4. Effect of Rehabilitation on Power Station Emissions to the Atmosphere

4.1 Introduction

The objective the rehabilitation of Munmorah is to improve the efficiency of the power station by generating more electricity from effectively the same input of energy (the same coal equivalent input). In this regard the rehabilitation is not predicted to result in any significant changes to the fundamental operation of the current power station. Minor changes to the plant and the proposed provision for gas firing, would result in a number of changes that affect the emissions characteristics of the existing power station. The most significant change in relation to coal firing is the provision of low NO_x burners which will reduce NO_x concentrations.

Comprehensive technical investigations into the effects of the rehabilitation have been conducted (Aurecon 2009). The results of these investigations have been summarised in this section for the purpose of highlighting the nature and significance of any changes to emissions to the atmosphere that will occur. This information is provided in the following sections.

4.2 Technical Investigations

The technical investigations were conducted to provide the necessary inputs to the assessment of the potential environmental effects of the rehabilitation.

A significant aspect of the technical investigation was the prediction of unit performance over a range of gas firing scenarios. The predicted thermal performance levels were then used to estimate emissions of sulfur dioxides, nitrogen oxides, particulates and carbon dioxide. The investigations also addressed stack exit conditions.

PROATES (PROcess Analysis for Thermal Energy Systems), a whole plant modelling package for analysing and improving power plant steady state thermal performance was used for the modelling of the plant. It contains modules representing the physical processes of individual plant components, linked together to make a mathematical model. The software is proprietary to E.ON (UK) (formerly Power Gen) and has been under continuous development since 1979. E.ON has extensively validated the software against real plant data. A more detailed discussion of this modelling is provided in Appendix C of the main EA for this proposal.

4.3 Performance, Efficiency and Emissions

The original design performance and performance test results during the life of the power station are summarised in Table 4.1. The 1969 test results show that when the plant was new, the design performance levels were not achieved. The December 2006 test results show that a further deterioration in performance occurred over the intervening decades.

A significant reason for the reduced performance levels is the change in turbine heat rate - a 14% higher heat rate was measured in 2006 compared to the original design.

Table 4.2 summarises the predicted thermal performance for the range of possible boiler firing scenarios from 100% coal up to 75% gas firing of the boilers (Aurecon 2009).

The predicted performance assumes full load operation and as new condition. In making these predictions the following assumptions were made:

- From the results in Table 3.2 it can be seen that here is a slight reduction in boiler efficiency with increasing gas proportion. This is due to the greater hydrogen content of natural gas and increased losses due to moisture in flue gas.
- The key parameter for the estimation of emissions is the fuel flow rates for the different configurations.

Table 4.1 Original design and estimated test performance

Parameter	Units	Original Design	Test 5S 9 Sep 69	WP Test 13 Dec 06
Unit load	MW-Gen	350	348	290
Coal input energy	%	100	100	100
Main steam T.	°C	566	561	-
Hot reheat steam T	°C	538	540	-
Coal flow	kg/s	40	43	39
Coal rate	t/GWh-Gen	416	442	488
Flue gas O_2	%	3.2	3.2	3.2
Boiler efficiency	%	88.9	88.8	88.8
Turbine heat rate	kJ/kWh	8109	8563	9244
Turbine efficiency	%	44.4	42.0	38.9
Unit efficiency (gen)	%	39.5	37.3	34.6

Table 4.2 Predicted performance for proposed rehabilitated Units

Parameter	Units	Predicted Performance			
Target load	MW-Gen	350	350	350	350
Gas input energy	%	0	25	50	75
Coal input energy	%	100	75	50	25
Natural gas flow	kg/s	0.0	4.3	8.6	13.1
Coal flow	kg/s	40	31	21	10
Coal rate	t/GWh-gen	416	316	214	108
Flue gas O2	%	3.2	2.4	2.4	2.4
Boiler efficiency	%	88.9	88.8	88.3	87.7
Turbine heat rate	kJ/kWh	8109	8109	8109	8109
Turbine efficiency	%	44.4	44.4	44.4	44.4
Unit efficiency - gen	%	39.5	39.4	39.2	38.9

4.4 Changes to Stack Exit Conditions and Emission Characteristics

4.4.1 Stack Exit Conditions

The stack exit conditions were estimated based on data obtained from the PROATES modelling and a report delivered by Howden ("Munmorah Unit 3-4: Draught and Fabric Filter Dust Collection Plant Study", 11 May 2009) to provide input to plume dispersion modelling. The stack gas exit temperature and velocity was calculated for the 100% coal case only, with both Units operating at 350 MW (Aurecon 2009).

Table 4.3 Exhaust stack exit temperatures

Location	Howden Temperature Data	Estimated Temperatures
Ambient	20°C	20°C
Air heater gas inlet	320°C	327°C [1]
Stack outlet	**144°C**	**137°C**

Source: PROATES modelling result.

The volumetric flow rate of the flue gas is highly reliant on the gas density, and therefore gas temperature. The density of the gas flow was calculated at specific locations between the air heater inlet and the stack exit based on temperature changes between these sections. The volumetric flow rate was calculated from the flue gas mass flow rate as provided by the PROATES modelling (Aurecon 2009). The flue gas exit velocity is calculated using the final volumetric flow rate and the exhaust stack exit dimensions.

The predicted flue gas stack exit velocity for the proposed Munmorah upgrade is summarised in Table 4.4. A comparison between the historical and the predicted conditions for the rehabilitated plant is provided in the following table.

Table 4.4 Exhaust stack exit velocity

Location	Parameter	Value
Stack outlet conditions for 2 units	Volumetric flow rate	465 m^3/s
	Stack exit velocity	19.0 m/s

Source: PROATES modelling result.

Table 4.5 Comparison of stack exit conditions in the historical case and the predicted conditions for the rehabilitated plant

Munmorah stack exit conditions (Stack ø7.9 m)	Average volumetric flow (Am^3/s)	Exit velocity (m/s)	Stack exit temperature (K)
Historical plant	892	18.2	403
Rehabilitated plant (2009 PROATE Modelling)	951	19.4	426
Percentage change	+6.6%		+5.7%

4.4.2 Emission Characteristics

NO_x Emissions

All fossil fuels produce NO_x during the combustion process. Nitrogen oxide production is a function of the boiler and burner design, operating conditions and fuel properties. As part of the plant rehabilitation, low NOx coal burners are proposed.

The NO_x emissions using the new burners will achieve emissions less than 500 mg/Nm^3 (SKM 2009). The use of gas will require new burners, which may also be specified as 'low NO_x', with a limit on emissions consistent with the new coal burners. The use of gas will therefore not impact NO_x emission compared to the 100% coal case.

NO_x emissions will meet the concentration limits for Munmorah Power Station emissions provided in Section 2.1. The existing records vs. load and expected change in the NO_x emissions following rehabilitation are shown in the following attached figures.

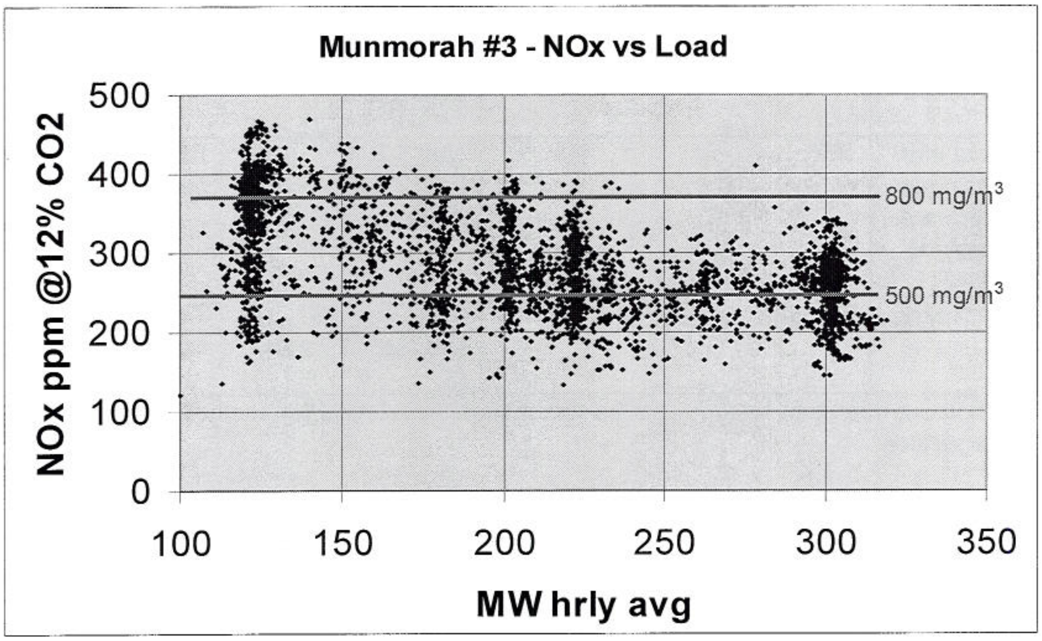


Figure 4.1 Current plant performance: NOx emissions concentrations versus plant load (Malfroy, c2007) (Original source: PPI (2000))

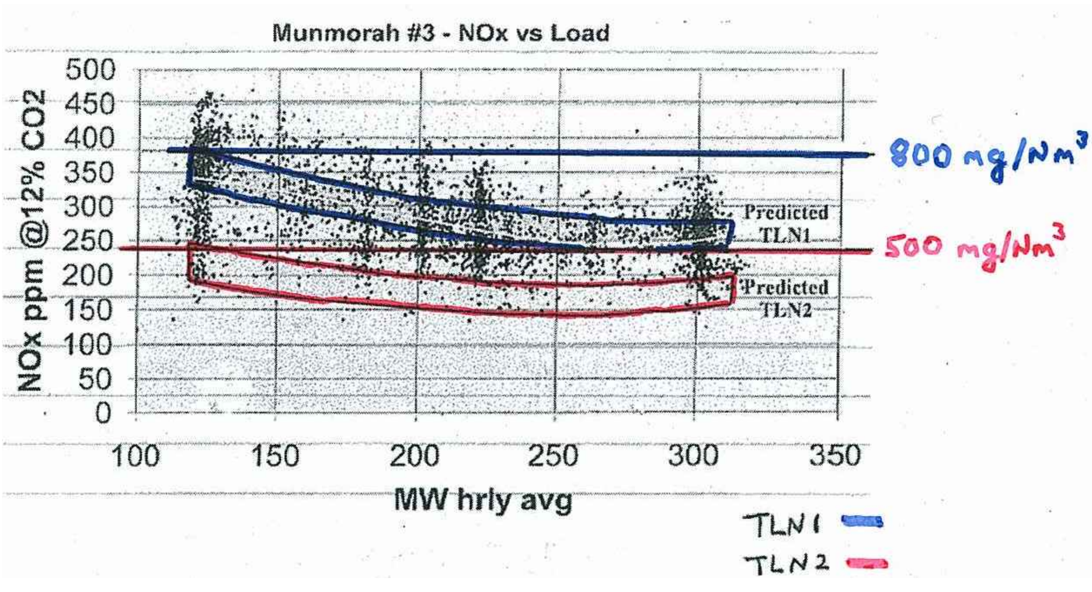


Figure 4.2 Rehabilitated (red line predicted:TLN2) NO_x performance versus plant load overlaid with current NO_x performance scatter plot (Worley Parsons, 2008).

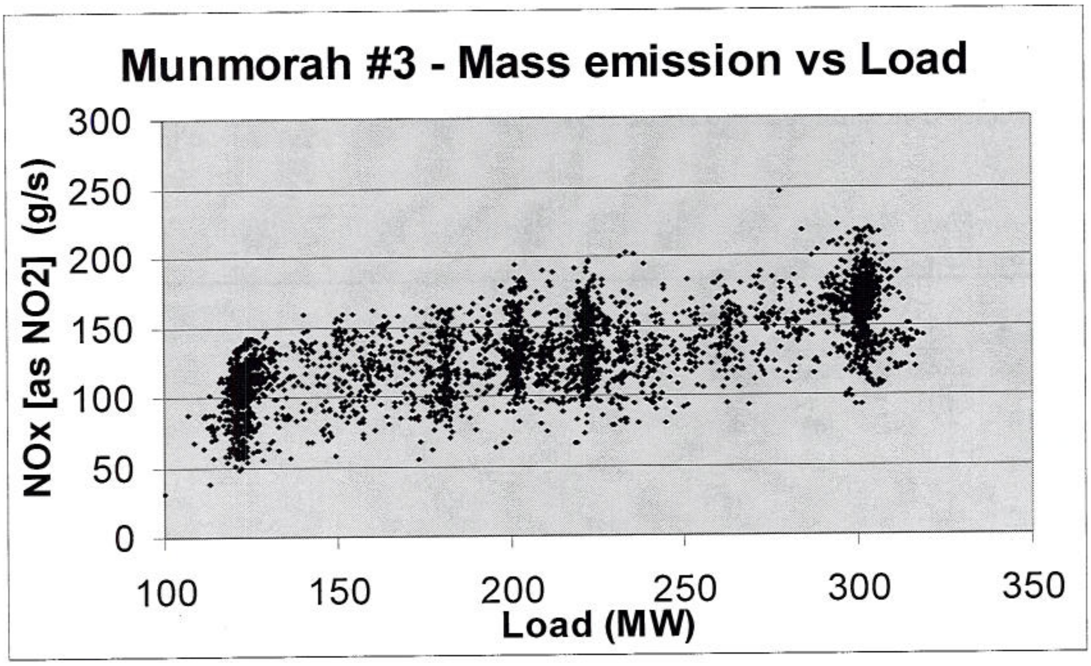


Figure 4.3 NO_x mass emission rates versus plant load (Malfroy, c2007 - Original source: PPI (2000))

SO_x emissions

The stack SO_x emissions have been predicted based on typical coal qualities provided by the Proponent (0.41% S) and the assumption that all sulfur in the fired coal is converted to sulfur dioxide (SO_2). It is also assumed that natural gas does not contain any sulfur. The SO_2 emissions have been calculated using Aurecon's boiler efficiency model, which has been verified and refined over a number of years (Aurecon 2009).

The key inputs to the model include the fuel composition on an "as received" basis and the oxygen (O_2) levels in flue gas. The coal properties are the same as used in the PROATES modelling.

The SO_2 concentrations have been calculated using the reference conditions as outlined in the "Protection of the Environment Operations (Clean Air) Regulation 2002". Schedule 5 of this regulation states reference O_2 levels of 7% are to be used for SO_x emissions for coal boilers.

The SO_2 concentration was calculated for the 100% coal case, and subsequently scaled for each gas option based on the percentage of coal fuel used. The results of the SO_2 emission concentration calculations for wet flue gas, based on 0.41% S, are summarised in Table 4.6. The emission rate for 0.7% S is calculated on an as received basis.

Table 4.6 Predicted SO_2 emissions from proposed Munmorah upgrade

	100% Coal	25% Gas	50% Gas	75% Gas
Coal Used for PROATES Modelling (0.41% S)				
SO_2 (mg/m3)	975	732	489	243
Worst Case Coal for AQ Modelling (0.7% S)				
SO_2 (mg/m3)	1665	1250	835	415

Note: The ratio between ppm to mg/m3 is 2.86

The sulfur emission rate based on this worst case ~0.7% sulfur grade coal is used in the air quality assessment. This emission rate is some 30% higher than the emissions that result from typical coal currently consumed at the station.

The co-combustion of low sulfur coal with natural gas would reduce emissions rates from the base case scenario. SO_2 emissions significantly reduce as the proportion of gas firing increases, as can be seen from Table 4.5.

If it is assumed that there is a direct relationship between SO_2 and sulfuric acid mist and sulfur trioxide (as SO_3) the proposed reduction of maximum coal sulphur content should result in a 30% reduction in the potential maximum emissions when compared to the current licence.

Particulate Emissions

It is not expected that the proposed Munmorah rehabilitation would change plant characteristics in relation to particulate emissions. The volumetric flow of the flue gas will be largely unchanged for all options, and the dust burden in the flue gas will vary with the amount of natural gas firing. The mass emission of particulate matter would be expected to decrease as the percentage of gas firing increases.

4.5 Review of Munmorah emissions

A review of air emissions concentrations for the relevant pollutants stipulated under Schedule 3 of the POEO (Clean Air) Act 2002 has been provided by Delta Electricity (Malfroy 2007).

The emission concentrations from Munmorah Power Station developed for this assessment consider historical performance data undertaken in accordance with the Approved methods for the sampling and analysis of air pollutants in NSW (DEC, 2005). Additional consideration is also required of the effects of anticipated future coal supplies in establishing limits to future emission concentrations. Comment on the effects of the rehabilitation is also provided in the following table.

Existing monitoring has shown that emissions over the period 2004-2006 comply with the current licensed emission requirements and that they are generally compliant with Group 6 emission standards.

With the introduction of low NO_x burners as part of the rehabilitation works, NO_x emissions will be compliant with Group 6 emission standards under normal operating conditions.

Table 4.7 provides a basis for estimating the maximum emission rates for the assessment.

4.5.1 Particulate emissions (PM)

The Munmorah Rehabilitation – Technical Investigation Report s3.5 p13 (Aurecon 2009) provides a succinct description of the dependency of PM emissions upon fly ash conditions and percentage of gas combusted. A comparison of historical levels (2004-06) against the Group 6 guidelines shows that the emission concentrations are generally well below the Group 6 standard of 50 mg/m^3 as shown in Table 4.7 – also see Appendix A), this is likely to remain largely unchanged.

The report noted that the volumetric flow of the flue gas will be largely unchanged for all options, and the dust burden in the flue gas will vary with the amount of natural gas firing.

The more gas firing that takes place, the lower the inlet dust burden of the fabric filter plant. Reduced inlet dust burden levels may assist in lowering fabric filter dPs and lengthening fabric filter bag cleaning cycles.

The emission of fine particles from fabric filters is a function of the bag condition and the effective management of the bag system rather than the load on them. The efficient maintenance and operation of fabric filters will lead to high levels of emissions control being achieved and particulate emissions levels being kept below regulated limits.

4.5.2 Other pollutants

The emission limits for DECCW licensing purposes for the following compounds remain to be determined in consultation with the DECCW:

- hydrogen fluoride (HF)
- cadmium (Cd)
- mercury (Hg)
- hydrogen chloride (HCl)
- Chlorine (Cl_2), and
- sulfur trioxide and sulfuric acid mist (SO_3 and H_2SO_4).

For the purposes of this assessment an upper practicable emissions limit has been estimated based on available information and ambient air quality concentrations are predicted with respect to the assumed emission limits. The assumed limits for these pollutants are presented in Table 4.8 (b).

Type 1 and Type 2 pollutants

Although the specifics of the proportions of coal and gas that will be co-fired is unknown at this stage, depending on the amount of gas in the fuel mixture the proportional decreases in emissions of particulate bound pollutants is expected.

Based on the historical performance of the plant; it is expected that the observed levels for Type 1[3] and Type 2[1] pollutants in stack emissions will be compliant with the Group 6 POEO emission limits. While some changes may occur in the characteristics of these emissions, it is predicted that the observed levels will be compliant with the POEO Group 6 limits.

[3] Type 1: antimony, arsenic, cadmium, lead or mercury; Type 2: beryllium, chromium, cobalt, magnesium, nickel, selenium, tin and vanadium.

