus annual stack test	Continuous plus Periodic. Three stacks twice per year. Six tests in total.
Oxygen, temperature and pressure	CEMS (oxygen and temperature) plus annual stack test	CEMS plus annual stack test	Continuous (Oxygen and Temperature) plus Periodic. Three stacks twice per year. Six tests in total.
NO_x	CEMS plus annual stack test	Annual stack test	PEMS plus Three stacks twice per year. Six tests in total
CO	CEMS plus annual stack test	Annual stack test	PEMS plus Periodic. Three stacks twice per year. Six tests in total
SO_2	CEMS plus annual stack test	CEMS	PEMS plus Periodic. Three stacks twice per year. Six tests in total
HCl (as Cl_2)	Annual stack test	Annual stack test	PEMS plus Periodic. Three stacks twice per year. Six tests in total.
Fluoride (as HF)	Annual stack test	Annual stack test	PEMS plus Periodic. Three stacks twice per year. Six tests in total
Total Particles	CEMS plus annual stack test	CEMS	CEMS

Notes: CEMS is Continuous Emission Monitoring System. PEMS is Process Emission Monitoring System

5.2 Emissions profile 2013-2017

The inherent variable nature and characteristics of brown coal quality (e.g. moisture, ash, sulfur and calorific value) is a significant contributor to changing emissions. Other variations are due to individual unit outputs to meet national electricity market demands.

[10] Based on information in 2016/17 Annual Performance Statement
[11] Based on information in 2016/17 Annual Performance Statement
[12] Based on information in 2016/17 Annual performance Statement

To assist in air dispersion modelling, GHD has examined emission characteristics of the Power Stations based on the data available from stack testing, Continuous and Process Monitoring Systems (CEMS/PEMS), and the National Pollutant Inventory (NPI).

The emissions from the Power Stations are quite variable due to levels of production, plant operational settings and fuel quality. Example plots in Figure 6 to Figure 10 indicate the variation that occurs at each of the Power Stations compared to the maximum emission limits set under each of the respective licences. The values in these figures show that actual operating conditions are typically lower than those permitted by licence limits.

An additional licence condition for Loy Yang A places annual percentile limits[13] on mass discharge rate of sulfur dioxide from the stack discharge points:

- A 90th percentile frequency distribution mass of 3,333 g/s
- A 50th percentile frequency distribution mass of 2,000 g/s

For Loy Yang B, the tiered licence conditions are:

- A 90th percentile frequency distribution mass of 1,667 g/s
- A 50th percentile frequency distribution mass of 1,000 g/s

Percentile limits place additional operating constraints on SO_2 emission rates in a reporting year.

Figure 6 Loy Yang A emission profiles – SO_2 (30 minute data)

[13] The use of percentile limits such as these is an effective way of applying a tiered licence limit.

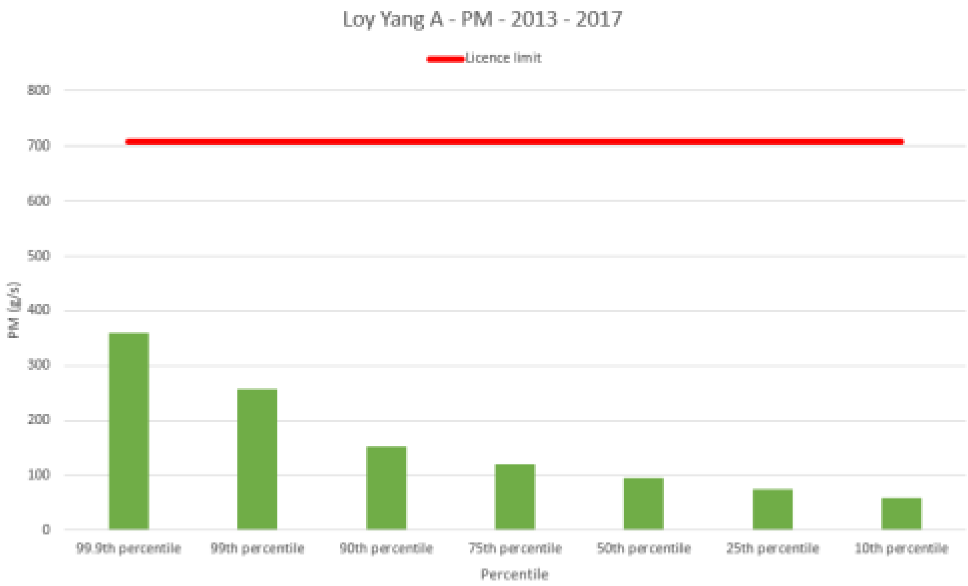


Figure 7 Loy Yang A emission profiles – total particles (30 minute data)

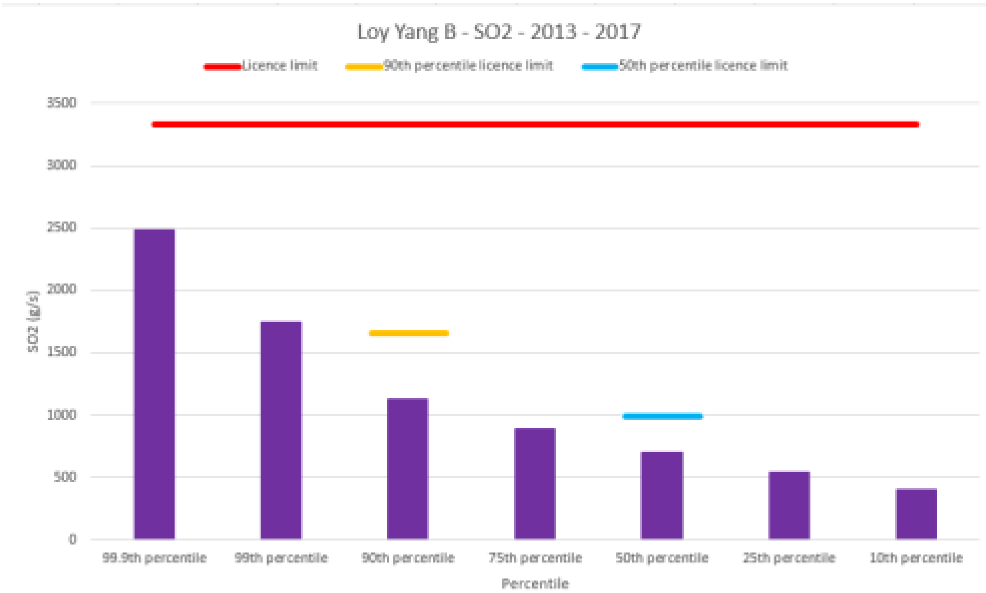


Figure 8 Loy Yang B emission profiles – SO_2 (30 minute data)

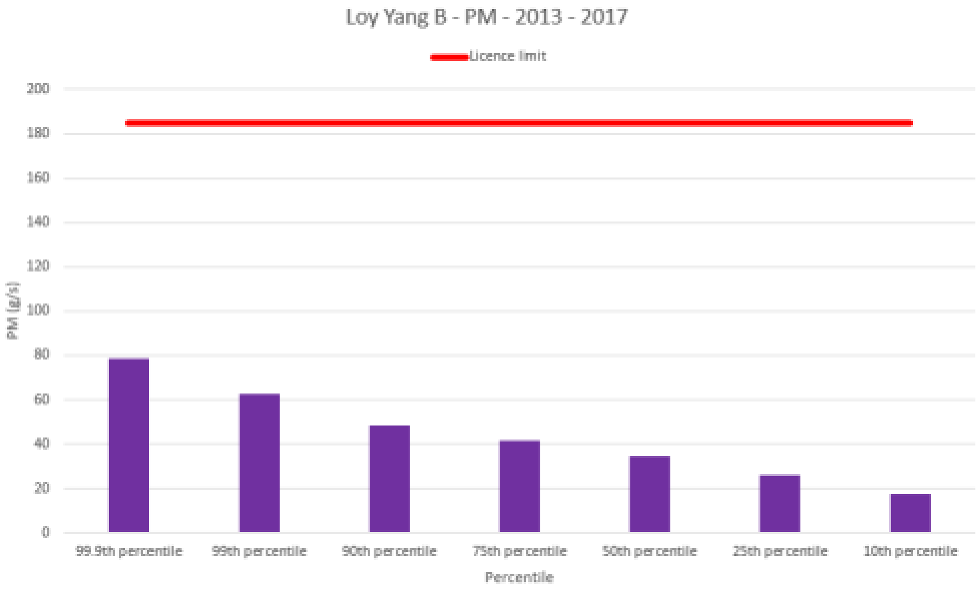


Figure 9 Loy Yang B emission profiles –total particles (30 minute data)

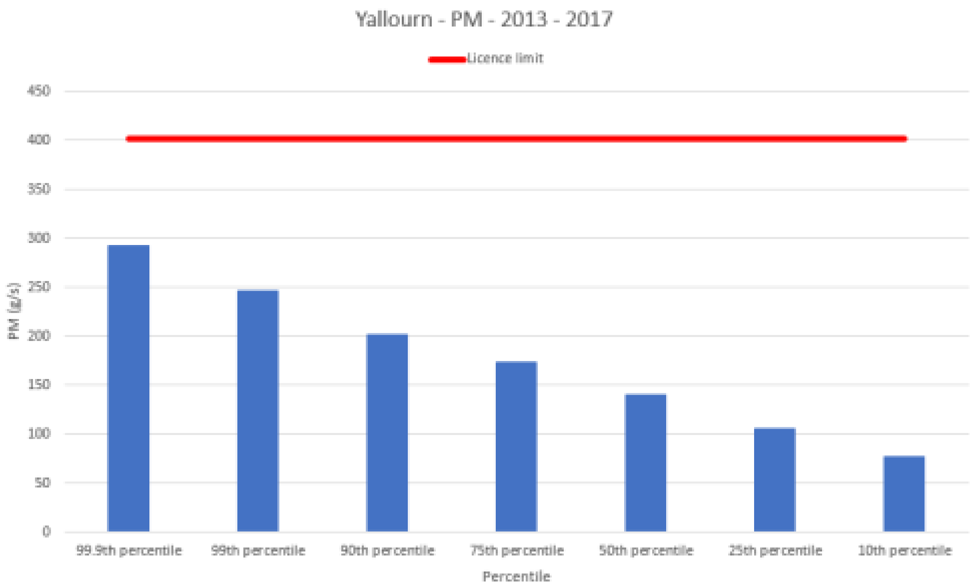


Figure 10 Yallourn emission profiles – total particles (30 minute data)

6. Latrobe Valley Air Quality Control Region ambient monitoring

EPA operates an ambient monitoring network across the Latrobe Valley.

The EPA are required to report on the ambient air quality monitoring network results to the NEPM AAQ. The annual summary reports produced by the EPA compare the measured ambient air quality across the network with the ambient air quality standards set by the SEPP AAQ, and can be accessed on the EPA website:

- https://www.epa.vic.gov.au/our-work/monitoring-the-environment/epa-airwatch

An analysis of five years of compliance summaries prepared by the EPA for the NEPM indicates that the Latrobe Valley is compliant for all criteria pollutants with the exception of short-term (24-hour) particulate matter $PM_{2.5}$, which the EPA attribute to 'planned burns'. In the case of compliance with particulate matter requirements, EPA Victoria publication 1663[14] provides this summary (for 2016):

- In Victoria, **PM_{10} is assessed against a one-day ambient air quality standard of 50 µg/m^3 and an annual ambient air quality standard of 20 µg/m^3**.
- The highest daily average for PM_{10} in the Latrobe Valley, recorded at the Traralgon monitoring station, was 98.4% of the ambient air quality standard.
- The highest annual average for PM_{10} in the Latrobe Valley, also recorded at the Traralgon monitoring station, was 56% of the ambient air quality standard.
- In Victoria, **$PM_{2.5}$ is assessed against a one-day ambient air quality standard of 25 µg/m^3 and an annual ambient air quality standard of 8 µg/m^3**.
- The highest daily average for $PM_{2.5}$ at the Traralgon monitoring station was 103% of the ambient air quality standard with the highest annual average at 97.5% of the ambient air quality standard[15].
- The one-hour standard for nitrogen dioxide was met at all EPA stations with Traralgon at 38.3% of the standard.
- The one-hour and daily standards for sulfur dioxide were met at all EPA stations with the highest one-hour average at Traralgon of 28.5% of the standard with the highest daily average being 7.5% of the standard. The annual mean was reported[16] as 0.001 ppm which meets the standard of 0.02 ppm.