Table 4.7 Assessment of Emission against Group 6 emission limits

Substance	POEO Regulation Group 6 Limit	Averaging time	Meets ambient goals at Group 6 limits	Calculated worst case emission concentration (see Note 1)	Munmorah 2004-2006 performance	Comment – data source	Expected Change Due to Rehabilitation	
							100% Coal Fired	With Gas Firing
SO_2	NA		Yes, except for occasional short term predictions	1665 **mg/m^3**			No change	Reduction in proportion to % gas
NO_2 or NO or both expressed as NO_2 equivalent	500 **mg/m^3**	1 hour block	Yes	500 **mg/m^3**	900 (~650@full load)	EPL – CEMS	Reduction to < 500 with low NO_x burner retrofit	
Solid particles	50 **mg/m^3**	**(1)**	Yes	50 **mg/m^3**	Unit 3: 11.5-51.6 Average 29.6 Unit 4: 3.4-13.6 Average 5.6	EPL – annual batch sample	No change	No expected change
Fluorine, as HF equivalent	50 **mg/m^3**	**(1)**	No	30 **mg/m^3**	Unit 3: 1.7-8.7 Average 4.1 Unit 4: 2-14.5 Average 5.6	EPL – annual batch sample	No change	Reduction in proportion to % gas
Type 1 and Type 2 substances in aggregate **(2)**	1 **mg/m^3**	**(1)**	Yes	1 **mg/m^3**	Unit 3: 0.003-0.11 Average 0.05 Unit 4: 0.02-0.11 Average 0.06	EPL – annual batch sample (most results for individual metals <LOD. For calculations results assumed to equal the LOD.	No change	Reduction in proportion to % gas

							Expected Change Due to Rehabilitation	
Cd or Hg individually	0.2 **mg/m^3**	**(1)**	Yes	**0.04 mg/m^3**	Cd Unit 3 &4: <0.00007-0.002 Average 0.00132 Hg Unit 3 & 4: <0.00007-0.004 Average 0.00030	EPL – annual batch sample. See comment above.	No change	Reduction in proportion to % gas
VOCs as n propane	40 VOC or 125 CO **mg/m^3**	1 hour rolling	NA	**125 mg/m^3 (CO)**	Unit 3 & 4 2006 <5 No VOC peak detected	EPL – batch (measurement of CO not required by EPL)	No change	Increase in proportion to % gas
Smoke **(3)**	Ringlemann 3 or 60% opacity (Note 6) or Ringlemann 1 or 20% opacity (Note 7)	6 minutes rolling	NA		<10% (4)	EPL – CEMS for *"undifferentiated particles"*	No change	No change
Hydrogen chloride	100 **mg/m^3**	**(1)**	Yes	**100 mg/m^3**	Unit 3 and 4 0.2-4.5 Average: 4.1	EPL – annual batch sample	No change	Reduction in proportion to % gas
Chlorine (Cl_2)	200 **mg/m^3**	1 hour block	No	**122 mg/m^3**	Unit 3 and 4: 0.005-0.4 Average: 0.16	EPL- annual batch sample	No change	No change
Hydrogen sulphide	5 **mg/m^3**	1 hour block	NA	**- mg/m^3**	Below level of detection (5)	Testing not required by EPL	No change	No change

							Expected Change Due to Rehabilitation	
Sulfuric acid mist or SO_3 or both expressed as SO_3 equivalent	100 **mg/m^3**	**(1)**	Yes	**44 mg/m^3**	Unit 3 & 4: 0.9-2.1 Average: 1.4	EPL – annual batch sample	No change	Reduction in proportion to % gas
Dioxin or furans **(8)**	0.1 ng/m^3		Yes	0.1 ng/m^3	0.0013 ng/m^3 (average of 2 tests)**(5)**	Testing not required by EPL	No change	Reduction in proportion to % gas

NOTE:

1. 1 hour, or minimum sampling period specified in the relevant test method, whichever is the greater.
2. Type 1: antimony, arsenic, cadmium, lead or mercury
   Type 2: Beryllium, chromium, cobalt, manganese, nickel, selenium, tin and vanadium
3. Approved circumstances – as applicable to Munmorah;
   For a period of not more than 20 minutes per 24hours after lighting a boiler or incinerator for cold, being the period that the boiler or incinerator is brought up to normal operation and that all practical means are employed to prevent or minimise the emission or smoke during that period.
4. Opacity us bit recorded at Munmorah. Instruments output data in mg/m$^{3.}$ Opacity data have been sourced form Vales Point Unit 6 which is now equipped with pulse jet bad filters and should be indicative of opacity in Munmorah ducts.
5. Based on measurements at Vales Point Power Station. Stephenson and Associates 1999.
6. In approved circumstances:
7. In other circumstances:
8. Dioxins or furans limit of 0.1ng/m^3, only applies to non-standard fuels containing precursors of dioxin or furan formation.

4.5.3 Stack exit conditions

The emission characteristics of the flow at the stack exit in terms of velocity were determined through the PROATES combustion modelling introduced in the previous sections (Aurecon, 2009). A comparison is made between the stack exit conditions assumed in historical air quality assessments (Cox, J., 2009 per comm.) and what is expected post rehabilitation.

The PROATES modelling outcomes demonstrate a small increase in the final stack exit velocity which equates to approximately 6% increase in the volumetric flow rate in comparison to that used in previous air quality modelling studies.

4.6 Modelled Emissions

The pollutant emissions modelled as part of the local air quality impact assessment were assessed based on the emission limits provided by the Proponent and those assumed for non-criteria pollutants for the purposes of the local air quality impact assessment. The limits for NEPM criteria pollutants have been set to be equal to the Group 6 emission standards as stipulated within the POEO (Clean Air) Act (Table 4.8 – part (a)). The assumed limits for non-criterion (that is the pollutants that are not listed in the standards) pollutants are presented in Table 4.8 – part (b).

As discussed in Section 4 the Proponent proposes to adopt a limit based on the firing of 0.7% sulfur coal.

The only source that was modelled as part of the dispersion modelling assessment was the Munmorah power station. The parameters that were used to represent Munmorah in the TAPM air dispersion model are summarised in Table 5.1 and Table 4.9. The stack exit conditions in particular were sourced from the PROATES modelling results summarised in Section 4.4 (and per Cox J (2009)) along with consideration of emissions examined in this chapter.

Table 4.8 Emission limits and rates for pollutants modelled as part of the local air quality impact assessment (a) criteria pollutant emission limits (b) non-critera pollutant assumed emission limits.

(a) Pollutant	PoEO Regulation Group 6 limits mg/Nm^3	Emissions limit (mg/Nm^3 unless stated otherwise)	Munmorah rehabilitated emission rates (g/s)*
Sulfur dioxide (SO_2)	-	1665#	1015
Oxides of nitrogen (NO_x)	500	500	305
Fine particulates (PM_{10})	50	50	30.5
Carbon monoxide (CO)˜	-	125	76.2
Lead (Pb)˜	-	11 mg/kg (coal content)	0.008

SO_2 - emission limit based on 0.7% sulfur coal

˜ Pb assumed emission limit based on reported coal content (Apr-Jun 09) of 11 mg/kg, coal feed rate 72.9 kg/s, and 99% baghouse capture efficiency.

* Emission rates are reported at standard conditions (0°, dry gas, 1 atm pressure, 7% O_2) Normalised volumetric flow rate – 609.8 Nm^3/s was used to determine specific pollutant air emissions.

(b) Pollutant	PoEO Regulation Group 6 limits	Assumed emissions concentration (mg/Nm^3 unless stated otherwise)	Munmorah rehabilitated emission rates (g/s)*
Fluoride (modelled as HF – hydrogen fluoride)	50	30	18.3
Cadmium (Cd)	0.2	0.04	0.024
Mercury (Hg)	0.2	0.2	0.122
Hydrogen Chloride (HCl)	100	40.9	24.9
Sulfuric acid mist and sulfur trioxide	100	44	26.8
Chlorine (Cl_2)	200	122	74.4
Dioxins and furans (PCDD/F) #	0.1	0.1 ng/Nm^3	6.1 x 10^{-8}

#Note: not strictly applicable to Munmorah as it burns only standard fuel

Table 4.9 Stack parameters as represented in air dispersion model.

Stack exit conditions	
Stack - height - base elevation	150 m 15 m
Diameter	7.9 m
Exit temperature	426 K
Exit velocity	19.4 m/s
Average volumetric flow rate at exit	951 m^3/s
Stack Easting	364183 mE
Stack Northing	6324290 mN

4.6.1 Discussion

A goal of the rehabilitation works at Munmorah Power Station is to achieve compliance with Group 6 emission standards. The shift to more efficient coal burners to rehabilitated low NO_x coal and gas burners (separate entities) will lead to a decrease in NO_x emission rates (g/s), when compared with historical conditions.

As shown in Table 4.2, the PROATE modelling results have demonstrated that the improved thermal performance of the system will provide increased generation capacity as well as result in decreased NO_x emissions rate overall. That is, greater thermal efficiencies leads to greater generation efficiency i.e. a reduction in coal burnt per MW output.

The marginal change in the stack exit temperature and exit velocities will not have a significant impact upon the dispersion of air pollutants as they exit the stack tip. This is largely due to the relatively small increase in the respective parameters as compared to the historical levels. The expected air quality emissions with the exception of reduced NO_x emissions are not predicted to change substantially from current operations.

Based on the evaluation of Group 6 Limits, Ambient Air Quality Goals and expected concentration ranges for substances in coal the worst case emissions parameters to be used in the modelling have been provided. Typical emission levels for most substances have been well below these limits.

5. Meteorological and air dispersion modelling

5.1 Introduction

The DGRs require an assessment of air pollutants in accordance with the Approved methods document (DEC, 2005) to quantify the nature and extent of potential worst case ground level concentrations from future air emissions. This local air quality impact assessment takes into account the changing nature of the air environment in this region with the upgrade of Eraring Power Station as well as the operation of the Colongra gas turbine facility.

As discussed in Section 1. TAPM (The Air Pollution Model) developed by the CSIRO has been used for this purpose. The TAPM model produces the necessary meteorological field to determine how pollutants are dispersed through a region when emitted from a tall point source. The modelling program leads to the determination of hourly averaged ground level concentrations that correspond to the characteristics and emissions from the source of interest. The characteristics and emissions data that correspond to the source that was modelled as part of this assessment is provided in Section 4. The characteristics of the prognostic numerical model itself are described in Section 5.2.2.

2004 was selected as an appropriate reference year for the modelling. The representativeness of 2004 in relation to ambient air quality has been discussed in Section 3. The following sections describe the observed meteorological conditions through 2004, and provide an assessment of the representativeness of this year compared the long term average meteorological conditions through this region. This is followed by an analysis of the performance of the meteorological component of TAPM, comparing predicted conditions to that which was observed through 2004 in a representative location.

Following an assessment of the veracity of the meteorological field developed through the simulation; Section 6 discusses the outcomes of the modelling in terms of the potential cumulative air quality impacts (in accordance with the requirements set out in the Approved methods documentation).

As this assessment relies on the contribution of the existing Vales Point and Eraring Power stations emissions to background ambient concentrations as the basis for assessment, this section is also provided to examine the representativeness of the contributions from these sources to background concentrations of measured pollutants during 2004.

5.2 Meteorology

The pollutant ground-level concentrations from emissions from a stationary source, such as Munmorah Power Station vary according to the emission characteristics of the facility and the weather conditions at the time.

The meteorology is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling plume dispersion.

In addition to the characteristics of the emissions, plume rise at the release point is affected by wind speed, ambient temperature and relative humidity. The subsequent dispersion of the plume from the source is affected by:

- Wind speed, profile and turbulence intensity;
- Buoyancy affected by the temperature gradient which is determined from *atmospheric stability* and;
- *Mixing height* which is the depth of the atmospheric boundary layer.

The following section examines data available from the Bureau of Meteorology automatic weather station (AWS) at Norah Heads for the period 1969 to 2005 with a view to demonstrating that 2004 is adequately representative of the long term average meteorological conditions .

5.2.1 Observed meteorological conditions

Suitability of reference year

As mentioned earlier the year 2004 was proposed as the reference year as this represented a year where the contribution of Munmorah to background air quality was low. This comparison of observed meteorological conditions through the reference year compared to the long term average conditions are discussed in this section.

Temperature distribution

Minimum temperature is a good indicator of the frequency of calm stable conditions which inhibit the dispersion of emissions. The analysis of mean minimum temperature through 2004, shown in Figure 5.1 illustrates good correlation with the long term average conditions between 1969 and 2005.

The congruence of the 2004 mean minimum temperatures with the long term average supports the selection of 2004 as an appropriate reference year.

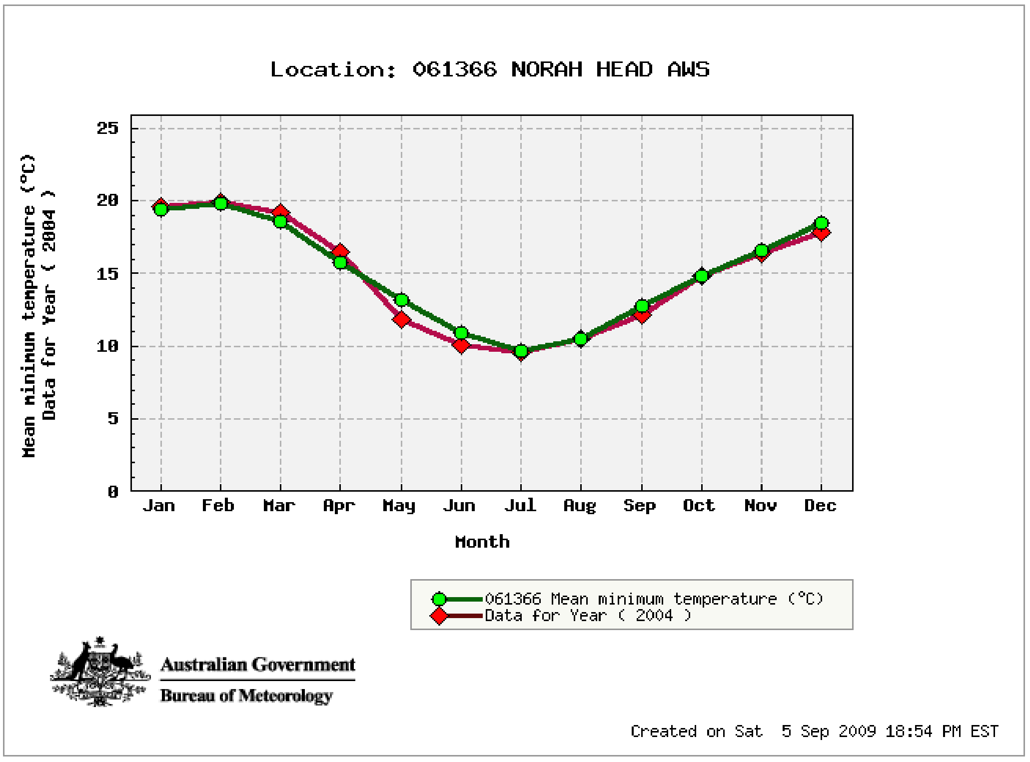


Figure 5.1 2004 mean minimum temperature compared to the long term average figures at Norah Head AWS (BoM, 2009)

Observed wind speed and direction

The 2004 mean 9 am and 3 pm wind speed conditions at the Bureau of Meteorology automatic weather station (AWS) at Norah Heads also correlate well with the long term average wind conditions through this region (refer Figure 5.2 and Figure 5.3).

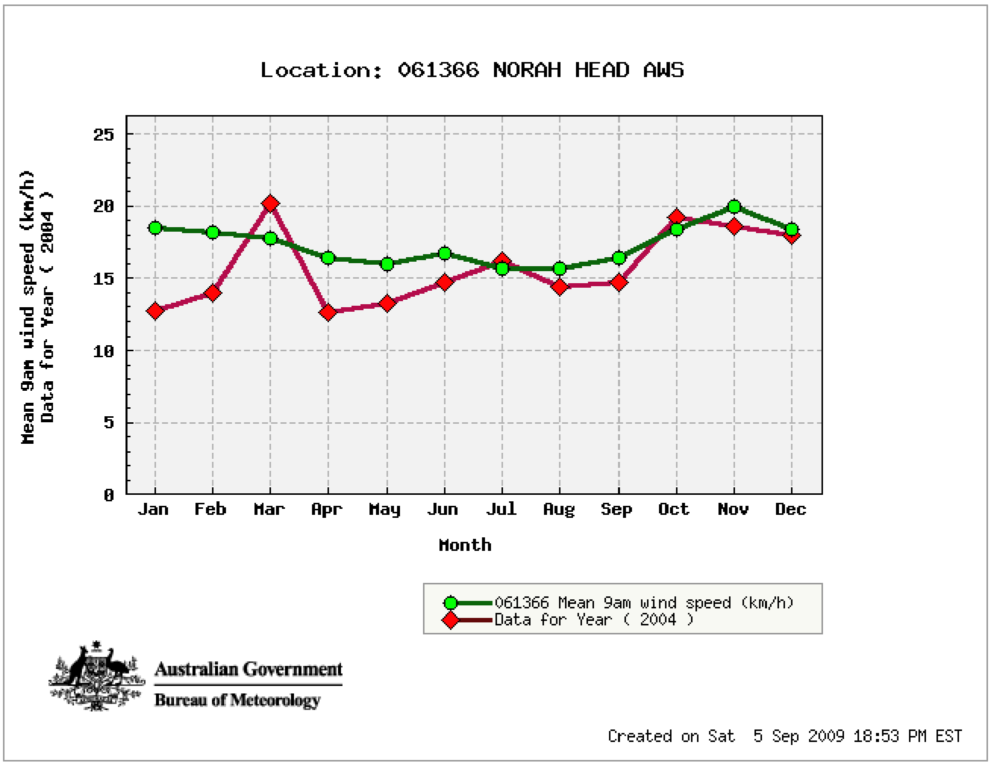


Figure 5.2 2004 average (a) 9 am wind speed conditions compared to Norah Head AWS long term averages (BoM, 2009)

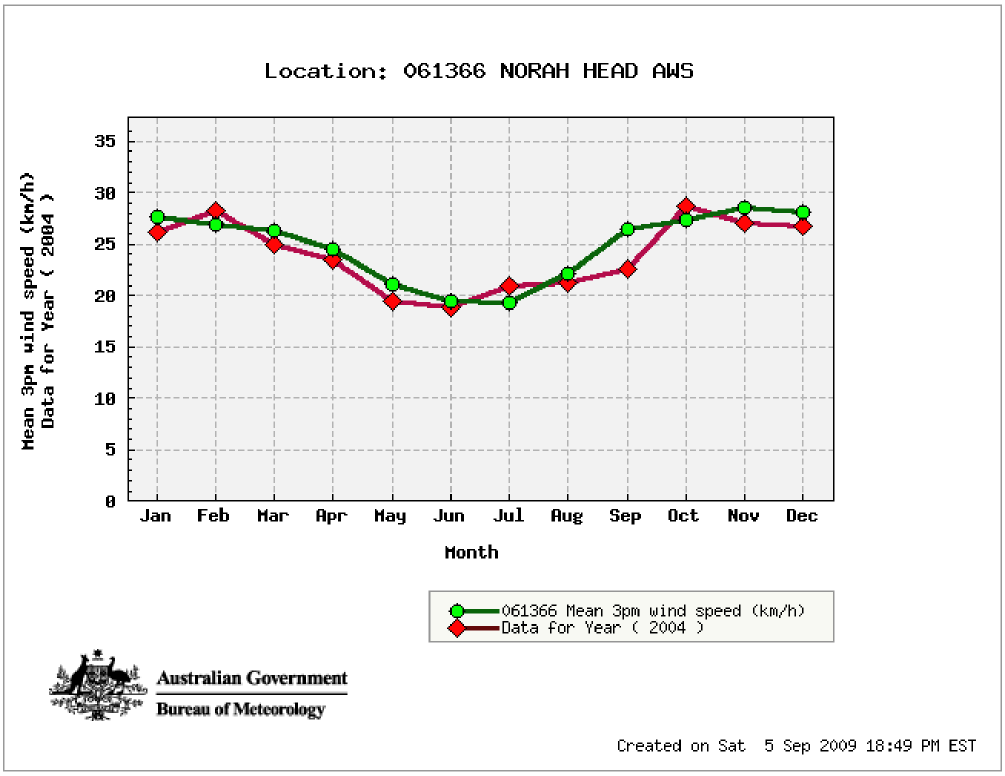


Figure 5.3 2004 average 3 pm wind speed conditions compared to Norah Head AWS long term averages(BoM, 2009)

Observed wind speed data were also obtained from the Delta air monitoring stations at Munmorah Climatic, Lake Munmorah Primary School (LMPS) and Wyee air monitoring stations. The data from these stations were assimilated into the prognostic numerical meteorological model simulation (TAPM) to predict more complex meteorological parameters that feed into the air dispersion model. This assimilation process allowed for a more robust assessment of wind speed conditions through this region.