In addition, major Latrobe Valley industrial licence holders, including the Power Stations, contribute to the operation of two additional ambient air monitoring stations at Jeeralang Hill and Rosedale South.

Daily ambient air charts and annual summary reports for these additional ambient air monitoring stations can be accessed at:

- http://www.lvamninc.com.au/

[14] Air monitoring report 2016 – Compliance with the National Environment Protection (Ambient Air Quality) Measure, Publication 1663 Published September 2017 (EPA Victoria, 2017, p.1):

[15] The inferred cause of the single $PM_{2.5}$ exceedance of the daily standard was due to a 'planned burn'. These are excluded from the database under NEPM procedures.

[16] EPA Publication 1632, Table 46. Note that Altona North recorded twice the annual average of Traralgon at 0.002 ppm.

The most recent five years of ambient monitoring data from the EPA and industry monitoring stations were analysed by GHD with comparison to the NEPM AAQ standards (see Figure 7). For gaseous pollutants this analysis found that:

- Carbon monoxide (CO) met the standard at all monitoring stations.
- Nitrogen dioxide (NO_2) met the standards at all monitoring stations.
- Sulfur dioxide (SO_2) met the standards at every monitoring station except the hourly standard at Jeeralang Hill.

Jeeralang Hill experiences between zero to five hours where SO_2 levels are above the objective. This occurs between October and April (warmer months) typically in the early hours of the morning. This is understood by EPA from modelling studies dating back more than 20 years and is the express reason why there is an industry funded monitoring station located at Jeeralang Hill. The reasons for this are its proximity to power stations, its location and elevation above the Latrobe Valley floor as well as the height of the Power Station stacks.

It should be noted that at the designated NEPM AAQ trend station at Traralgon[17], the SO_2 one-hour peak has been between 22 and 51 percent of the AAQ standard of 523 $\mu g/m^3$ for the past five years.

Ambient monitoring for particulate matter PM_{10} and $PM_{2.5}$ is discussed further in Section 7.1.

[17] "NEPM AAQ Clause 13 (2): Performance monitoring station(s) must be located in a manner such that they contribute to obtaining a representative measure of the air quality likely to be experienced by the general population in the region or subregion." Clause 15 (1): "A number of performance monitoring stations in each participating State and participating Territory must be nominated as trend stations."

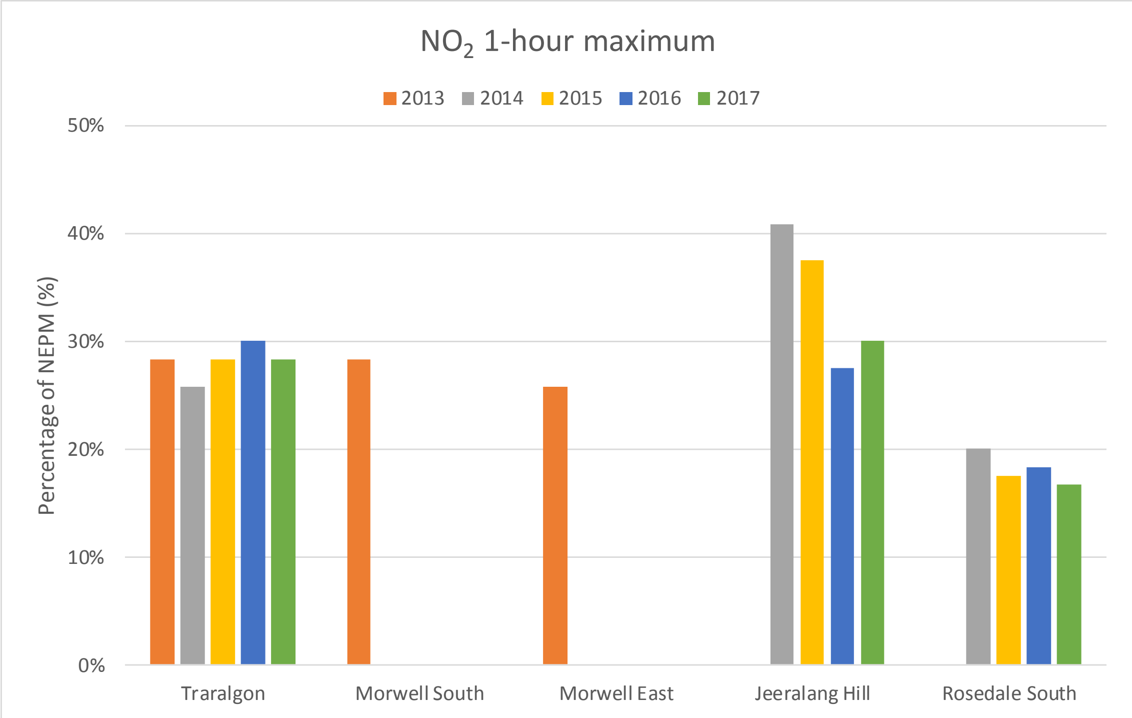


Figure 11 NO_2 1-hour maximum, as a percentage of NEPM AAQ standard

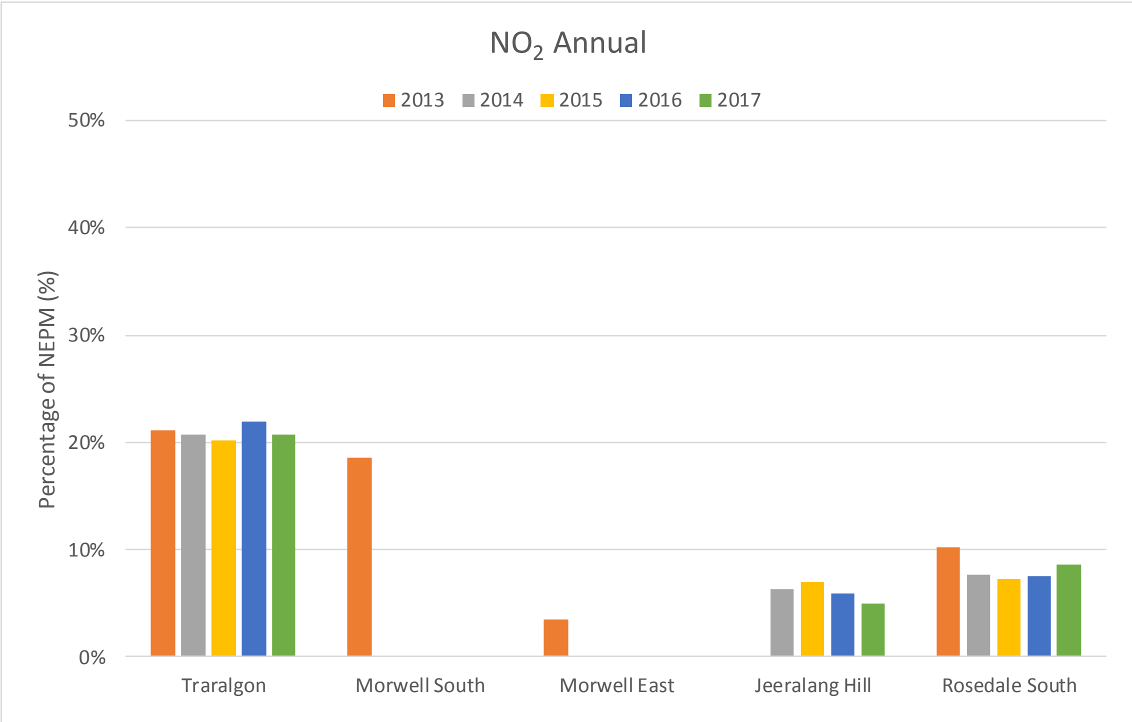


Figure 12 NO_2 annual, as a percentage of NEPM AAQ standard

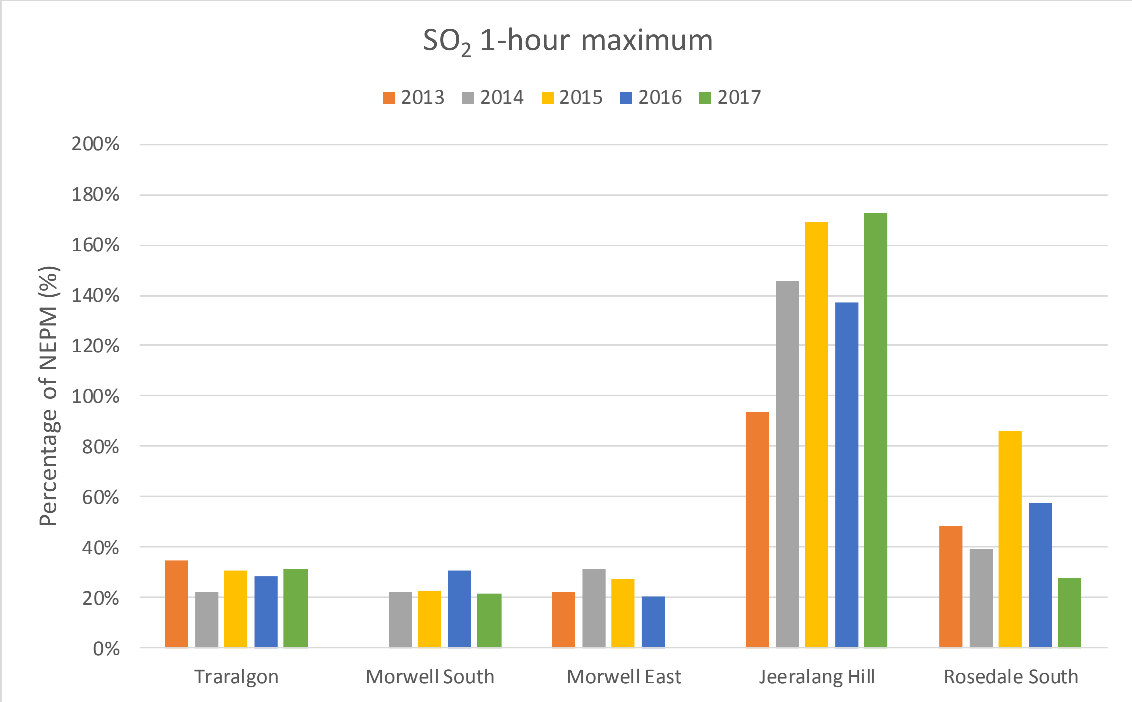


Figure 13 SO_2 1-hour maximum, as a percentage of NEPM AAQ standard

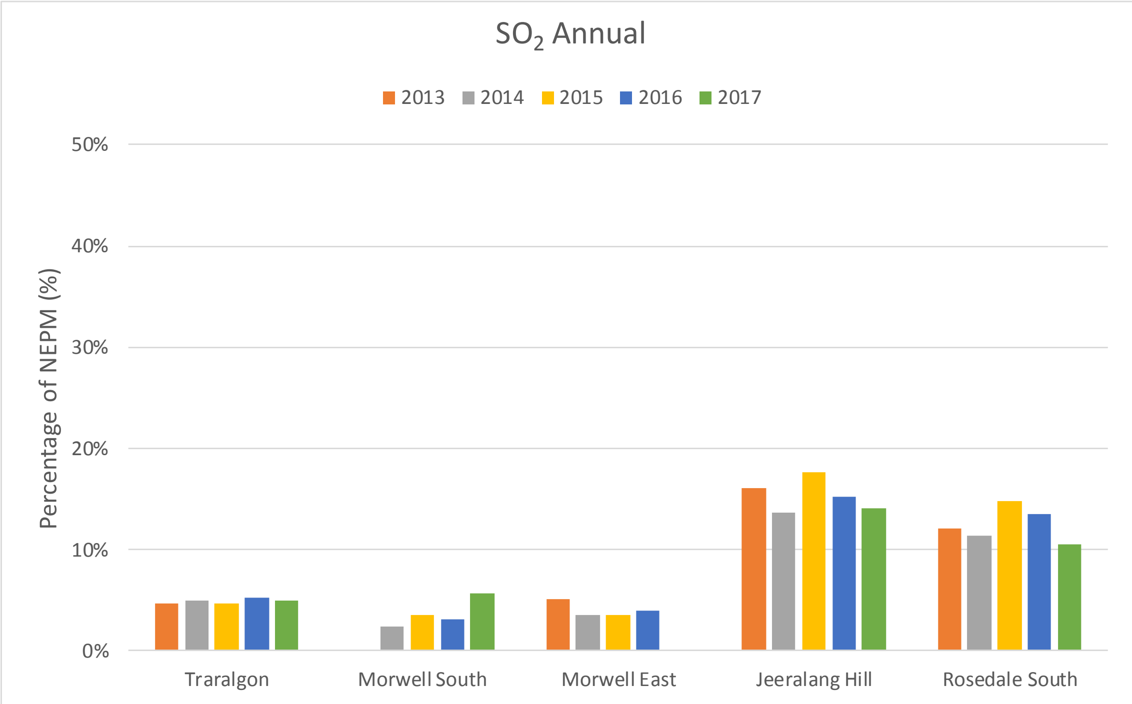


Figure 14 SO_2 annual, as a percentage of NEPM AAQ standard

6.1 Review of previous air quality modelling

All EPA licences for the Latrobe Valley with a discharge to air requirement, including the Power Stations, are subject to standard licence condition G5.2. This condition requires an assessment of the effect of their emissions on the ability of the Latrobe Valley Air Quality Control Region to comply with Schedule 2 of SEPP AAQ. Modelling, based on a set monitoring protocol, is conducted at regular intervals by licensees to support condition G5.2.

The Power Stations have conducted the following air dispersion modelling assessments over time:

- *Latrobe Valley Air Quality Control Region 2011-2012 Air Quality Modelling Assessment - Loy Yang B*, SKM, 12 October 2012
- *Latrobe Valley Air Quality Control Region 2011-2012 Air Quality Modelling Assessment - Loy Yang A*, SKM, 12 October 2012
- *Latrobe Valley Air Quality Control Region 2011-2012 Air Quality Modelling Assessment – Yallourn W,* SKM, 12 October 2012
- *Latrobe Valley Air Quality Control Region 2012-2013 Air Quality Modelling Assessment - Loy Yang B*, SKM, 12 October 2013
- *Latrobe Valley Air Quality Control Region 2012-2013 Air Quality Modelling Assessment - Loy Yang A*, SKM, 12 October 2013
- *Latrobe Valley Air Quality Control Region 2012-2013 Air Quality Modelling Assessment – Yallourn W Power Station*, SKM, 12 October 2013
- *Latrobe Valley Air Quality Control Region 2014-15, Air Quality Assessment – Loy Yang B Power Station*, Jacobs, 8 November 2016
- *Latrobe Valley Air Quality Control Region 2014-15, Air Quality Assessment – Loy Yang A Power Station*, Jacobs, 8 November 2016
- *Latrobe Valley Air Quality Control Region 2014-15, Air Quality Assessment – Yallourn W Power Station*, Jacobs, 8 November 2016

GHD has independently reviewed these reports, with the following conclusions:

- Dispersion modelling methodology:
  - The model used the actual measured power station emission data and is based on the actual meteorology for the particular year of assessment.
  - This modelling produces predictions for impact, which in turn provides a guide for measurement of pollutants against standards and goals at particular locations.
- This modelling approach, including choice of model, model settings, input parameters and treatment of background, are all in line with good industry practice.
- The modelling reports support the general conclusions:
  - Compliance is occurring to ambient quality standards at all population exposure stations in the EPA network for gaseous pollutants.
  - Any non-compliance due to particles (dust and smoke) when there is an exceedance of the PM_{10} and $PM_{2.5}$ standards is only due to minor contributions from the Power Station emissions.

7. Proposed new licence parameters

EPA has requested that the licence review consider PM_{10}, $PM_{2.5}$ and mercury as proposed new licence parameters.

7.1 Particulate matter

PM_{10} refers to atmospheric particulate matter (PM) that has a diameter of less than 10 micrometres (0.01 mm). PM_{10} can also be described as 'coarse particles' where high levels can irritate the eyes and throat.

$PM_{2.5}$ refers to atmospheric particulate matter that has a diameter of less than 2.5 micrometres, which is about 3% the diameter of a human hair. $PM_{2.5}$ can also be described as 'fine particles'. These fine particles cannot be seen directly by the human eye. Since they are so small and light, fine particles tend to stay longer in the air than heavier particles. Owing to their size, these are able to penetrate deep into the lungs.

Particles result from all types of combustion. They are emitted from industrial processes, motor vehicles, domestic fuel burning, planned burns and industrial and domestic incineration. Quarry and mining activities as well as agriculture practices also release particles into the air. Dust particles can be lifted into the air, for example, as cars and trucks travel on roads or as dry soil is exposed to the wind. Natural sources of particles include bushfires, windblown dust, pollens and salt spray from the oceans (oceanic aerosol). Particles can also form in the air during chemical reactions ('secondary aerosols').

Although not required under the EPA licences held for each of the Power Stations, each licence holder has undertaken periodic PM_{10} and $PM_{2.5}$ testing in their flue gas emissions to:

- Assist annual NPI reporting
- Support air quality risk assessment of impacts to the airshed under licence condition G5.2.

This data is also being used to inform this licence review air dispersion modelling activity.

Short-term exceedances of the SEPP AAQ standards for particulate matter do occur, such as during the 2014 Hazelwood Mine fire, planned burns and other bushfire events. The longer term annually averaged particulate matter data are generally within the SEPP AAQ standard. However, higher levels were recorded at the Traralgon monitoring station compared to the Churchill monitoring station, suggesting that there are contributions of particulate matter from other (non-power station) sources from more urbanised areas such as Traralgon. Consistent with previous studies (both recent and dating back many years), Power Station particle emissions are ultimately minor contributors to ground level concentrations - further details of this finding is provided in section 8.3 of this report.

The charts in Figure 15 to Figure 18 show daily maximum and annual average levels of PM_{10} and $PM_{2.5}$ recorded at ambient air quality monitoring stations in Traralgon, Morwell East and Jeeralang Hill from 2013-2017 and compared to NEPM AAQ standards. Note Hazelwood Power Station ceased operations in March 2017.