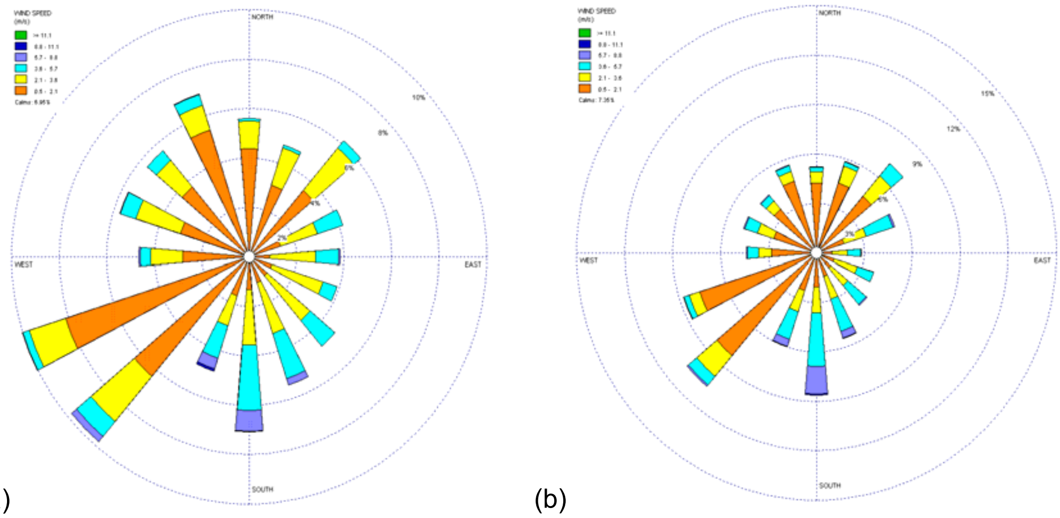
The wind roses developed from the observed datasets for the Munmorah, LMPS and Wyee stations are shown in Figure 5.4, 5.5 and 5.6 respectively. The wind roses illustrate the local variability in wind speed and direction within the region.

The wind conditions through 2004 and over the long term from 2001-2007 at Munmorah is shown in Figure 5.4 (a) and (b) respectively. The wind roses illustrate that the directionality characteristics of 2004 conditions are largely similar to the long term directionality characteristics. Wind from the south west is seen to be dominant throughout the year. Furthermore there is good representation of wind from all other directions, with the exception of easterly winds.

The wind conditions through 2004 and over the long term from 2001-2007 at Lake Munmorah Primary School is shown in Figure 5.5 (a) and (b) respectively. The wind roses illustrate that winds at this site are dominated largely by those blowing from the north and south. The comparison between the conditions through 2004 and the long term average illustrates a good level of agreement.

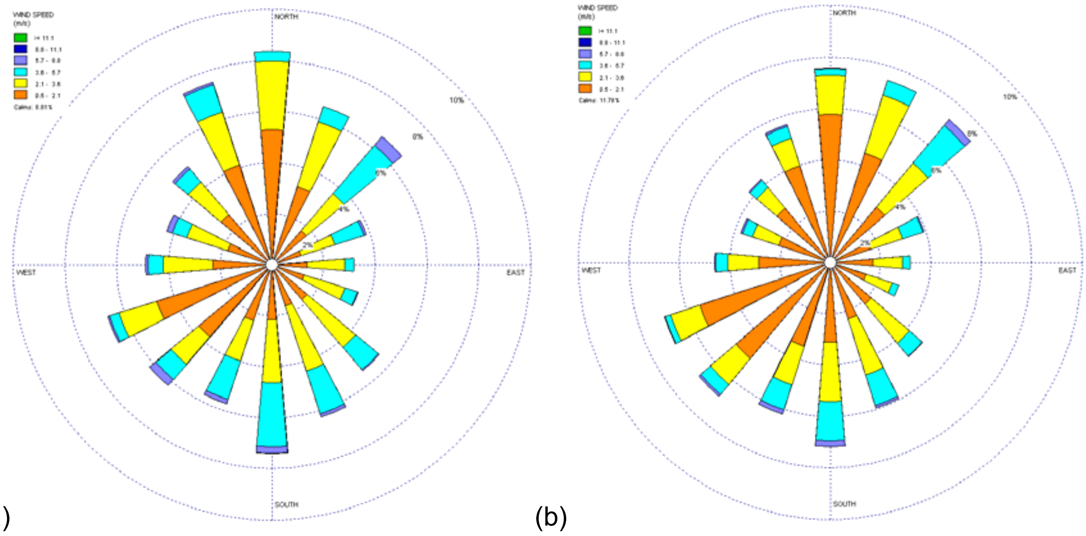
The wind conditions through 2004 and over the long term from 2001-2007 at Wyee air monitoring station is shown in Figure 5.6 (a) and (b) respectively. These wind roses illustrate good agreement with the long term average directionality characteristics. The figure shows that winds from the west, south and north east are dominant with all other directions being less frequent.

The veracity of the predicted meteorological conditions as assessed against that observed is presented in the following section.



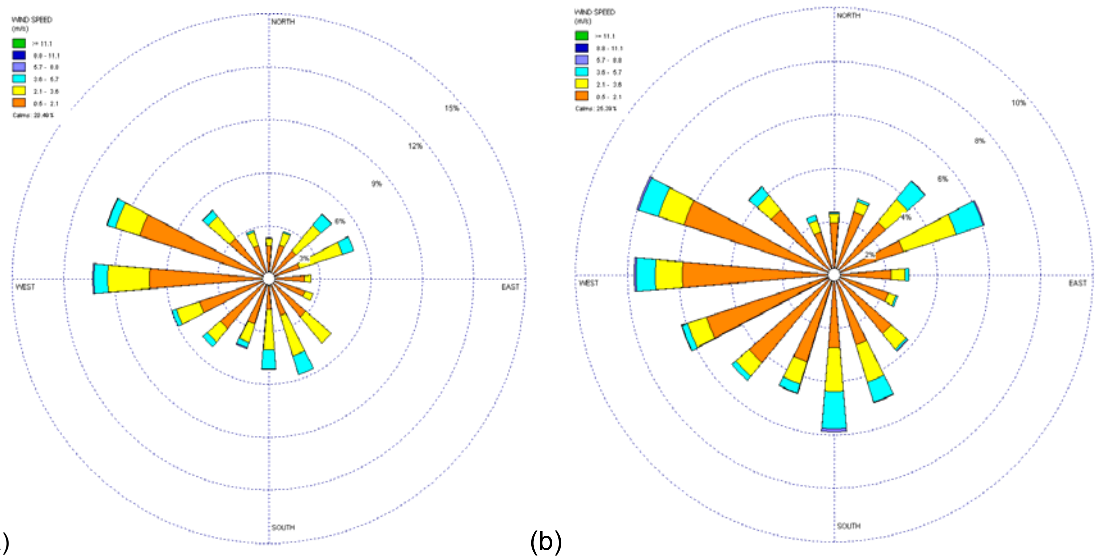
(a) (b)

Figure 5.4 Observed (a) 2004 and (b) long term (2001-2007) wind roses for Munmorah weather station.



(a) (b)

Figure 5.5 Observed (a) 2004 and (b) long term (2001-2007) wind rose from Lake Munmorah Primary School air monitoring station.



(a) (b)

Figure 5.6 Observed (a) 2004 and (b) long term (2001-2007) wind conditions from Wyee air monitoring station.

5.2.2 Predicted meteorological conditions

TAPM – The Air Pollution Model v3.0

TAPM (The Air Pollution Model) a CSIRO developed prognostic meteorological and air dispersion model was used to develop the pre-processing spatially varying hourly meteorological data for this region. Previous studies of available models have shown that this model performs well for the range of conditions experienced on the Central Coast, although it has a tendency to over-predict the highest concentrations on occasions (Lilley et al 2007).

The TAPM model produces meteorological data, upper air information and temperature profiles for the simulation period in three dimensions for all the grid points across the domain. The gridded meteorological data generated by TAPM is calculated from the synoptic information determined from the six hour interval limited area prediction system (LAPS) (Puri K et al 1998).This final meteorological data is representative of the local topography, land use, surface roughness and temperature effects caused by water bodies.

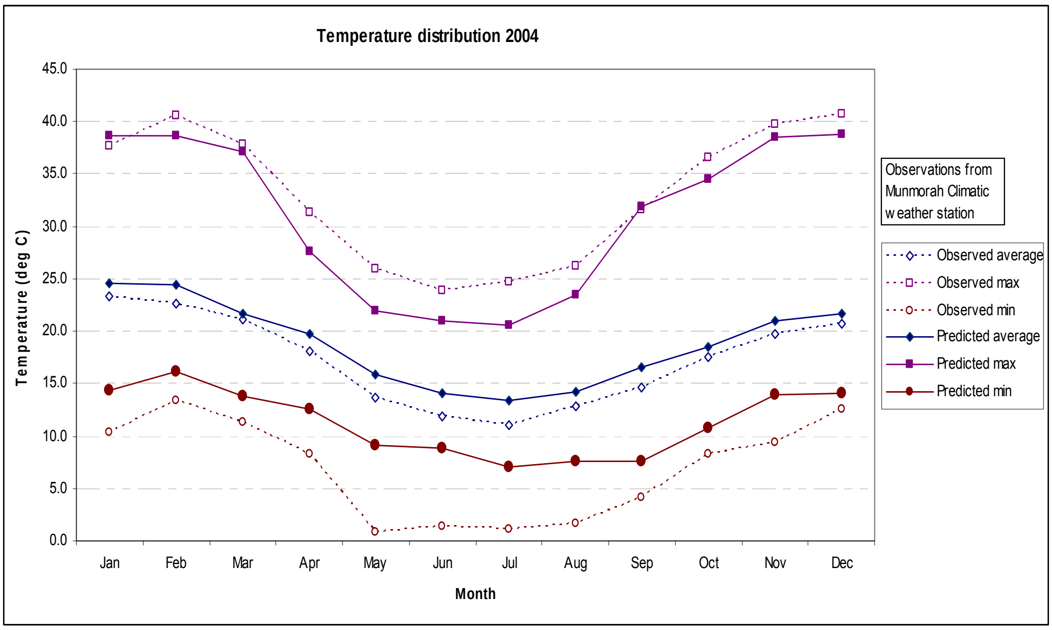
The TAPM nesting grid or mesh was determined for this model via the consideration of the required terrain resolution in the radius of influence (approximately 20 km). Due to the gentle, ‘rolling’ gradient of the hills the required terrain resolution was achieved via the use of nested grid with a minimum spacing of 1,000 m The dispersion grid was modelled with still smaller a grid spacing (500 m) to resolve the impacts at near field sensitive receptors. When running the TAPM in the dispersion modelling mode the Eulerian computational option was selected.

A basic summary of the data and parameters used in both the meteorological and dispersion parts of the TAPM model is shown in Table 5.1. The pollutants were modelled as tracers in the absence of any chemical transformations or deposition.

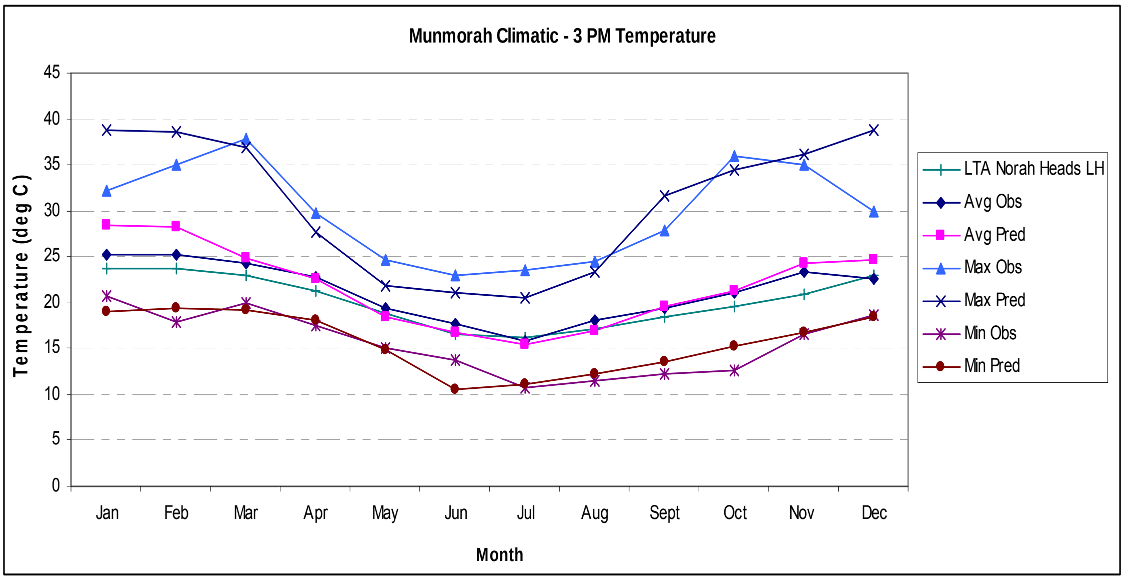
The cumulative impact (background plus contribution of Munmorah) of the rehabilitated Munmorah Power Station facility is considered in Section 3.

Table 5.1 TAPM input parameters

	Meteorology	Dispersion
Centre	33° 12′ 30″ **S** 151° 32′ 30″ **E** Easting: 364183 m Northing: 6324290 m	
Dates	2004 (GMT +10.1)	
Grid	25 x 25 x 20 (nx x ny x nz)	41 x 41 (nx x ny)
Nesting	30 – 10 – 3.0 – 1.0 km	15 – 5.0 – 1.5 – 0.5 km
Meteorology assimilation	Hourly wind speed/direction data from Munmorah climatic, Wyee and Lake Munmorah Primary School ambient air monitoring stations.	
Dispersion computation	Tracer mode emissions (no chemistry or deposition) - Eulerian grid approach	



(a)



(b)

Figure 5.7 Observed and TAPM predicted temperature distributions through respective 2004 datasets (a) (observed and predicted) and (b) observed and predicted 3 pm conditions only (all observations from Munmorah climatic weather station).

Predicted temperature

The distribution of the observed and predicted average, maximum and minimum statistics is presented in Figure 5.7 (a) and (b). The (a) distribution illustrates that although there is generally good agreement between the observed and predicted average conditions and the observed and predicted maximum temperatures, with a larger difference between the observed and predicted minimum temperatures through the reference year. The 3 pm conditions illustrate that there is good agreement between the average observed 2004, long term observed data and predicted conditions. There is also reasonable agreement between the maximum temperatures conditions at 3 pm, through the year with the exception of Jan, Feb and Dec.

The results of a statistical analysis of the ability of the model to simulate measured climatic conditions are provided in Table 5.2. The TAPM predictions have been compared with the observed conditions at Munmorah climatic weather station. The difference in the levels is based on Root Mean Square Error (RMSE) and is greater in Jan, similar to the RMSE in Feb, and greater than the RMSE in Dec. The analysis of these figures on its own does not allow for a sufficiently robust assessment of the performance of the model in predicting meteorological conditions through 2004.

The statistics that are used to measure the performance of meteorological predictions from TAPM in this instance are based on those used by Willmott (1981) and Pielke (1984) as published in TAPM Technical Paper Part 2 (Hurley et. al., 2005). The equations for each of the statistics estimated below are provided in Appendix A.

An Index of Agreement (of 1 = perfect agreement and 0 = no agreement); Pearson Correlation coefficient (of 0 = no correlation and 1 = perfect correlation); $SKILL_V$ (near to 1 shows skill), $SKILL_R$ (<1 shows skill). These tests of skill and correlation between the observed and predicted temperature datasets have been satisfied. Further to this the RMSE is much less than the standard deviation of the predicted dataset, which is indicative of the error margin between the observed and predicted dataset is low (Hurley et. al., 2005).

Table 5.2 Statistics for TAPM simulation for temperature conditions c.f. Munmorah Climatic 2004 observations.

Index of Agreement	0.89
Pearson correlation coefficient	0.85
Predicted dataset standard deviation	5.2°C
RMSE	3.6°C
$RMSE_S$	2.4
$RMSE_U$	2.7
$SKILL_E$	0.44
$SKILL_V$	0.83
$SKILL_R$	0.59

Predicted wind speed

The predicted wind rose and the frequency distribution of the modelled wind classes for the reference year 2004 are provided in Figures 5.8 to 5.13.

An analysis of the predicted Munmorah and LMPS wind roses shows that there is a relatively even distribution of wind directionality across the range from 0-359°, although the westerly winds dominate both the observed and predicted Munmorah datasets.

The predicted LMPS dataset seems to have over predicted the frequency of westerly winds, the observed dataset showing dominance by northerly and southerly wind directions. There is quite a good degree of similarity however between the Wyee observed and predicted wind roses with westerly wind conditions dominating both datasets.

Although there has been some compromise in the accuracy of the predicted LMPS dataset, overall there is relatively good agreement in the directionality of the observed and predicted wind conditions. This analysis follows the predicted meteorological dataset being nudged towards observed levels through assimilation with of the contemporaneous dataset (refer Table 5.1).

A summary of wind roses that includes annual predicted and observed wind data delineated on a seasonal basis for the reference year (2004), 2004 and long term average (2001-2007) wind roses are presented in Appendix B.

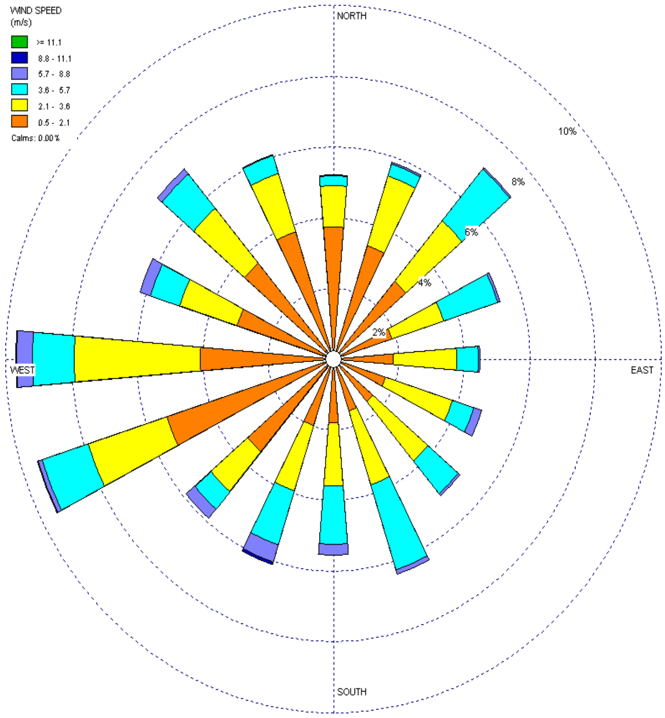


Figure 5.8 TAPM predicted wind rose for 2004 at Munmorah.