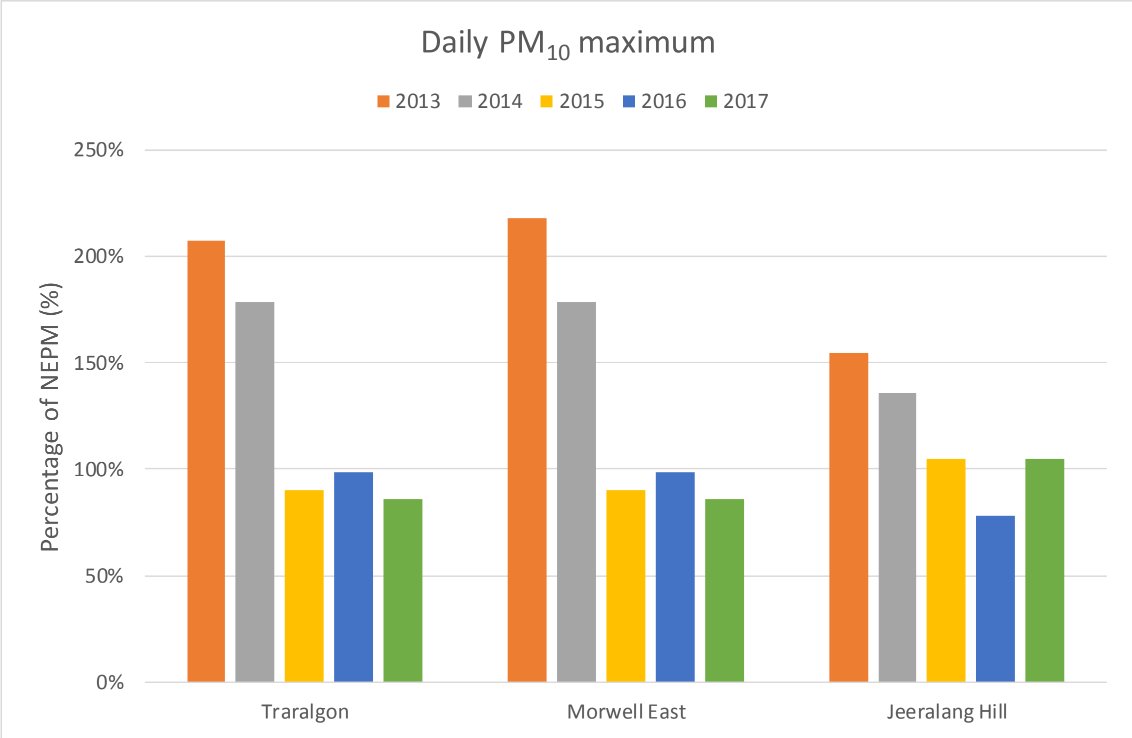


Figure 15 Daily maximum PM_{10}, as a percentage of NEPM AAQ standard

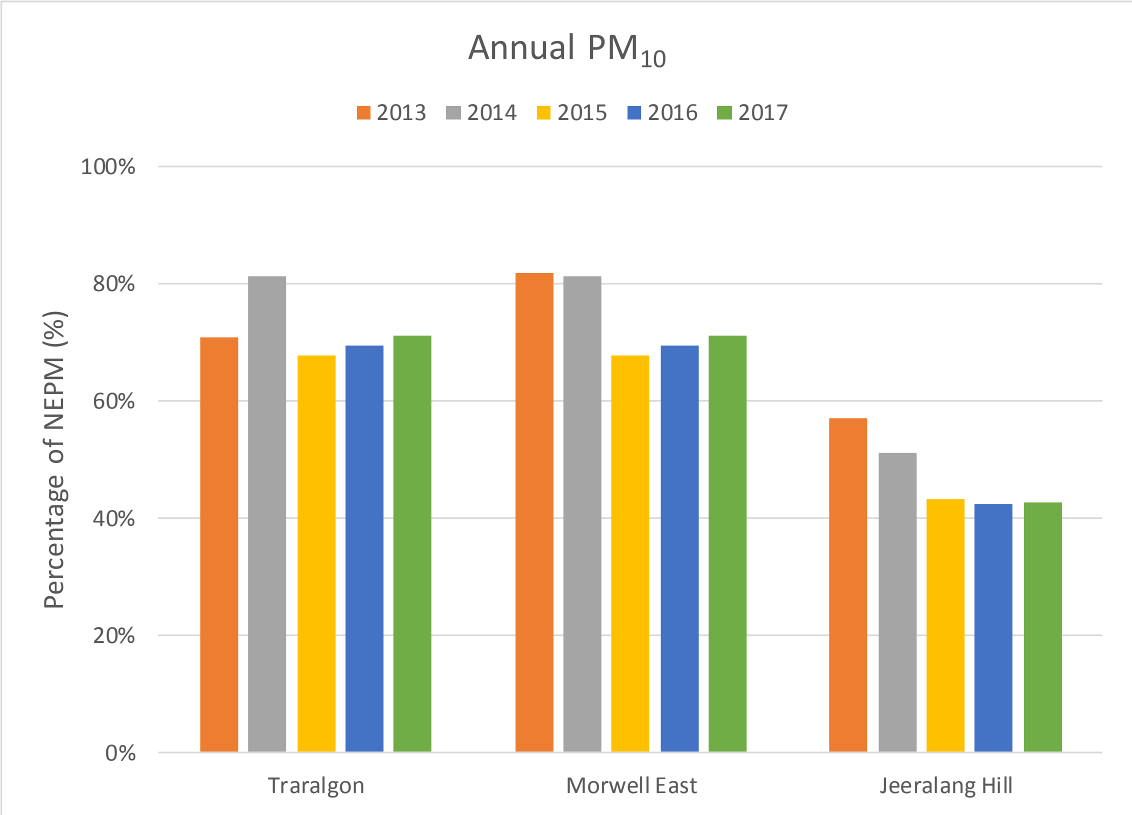


Figure 16 Annual PM_{10}, as a percentage of NEPM AAQ standard

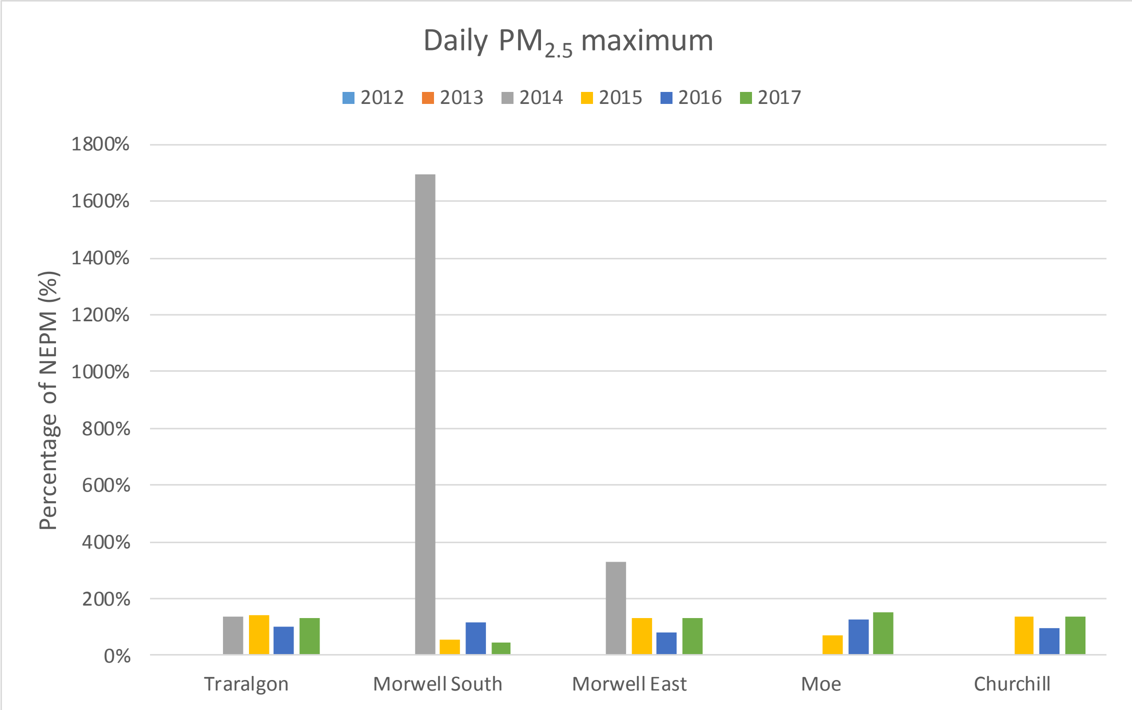


Figure 17 Daily maximum $PM_{2.5}$, as a percentage of NEPM AAQ standard

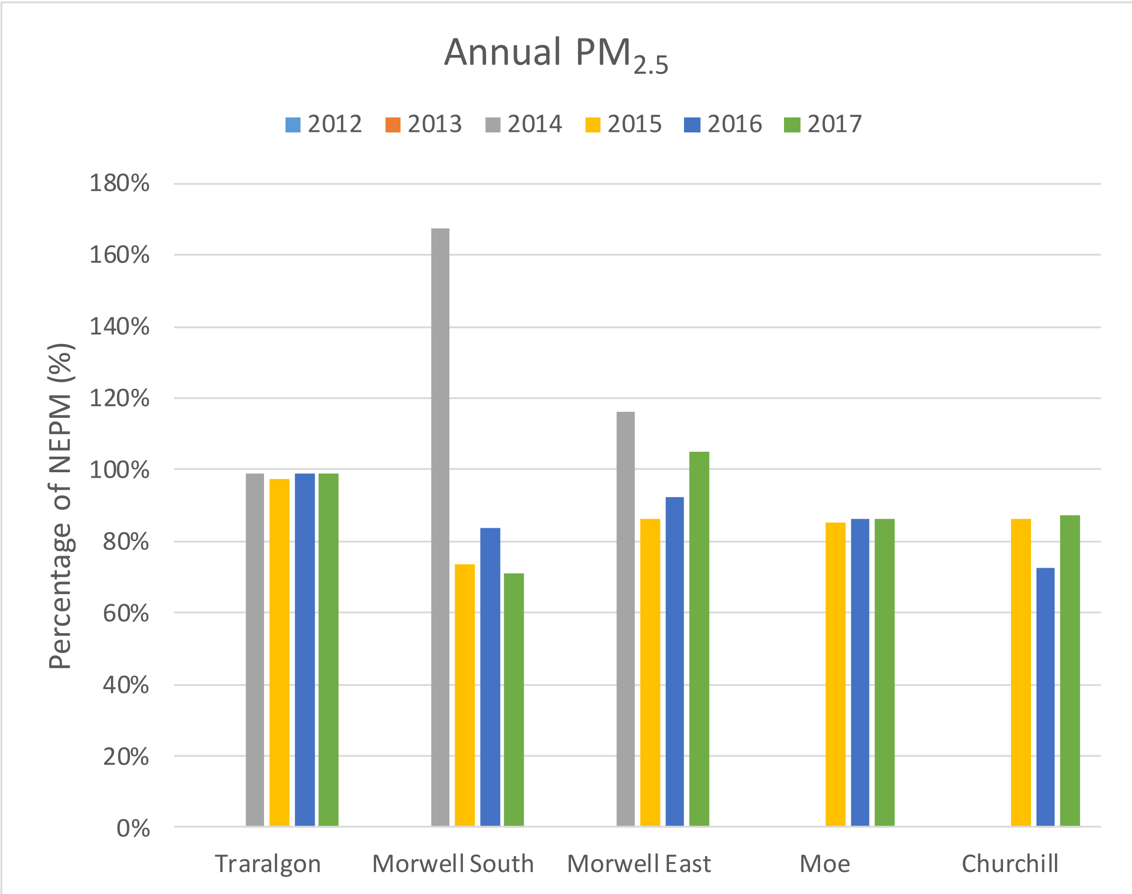


Figure 18 Annual $PM_{2.5}$ as a percentage of NEPM AAQ standard

Figure 18 shows an annual average for $PM_{2.5}$ close to the SEPP AAQ standard for Traralgon, while the daily average standard is occasionally exceeded at population centres in the Latrobe Valley. Recorded exceedances of PM_{10} and $PM_{2.5}$ daily and annual ambient air quality standards over the last five years at EPA's Traralgon and Morwell monitoring stations have been due to localised events such as bushfires, the 2014 Hazelwood Mine fire, prescribed burns or seasonal use of wood fire heating in urban areas. This is accommodated by the SEPP AAQ which, since the introduction of the new PM_{10} and $PM_{2.5}$ standards in 2016, allows for consideration of 'exceptional circumstances', which are defined as:

- "*A fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedance of one day average standards in excess of normal historical fluctuations and background levels, and is directly related to: bushfire; jurisdiction authorised hazard reduction burning; or continental scale windblown dust.*" (SEPP AAQ, Clause 5(2)).

Air quality assessments, undertaken in the Latrobe Valley over many years, and confirmed by the new assessments undertaken by GHD for this study, conclude that Power Station emissions are a minor contributor to the ambient levels of particulates. Monitoring at more urbanised locations consistently records higher concentrations of particulates than the monitoring at other ambient monitoring locations that are known to respond to emission impacts from the Power Stations. This points to 'sources' other than the Power Stations as being major contributors to levels of particulates across the Latrobe Valley.

The ambient monitoring data suggests there is a level of seasonal influences in the $PM_{2.5}$ measurements dominated by sources other than Power Station emissions. Figure 19 shows $PM_{2.5}$ levels at Traralgon monitoring station are elevated during the middle months of every year. Of the 10 days above the standard of 25 µg/m^3, they all occurred in the months of April to July.

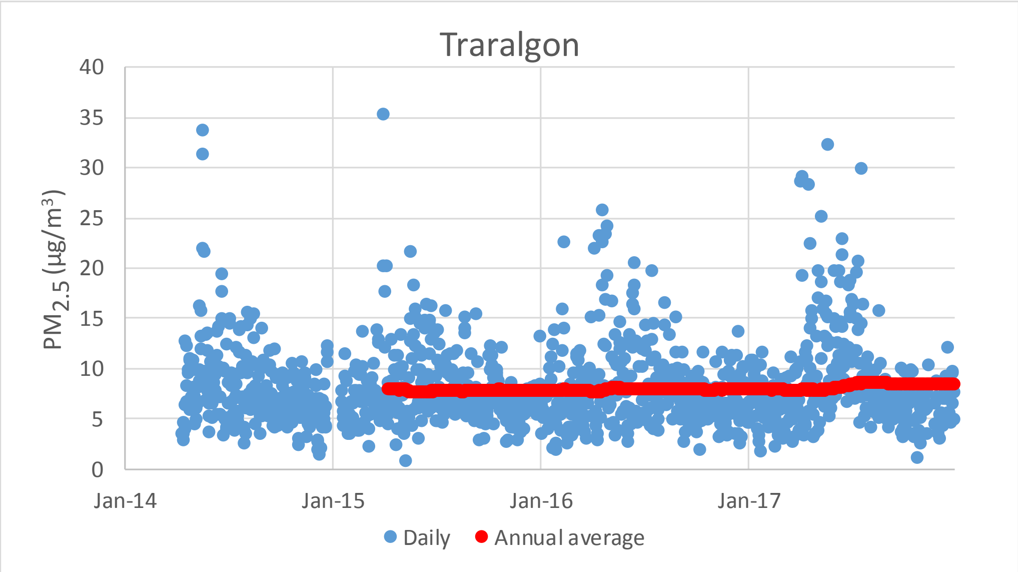


Figure 19 Daily and rolling annual average at Traralgon $PM_{2.5}$ 2014 to 2017

In the absence of a particle characterisation study being undertaken to identify particle contribution to their emission sources (combustion, fires, aerosols, mining, industry, agriculture etc.), it is important to record local geographical events (smoke, haze, fire, burns etc.) with any elevated readings recorded. In other regions of Australia, particle characterisation studies such as Robinson (2016)[18] have demonstrated that particulate emission due to wood smoke in urban areas is the most significant contributor to annual average of $PM_{2.5}$.

As shown in Figure 20, throughout the year in the upper Hunter Valley (NSW), the contributing sources such as vehicle/industry (purple), soil (red) and sea salt (blue) are steady contributors to the ambient $PM_{2.5}$ levels – with the combined non-wood smoke sources adding up to an annual average of 5 to 7 µg/m^3. When the colder month's wood smoke (yellow) is added, the total monthly average can exceed 10 µg/m^3.

It is suspected that a similar scenario may be occurring in the Latrobe Valley as monitoring of $PM_{2.5}$ indicates a similar spike in the late autumn to winter months.