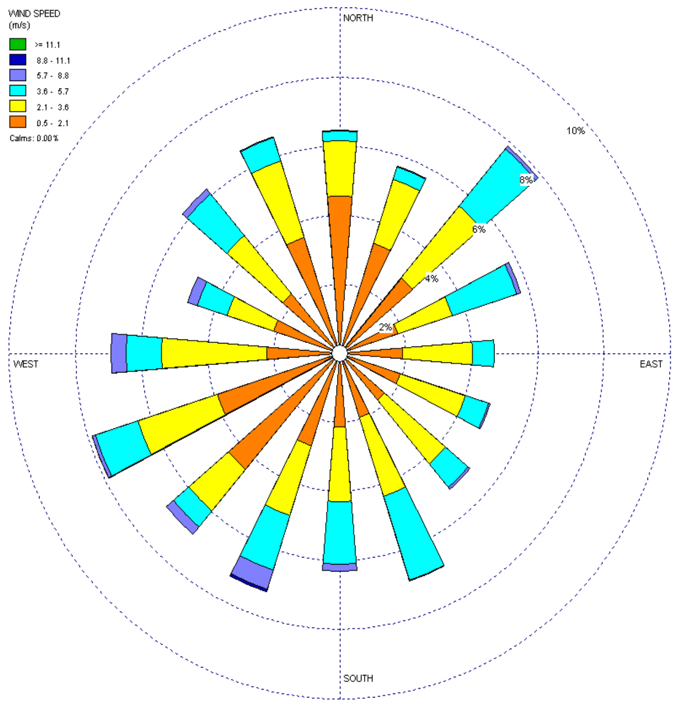


Figure 5.9 TAPM predicted wind rose for 2004 at Lake Munmorah Primary School.

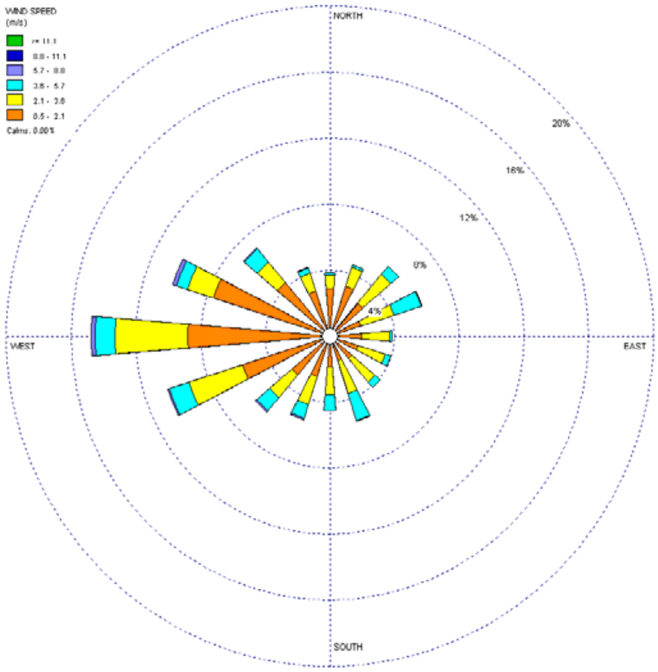


Figure 5.10 TAPM predicted wind rose for 2004 at Wyee.

The wind class frequency distributions shown in Figures 5.11 to 5.13 illustrate that the bulk of winds through this region are less than 6 m/s. The TAPM simulation has been unable to accurately represent calm conditions but has represented all other wind classes including high wind speed classes (i.e. > 9 m/s) with reasonable accuracy.

The assimilation of the observed datasets in the TAPM simulation illustrates some skew towards the lower wind classes in the frequency distribution. However this being the case the model will tend to over predict air quality impacts and thus allow for some conservatism.

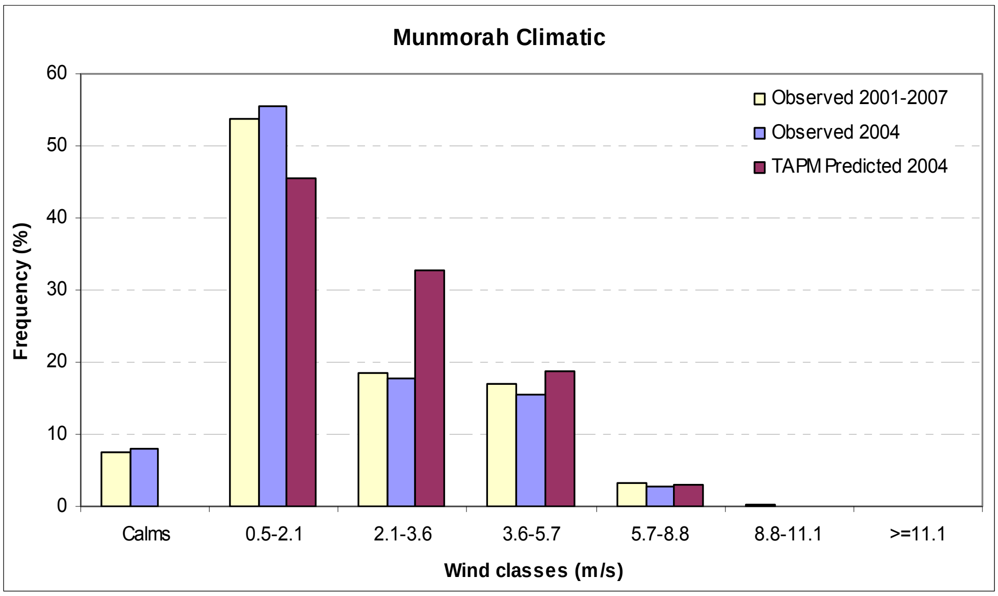


Figure 5.11 Comparative histograms of predicted against observed wind class frequency distributions for Munmorah weather station

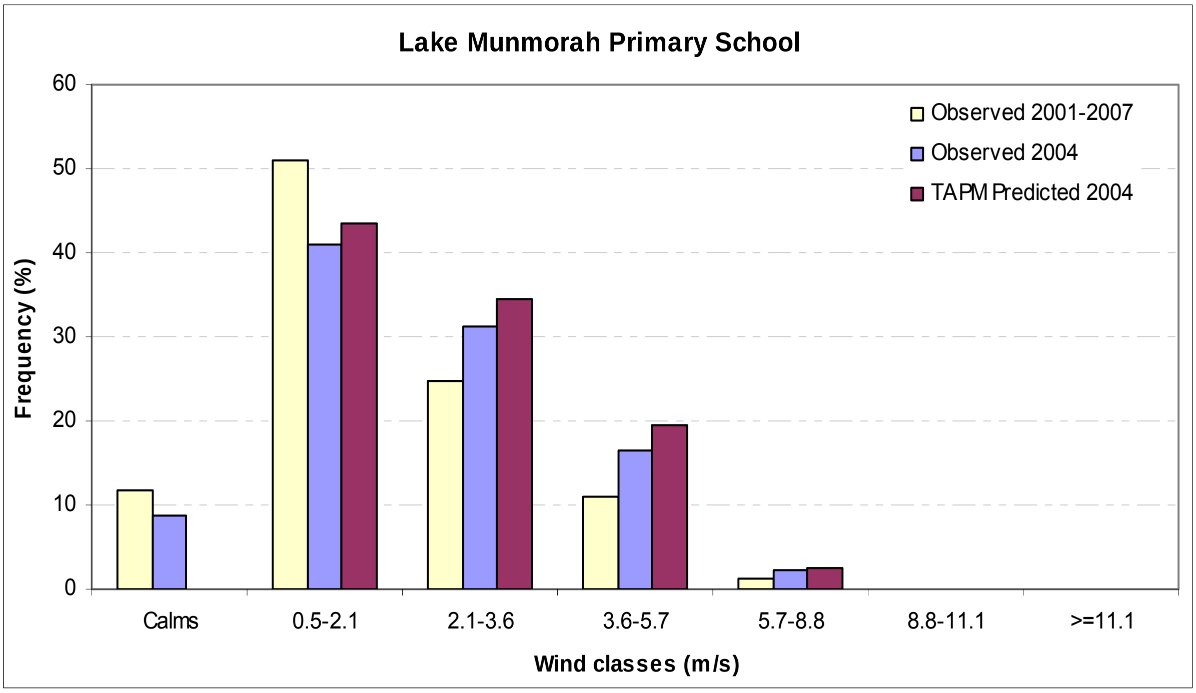


Figure 5.12 Comparative histograms of predicted against observed wind class frequency distributions for LMPS air monitoring station

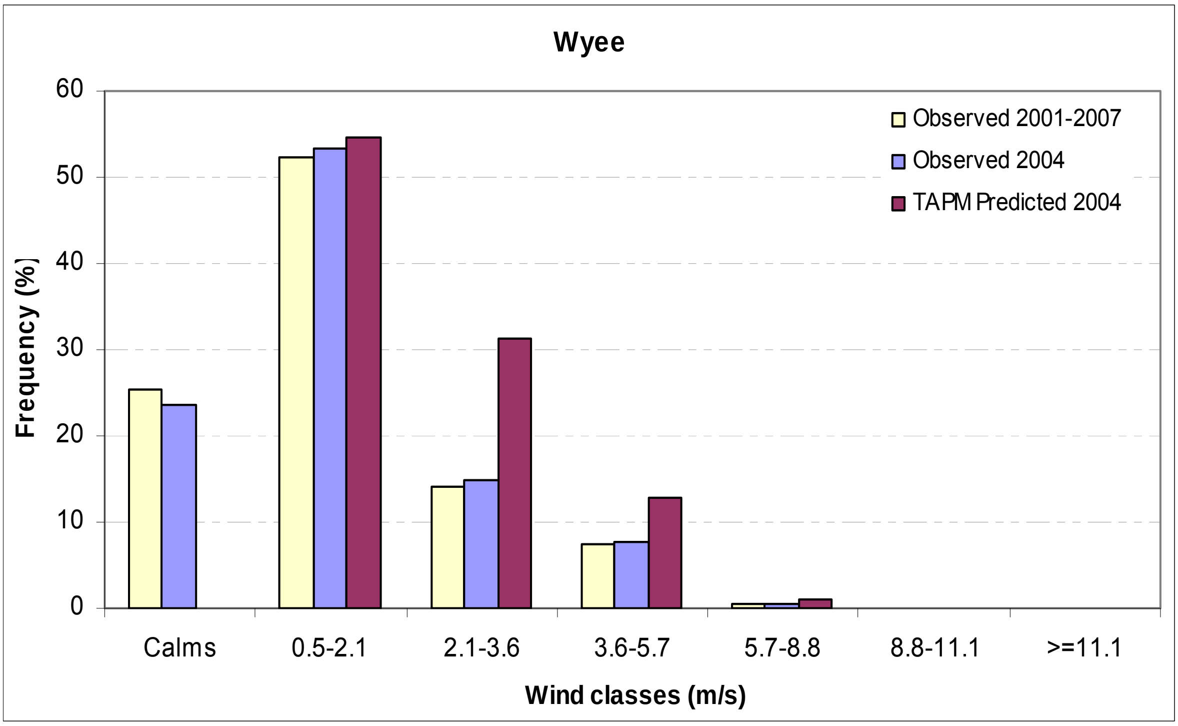


Figure 5.13 Comparative histograms of predicted against observed wind class frequency distributions for Wyee air monitoring station

The wind speed prediction performance statistics for the TAPM simulation at Lake Munmorah Primary School (LMPS), Munmorah and Wyee is presented in Table 5.3. The equations describing each of these statistics are provided in Appendix A.

An Index of Agreement (of 1 = perfect agreement and 0 = no agreement); Pearson Correlation coefficient (of 0 = no correlation and 1 = perfect correlation); $SKILL_V$ (near to 1 shows skill), $SKILL_R$ (<1 shows skill). These tests of skill and correlation between the observed and predicted wind speed datasets seem to have been satisfied. Further to this the RMSE is much less than the standard deviation of the predicted dataset, which is indicative of the error margin between the observed and predicted dataset being low (Hurley et. al., 2005).

Table 5.3 Statistics for TAPM simulation for wind speed conditions c.f. 2004 observations.

Location	LMPS	Munmorah	Wyee
Index of agreement	0.93	0.90	0.88
Pearson correlation coefficient (r)	0.87	0.82	0.85
Predicted dataset standard deviation	1.5	1.3	1.5
RMSE (m/s)	0.77	0.94	0.88
$RMSE_S$	0.98	0.62	0.72
$RMSE_U$	1.2	1.0	1.1
$SKILL_E$	0.81	0.72	0.90
$SKILL_V$	1.0	1.1	1.1
$SKILL_R$	0.53	0.65	0.72

Atmospheric stability

The degree of stability in the atmosphere will affect the dispersion of emissions from a source. The Pasquill-Gifford (P-G) stability category scheme is used to denote atmospheric stability. Stability class under this scheme is designated a letter from A-F (and sometimes G), ranging from highly unstable to extremely stable. The TAPM model simulates this atmospheric stability through turbulence intensity.

Atmospheric movement is characterised by four basic conditions that describe the general stability of the atmosphere. In stable conditions, vertical movement is discouraged, whereas in unstable conditions the “air parcel” tends to move upward or downward and to continue that movement. When conditions neither encourage nor discourage vertical movement, beyond the rate of adiabatic heating or cooling, they are considered neutral.

When conditions are extremely stable, cooler air near the surface becomes trapped by a layer of warmer air above it. Under these conditions, called an inversion, virtually no vertical air motion occurs. The data presented in Table 5.4, illustrates how the amount of incoming solar radiation affects stability, as does wind speed. The frequency distribution of stability class with wind speed classes (Table 5.5) shows that neutral conditions occur through all wind speeds but stable and unstable conditions only occur through the lower wind speed ranges (predominantly those below 6 m/s). This is consistent with what is expected for this region and the empirical expectations described in Table 5.4.

The stability class frequency distribution for the reference year (2004) in the predictive modelling for Munmorah is shown in Table 5.2. These results demonstrate the high frequency of unstable meteorological conditions during the day time and neutral to stable conditions being prevalent during the night. This is as expected as mixing is enhanced during the day time due to solar irradiation as well as mechanical mixing by the wind. However during the night, mixing only occurs through mechanical means i.e. wind, which is less pronounced in comparison to day time hours. This leads to more stable meteorological conditions being observed.

Table 5.4 Atmospheric stability categories

Wind speed (m/s)	Solar irradiation (mW/cm^2)				Time after sunset or before sunrise	Night-time cloud cover (octas)		
	>60	30-60	<30	Overcast		0-3	4-7	8
< 1.5	A	A-B	B	C	D	F or G[b]	F	D
2.0 – 2.5	A-B	B	C	C	D	F	E	D
3.0 – 4.5	B	B-C	C	C	D	E	D	D
5.0 – 6.0	C	C-D	D	D	D	D	D	D
> 6.0	D	D	D	D	D	D	D	D

[a] Wind speed is measured to the nearest 0.5m/s.
[b] Category G is restricted to night-time with less than 1 octa of cloud and a wind speed less than 0.5m/s.

Table 5.5 Stability class frequency distribution with respect to wind speed classes.

Speed (m/s)	A	B	C	D	E	F
0.5 - 2.0	65	220	220	1367	889	706
2.1 – 4.0	105	723	723	858	212	1307
4.1 – 6.0	0	268	268	459	264	0
6.0 – 8.0	0	0	0	166	0	0
> 8.0	0	0	0	27	0	0

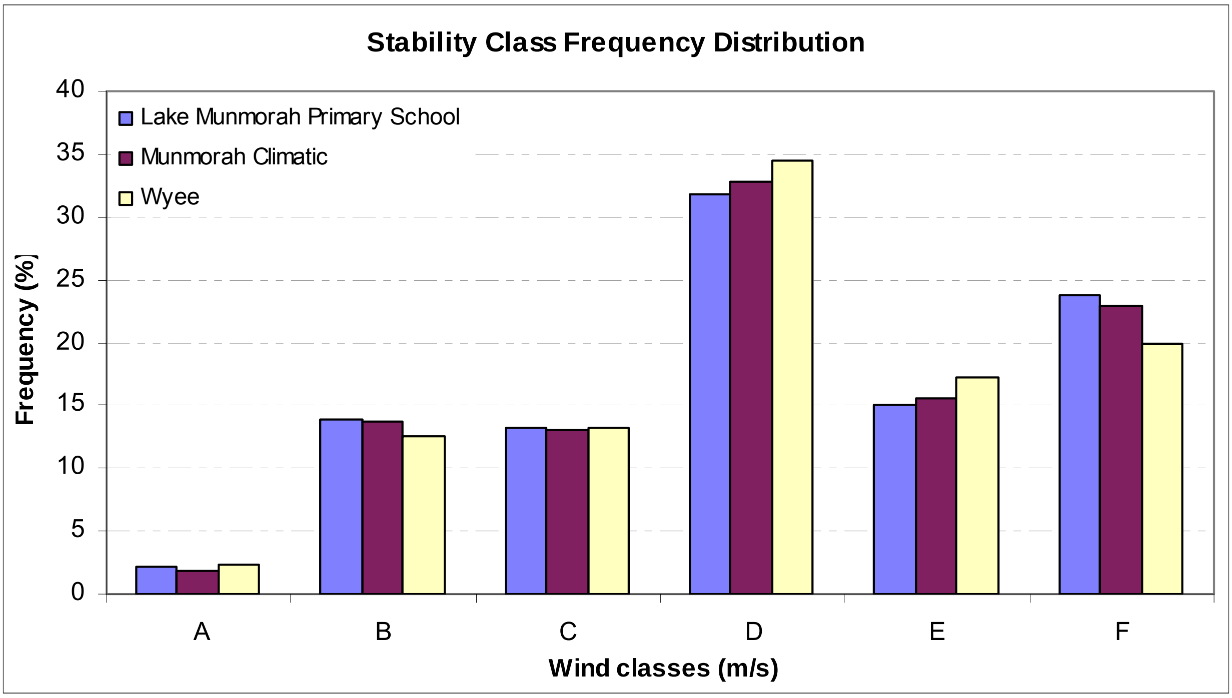


Figure 5.14 Annual stability class frequency distribution at Lake Munmorah Primary School, Munmorah and Wyee.