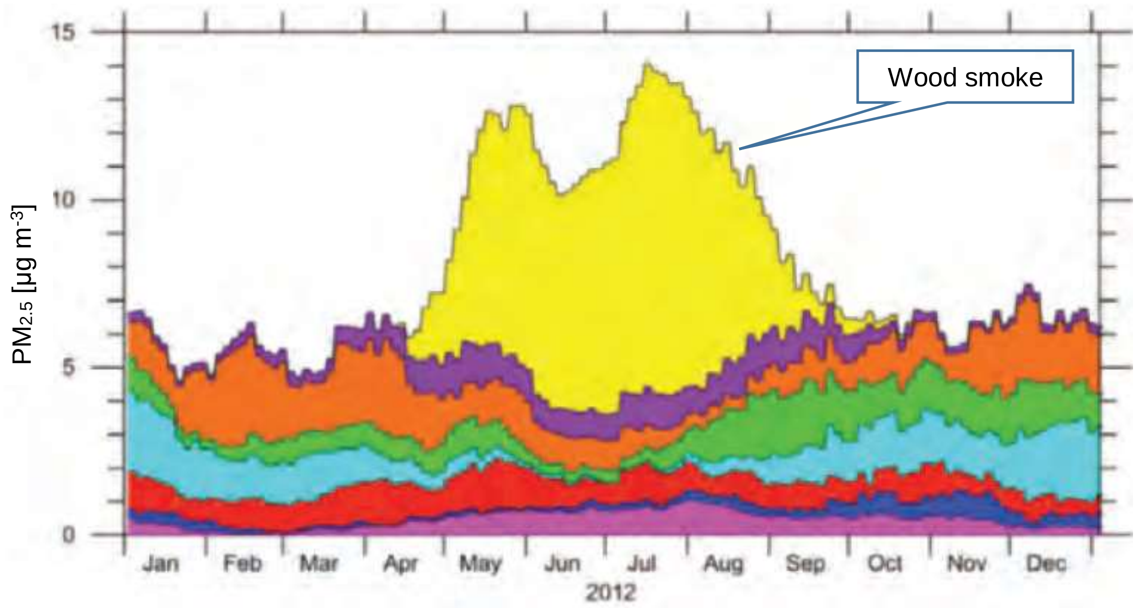


Figure 20 Particle characterisation study of the Hunter Valley (Robinson, 2016)

7.2 Mercury

7.2.1 Overview

Mercury is a heavy metal that is widespread and persistent in some environments worldwide. Nelson et al (2009)[19] reports that the global, annual average of ambient air mercury concentration levels (on a continental scale), is within the range of 1.1–1.3 nanogram per cubic metre (ng/m^3), increasing up to 3 ng/m^3 around fires and major industrial sources. 3 ng/m^3 is a similar ambient air concentration to the levels that are found in urban areas such as Melbourne and Sydney. In 2001, the United Nations Environment Programme (UNEP) undertook a global assessment of mercury and its compounds, and developed a treaty to reduce the amount of harmful mercury in the environment. The treaty is known as the Minamata Convention, to which Australia became a signatory on 10 October 2013, but has not yet ratified.

[18] Robinson, D.L. (2016). What makes a Successful Woodsmoke-Reduction Program? Air Quality and Climate Change Volume 50 No.3. August/November 2016.
[19] Nelson, et al. (2009). Mercury Sources, Transportation and Fate in Australia. Department of Environment, Water, Heritage & the Arts. December 2009.

In response to the Minamata Convention, EPA has indicated that mercury monitoring should be included in Power Station licences.

Both the Minamata Convention and SEPP AQM provide a general obligation to implement best practice measures to control emissions. The drive to implement tighter standards in Europe (than those in Australia) arises from the health ramifications of denser populations and resulting greater impacts on air quality, with over 30% of EU citizens being exposed to air pollution levels above EU standards. While Victoria has similar air quality standards to Europe, the air quality experienced by Victorians is considerably better. As Power Stations are only a minor contributor to the mercury levels present in the Latrobe Valley ambient air, applying 'international practice' is unlikely to significantly impact the ambient air quality in the LVAQCR.

Brown coal in the Latrobe Valley, which fuels the Power Stations, contains naturally occurring trace levels of mercury. Australian coal is relatively low in mercury content compared with other coal resources.

Other natural sources of mercury found in the atmosphere can come from bushfires and prescribed burns. Historic gold mining activities throughout the Gippsland region are also a key contributor to the environment (land and water).

Atmospheric mercury primarily exists as elemental mercury vapour (Hg^0) and to a lesser degree in particulate form as oxidised mercury (Hg^{2+}), or attached to particulates (Hg^p). The gaseous vapour form disperses in the air and will not be subject to deposition. However, the particulate forms can be subject to deposition, and the oxidised form may react with sulfur or chloride, increasing its water solubility and potential for wet deposition closer to its source.

7.2.2 Mercury assessment in the Latrobe Valley

In 2015, the CSIRO[20] published a report of air modelling of mercury sources and sinks in the Latrobe Valley. The report aimed "*to investigate the contribution of the atmospheric mercury emissions from Latrobe Valley power stations compared to the other mercury sources in the region*" (ibid., p.33). The CSIRO report specifically considered atmospheric mercury emissions from the Power Stations and took into account other mercury sources in the region.

The CSIRO report found that:

- The total mercury concentration (the three forms of mercury) from the four power stations' stacks contribute less than 1% of 'all sources'

  i.e. the four power stations operating at the same time (the three Power Stations which are the subject of this study, plus Hazelwood power station, plus other man-made sources, as well as contributions from vegetation, soil and water). The CSIRO reported on mercury emissions down to the nanogram (ng) level (one ng is a billionth of a gram or one 0.000,000,001 grams). The CSIRO found that the concentrations from power stations were predicted to be 0.0012 ng/m^3 on average, with a maximum concentration of 0.015 ng/m^3

[20] K.M. Emmerson, M.E. Cope, S. Lee, M.F. Hibberd and P. Torre (2015). Modelling atmospheric mercury from power stations in the Latrobe Valley, Victoria. Air Quality and Climate Change Volume 49 No.1. February 2015.

- The maximum total mercury concentration modelled in the Latrobe Valley for all sources, including the four power stations operating at the time, centred on the Hazelwood power station due to its shorter stack. The maximum concentration level for all sources was 1.58 ng/m^3 – approximately two thousand times less than the design criterion for inorganic mercury (the expected form of the mercury from hot processes such as power stations). Further, Emmerson et al. (2015, p.35) found that "*The contribution of the four power station stacks is less than 1% of the 'all sources' run*".

With the closure of the Hazelwood Power Station on 31 March 2017, estimates of mercury emissions from Power Stations in the Latrobe Valley are expected to have decreased by about 24 percent.

In 2015, the Department of Health and Human Services in collaboration with the EPA and Fisheries Victoria, published a report[21] to assess the levels of mercury in fish from the Gippsland Lakes. The report found that the levels of mercury in fish have remained relatively stable over the past 35 years from 1980 to 2015. The study found that the dietary advice from the Food Standards Australia and New Zealand in regard to fish consumption does not need to be revised from that issued for all Australia, and that a site-specific health advisory was not warranted for fish sourced from the Gippsland Lakes.

Although not required under the existing EPA licences issued for Power Station operators, each operator has undertaken monitoring for mercury in their brown coal supply and flue gas emissions to assist in NPI emission estimation and provide an understanding of the mass balance of mercury as it moves through the Power Stations. This data was used to inform the modelling undertaken by GHD. As the Power Stations are only a minor contributor to the mercury levels present in the ambient air, applying best practice is unlikely to significantly impact the ambient air quality in the LVAQCR.

[21] Department of Health and Human Services (2017). Mercury levels in black bream and dusky flathead from the Gippsland Lakes, Victoria.

8. New air dispersion modelling

8.1 EPA approved modelling proposal

GHD has carried out air quality dispersion modelling as part of this review. The modelling shows:

- Current performance and licence limits for oxides of nitrogen (NOx), sulfur dioxide (SO_2) and carbon monoxide (CO) meet policy requirements.
- Assessment of the proposed new EPA parameters for power station licences; particulate matter PM_{10} and $PM_{2.5}$ and mercury.

The methodology for this work was reviewed and approved by the EPA after a workshop held on 7 May 2018 between GHD and EPA Air Quality specialists to discuss and establish model requirements. A formal modelling proposal was lodged with EPA on 11 May 2018 with approval granted on 13 June 2018. The methodology follows US EPA guidance for assessing emissions from multiple sources. In this work:

- 'Nearby sources' are "*all sources expected to cause a significant concentration gradient in the vicinity of the source*"
- "*The number of such sources is expected to be small except in unusual situations*".

The methodology approved by the EPA includes:

- Use of the CALMET/CALPUFF dispersion models in preference to the AERMOD model. This is due to the size of the domain model being greater than 20 km and the terrain features altering wind patterns making AERMOD unsuitable.
- Three-dimensional, both surface and upper air, meteorological fields informed by surface meteorological monitoring stations.
- Consideration of fixed emission rates but which can be varied in various modelling scenarios to quantify the impacts of input emission rates.
- Assessment at grid locations to cover all the region but also discrete locations for more detailed analysis.
- Various techniques to include and compare background data.

8.2 Modelling with fixed emission rates

The agreed methodology involved:

1. Working on the assumption that the current and existing Power Station licence limits provide the required acceptable ground level impact, impacts were calculated as if the discharge points were operating at maximum allowed levels ('top-down' approach) at all times. As the Power Stations operate at some lower fraction of the licence limits, this scenario is the most conservative and leads to an over prediction of impacts. Only licence limits that apply to ambient monitored gaseous pollutants were considered in this scenario.

2. An alternate approach was to use a 'bottom-up' method that calculates impacts based on a low, uniform, fixed emission rate (termed unity so that it can be scaled higher). This emission rate is then equally applied to each discharge point. After scaling, the maximum emission rate that could be applied and still remain within the required limits is estimated. This methodology enables multiple scenarios to be tested, as the model can multiply any individual source by a scaling factor and calculate the cumulative impact.
3. Using realistic estimates from the above modelling scenarios, test possible PM_{10}, $PM_{2.5}$ and mercury licence limits that continue to meet the SEPP AAQ ambient air quality objectives and NEPM AAQ standards for ground level concentrations.

The results of the modelling carried out is summarised below.

8.2.1 Maximum discharges at current licence limits (top-down model scenario)

This "top-down" modelling predicts the cumulative effects of the three Power Stations emitting continuously at licence limit rates ('top') and to what degree these could be reduced ('down') if required to achieve compliance with policy requirements. This is an absolute worst case scenario to predict what the air quality would be if the Power Stations were all emitting at the maximum, licensed rates for an entire year. If the standards are met under this scenario, then the licence limits should be considered adequate.

The example contour plot (Figure 21) shows the predicted ground level concentration for maximum one-hour SO_2 for 2014 where the orange circles identify the Power Stations and the green triangles are ambient air monitoring stations. Even in this worst case scenario the predicted air quality remains within air quality standards for the majority of the airshed – with the exception of a few hours each year as indicated by the light blue contour. The light blue contour lines each represent a nominal exceedance of the SEPP AQM design ground level concentrations (450 µg/m³).

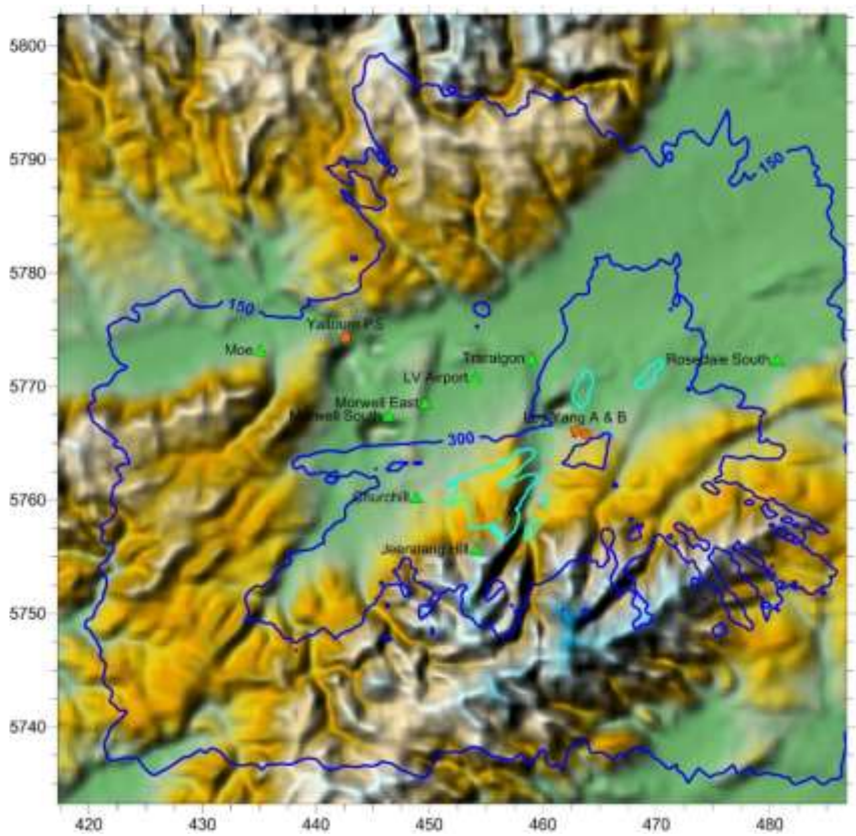


Figure 21 Predicted maximum one-hour SO_2 for 2014 - maximum emissions

The nominal exceedances in Figure 21 are not significant as each of the Power Stations do not operate at the maximum emissions licence limit on a continuous basis, rather the emissions are a varying fraction of these upper licence limits.