Table 5.6 Stability class frequency distribution with respect to time of day

Hour of day	A	B	C	D	E	F
1	0	0	0	77	118	171
2	0	0	0	68	129	169
3	0	0	0	76	128	162
4	0	0	0	91	127	148
5	0	0	0	110	117	139
6	0	0	0	209	71	86
7	0	0	8	306	16	36
8	0	2	106	258	0	0
9	0	64	145	157	0	0
10	7	144	136	79	0	0
11	17	171	113	65	0	0
12	35	178	86	67	0	0
13	44	167	92	63	0	0
14	33	166	97	70	0	0
15	22	144	109	91	0	0
16	12	113	96	145	0	0
17	0	61	103	202	0	0
18	0	1	57	249	18	41
19	0	0	0	200	59	107
20	0	0	0	52	122	192
21	0	0	0	50	127	189
22	0	0	0	64	101	201
23	0	0	0	61	115	190
24	0	0	0	67	117	182

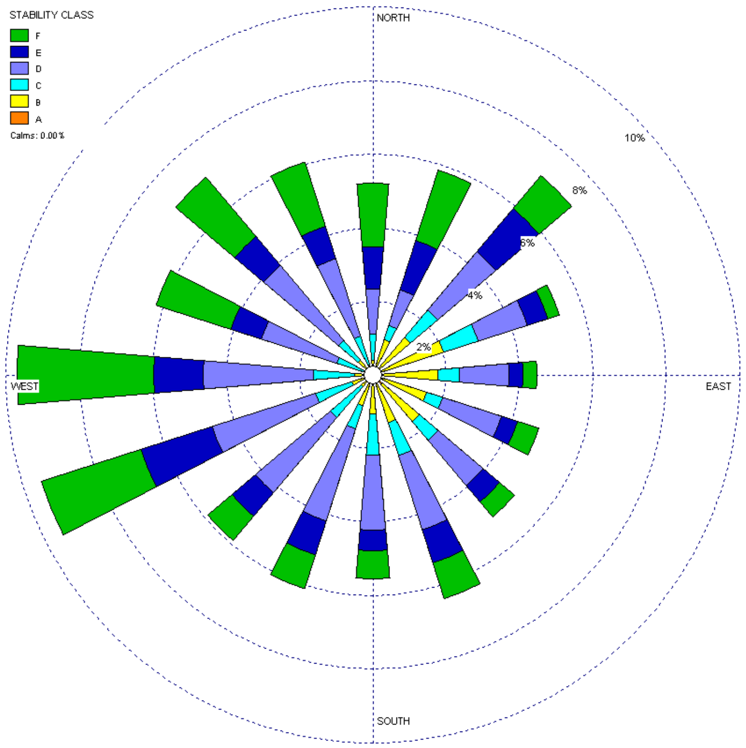


Figure 5.15 Stability class rose at Munmorah.

Mixing Height

The mixing height is the height of the turbulent (boundary) layer of air near the earth's surface, into which ground level emissions will be rapidly mixed. A plume emitted above this height will remain isolated from the ground until the mixing height reaches the height of the plume. A plume emitted below this height will be mixed subject to the stability class and wind climate. The height of the mixing layer is controlled by convection (resulting from solar heating of the ground during the day), by mechanically generated turbulence as the wind blows over 'rough' ground and also presence or absence of higher level subsidence.

The mixing height at Munmorah was estimated using gridded surface and upper air meteorological data that was generated by TAPM. TAPM is able to generate meteorological data up to a level of 8 km above sea level. Hence with this data the mixing height can be estimated. The hourly mixing height profile (average, 2^{nd} and 99^{th} percentiles) for the reference year is provided in Figure 5.16.

The estimated mixing height for this site rises very quickly in the early morning from just after sunrise until mid afternoon, at which point the mixing height remains at a relatively stable value until returning to a lower level early in the evening. This diurnal variation in the atmospheric structure is consistent with that found at similar sites. Large values for mixing height occur in the summer months as expected due to the greater convective effects. The main change throughout the year is the length of the period of strong convection and wind variation.

Figure 5.16 Hourly mixing height profile at Munmorah, as predicted by the TAPM meteorological simulation

5.3 Inclusion of Colongra Gas Turbine Facility and Eraring Upgrade in the Assessment

5.3.1 Eraring upgrade

Approval has been granted to upgrade the existing four 660 MW generating units at Eraring Power Station to a maximum continuous rating of 750 MW, increasing the total capacity of the station by 360 MW. This corresponds to approximately a 14% increase in total generating capacity.

A conservative assumption can be drawn that there may be a commensurate increase in emissions from the power station and a corresponding increase in the ground level concentrations of air pollutants in the regions surrounding the Munmorah power station, as defined by the observations at Lake Munmorah Primary School.

The upgrade of Eraring is therefore considered in this assessment on the basis of a linear scaling of the background concentrations (summarised in Section 3). The background levels of NO_2, SO_2 and HF have been scaled up by this 14% factor to reflect the upgrade of this facility.

5.3.2 Colongra gas turbine

The results of the study carried out as part of the Environmental Assessment for the Colongra gas turbine facility (Holmes Air Sciences 2005) has been used to represent the contribution of this facility to the local atmospheric NO_x load in the worst case scenario.

The impact through normal operations using distillate has been assessed by adding the contribution in Table 5.7 to the level of NO_x, predicted for Munmorah through the dispersion modelling carried out as part of this assessment.

A summary of the parameterisation of the Ozone limiting method calculation used to account for the atmospheric transformation of NO to NO_2 in the atmosphere with regard to emissions from the Munmorah Power Station is provided in Table 5.7.

5.4 Cumulative NO_2 impacts using the Ozone limiting method (OLM)

The explicit analysis of atmospheric chemistry in air dispersion modelling is not always necessary to accurately determine the amount of NO and NO_2 within the plume at any time. The most conservative approach is to assume that all of the NO_x emitted from the power plant is NO_2, even though this is unlikely to ever occur for an extended period of time in practice.

The ozone limiting method developed by the US EPA assumes that all available atmospheric ozone will react with NO in the plume until either O_3 or NO is completely exhausted. One limitation of this method is that the atmospheric reaction is assumed to be instantaneous, but in reality these reactions take place over several hours.

In order to calculate total NO_2 concentrations from the OLM method the background levels of O_3 and NO_2, have to be known or assumed and the maximum NO_x concentration in the atmosphere must be predicted. This can be done through simulation. Equation 1 describes the calculation of ground level NO_2 concentrations using the OLM method.

Ozone background

Assuming a background level of ozone based on the 2004 dataset alone does not enable a reasonable characterisation of the changing nature of the air environment through this region. It is important to characterise this changing nature given the influence of VOC and NO_x emission reduction strategies implemented by the DECCW over the past decade on ozone concentrations.

In addition the ozone levels in this region are heavily influenced by other sources such as bushfires and biogenic emissions (eg from vegetation).

Bushfires lead to significant emissions, (over and above those from industrial and diffuse sources) of NO_x and VOCs and have contributed to ozone events that exceed the NEPM limit through the NSW Lower Hunter and Central Coast regions.

An average of the maximum levels recorded over the period from 2003-2008 at the DECCW air monitoring stations through the Lower Hunter has been used to represent the ozone background. The data considered DECCW station reports for Beresfield, Newcastle and Wallsend specifically.

Equation 1

$$[NO_2]_{total} = \{0.1 \times [NO_x]_{pred.}\} + MIN\{(0.9) \times [NO_x]_{pred.}\, or (46/48) \times [O_3]_{bkgd.}\} + [NO_2]_{bkgd.}$$

(*pred.* – predicted; *bkgd.* – background)

Table 5.7 Parameterisation of OLM calculation.

Parameter	Value ($\mu g/m^3$)
Predicted NO_x levels	
- Munmorah	TAPM dispersion modelling result for each grid point within domain
- Colongra gas turbine	70*
Ozone background $[O_3]_{bkgd}$	188
NO_2 background $[NO_2]_{bkgd}$ (excluding Eraring and Colongra contribution)	LMPS contemporaneous data
i.e. for NO_2: 1 ppb = 2.05 $\mu g/m^3$	

6. Local air quality impacts

6.1 Methodology for the assessment of cumulative air quality impacts

This section assesses the local air quality impacts associated with the rehabilitation of the Munmorah Power Station. The assessment modelled the Munmorah facility alone, on the basis of the parameters described in Tables 4.8 and 4.9, along with the meteorological files developed for the assessment, discussed in Section 5.2.

Cumulative impacts are determined by considering the predicted impact of Munmorah Power Station in addition to the existing level of air quality in this region (background) as well as the changing nature of the air environment through this region given additional input from the operation of the upgrade of Eraring power station (see Section 5.3.1) and the Colongra gas turbine facility (see Section 5.3.2)

The existing (background) air quality was discussed in Section 3. Section 5.4 outlines the methodology adopted to represent cumulative impacts for NO_2.

The assessment has been done according to the Level 2 Approved Methods. At each receptor, each individual dispersion model prediction has been added to the corresponding measured background concentration at LMPS monitoring station to obtain hourly predictions of total impact. Contour plots showing the distribution of worst case air quality impacts are provided in Appendix C.

6.2 Cumulative air quality impacts and sensitive receptor analyses

The cumulative air quality impacts for the pollutants, SO_2, NO_2, and PM_{10} are presented in Table 6.1, Table 6.2 and Table 6.5. The contour plots showing the worst case ground level concentrations are provided as Appendix C.

The conservative nature of the methodology adopted as part of this assessment provides a robust characterisation of the worst case air quality impact through this region considering the operation of Eraring, Vales Point, and Munmorah power stations along with the proposed upgrade to Eraring Power Station and the commencement of operations at Colongra Gas Turbine Facility; as well as the contribution emissions from fugitive sources make to background ambient concentrations of NO_2, SO_2 and PM_{10}.

6.2.1 Sulfur dioxide (SO_2)

The cumulative SO_2 ground level concentrations are presented on annual, daily, hourly and ten minute averaging periods in Table 6.1. The cumulative SO_2 impacts predicted over annual, and daily, averaging periods, is shown to be compliant with the relevant air quality goals. This is notwithstanding the low likelihood that emissions would be emitted at worst case levels throughout the year, as has been assumed.

This assessment shows an exceedance in the cumulative hourly averaged SO_2 air quality goal at sensitive locations at most on two occasions in the year assessed at sensitive land uses. A time series of the cumulative predicted hourly SO2 is provided as Figure 6.1. The results of the modelling also predict exceedances in the ten minute average SO_2 goal at four sensitive receptors through three distinct hours of the year. The predicted cumulative impact at each sensitive receptor is provided in Table 6.2.

The cumulative levels predicted at each of the 14 sensitive receptor points (see Figure 3.1 for locations) indicates an exceedance in the hourly averaged goal at sensitive receptor R1, R10 and R12. It is important to note however these exceedances correspond to one distinct hour through the modelled reference year.

Table 6.1 Predicted first highest SO_2 cumulative ground level concentrations at emissions equivalent to the firing of 0.7% sulfur grade coal

Pollutant concentrations (µg/m^3)	SO_2 ~ 0.7% Sulphur coal					
Averaging period	**10 min**		**1 hr**		**24 hr**	**Annual**
Method	**Level II**		**Level II**			
Predicted cumulative impact	**836[E1]**	**1057[E2]**	**584[E1]**	**738[E2]**	**172**	**12.0**
Background air quality #	50	79	35	55	30	4.2
Munmorah contribution	786	978	549	683	142	7.8^
Ambient Air quality goal	*712*	*712*	*570*	*570*	*228*	*60*

***** NSW DECCW (DEC) air quality goal.

The background air quality in this has been scaled by a factor of 14% to the LMPS background air quality data to take account of the contribution the Eraring upgrade.

Note: the exceedances in the air quality goal over 10 min and 1 hour averaged levels correspond to two distinct hours through the year and occur through the same hours through non-sensitive land uses. The events are classified as E1 and E2.

E1 Exceedance corresponds to date Jan 28 at 11 AM; this exceedance is in a non sensitive land use (UTM mE, mS 364183, 6323790). As the discussion pertaining to the analysis of impacts at each sensitive receptor identified in Figure 3.1 illustrates; there is no exceedance in the hourly averaged air quality goal at a sensitive receptor that corresponds to this exceedance that has been identified to be through a non-sensitive land use.

E2 Second exceedance (apparent in Figure 6.1) occurs on date 31 Mar at 12 PM – this exceedance occurs in a non-sensitive land use (UTM mE mS 365183, 6323790). There is however an exceedance at sensitive receptors that correspond to this hour in the 10 min and hourly averaged air quality goals.

^ Annual average concentration was calculated based on an analysis of the 'CONC' time series for the grid point in the TAPM modelling domain for which the maximum 24 hr averaged concentration was predicted. This is posited to be more representative of the actual annual average level as opposed to an average of the maximum concentrations predicted by TAPM across any grid within the domain.

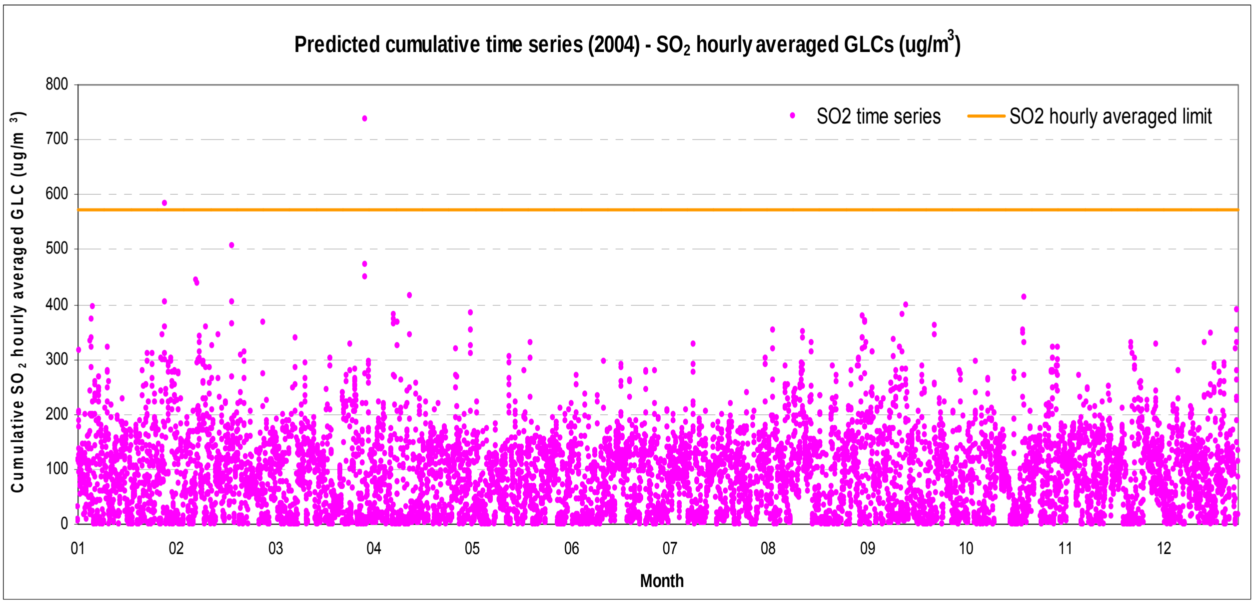


Figure 6.1 Time series of cumulative predicted SO_2 hourly averaged ground level concentrations (µg/m^3)

Table 6.2 Hourly averaged SO_2 ground level concentrations predicted at each sensitive receptor ($\mu g/m^3$)

Receptor number	Cumulative SO_2 **($\mu g/m^3$)**	
	10 min averaged	**Hourly averaged**
Air quality goal	**712**	**570**
R1 – Kamilaroo Ave, Lake Munmorah	982[^a]	686*
R2 – Halekulani *East*	471	329
R3 – Halekulani *West*	765[^b]	535
R4 – Barega Cl, Buff Point	724[^c]	506
R5 – San Remo / Camp Breakaway	591	413
R6 – Doyalson	659	460
R7 – Pacific Hwy, San Remo	488	341
R8 – Mootay Cl Buff Point	654	457
R9 – Noela Pl Oval, Budgewoi	529	369
R10 – Colongra Bay Rd, Lake Munmorah	932[^d]	651*
R11 – Lake Munmorah Primary School	661	462
R12 – 'All Paws Pet Motel' Pacific Hwy	861[^d]	602*
A – Flower greenhouse, Pacific Hwy	442	309
B – Pacific Hydroponics, Pacific Hwy	491	343

^ These four exceedances of the air quality goal at the corresponding sensitive receptors occur through three distinct hours in the simulation year specifically (a, d) Mar 31 @ 12PM, (b) Sept 29 @ 11AM, (c) 18 Feb @ 10 AM.

* All three exceedances reported at three different sensitive receivers occur at the same time Mar 31 @ 12 PM.

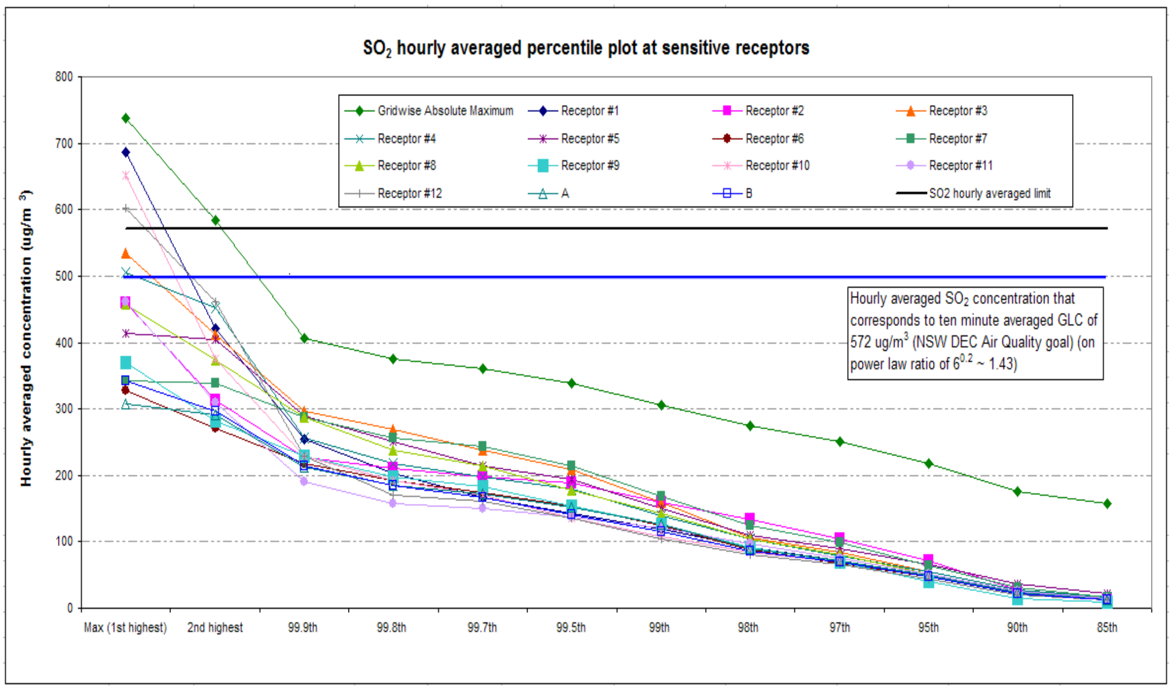


Figure 6.2 Percentile plot of hourly averaged SO_2 concentrations (µg/m^3) at each sensitive receptor (as highlighted in Figure 3.1). Note: the grid wise absolute maximum exceedance occurs in a non-sensitive land use south of Receptor 1 at the same time as the three exceedances reported in the Table above.

The results from the sensitive receptor analysis indicates the potential for an exceedance in the hourly averaged air quality criterion at Receiver 1, 10 and 12 and exceedances of the ten minute average criterion at Receivers 1, 3, 4, 10 and 12. As the footnotes to the table indicate, the reported exceedance in the hourly averaged air quality goal reported at receivers 1, 10 and 12 all occur on the same date and hour in the modelled reference year (2004). It is relevant to note the skewed nature of the frequency distribution above the 99.9th percentile.

The exceedances in the ten minute averaged concentrations three distinct hours through the reference year. The lower horizontal line (blue line) illustrates the cumulative hourly averaged concentration that correspond to a ten minute averaged concentration of 712 µg/m^3 (air quality goal), based on a relationship between the hourly averaged and ten minute averaged concentration relating to a ratio of 1.43 (C_{10min}/C_{1hr}).

The specific dates through the simulation year to which these exceedances occur, correspond to the dates January 28th, February 18th and March 31st between the hours 10 AM – 12 PM..

It is important to note in this instance, the findings of Lilley *et. al.* (2007) indicate that the highest predictions of air quality models like TAPM can over estimate impacts by as much as 50%. This is illustrated by the significant difference between the first (maximum) and second highest ground level concentrations predicted at all of the highlighted sensitive receptors in the percentile analysis shown in Figure 6.2. The difference in the first and second highest predicted SO_2 ground level concentrations is not reflected in the monitoring data observed at either Wyee or Lake Munmorah Primary School. The observed difference through any given year is better reflected by the difference between the 2nd and 99.9th percentiles (corresponds to the 9th highest figure through a given year of 8760 hours) as opposed to the difference between the 1st and 2nd highest predictions.

Given the explicit prediction of ten minute average ground level concentrations is not possible (with TAPM), the power law function based on historical data (Rae (et. al.) (2008)) was used to predict the worst case 10 minute averaged ground level concentrations. A form of this function is presented below:

$$C_{10\,\min} = C_{60\,\min}\left(\frac{60}{10}\right)^{0.38}$$

i.e. peak 10 minute average concentrations are on average twice the hourly averaged ground level concentration:

$$C_{10\,\min} = 1.98C_{60\,\min}.$$

However a more recent assessment of air quality impacts on the Central Coast (Rae et. al., 2008) shows that the use of such a relationship may in fact significantly over estimate the 10 minute average concentrations.

The assessment by Rae (et. al.) (2008) suggests that, as hourly averaged concentrations are maximised the ratio of 10 min average concentrations to hourly average concentrations *tends* towards unity.

i.e. $\frac{C_{10\,\min}}{C_{60\,\min}} \rightarrow 1;$ as $C_{60\,\min}$ = peak

The analysis of 10 min to hourly averaged (peak to mean) SO_2 ratios for the LMPS and Wyee datasets for the 2004 reference year (Holmes Air Sciences 2005) is included in Appendix D. The profile provided in the appendix illustrates the point above in a graphical form. The more standard power law conversion equation is therefore used in this instance to represent the worst case impacts through the reference year. The power law relationship to derive ten minute averaged air quality impacts is provided below:

$$C_{10\,\min} = C_{60\,\min}\left(\frac{60}{10}\right)^{0.2}$$; (Duffee et. al. 1991)

The use of this methodology to predict cumulative 10 minute average concentrations leads to the prediction of levels that exceed the air quality goal.

Thus it is believed that the predicted highest concentrations in both the hourly averaged and ten minute averaged ground level concentrations should be treated with caution due to the tendency of TAPM to over predict the peak predicted impact. The 2^{nd} highest ground level concentrations predicted at each of the sensitive receptors is compliant with both the hourly and ten minute averaged DECCW air quality goals.

The pollutant contours for SO_2 provided in Appendix C across the various time averaging periods provide a graphical representation of the locations through which the worst case impacts corresponding to the Level II assessment are likely to occur.

The preference for the use of the contemporaneous observed Lake Munmorah Primary school dataset over that observed at Wyee is contended to be appropriate given the predicted results illustrate that the worst case impacts from Munmorah are within the region of influence of Lake Munmorah Primary school. The impacts of emissions from Munmorah in the regions surrounding the Wyee air monitoring station are significantly reduced in comparison to those observed near Lake Munmorah.

6.2.2 Nitrogen dioxide (NO_2)

The hourly and annual average cumulative air quality impacts for nitrogen dioxide are summarised in Table 6.3. The predicted maximum annual average ground level concentration is seen to be compliant with the respective air quality goal of 62 µg/m^3. The annual averaged background level observed at Lake Munmorah Primary School through the reference year (2004) was scaled up by a factor of 14%, to account for the influence of the Eraring upgrade on ambient air quality through this region into the future.

The cumulative hourly averaged level predicted is based on the assumption that Munmorah's operation at peak output being contemporaneous with worst case meteorological conditions, the Colongra gas turbine operating at worst case emissions. A consideration of the likelihood of these events being coincidental in light of the predicted worst case air quality impacts represented in Table 6.3 stands as evidence in favour of the proposition that any exceedances in the hourly average NO_2 limit being highly unlikely.

The peak hourly averaged NO_2 concentration occurs when the background level is approximately 72 µg/m^3, the predicted level of NO_x through the same hour is approximately 105 µg/m^3 (referenced to NO_2), with all other parameters of the OLM calculation remaining the same, as discussed in Section 5.4. The assumption that the worst case operating conditions from Colongra are always coincident with the emissions from Munmorah throughout the year is considered to be conservative, as Colongra is a peaking power station that will only operates to satisfy peak load demands.

The hourly averaged NO_2 contours illustrate that the worst case impacts occur in the locality of the Lake Munmorah Primary School monitor. They also illustrate that while there is one minor exceedance of the goal there will be no exceedance in the relevant air quality goal, at any of the sensitive receptors identified in Figure 3.1. The results of the Level II analysis at each of the sensitive receptors (as highlighted in Figure 3.1) yield the cumulative hourly averaged NO_2 concentrations. These statistics are presented in Table 6.3 and shown graphically in the time series in Figure 6.3. This analysis shows that the cumulative worst case NO_2 concentration will be compliant with the corresponding hourly averaged air quality goal at each of these sensitive receptors.

The percentile analysis of cumulative hourly averaged NO_2 ground level concentrations at each sensitive receptor is presented in Table 6.4. This illustrates that there is not a significant difference between the maximum worst case concentration and the second highest level predicted through the reference year. However the 99.9th percentile level is predicted to be significantly smaller than the maximum and second highest levels. There is a gradual linear decrease in concentrations through the percentiles from the 99.8th to 85th percentile level.

This analysis demonstrates that the maximum hourly averaged cumulative ground level concentration will be compliant with the corresponding air quality goal of 246 µg/m^3. Thus the assessment predicts that emissions from the rehabilitated Munmorah Power Station will not have any unacceptable NO_2 air quality impacts.

Table 6.3 Predicted first highest cumulative NO_2 ground level concentrations.

Pollutant concentrations (µg/m^3)	NO_2	
Averaging period	**1 hour**	**Annual**
OLM Method	**Level II**	
Predicted cumulative impact (NO_2)	**246.7**	**19**
Background air quality (**NO_2**)^	72	16.1
Munmorah power station contribution (**NO_x**)	105	2.3$^{\#}$
Colongra gas turbine contribution (**NO_x**)*	70	0.2
Air quality goal	*246*	*62*

Pollutant concentrations (µg/m³)	NO_2

^ Background air quality has been scaled by a factor of 14% to account for the upgrade of Eraring Power Stations.

* Worst case operation assumed to be contemporaneous with worst case impact from Munmorah power station.

Annual average concentration was calculated based on an analysis of the 'CONC' time series for the grid point in the TAPM modelling domain for which the maximum 24 hr averaged concentration was predicted. This was thought to be more representative of the actual annual average level as opposed to an average of the maximum concentrations predicted by TAPM across any grid within the domain.

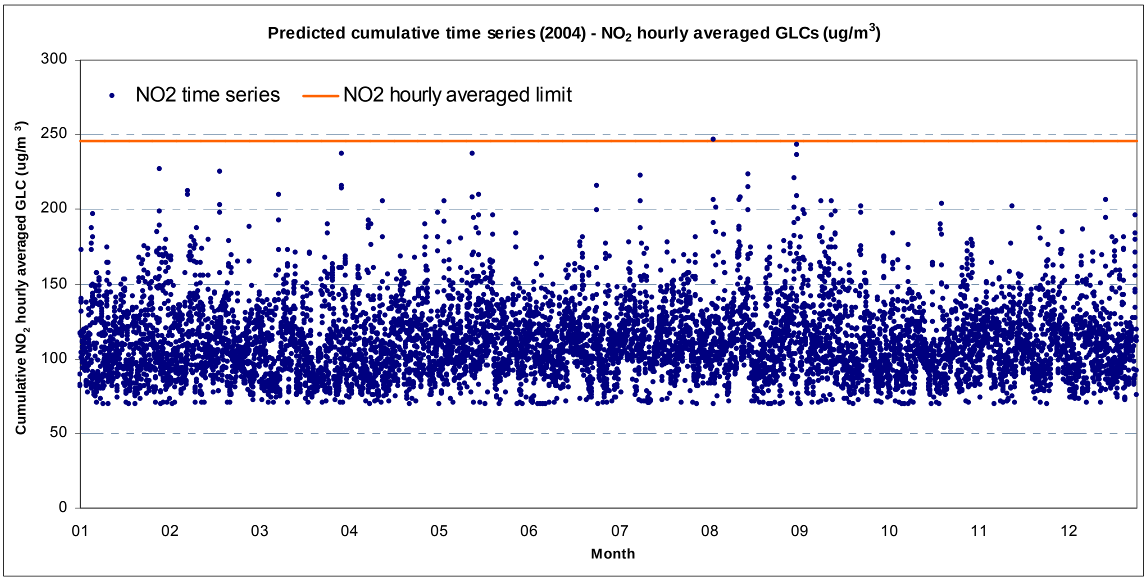


Figure 6.3 Time series of maximum predicted cumulative NO_2 hourly averaged ground level concentrations (µg/m³).

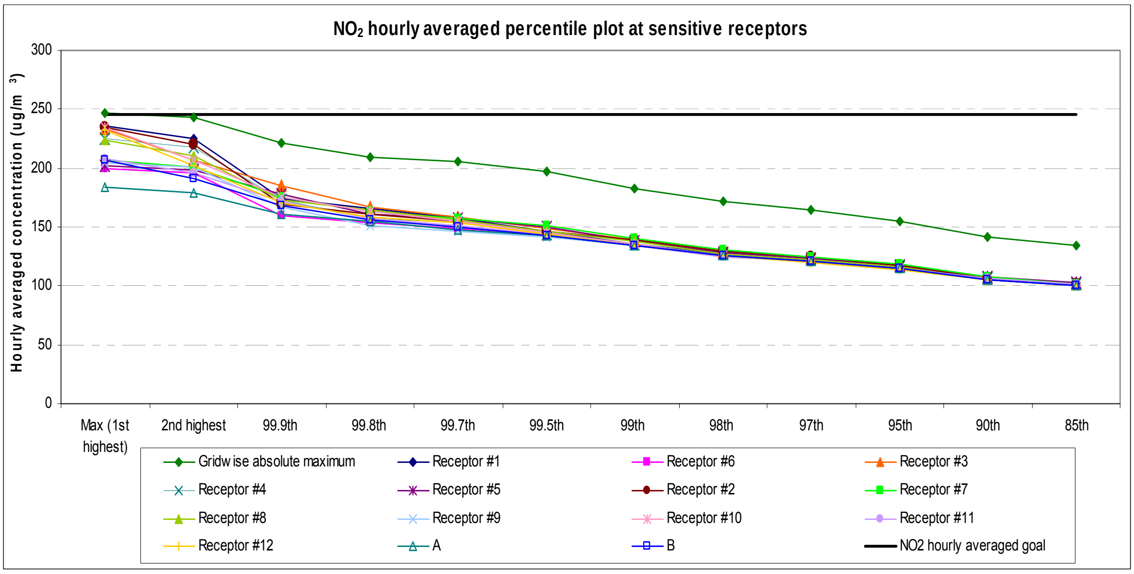


Figure 6.4 Percentile plot of hourly averaged NO_2 concentrations (µg/m³) at each sensitive receptor (as highlighted in Figure 3.1)

Table 6.4 Sensitive receptor analysis of cumulative hourly averaged NO_2 ground level concentrations (µg/m^3). Sensitive receptors as highlighted in Figure 3.1

Receptor number	Cumulative NO_2 (µg/m^3)
	Hourly averaged
Air quality goal	**246**
R1 – Kamilaroo Ave, Lake Munmorah	235
R2 – Halekulani *East*	235
R3 – Halekulani *West*	233
R4 – Barega Cl, Buff Point	225
R5 – San Remo / Camp Breakaway	203
R6 – Doyalson	199
R7 – Pacific Hwy, San Remo	206
R8 – Mootay Cl Buff Point	224
R9 – Noela Pl Oval, Budgewoi	205
R10 – Colongra Bay Rd, Lake Munmorah	234
R11 – Lake Munmorah Primary School	208
R12 – 'All Paws Pet Motel' Pacific Hwy	233
A – Flower greenhouse, Pacific Hwy	183
B – Pacific Hydroponics, Pacific Hwy	207

6.2.3 Fine particulates (PM_{10})

The background level of PM_{10}, Munmorah's contribution and the cumulative daily averaged PM_{10} levels are summarised in Table 6.4. The negligible contribution that emissions from Munmorah make to cumulative levels, is shown in Figure C5 of Appendix C.

In respect of the daily averaged air quality goal; it is important to note that the maximum background level through the reference year exceeds the relevant air quality goal. The peak contribution of emissions from Munmorah shown in Table 6.4 shows the minor contribution emissions from Munmorah makes to the cumulative impact (<10% of the peak background level).

An additional analysis of the results is undertaken to understand the frequency of exceedances of the aforementioned daily averaged criterion and whether the predicted impact from the facility contributes to any *additional* exceedances in the air quality criterion. The contemporaneous analysis of daily averaged observations at Wallsend air monitoring station and the maximum concentrations predicted from the air dispersion modelling is presented in Figure 6.5. Figure 6.5 shows that there will not be any *additional* exceedances in the air quality criterion.

The predicted impact from the Munmorah power station was considered based on emissions from Munmorah assumed to be compliant with Group 6 standard of 50 mg/Nm^3 for solid particles. However, the observed emissions from the facility through 2002-2004 varied between 3.4 -13.6 mg/m^3 (Unit 3) and 11.5 – 51.6 mg/Nm^3 (Unit 4). This suggests that under average operating emissions of PM_{10} compounds from Munmorah will generally be well below the Group 6 limit.

This being the case Munmorah Power Station would be expected to make an even smaller contribution to peak PM_{10} concentrations than is predicted in the tables below and the discussion preceding this paragraph.

The majority of any exceedances of the PM_{10} limit will be associated with local wind blown dust events and bushfires through the summer months.

Table 6.5 Predicted first highest PM_{10} cumulative ground level concentrations.

Pollutant concentrations (µg/m^3)	PM_{10}	
Averaging period	**Daily (Level II)**	**Annual**
Number of additional exceedances through reference year	*0*	*0*
Predicted cumulative impact	**56.1**	**19.8**
Prediction with Munmorah alone	4.3	1.3
Background air quality	51.8	18.5
Air quality limit	*50*	*30*

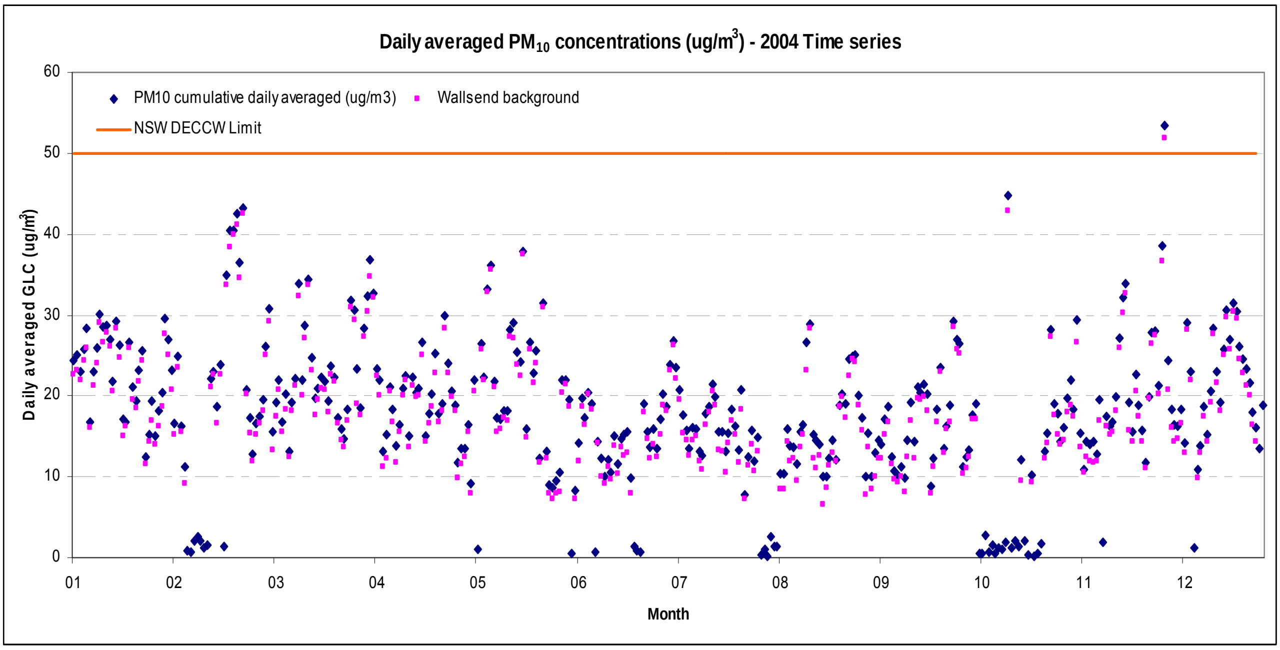


Figure 6.5 Contemporaneous time series analysis of maximum predicted PM_{10} daily averaged concentrations (µg/m^3) using 2004 Wallsend daily averaged air monitoring data – Level II assessment.

6.2.4 Carbon monoxide (CO)

The predicted cumulative impacts over 15 minute, 1 hour and 8 hour averaging periods for carbon monoxide is provided in Table 6.6. The background level in this instance is represented by the observations at the NSW DECCW Newcastle ambient air monitoring station through the reference year. The 8 hour averaged levels were scaled using the power law relationship to convert between time averages with exponent 0.2.

The resultant cumulative impact illustrates that the predicted levels are well below the relevant air quality goals. In addition to this it is important to note the largely negligible contribution that emissions from Munmorah make to the cumulative impact.

Table 6.6 Predicted air quality impact for carbon monoxide

Pollutant concentrations (mg/m^3)	Carbon monoxide (CO)		
Averaging period	**15 min**	**1 hour**	**8 hour**
Cumulative impact	6.1	4.6	3.0
Predicted impact	0.07	0.05	0.02
Background*	6.0	4.5	3.0
Ambient air quality goal (mg/m^3)	100	30	10

* NSW DECCW Newcastle air monitoring station 2004 - 8 hour (rolling) averaged maximum; 1 hour and 15 min average background assessed through power law relationship with exponent of 0.2.

6.2.5 Lead (Pb)

The predicted impact over an annual averaging period for lead compounds is presented in Figure 6.7. The impact predicted is based on the level of lead observed to be in the coal that is fired at Munmorah Power Station. This level of lead in the coal was the maximum level observed over the period from January to June 2009.

The predicted incremental contribution from Munmorah Power Station is several orders of magnitude below the respective air quality limit.

Table 6.7 Predicted air quality impact for lead

Pollutant concentrations (µg/m^3)	Lead (Pb)
Averaging period	**Annual**
Predicted impact*	6.1×10^{-5}
NEPM Ambient air quality goal (µg/m^3)	0.5

6.2.6 Hydrogen fluoride (HF)

The ambient air quality impacts for hydrogen fluoride are presented in this section. The concentrations were predicted on a pro rata basis with respect to the modelled emissions concentration presented in Table 4.8. It is likely that the Proponent will seek a different limit when outlining the guaranteed concentration for the operating licence.

The ambient air quality impacts have been represented for a total of fourteen sensitive receptors that are outlined in Figure 3.1. The land use surrounding the Munmorah power station facility largely consists of residential receivers. As discussed in Section 3.3, the closest identified agricultural land uses are prescribed by sensitive receivers A and B which have been classified as 'General Land Use" for the purpose of the assessment.