In this top-down scenario it was found that:

- The predicted maximum SO_2 level for all years (2013-2017) at the Traralgon monitoring station was below the relevant one-hour, daily and annual standard.
- For the daily and annual SO_2 standards, all other stations in the model domain were compliant.

2014 plots for SO_2 are shown in Figure 22 as they produced the highest one-hour impacts while all other years produced lower predictions.

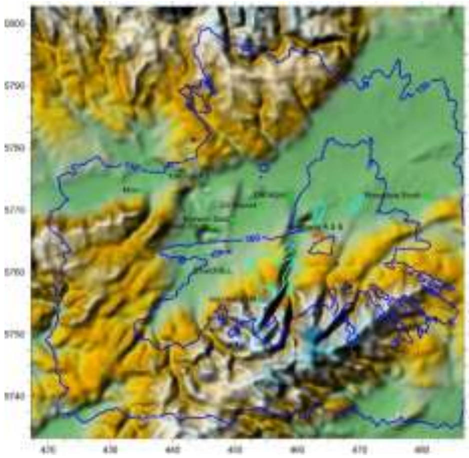
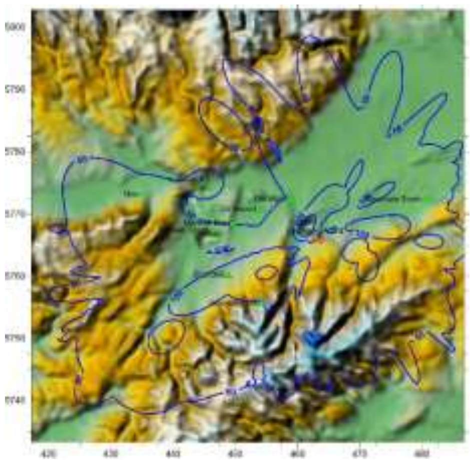
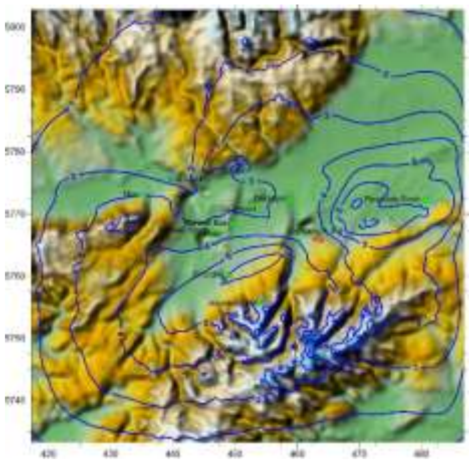
SO_2 1-hour for one-year	**Longer term maximum impacts**	**Compliance to SEPP AAQ**
	**Daily** 	Yes Grid max = 196 $\mu g/m^3$ Standard = 209 $\mu g/m^3$
	Annual 	Yes Grid max = 7.1 $\mu g/m^3$ Standard = 20 $\mu g/m^3$

Figure 22 Predicted hourly, daily and annual SO_2 concentrations - maximum emissions

For CO and NO_2, operating at the licence limits in this top-down approach always resulted in predicted ground level concentrations being within SEPP AAQ standards across all of the modelled domain.

When considering particulate matter:

- For the total suspended particles (TSP, or 'nuisance dust'), Table 5 shows the highest predicted 3-minute concentration for TSP is at least three times lower than the design ambient ground level concentration (e.g. the allowed limit). TSP in air is defined as an amenity related parameter (rather than health) and compliance is only relevant to SEPP AQM, with no standard for ambient monitoring in SEPP AAQ.
- There is no current Power Station licence limit for a PM_{10} emission rate. The top-down scenario assumed 100% of the TSP is PM_{10}. The predicted PM_{10} as shown in Table 6 indicates the maximum grid concentration compared to the ambient air standards. For one-hour PM_{10}, the predicted ground level concentrations are always below the applicable air quality criterion (SEPP AQM) and this applies across the daily and annual averaging periods.
- Model predicted $PM_{2.5}$ (at 100% of TSP) at times exceed the one-hour design ambient air quality criteria under SEPP AQM, but remain below the daily and annual NEPM AAQ standards. This is without factoring in that $PM_{2.5}$ is an even lower fraction than PM_{10} of the TSP emission rate limit. The predicted annual averages (the same value in Table 6 for PM_{10} and $PM_{2.5}$ as both assumed to be 100% of TSP) for each year are all less than 1 µg/m^3 and therefore well under the standard of 8 µg/m^3. Two of the five years are predicted to be under the one-hour criterion.

Table 5 Highest impacted grid point for total suspended particles (TSP)

TSP	Maximum predicted 3-min concentration (µg/m^3) SEPP AQM = 330 µg/m^3 (No SEPP AAQ criteria)
2013	93
2014	87
2015	77
2016	93
2017	102

Table 6 Highest impacted grid point for PM_{10} and $PM_{2.5}$

PM_{10} and $PM_{2.5}$ emitted at 100% TSP	Maximum predicted concentration (µg/m^3)		
	One-hour	Daily	Annual
2013	51	19	0.8
2014	48	18	0.8
2015	42	17	0.7
2016	51	19	0.8
2017	56	20	0.9
PM_{10} SEPP AQM PM_{10} SEPP AAQ	80 N/A	N/A 50	N/A 20
$PM_{2.5}$ SEPP AQM $PM_{2.5}$ SEPP AAQ	50 N/A	N/A 25	N/A 8

Note: The same values apply for PM_{10} and $PM_{2.5}$ as both are assumed at 100% of the total particles emitted.

Key findings from the top-down approach are:

- As expected, the model predictions are generally higher than measured at air monitoring stations due to the Power Station emission profiles (as examples shown in section 5.2) being lower than the emission rate at maximum licence limits at all times.
- The top-down methodology suggests that the current licence limit for TSP is able to achieve compliance to the various PM_{10} and $PM_{2.5}$ criteria.

8.2.2 New licence parameters (bottom-up model scenario)

As agreed with EPA, an alternative approach to the 'top-down' scenario is a 'bottom-up' modelling scenario approach. Here the Power Stations are assigned the same low ('bottom') emission rate out of each stack, where the emission rate can then be increased, or scaled, ('up') until the predicted maximum ground level concentration reaches the relevant SEPP AQM or SEPP AAQ standard. A uniform, nominal emission rate limit 'unity' (set as mass per time in line with the units currently specified in the licences) was modelled by Jacobs[22].

Particulate matter PM_{10} and $PM_{2.5}$

When applying the bottom-up scenario, a uniformly applied Power Station PM_{10} emission rate achieves the design ground level SEPP AQM standard when all sources are uniformly restricted to 410 g/s out of each stack[23] (see red dot-dash line below). As Figure 23 shows, the current licence limit for total particles for the single stack at Loy Yang B (see purple dotted line) of 185 g/s (11,100 g/min)[24] is well below the modelled 410 g/s emission rate.

Model outputs indicate that all stack sources could emit PM_{10} as 100% of TSP and result in all predicted ground level air quality concentrations being within ambient air standards. This suggests that if a PM_{10} licence limit were to be set at 100% of the controlled TSP emission limit, then the ground level air quality concentrations at all averaging periods will be achieved. Figure 23 confirms how the current licence limits for each stack (with PM_{10} 100% of TSP) are all below the value where they would contribute to the predicted hourly SEPP AQM criterion being 'achieved'.

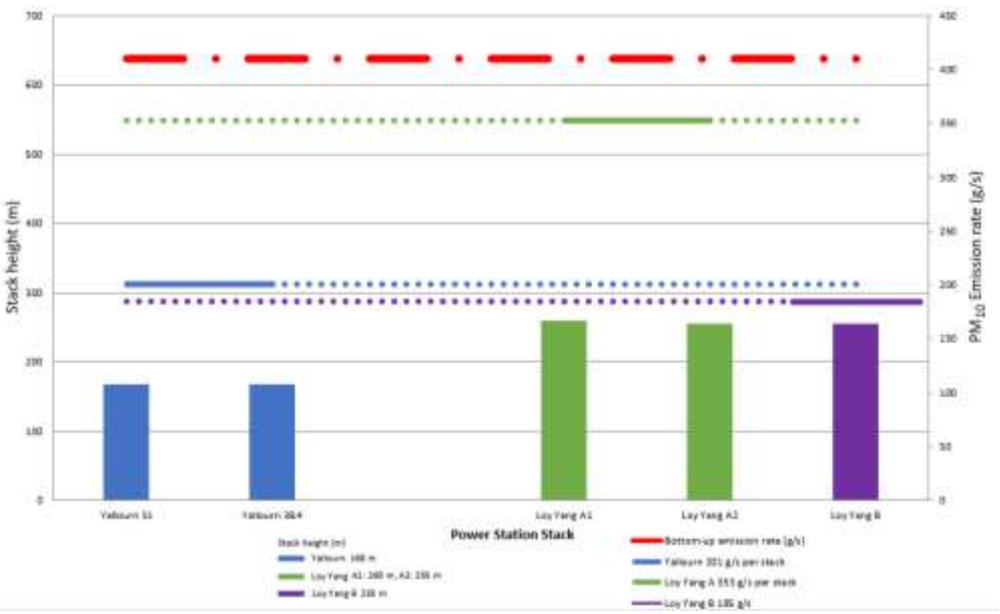


Figure 23 PM_{10} at 100% of TSP using bottom-up approach to compare to existing emission limits

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22 http://www.jacobs.com/

23 Worst-case year (2017) for unity emission at 1-hour is 0.195 µg/m³. The 1-hour SEPP AQM criterion for PM_{10} is 80 µg/m³. The scaling up is 80 divided by 0.195 = 410 g/s.

24 Single stack at Loy Yang B is 185 g/s; Loy Yang A is 353 g/s per stack; Yallourn is 201 g/s per stack.

As indicated in Table 7, the particular circumstances of the design criteria for $PM_{2.5}$ suggests that a uniform emission limit of 256 g/s (15.4 kg/min) per stack would result in compliance to the one-hour SEPP AQM criterion. For each stack at Loy Yang A to be within the predicted, worst-case 256 g/s, this would be achieved if $PM_{2.5}$ was always lower than 72.6% (15.4 divided by 21.2 kg/min of the bubble limit) of the currently applied total particles licence limit. All other stacks (185 g/s at Loy Yang B and 201 g/s each stack at Yallourn) are not able to contribute enough for the SEPP AQM criteria to be exceeded. The SEPP AAQ objectives are met even at 100% of the $PM_{2.5}$ fraction being in total particles being emitted a t licence limits.