The ground level concentrations across the various averaging periods were calculated explicitly following analysis of the daily averaged time series output for the point of interest (location of sensitive receiver) within the TAPM modelling domain. The analysis of this time series yielded 7, 30 and 90 day averaged predictions for each sensitive receiver (i.e. grid point on the domain). The averaging process was conducted for the selected grid point in particular which is represented by the *'CONC'* column in the TAPM time series output.

The concentration predicted at each sensitive receptor was then summed with the background level that was scaled by 14% to reflect the Eraring upgrade to achieve a cumulative prediction for the level of HF in the atmosphere for the reference year. An emissions flux rate corresponding to an emissions concentration of up to 30 mg/m^3 allows for the predicted cumulative ambient air concentrations to be compliant with the commensurate air quality goals.

Table 6.8 Fluoride concentrations predicted as hydrogen fluoride at 14 sensitive receptors as identified in Figure 3.1.

Hydrogen fluoride concentrations (µg/m^3)	Emissions limit – 30 mg/m^3			
Averaging period	**24 hr**	**7 days**	**30 days**	**90 days**
Air quality goal	*2.9*	*1.7*	*0.84*	*0.5*
Background concentration	0.18	0.13	0.09	0.06
Predicted cumulative impact at receivers 1-12 and A, B				
R1 – Kamilaroo Ave, Lake Munmorah	2.19	***1.01***	***0.66***	***0.46***
R2 – Halekulani *East*	1.50	0.50	0.33	0.24
R3 – Halekulani *West*	1.77	0.70	0.32	0.23
R4 – Barega Cl, Buff Point	1.46	0.59	0.36	0.28
R5 – San Remo / Camp Breakaway	2.06	0.65	0.36	0.29
R6 – Doyalson	1.80	0.57	0.27	0.19
R7 – Pacific Hwy, San Remo	***2.75***	0.60	0.39	0.25
R8 – Mootay Cl Buff Point	1.71	0.58	0.31	0.24
R9 – Noela Pl Oval, Budgewoi	1.15	0.37	0.21	0.14
R10 – Colongra Bay Rd, Lake Munmorah	1.37	0.57	0.29	0.18
R11 – Lake Munmorah Primary School	1.59	0.55	0.32	0.20
R12 – 'All Paws Pet Motel' Pacific Hwy	1.20	0.53	0.27	0.17
A – Flower greenhouse, Pacific Hwy	1.65	0.51	0.29	0.19
B – Pacific Hydroponics, Pacific Hwy	1.69	0.65	0.22	0.17
Averaging period	**24 hr**	**7 days**	**30 days**	**90 days**
R1 – Kamilaroo Ave, Lake Munmorah	2.01	***0.9***	***0.6***	***0.4***
R2 – Halekulani *East*	1.32	0.4	0.2	0.2
R3 – Halekulani *West*	1.59	0.6	0.2	0.2
R4 – Barega Cl, Buff Point	1.28	0.5	0.3	0.2
R5 – San Remo / Camp Breakaway	1.88	0.5	0.3	0.2
R6 – Doyalson	1.62	0.4	0.2	0.1
R7 – Pacific Hwy, San Remo	***2.57***	0.5	0.3	0.2
R8 – Mootay Cl Buff Point	1.53	0.5	0.2	0.2
R9 – Noela Pl Oval, Budgewoi	0.97	0.2	0.1	0.1
R10 – Colongra Bay Rd, Lake Munmorah	1.19	0.4	0.2	0.1
R11 – Lake Munmorah Primary School	1.41	0.4	0.2	0.1
R12 – 'All Paws Pet Motel' Pacific Hwy	1.01	0.4	0.2	0.1

Hydrogen fluoride concentrations ($\mu g/m^3$)	Emissions limit – 30 mg/m^3			
A – Flower greenhouse, Pacific Hwy	1.47	0.4	0.2	0.1
B – Pacific Hydroponics, Pacific Hwy	1.51	0.5	0.1	0.1

6.2.7 Other pollutants

The potential ambient air quality impacts for all other pollutants described as including cadmium (Cd), mercury (Hg), hydrogen chloride (HCl), chlorine (Cl_2), sulfur trioxide and sulfuric acid mist (SO_3 and H_2SO_4) and dioxins and furans (PCDD/F) have been assessed in accordance with the requirements of the Approved Methods.

A comparison of the emission rates used in predicting the impacts for these pollutants to those recorded over the historical period for Munmorah (refer Table 4.7) supports the view that the assessment is conservative. Average in stack emission concentrations observed over 2004-2006 are at levels that are at least an order of magnitude below the modelled levels. The modelled levels have considered possible changes in coal quality for future supples, as indicated in coal quality data provided by Delta. Due to the low number of samples, endeavouring to prescribe limits below Group 6, as indicated as an objective by DECCW, should be approached on a conservative basis to allow for unforseen variations in coal quality.

Table 6.9 Predicted first highest cumulative ground level concentrations through proposed upgrade scenario for cadmium (Cd), mercury (Hg), hydrogen chloride (HCl), chlorine (Cl_2), sulfuric acid mist (H_2SO_4) and sulfur trioxide (SO_3), and dioxins and furans (PCDD/F)

Pollutant concentrations ($\mu g/m^3$)	Cadmium	Mercury	Hydrogen Chloride (HCl)	Chlorine (Cl_2)	Sulfuric acid and sulfur trioxide	PCDD/F*
Averaging period	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**	**1 hour**
Predicted impact*	0.016	0.082	16.7	49.8	18	4.1×10^{-8}
NSW DECCW (DEC) Air quality goal ($\mu g/m^3$)	0.018	1.8	140	50	18	2.0×10^{-6}

* Pollutant emissions at 1 g/s is equivalent to a predicted maximum hourly average impact of 0.67 $\mu g/m^3$

6.3 Fugitive dust emissions

While the level of activity through the coal stock pile is expected to increase, given the proposal to operate the plant at a higher level, the management of the fuel delivery and processing will remain substantially unchanged. The air quality observed as a result of existing operations in the existing monitoring data discussed in chapter 3 is expected to be maintained. Furthermore any increased proportion of gas co-firing through the plant will inherently lead to reduced coal handling resulting in a further mitigating influence on impacts.

The assessment of dust deposited (assessed as insoluble solids) on a monthly basis at each of the six dust gauges surrounding Munmorah power station illustrated that although there have been occasional events above the DECCW cumulative impact assessment criterion of $4g/m^2$/month over the 16 year period analysed; these events have been very infrequent and in most cases the highest results are probably the result of external “interference” with the relevant gauge.

Most of the observed levels have been below the level stipulated as the maximum allowable increase in the deposited dust level (2 g/m^2/month). A large proportion of the observed monthly figures since

2004 have been below 1 g/m^2/month. Further to this evidence supporting the likelihood of interference is represented by the high(er) frequency of deposited dust events concentrations greater than 10 g/m^2/month; as opposed to the frequency of deposition concentration in the range between 4-10 g/m^2/month (refer to Figure 3.12).

Accordingly it is predicted, with the ongoing maintenance of air quality management plans and adherence to mitigation measures that the contribution of Munmorah to dust deposition will continue to be acceptable. Management and mitigation measures are discussed in Chapter 8.

7. Regional and Inter-Regional Impacts

The regions broadly described as the NSW Central Coast and Sydney Greater Metropolitan are densely populated with numerous fugitive and industrial NO_x and anthropogenic/biogenic volatile organic compound (A/BVOC) emission sources, which are precursors to ozone formation and photochemical smog.

The rehabilitation of Munmorah Power Station will result in two outcomes with respect to NOx emissions which may appear to be contradictory but are the result of a lower rate of emission on the one hand and higher annual output on the other.

Following the rehabilitation of Munmorah Power Station the rate at which NOx is emitted, expressed in terms of either mg/m3 or mass per unit of station output, will decrease due to the installation of new low NOx burners. (see section 1.3)

On the other hand, it is expected that the more efficient refurbished power station will compete more effectively in the National Electricity Market and therefore it will generate more electricity annually than did the old station, resulting in potentially greater emissions of NOx on an annual basis.

In the assessment of potential regional and inter-regional ozone and photochemical (smog) impacts, it is the rate of NOx emission at full load on days conducive to smog formation that is relevant to assessing the maximum potential impacts of the refurbished power station, rather than the annual emission.

The formation of NO_2 and ozone in the lower atmosphere is dependant upon numerous factors, relating to the interaction of various organic and inorganic reagents, meteorological conditions, and the local/regional atmospheric NO_x load.

The photochemical smog study for the yet to be commissioned Colongra Gas Turbine (Cope et. al. 2005) examined the impact of the open cycle gas turbine facility, a new significant NO_x emission source in this region. The following sections provide an assessment of the likely impact of the rehabilitated Munmorah Power Station on regional and inter-regional air quality, considering the probable NO_2 and O_3 impacts separately.

7.1 Ozone

The Colongra assessment over several historically high ozone concentration days showed that the Colongra Gas Turbine would have a negligible impact upon exceedances of the criterion stipulated by the NSW DECC over the one hour averaging period for both NO_2 and O_3. This assessment included Munmorah Power Station operating two units at 600MW (same emission as the rehabilitated 700MW station).

The isopleths shown in Figure 7.1 are for hourly averaged ozone ground level concentrations over the period 11-13 March 1998 (Cope et. al., 2005). The plot on the left is the overall predicted ozone concentration, the plot on the right being the difference between the baseline, which includes Munmorah Power Station emissions, and the test case (Colongra Gas Turbine emissions included).

The highlighted plots show that the highest increase in predicted concentration, once the Colongra gas turbine commences operating, is expected to occur in a small area over sparsely populated but densely forested regions north of Lithgow. These predicted increases in ozone, for one hour and four hour averaging periods with Munmorah operating, were accepted and the Colongra Gas Turbine project was approved in July 2006.

The results from this study (Cope et. al., 2005) indicate that the formation of ozone through this region is not limited by the availability of NO_x in the atmosphere but rather on the availability of AVOC and BVOC (Nelson et. al., 2002). A similar trend is observed when the results for the other historical ozone event days considered within this study are analysed. This trend was first outlined by Nelson (et. al.) (2002) (IRTAPS).

The proposed rehabilitation of Munmorah Power Station is unlikely to be a major contributor to any exceedances of regulated ozone criterion in the Central coast region of NSW or in the Greater Metropolitan Region of Sydney.

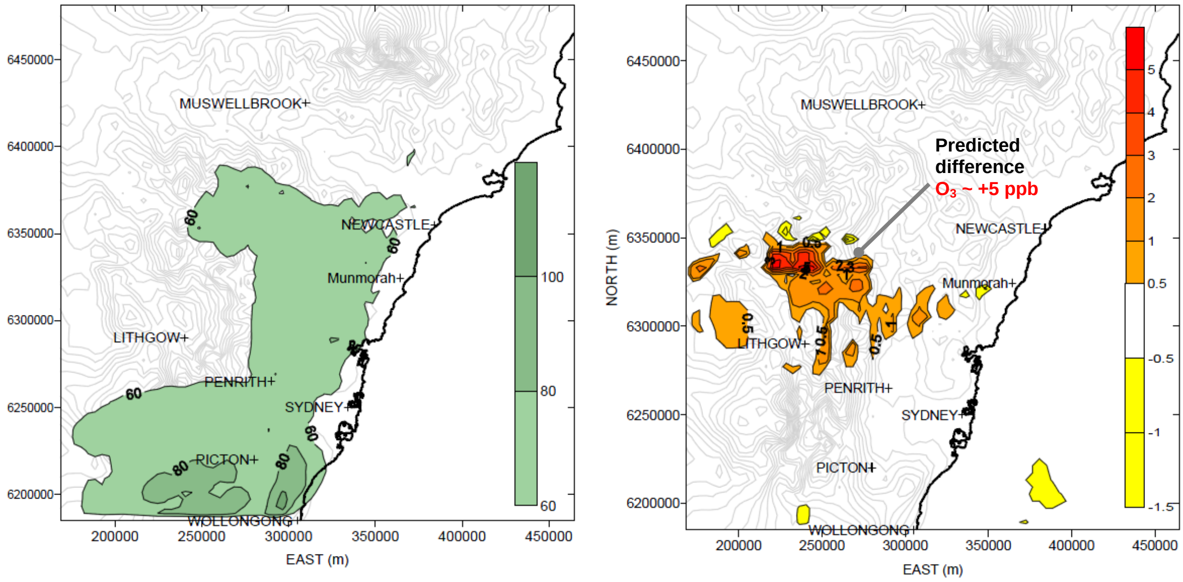


Figure 7.1 Hourly averaged O_3 ground level concentrations (ppb) – Baseline case (left) and test case (with Munmorah gas turbine) (right) (Cope et. al., 2005).

7.2 Nitrogen dioxide

The assessment of the effect of the Colongra gas turbine facility upon NO_2 impacts in the regional setting included Munmorah Power station (two Units) operating at full load. This information has been used to infer the likely air quality impacts following the rehabilitation of Munmorah Power station.

The hourly averaged NO_2 concentration isopleths in Figure 7.2 show that a significant addition to the atmospheric NO_x load in the form of emissions from Colongra gas turbine is not expected to lead to appreciable air quality impacts in the urbanised regions along the coast.

A relatively minor change in the temporal anthropogenic NO_x emissions profile through this region following the proposed rehabilitation program and the operation of Colongra Gas Turbine is not likely to have any appreciable adverse impacts upon either regional or inter-regional air quality.

The predicted impacts of both Munmorah Power Station and Colongra Gas Turbine operating were assessed and approved by the Department of Planning in consultation with the DECC (DOP 2006).

The rehabilitation of the Munmorah plant will decrease the intensity of NO_x emissions from the plant. The effect of this change will decrease regional NO_2 or O_3 concentrations over an hourly averaged time period. The effect of a change in atmospheric mixing ratios (VOC/NO_x) varies significantly through diurnal, seasonal and weekday-weekend basis, with motor vehicle emissions being the primary driver of this system. This complexity cannot be simplified in terms of a single figure.

The qualitative assessment of existing relevant work in the Colongra assessment demonstrated that there will be no adverse impacts upon the regional and/or inter-regional atmospheric environments following the reduction of NO_x emissions through the rehabilitation of Munmorah.

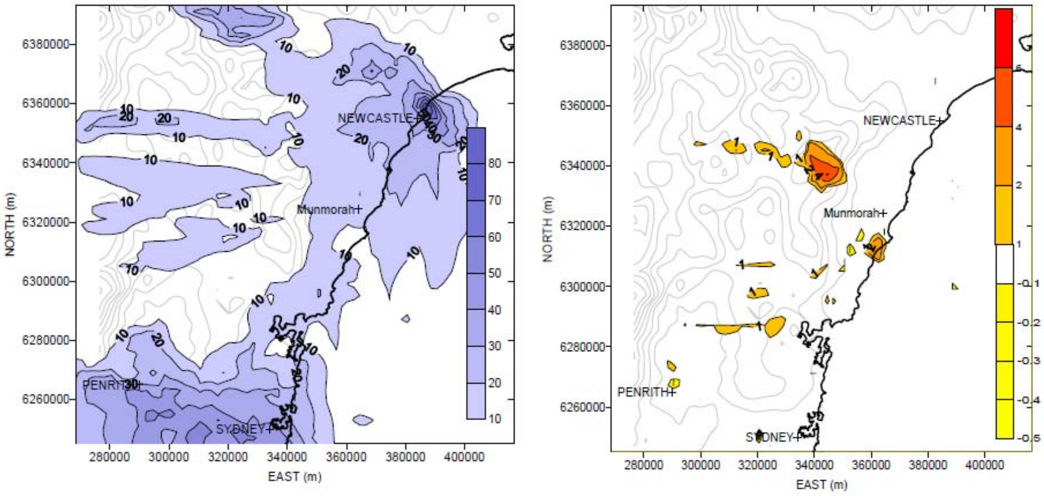


Figure 7.2 Hourly averaged NO_2 ground level concentrations – Baseline case (left) and test case (with Munmorah gas turbine) (right) (Cope et. al., 2005).

7.3 Acid deposition impacts

The deposition of NO_x and SO_2 from the atmosphere can lead to acidification of freshwater bodies and soils over time, via wet and dry deposition processes. Acid deposition can lead to a range of adverse outcomes including damage to forests and crops, soil changes and loss in fertility, damage to aquatic systems including loss of sensitive freshwater species and damage to materials, buildings and monuments.

Uniform environmental standards for acid deposition do not exist because ecosystems vary significantly in their ability to tolerate and neutralise acid inputs. In describing the potential for acid deposition to cause adverse outcomes reference is often made to "critical" or "target" loads, which is the level of acid input below which adverse outcomes are unlikely to occur in the long term – for the specified ecosystem or region under consideration.

Between 1992 – 1996 CSIRO Atmospheric Research (CSIRO 1997) carried out an extensive measurement program and assessment of acid deposition in the Central Coast and Hunter Valley regions (CCHV). This work was reported to the then Environment Protection Authority.

The CSIRO concluded that:

- "...*acid deposition derived from power station emissions can be measured and inferred at some locations in the Central Coast- Hunter Valley region, although at rates that are low by world standards. There is no significant influence apparent on the potentially sensitive native bushland to the west and south west of the Hunter Valley*."
- "*Therefore, at this stage, given the level of understanding achieved by the Study, a "watching brief" is probably all that is required to ensure an ongoing knowledge of the state of acid deposition in the region, unless any significant changes in emissions, land-use or other related factors occur."*

The measured deposition levels at the 2 sites in the coastal region (Catherine Hill Bay and Dooralong) and at a site slightly further inland (Abermain) were assessed as being below the target load for soils in the region, that is below levels of long-term environmental concern.

In considering potential acid deposition impacts, it is the annual emission of acid gases on a regional scale that is relevant, as opposed to short-term peak concentrations from individual facilities. It is not expected that the proposed refurbishment of Munmorah Power Station will significantly change the annual emission of acid gases on a *regional scale*, as there are other larger emitters nearby.

However, notwithstanding this consideration and consistent with the CSIRO 1997 conclusions, it would be prudent to re-visit the benefit in undertaking acid deposition monitoring in the region.

- CSIRO 1997, Central Coast and Hunter Valley Acid Deposition Study. December 1992 - December 1996. Final Report to Macquarie Generation, Delta Electricity and Pacific Power

8. Mitigation and control measures

8.1 International Best Available Techniques (BAT)

The European Council under Article 16(2) of Council Directive 96/61/EC required the Commission to organise '*an exchange of information between Member States and the industries concerned on best available techniques, associated monitoring and developments in them*', and to publish the results of the exchange.

The 'Large Combustion Plants' Best Available Techniques Reference (LCP BREF) is a document produced under this Directive. The LCP BREF covers large combustion plants and includes specific BATs applicable to coal combustion plants.

The following information, sourced from the BREF is provided as background information.

8.1.1 Sulfur dioxide

Removal of SO_2 from coal fired power stations can be achieved by the implementation of the following measures (DTI, 2000).

Fuel switching

This could include switching to coal sources with lower sulfur content or making a switch to natural gas. As part of the Munmorah rehabilitation project, the Proponent is proposing to reduce the limit of sulfur in coal from 1% to 0.7%. Should co-firing with natural gas proceed, this would further reduce the SO_2 emissions further.

Desulfurisation technologies

The following desulfurisation options are available:

- Pre-combustion: this involves removing sulfur with chemical cleaning processes. However coal cleaning does not remove inorganic sulphur (pyrites) and it is not practised on a commercial scale. Gasification could be considered a pre-combustion technology (IGCC). Although commercially available, this technology is still not fully mature and is not considered feasible in the short to medium term due to high construction costs (See Section 2.3.3.).
- During combustion: this involves the addition of sorbents eg lime or limestone to the furnace during combustion. Although this technology has been used in pulverised fuel boilers, it is more applicable to fluidised bed combustion where higher residence times (between the SO_2 and sorbent) can be achieved.
- Post-combustion: this is the most common method of achieving sulfur emission reductions from conventional coal fired power stations. Flue gas desulfurisation (FGD) technologies include limestone gypsum wet scrubbing, sea water scrubbing, combined de-SO_x and de-NO_x technologies, ammonia scrubbing etc. The use of FGD technologies also results in significant increases in the use of auxiliary power.