Table 7 $PM_{2.5}$ Emission rates (uniformly) scaled upward to match the ambient standard set-points

Year	Unity Max. 1-hr GLC (grid point results) (µg/m³)	Unity Max. 24-hr GLC (grid point results) (µg/m³)	Unity Max. annual GLC (grid point results) (µg/m³)	g/s to achieve SEPP AQM 1-hr 50 µg/m³	g/s to achieve SEPP AAQ 24-hr 25 µg/m³	g/s to achieve SEPP AAQ annual 8 µg/m³
2013	0.187	0.062	0.003	267	403	2667
2014	0.193	0.071	0.003	259	352	2667
2015	0.176	0.058	0.003	284	431	2667
2016	0.187	0.062	0.003	267	403	2667
2017	0.195	0.065	0.004	256	385	2000

The key point of this analysis is that if a licence limit for $PM_{2.5}$ was applied at the same current level for the existing bubble licence relating to all particles (at a 100% ratio), then the daily[25] and annual standards of the NEPM AAQ would be met. Actual $PM_{2.5}$ ratios to TSP are typically between 25% and 40%, but a fixed value of 60% was assumed in the modelling of Section 8.3.2). The 2,000 g/s of the worst-case year relating to the annual standard is 10 times higher than the current licence limit at the higher emitting Yallourn (201 g/s per stack).

Mercury

There are no ambient monitoring standards for mercury in SEPP AAQ or NEPM AAQ. The only applicable criterion is a design ground level concentration in SEPP AQM as shown in Table 8. The results show that to achieve the three-minute inorganic[26] mercury criterion of 3.3 ug/m³ a uniform stack emission rate limit can be as high as 9 g/sec.

[25] The 352 g/s worst case (2014) is just a rounding error below the actual licence limit at Loy Yang A of 352 g/s.
26 SEPP AQM has both organic and inorganic mercury as design criteria. Due to the hot processes in a Power Station, the emissions will be inorganic.

Table 8 Mercury Emission rates (uniformly) scaled upward to match the ambient standard set-point.

Year	Predicted max. 3-minute[27] GLC at unity emission rate (grid point results)	g/s to achieve SEPP AQM 3-minute inorganic 3.3 µg/m^3
2013	0.340	10
2014	0.351	9
2015	0.320	10
2016	0.340	10
2017	0.355	9

8.3 Model prediction sensitivity to new parameters

8.3.1 PM_{10}

The current particulate matter licence limits imposed on each of the Power Station licences also controls the sub-categories of PM_{10} and $PM_{2.5}$.

In the absence of any systematic, long-term measurements of the PM_{10} fractions emitted from the Power Stations (e.g. how much of the particulate matter is PM_{10}, and how much is $PM_{2.5}$), a conservative assumption of a 90% PM_{10} to TSP ratio has been used in the new modelling. A more accurate ratio could be determined through further testing. This further work would be required to better understand emissions variations and information gaps.

Current monitoring data from the Power Stations shows that the ESPs are able to achieve the current TSP licence limits. Given the model assumption of a 90% ratio of PM_{10} to TSP at all times, Figure 24 and Figure 25 shows the Power Stations can only provide a 6.1 µg/m^3 increment to the daily average standard, and only a 0.5 µg/m^3 increment to the annual average standard at Traralgon.

Both of these increments are well under the air monitoring standard and just a fraction of the maximum PM_{10} that is actually measured at Traralgon (most right-hand columns of Figure 24 and Figure 25). These model results indicate there would be little benefit by introducing a new licence limit for PM_{10}. This further supports the position that other sources, such as exceptional events (bushfires, controlled burning etc.) and local urban sources, are contributing to the monitoring results recorded.

27 Correction factor from hourly value modelled with the peak to mean correction factor for 1-hour to 3-minutes being 1.82.

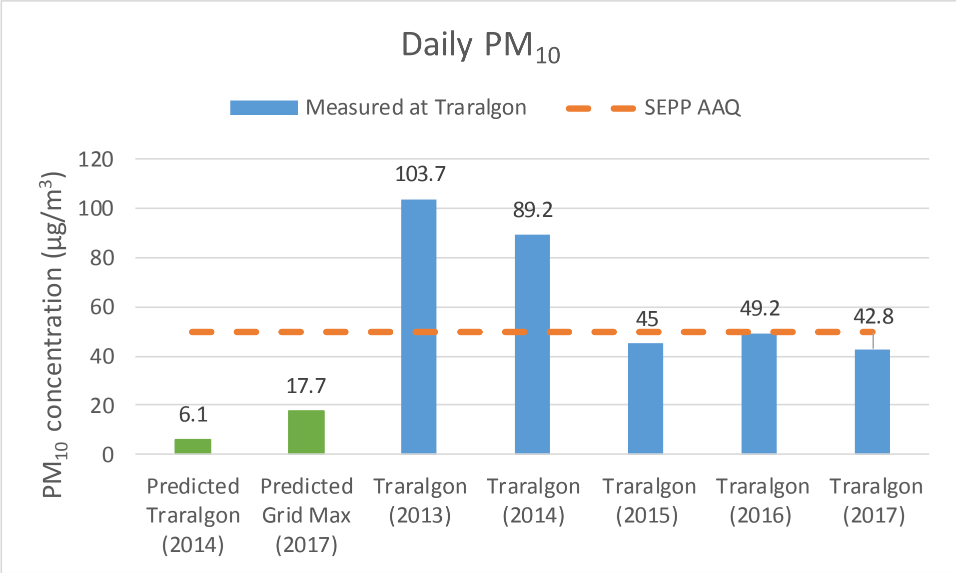

Figure 24 Predicted maximum daily PM_{10} compared to standard and measured

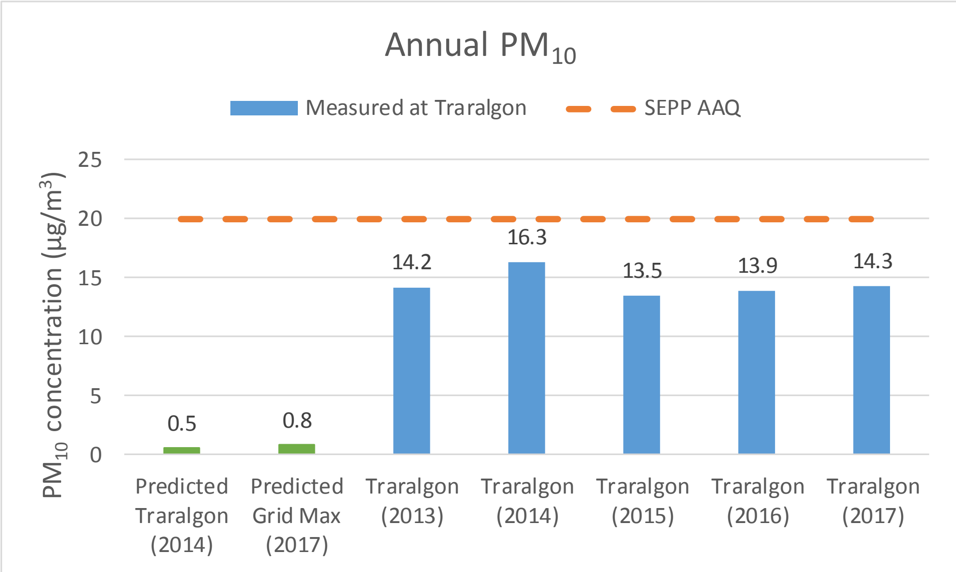

Figure 25 Predicted annual PM_{10} compared to standard and measured

8.3.2 $PM_{2.5}$

The US EPA documentation[28] on lignite fired boilers with control devices suggests a $PM_{2.5}$ to TSP ratio of 27%.

In the absence of systematic long-term measurements of the $PM_{2.5}$ fractions emitted from the Power Stations, a conservative assumption of 60% ratio was applied in the bottom up approach. Similar to PM_{10}, further testing is required such that a more accurate ratio can be determined.

Current monitoring data from the Power Stations shows that the ESPs are able to achieve TSP licence limits. Figure 26 shows the low contributions by power station emissions to daily and annual $PM_{2.5}$ standards. Even with the assumption of a 60% ratio of $PM_{2.5}$ to TSP at all times, the Power Stations can only provide at Traralgon a 4.1 µg/m^3 increment to the daily average standard, and a 0.28 µg/m^3 increment (<4%) to the annual average standard.

[28] US EPA, AP-42 Chapter 1.7 Lignite Combustion. Table 1.7-7. https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s07.pdf

This also supports the proposition that other sources are the major contribution to measured $PM_{2.5}$ values and indicates there would be little incremental benefit by introducing a new licence limits for $PM_{2.5}$ for the Power Stations.

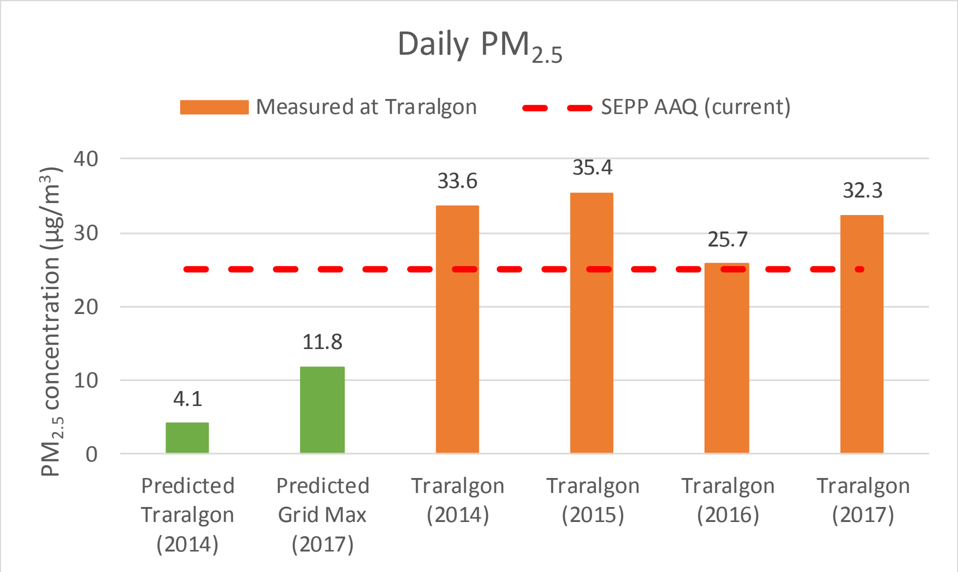

Figure 26 Predicted maximum daily $PM_{2.5}$ compared to AAQ standard and measured

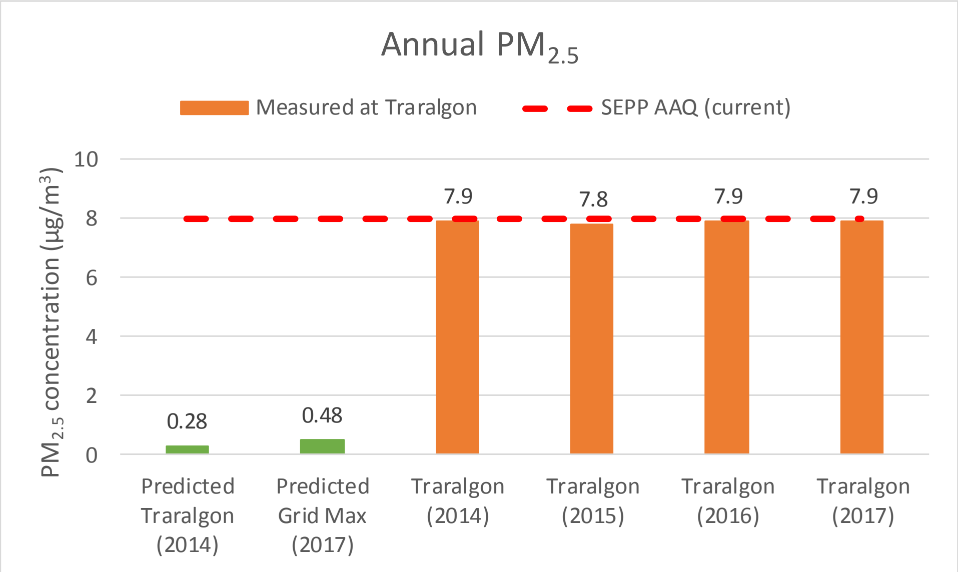

Figure 27 Predicted annual $PM_{2.5}$ compared to AAQ standard and measured

8.3.3 Mercury

The 'bottom-up' analysis presented in section 8.2.2 was able to demonstrate that the design ground level concentrations limits of SEPP AQM can be achieved if all individual stack sources at the Power Stations had a 9 g/s licence limit applied. The mercury emission limit that applies at NSW power stations[29] is 200 to 1000 µg/m^3. An emission rate of 100 ug/m^3, half of the lower limit that applies in NSW, was applied in the modelling.

[29] Licence limits can be imposed as a concentration – these may be converted to a mass emission rate for a give exit volume of air.

The predicted ground level concentrations are shown in Figure 28 for the year 2017. The contours have the unit of ng/m^3 averaged over three-minutes, while the design limit from SEPP AQM is 3300 ng/m^3 for inorganic mercury.

Figure 28 shows the maximum concentration predicted is 96.5 ng/m^3, located close in to the rising terrain just south of the Loy Yang power generating complex. This is 2.9% of the design ground level concertation limit.

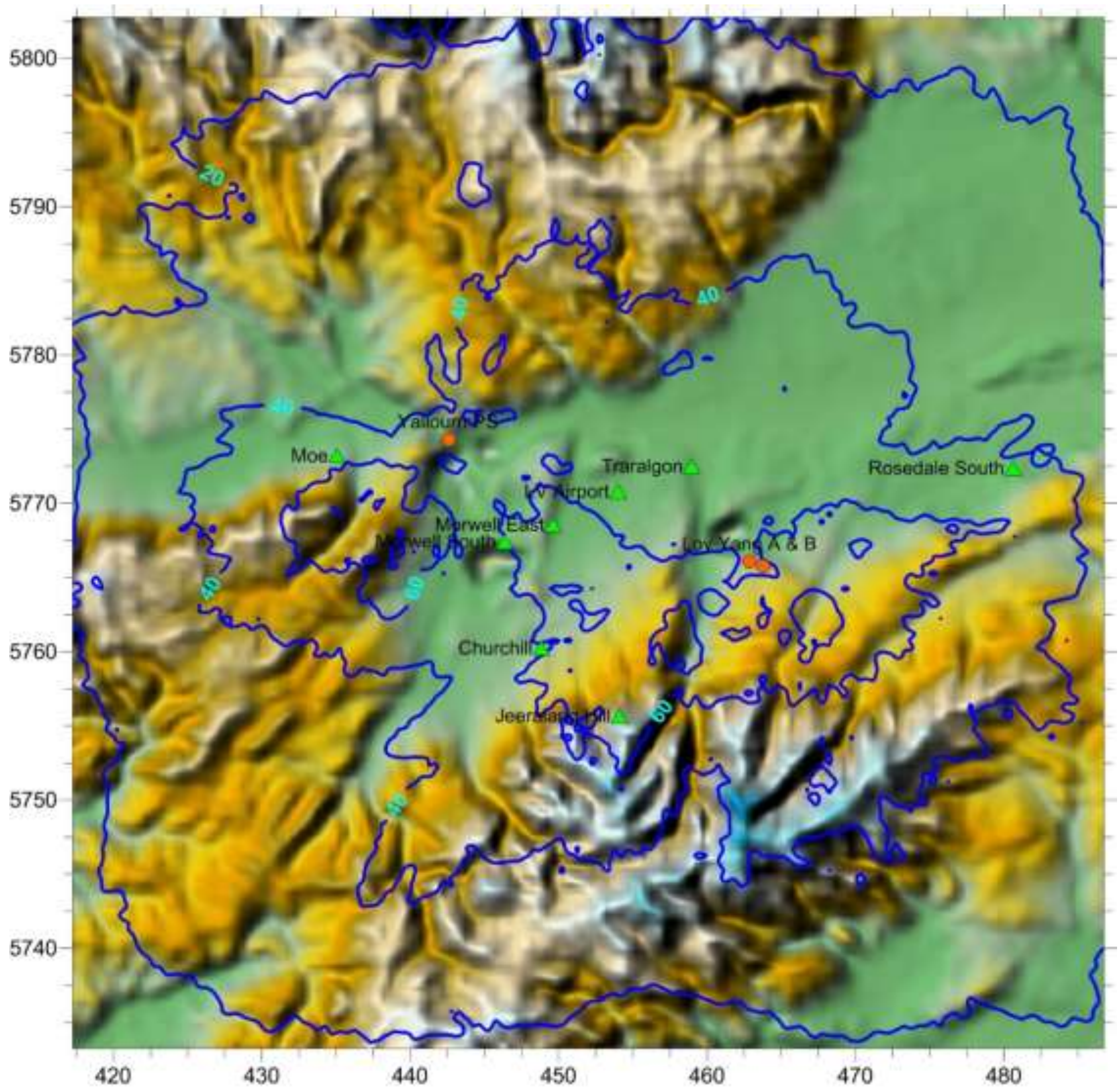

Figure 28 2017 Predicted 3-minute mercury concentrations (ng/m^3)

9. Other items

9.1 Best practice emission management

As outlined in Section 2.3, SEPP AQM requires that generators of emissions to air pursue continuous improvement in their environmental management practices and environmental performance by applying best practice approaches. EPA Publication 1517.1[30] defines the term "*best practice*" as:

- "The best combination of eco-efficient techniques, methods, processes or technology used in an industry sector that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity." (EPA Victoria, 2017, p.2)

The term 'best practice' implies a degree of pragmatism and cost effectiveness and that:

"*EPA does not expect best practice to be pursued 'at any cost'. It is important that the proposed approach be cost effective in the context of the relevant industry sector within which the site operates or is planned to operate, as well as within the context of the total project cost. Most important is that the preferred option is proportional to the environmental risk*" (ibid., p.3).

Comparisons are often made to the environmental performance of international coal fired power stations as to what is "best practice".

Best practice for Latrobe Valley coal fired power stations compared to international facilities differs due to:

- Air quality monitoring measurements may be poor and in exceedance to the objectives for other regions.
- Other environmental factors that may have occurred in their region. For example, acid rain damage to European or North American forests or elevated mercury in soil and groundwater due to centuries of industrial activity.
- Other airsheds may have worse dispersion characteristics than the Latrobe Valley with higher emissions loads and population densities.

The Latrobe Valley Power Stations:

- Are fitted with electrostatic dust precipitators (ESPs) which, for the moisture content in the flue gases, are effective in reducing particulate emissions and particle bound mercury emissions.
- Burn a brown coal resource that is relatively low in levels of sulfur and mercury compared to many other coals used in, for example, the EU and USA.
- Operate in an airshed which has effective dispersion characteristics due to the prevailing meteorology and terrain.

[30] EPA Victoria, 2017. Demonstrating Best Practice. Publication 1517.1 October 2017

9.2 Monitoring technical limitations

GHD is not aware of any commercially available continuous measurement options for in stack $PM_{10}/PM_{2.5}$ measurement. This is due to the sampling and measurement of fine particulates at sources such as coal-fired power plants being problematic for several reasons (IEA, 2016, p.38)[31]:

- "Particulates measured in ambient air downstream of a source are actually a combination of primary particles and secondary particles formed from precursors in the stack, as well as from reactions with other pollutants in the ambient air. Particulates in the stack gases are cooling and therefore also represent a combination of primary and secondary particles, but not necessarily those that would form when the plume mixes with polluted air."
- "The primary particles are small and tend to 'bounce' in standard particulate capture systems."
- "The particles are present in very low concentrations. Testing for compliance is even more challenging with the lower emission limits."
- "Precursor species and other emitted gases can form secondary products in the measurement systems which may, or may not, represent those which would genuinely have formed in the ambient air."

Continuous measurement for total particles using optical density measurement is installed at the Power Stations. As particle size diameters decrease, the light-based measurement response increases for a given concentration and becomes less accurate. Optical density measurement is unsuitable to be used as a surrogate for continuous monitoring of PM_{10} and $PM_{2.5}$ as a poor correlation exists.

[31] IEA (2016). Emission standards and control of $PM_{2.5}$ from coal-fired power plant. Xing Zhang, IEA Clean Coal Centre, London. July 2016

10. Findings and recommendations

This report summarises the results of ambient air monitoring, reviews past modelling of emissions undertaken, and new modelling of the emissions based on the past five years of data as approved by the EPA. The key findings are set out in the following section.

10.1 Current ambient monitoring

There is an air quality monitoring network operating in the Latrobe Valley. This network involves monitoring stations operated by EPA, and two monitoring stations supported by Latrobe Valley industrial licence holders. The results of this monitoring were reviewed, and it was found:

- The results from the ambient monitoring have the potential to provide the best understanding of how Power Station emissions are affecting the air quality of the Latrobe Valley. The current monitoring network for gaseous pollutants appears to be adequate. However, the current monitoring network for particulate pollutants can be improved, and recent work by EPA to expand the monitoring network for particulate matter is supported.
- Extensive and complex modelling of the Power Station emissions is carried out by the Power Stations. This work confirms that the monitoring stations used for compliance provide a good indication of air quality in the Latrobe Valley. Because of the importance of understanding upper air meteorological conditions when carrying out modelling, it is recommended that upper air monitoring be re-established for at least one central location so as to improve the ability of the modelling to take into account the effects of the complex three-dimensional nature of the terrain in the Latrobe Valley.
- Modelling (historic and new) has confirmed that the existing monitoring network provides a good measure of air quality. Future assessments of air quality in the Latrobe Valley should focus on ambient air quality monitoring.

10.2 Assessment of ambient air monitoring and modelling of the Power Station emissions

This review assessed the ambient air monitoring results and the power stations past modelling of emissions. In addition, new modelling was carried out by GHD using the past five years of meteorological data and maximum licence limits (“worst case option”). This review has found:

- For gaseous pollutants CO and NO_2 the standards for ambient monitoring are not being exceeded. For SO_2 this work indicates that SO_2 generally complies with the standard over most of the Latrobe Valley, although there can be short-term localised exceedances of the standard that are not directly measured by the EPA monitoring stations.
- For particulate fractions (PM_{10} and $PM_{2.5}$) the standards for ambient monitoring are generally not being exceeded, although there are occasional short-term (daily) exceedances. This review finds that these exceedances are most likely to be the result of other sources associated with the more urbanised areas or with regional bushfires and planned burns. This is supported by EPA assessments and annual summaries.
- A particle characterisation study, similar to that which has been carried out in the Upper Hunter Valley, could identify the sources that should be targeted for reduction, and it is recommended that EPA may consider to carry out such a study in the Latrobe Valley.
- The modelling indicates that if all the Power Stations were operating at their maximum licence limits, the ambient air quality generally complies with policy.

- A review of the Power Stations emissions profiles indicates emissions are significantly less than the maximum limits.
- Existing power station licence conditions are adequate to maintain Latrobe Valley ambient air quality to SEPP AAQ objectives. Further work should be undertaken to better characterise the PM_{10} and $PM_{2.5}$ fractions by the Power Stations.

10.3 The adequacy of existing air pollution control technology

The review considered whether the existing Power Station air pollution control systems accord with Best Available Technology for emissions reduction, particularly for particulate matter (eg PM_{10} and $PM_{2.5}$), and mercury.

Coal resources in the Latrobe Valley have sulfur and mercury levels that are relatively low compared with those in the EU and the USA.

Air pollution control systems for particulate removal employed at the Power Stations are consistent with international practice, with the primary control measure being the use of electrostatic dust precipitators (ESPs) for particulate matter reduction. As collection of fly ash through ESP's increases with increasing moisture, these units on the Power Stations perform well given higher flue gas moisture than found internationally. This control measure also controls the portion of mercury which is associated with particulate matter.

Independent modelling to determine the concentrations of mercury that can be expected at ground level when an emission control at half that of the best controlled coal-fired power stations in NSW found that the concentrations of mercury are approximately 2.9% of the criterion. Existing air pollution control systems provide an adequate level of treatment of the emissions.

11. Scope, limitations and assumptions

This report has been prepared by GHD for AGL Loy Yang, Loy Yang B and Energy Australia Yallourn and may only be used and relied on by AGL Loy Yang, Loy Yang B and Energy Australia Yallourn for the purpose agreed between GHD and the AGL Loy Yang, Loy Yang B and Energy Australia Yallourn as set out in section 1.2 of this report.

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