The SO_2 levels potentially available from the implementation of the BAT are outlined in Table 8.1. As discussed in Section 4.4, the Proponent proposes a lower maximum sulfur level in the fuel from 1% to 0.7% to mitigate SO_2 emissions.

The performance of the rehabilitated plant is governed by its original design characteristics and practical/economic factors. As shown elsewhere in this assessment, the improved performance is considered acceptable. Design constraints are discussed further in Section 8.1.4.

Table 8.1 Directive 96/61/EC – SO_2 emissions associated with coal combustion BAT (existing plants)

<table>
<tr><th>Fuel</th><th>Combustion techniques</th><th>Emission control techniques</th><th>SO_2 emission level associated with BAT (mg/Nm^3)</th></tr>
<tr><td rowspan="3">Coal
Capacity > 300 MW_{th}</td><td>Pulverised/ bubbling/circulating fluidised bed combustion</td><td>Low sulfur fuel, pulverised combustion.
Wet/dry (sorbent injection) flue-gas desulfurisation
Seawater scrubbing
Combined techniques for the reduction of NO_x and SO_2.</td><td>20-200$^{(1)}$ mg/Nm^3</td></tr>
<tr><td>Bubbling/pressurised fluidised bed combustion</td><td>Low sulfur fuel
Limestone injection</td><td>100-200$^{(2)}$ mg/Nm^3</td></tr>
<tr><td>Bubbling fluidised bed combustion</td><td>Low sulfur fuel
Wet flue-gas desulfurisation</td><td>20-200$^{(3)}$ mg/Nm^3</td></tr>
</table>

(1) Upper level of 400 mg/Nm^3

(2), (3) Upper level of 300 mg/Nm^3

These levels are proposed by Industry (EU) because they claim that better takes into account the fuel characteristics, the inlet flue-gas SO_2 concentration affects the BAT achievable levels considering the agreed wet scrubber SO_2 removal efficiencies of 85 – 98 %, the high energy consumption of such a wet scrubber system in relation with the net unit efficiency requirements, and because an optimisation is necessary between emission control technique performance (low emission levels) and related energy consumption (energy penalty).

8.1.2 Oxides of nitrogen

Nitrogen bound in the coal, and nitrogen present in air contributes to the formation of NO_x during combustion. The following mechanisms contribute to the formation of NO_x:

- Thermal NO_x results from the presence of nitrogen in combustion air reacting with oxygen at high temperatures (5-25% of total NO_x formed).
- Fuel NO_x results from the oxidation of the nitrogen in the fuel (70-80% of total NO_x formed)
- Prompt NO_x is formed at the flame front (<5% of total NO_x formed).

Investigations have shown that optimisation of the boiler can achieve up to 20% reduction in NO_x emissions. Optimisation can be achieved through balancing fuel and air flows, reducing excess air levels etc (DTI, 1997).

Combustion modification technologies include the following:

- installation of low NO_x burners: these burners aim to reduce the temperature and oxygen availability in the flame by various means;
- air and fuel staging: this technology aims to stage the supply of combustion air and fuel through the burners with ~70-90% air being supplied to the burners and the remaining 10-30% being injected above the burners (referred to as 'overfire' air);
- reburning: this involves the staged supply of fuel and combustion air in the furnace. Stage 1 includes the primary zone where coal is burnt with excess air to produce NO_x. Stage 2 involves the addition of a secondary fuel, either natural gas, coal or oil, which is injected above the burner to create the reburn zone reducing the NO_x formed in the Stage 1 to molecular nitrogen. Stage 3 involves the injection of the remaining combustion air to ensure complete combustion. Up to 70% NO_x reduction can be achieved using this mechanism.

These are relevantly inexpensive modifications which can achieve up to 50% NO_x reduction when applied individually (DTI, 1997).

A number of flue gas NO_x reduction systems are available commercially. These include:

- selective catalytic reduction (SCR) – 90% reduction achievable
- Non-selective catalytic reduction (NSCR) – 50% reduction achievable
- combined NO_x/SO_x control (DTI, 1997)

Flue gas treatment is more expensive due to high capital, operating and maintenance costs and introduces collateral technical and environmental issues such as transport, handling and consumption of chemicals, reduced efficiencies, increased greenhouse gas emissions, resource consumptions including large volumes of fresh water, along with significant waste management issues.

It is proposed that tangential low NO_x burners with separate overfire air technology (TLN2) be installed during the rehabilitation. These burners will provide significant reductions and are likely to meet, or be very close to Group 6 limits (500 mg/Nm^3). This emission level will be achieved at a modest cost compared to the costs and introduce other penalties associated with the installation of catalytic or non-catalytic de-NO_x.

The BAT emissions guideline for the NO_x emissions achievable by coal and/or gas combustion within existing plants is provided in Table 8.2. The NOx emission levels from the proposed facility will be within the practicable range for the oldest of the existing combustion plants with thermal capacity > 300 MW as outlined in Table 8.2.

Furthermore due to the lack of any NO_x emission trading systems for, and the onerous responsibilities placed upon European member states to reduce industrial source NO_x emissions to mitigate the large diffuse NO_x load (as a result of the extent of industrialisation) the most stringent BAT recommendations are not relevant to the Australian air environment. In addition to this, the very low levels of ambient NO_2 in the local atmosphere recorded over the past decade (see Section 5.1) demonstrate that further control measures are unnecessary. High quality low NO_x burners will provide significant reductions and are expected to meet Group 6 limits. The additional costs of catalytic or non-catalytic de-NO_x is not justified given the low ambient impacts.

Table 8.2 Directive 96/61/EC - NO_x emissions associated with coal and gas combustion BAT (existing plants)

Fuel	Combustion technique	NO_x emission level associated with BAT (mg/Nm^3)
Coal Capacity > 300 MW_{th}	Pulverised combustion. Combination of primary measures to reduce NO_x (incl. air and fuel staging, low NO_x burners, reburning etc.) in combination with selective catalytic reduction or combined techniques	90-200$^{(1)}$ mg/Nm^3
Gas (new and existing gas-fired boilers) O_2 reference level – 3%	Low NO_x burners, selective catalytic and non-catalytic reduction.	50-100 mg/Nm^3 (upper limit – 120 mg/Nm^3)

(1) The document states that for the European scenario a strict target of 150 mg/Nm^3 can be achieved in a cost effective way by a system of NO_x emission trading, this infrastructure is not available to Australian operators. However, to have maximum flexibility in the system of NO_x emission trading, a Member State explained that for the oldest combustion plants, a range of 100 – 650 mg/Nm^3 for existing plants over 300 MW was more practicable.

8.1.3 Fine particulates, Persistent organic and non-organic pollutants

The best available techniques for controlling the emissions of dust, and by association particulate bound trace elements and VOCs are stipulated in the LCP BREF document. Achievable particulate emission limits summarised in Table 8.3).

Table 8.3 Best available techniques emission limits for the control of dust from large existing coal fired combustion plants

Type of fuel	Rated thermal input (MW_{th})	Emission limit values (mg/Nm^3)
Solid	≥ 500	50*
	< 500	100

* A limit value of 100 mg/Nm^3 may be applied to plants with a rated thermal input greater than or equal to 500 MW_{th} burning solid fuel with a heat content of less than 5,800 kJ/kg (net calorific value), a moisture content greater than 45 % by weight, a combined moisture and ash content greater than 60% by weight and a calcium oxide content greater than 10%.

Many trace metals preferentially adsorb onto smaller particles i.e. those with aerodynamic diameter < 2.5μm. Thus it is important to apply best available techniques for controlling these fine particles and adsorbed pollutants that not only include metals but also persistent organic pollutants (POPs) (including polycyclic aromatic hydrocarbons).

The main technologies used for the removal of fly ash from coal fired power stations include:

- electrostatic precipitation;
- electrostatic precipitation with sulfur trioxide (SO_3) conditioning;
- fabric filters.

The LCP BREF document states that the BATs for large coal combustion plants in this instance is the use of fabric filters, as they are highly efficient at controlling small particles; i.e. more so than electrostatic precipitators.

Fabric filters were installed to replace the older electrostatic precipitator technology at Munmorah Power Station in the late 1980s.

The implementation of effective management strategies is also important in maintaining the high particulate control efficiencies associated with a fabric filter emissions control system. Baghouse fabric filter management strategies are stipulated to ensure that they do not become clogged with particulate matter and include;

- monitoring of pressure differentials (dPs) across the fabric filters in the baghouse,
- ensuring that the actuators shaking the dust off the fabric filters are operating properly,
- ensuring the availability of spare sections through the baghouse which can be brought in to service in the event of a tear in the fabric filters in another section of the bag house.

The limits that are achievable through application of the BATs are provided in Table 8.3. The particulate limit applicable to Munmorah Power Station is 50 mg/Nm^3, this limit coincides with the NSW DECC Group 6 emission standards as well as BAT limits. The assessment by Malfroy (2007) (refer relevant extract in Appendix A) reported the levels recorded over the period from 2004-2006 were generally within this guideline: Unit 3 (2 – 14.5 mg/m^3) and Unit 4 (11.5 – 51.6 mg/m^3).

The emissions of persistent organic pollutants such as polychlorinated dibenzodioxin and dibenzofuran (PCDD/F) along with inorganic pollutants such as mercury can be further controlled where emission levels are unacceptable. Additional control of organic compounds and trace elements can be achieved through the adoption of sorbent injection techniques. However the significant economic costs of this type of infrastructure significantly outweighs any potential environmental benefits that arise from its application.

8.1.4 Design constraints

The primary constraint in regards to the implementation of the described BAT arises from a problem of optimisation. The various pieces of plant in a typical facility such as Munmorah are highly interrelated and operate in a manner that requires cross optimisation to enable the greatest efficiency in heat throughput and emissions control. It is thus important to note that in this instance only the burners are being replaced, given that they contribute most significantly to combustion inefficiencies and emissions.

The physical constraints associated with the design of this system do not allow for the optimisation of the entire boiler system for the specific temperatures and pressure of flow created by the new burner technology. The addition of any emissions control system would lead to further inefficiencies, as this piece of plant effectively acts as a flow restriction device through the power plant system. The primary penalty that is associated with additional non-optimised pieces of plant is decreased generation efficiency, and will potentially also lead to the non-attainment of the maximum level of emissions control. This decreased electrical generation efficiency would result in a greenhouse gas penalty and a proportionate increase in other air and water emissions. Thus further emissions control would entail a significant economic cost with minimal environmental benefits. Nonetheless, despite its age, the plant is still using some worlds' best practice emissions control technology in the form of the baghouse fabric filters, and low NO_x burners to minimise air emissions.

8.2 Mitigation and Management Measures

8.2.1 Construction

Dust sources during the rehabilitation works include vehicle emissions, and dust generated from demolition of redundant structures, construction associated with the rehabilitation works and upgrading of the existing conveyors. Dust suppression measures are proposed to minimise impacts on local air quality throughout the construction period.

Much of the construction work associated with the rehabilitation will occur within the existing buildings and involve the replacement of existing components and systems, as such it would not be expected to involve the generation of significant quantities of dust. Potentially dusty activities would be identified in the Construction Environmental Management Plan (CEMP) and appropriate control measures implemented.

The following dust mitigation measures are proposed to be implemented, as appropriate, through the construction phase:

- Use of paved surfaces for high traffic areas around the site
- Routine wash down of hard stand areas
- Restrict traffic to defined access ways
- Ensure wind blown dust is kept to a minimum through strategic use of dust suppression including watering of stockpiles, unsealed access roads and work areas
- Management of stockpiles to minimise dust generation
- Maintain low vehicle speeds on unsealed roads (e.g. 40km/h)
- Trucks transporting material to and from the premises on public roads would be covered with tailgates securely fixed to prevent wind blown emissions and spillage. The covering would be maintained until immediately before unloading
- Ensure trucks and plant involved in off road activities exit the site via a cleaning facility established at the exit of the construction site to prevent any dirt/soil being transported onto external public roads
- Ensure no incineration or burning of any material on the premises. Prompt action would be taken to extinguish any fire

- Record and action all air quality complaints
- Clean up of all spills
- Revegetation of disturbed areas as soon as works are completed

The nominated construction contractor would be required to prepare and implement a dust management plan as part of the CEMP.

8.2.2 Operation

Mitigation

The current operational practises and the proposed rehabilitation of Munmorah Power Station include a number of mitigation measures to control atmospheric emissions.

- The use of fabric filters, which were installed at Munmorah Power Station in the 1990s to collect fly ash from the stack gas stream
- The retrofitting of "low-NO_x" burners to control the production of NO_x to meet Group 6 limits (500 mg/Nm3).
- Limiting the sulfur content of the coal from 1% (the current EPL limit) to 0.7%. to control SO_2 emissions. As sulfur emissions are directly related to the sulfur content in the coal, any co-firing with gas will effectively act as an SO2 emissions control mechanism
- The implementation of dust mitigation and control techniques to control the emission of "fugitive" dust

In addition to the above measures, the proposed rehabilitation works may incorporate post combustion carbon capture technology should it be required in the future. Future installation of a gas delivery system would be designed and constructed to comply with the applicable standards and regulations.

It is expected that the increased efficiency of the plant resulting from the rehabilitation will result in a reduction in the emissions to atmosphere per unit of electricity generation, particularly the emission of greenhouse gases.

Specific measures adopted to reduce fugitive dust emission from the site include:

- Use of paved surfaces for high traffic areas around the site
- Routine wash down of mobile plant and hard stand areas
- Maintenance of equipment such as the coal handling and ash management systems to minimise leaks and spills
- Management of stockpiles to minimise dust generation
- Management of ash storages in accordance with the principles outlined in the Central Coast Ash Management Plan
- Record and action all air quality complaints
- Clean up of all spills

The level of activity through the coal stock pile is expected to change, given the proposal to operate the plant at a higher level. However the appropriate maintenance of air quality management plans and adherence to mitigation measures will lead to the maintenance of satisfactory observed air quality. Furthermore, should gas co-firing be implemented, this will lead to reduced coal handling with inherently lower air-borne coal dust levels.

Coal dust air quality management is addressed with the use of water tankers and spray systems. A Water Tanker with water distribution system is used to control airborne coal dust from the stockpiles on dry, windy days especially when coal truck and dozer movements are high. On average two runs per power station per day are required and are carried out by appropriately trained and qualified personnel. This typically involves many truck movements being scheduled each day.

A truck wash facility has been placed at Vales Point to reduce coal dust on public roads. This is used every time trucks re-enter the public road system. There is no truck wash facility currently available at Munmorah Power Station as there are no coal deliveries by truck to the site.

Conveyor water sprays to suppress dust are used as required on the RV1 coal conveyor from the rail unloader to Vales Point .The conveyors from Mandalong mine also have spray systems which are used as required.

The management of dust at the Delta Central Coast ash dams is outlined in the Delta Central Coast Ash Management Plan (Delta Electricity, 2009) as discussed in the following section. Dusting from the ash dam occurs on windy days from two primary sources – cenospheres and fly ash. Furnace is not normally a problem as the furnace ash tends to be too heavy to be left by the wind. Therefore, based on the current arrangement, most of the following actions apply to the Vales Point Ash Dam.

The properties of cenospheres make them very susceptible to dusting when they are dry and exposed to the wind. Harvesting of cenospheres has proved to be effective in controlling airborne cenospheres provided regular harvesting occurs. The regular harvesting of cenospheres in recent years has provided good control over the retention of cenospheres and the suppression of wind induced dusting from the Vales Point Ash Storage area. Harvesting by (Erinbrook Pty Ltd (Blue Circle Ash)) is currently undertaken from a bay upstream from the concrete skimmer structure.

The primary dust control for fly ash is to keep the surface wet. Currently this is achieved by maintaining a relatively small fly ash delta. The principles are:

- Segregate the delta into manageable zones. Once the ash delta is reduced to manageable areas experience has shown that the slurry water wetting the ash should be sufficient to prevent dusting.
- If necessary the water level can be used to cover new ash deltas when the potential for dusting is high.
- Progressive capping and revegetation of the fly ash once it attains its final height
- Where larger areas of dry ash are exposed for prolonged periods additional methods such as binding the surface using Polyvinyl-alcohol (PVA) can be used.

A number of possible methods are available for capping. This includes the use of landfill, topsoil, chitter, furnace ash or clay as an over topping layer of material or mixing the last layer of the fly ash with a binder such as clay or cement.

Ambient air monitoring network

The preceding analysis of observed local air quality records for the Wyee and LMPS have shown that the existing air quality is well within relevant criteria. The period of historical records include years when Munmorah Power Station has operated as a two unit power station, with periods when this has been at full load capacity.

The predicted worst case impact pollutant isopleths in Appendix C, as well as the historical analysis by Holmes air sciences (2005), illustrate that the LMPS air monitoring station is reasonably located to measure potential worst case impacts at a sensitive receptor location. The pollutant isopleths illustrate that peak concentrations are expected to occur to the north east of the facility, through an area proximate to where the Lake Munmorah Primary School air monitoring station is currently located (refer Appendix C for pollutant contours generated as part of the modelling study undertaken for this project).

The pollutant contours also show that peak concentrations from Munmorah are not likely to be captured by the observations at the Wyee air monitoring station.

A consideration of the long term monitoring results combined with the predicted results from the current dispersion modelling indicates that it may be an appropriate time to review the existing ambient monitoring network to ensure that it continues to provide an adequate level of coverage for the protection of human health and the environment.

Such a review would best be undertaken cooperatively with DECCW and include consideration of other major sources in the region and other existing monitoring sites.

This would best done in consideration of the whole Central Coast ambient monitoring network, which includes a recently established additional ambient monitoring station at Morisset Peninsula that is operated by Delta Electricity.

Stack emissions monitoring

Delta will continue to carry out continuous and manual in stack emissions monitoring, as it has done so historically, for the regulated pollutants stipulated within its PoEO (Clean Air) Act licence, in order to monitor compliance with the regulated emission limits.

Delta has been in discussion with the DECC regarding improvements in stack sampling methods necessary to meet current stack emission sampling requirements. The Proponent has proposed that the rehabilitation will include a requirement to upgrade sampling to include in-stack sampling to meet the current DECCW Approved Sampling Methods. This will improve the quality of data and better monitor performance of the combustion and associated emissions control systems.

The sulfur content of coal is currently monitored through analysis of a monthly composite sample of the coal. DECCW has proposed to establish an emission limit for SO_2. Should this be the case, the need to report coal sample data to DECCW may no longer be required. The need for additional monitoring would be considered, as required, to monitor compliance with any such licence conditions.

9. Conclusion

The preceding air quality assessment has assessed the effects of the rehabilitated Munmorah Power station on air quality, in accordance with the requirements of the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005). The nature of the rehabilitation works proposed for the Munmorah Power Station with regard to air quality issues have been considered, along with the requirements of existing regulations with regard to emission limits and ambient air quality goals.

Previous studies and technical investigations undertaken as part of the assessment of the power station following rehabilitation (Aurecon 2009) have demonstrated that emissions of all pollutants will be compliant with POEO (Clean Air) Regulation Group 6 emission standards following the installation of low NO_x burners.

In addition to this the Proponent has also committed to a reduction in the licensed maximum sulfur content in coal from 1.0% to 0.7% sulphur, which is well above historical averages for coal consumed by Munmorah Power Station, which is 0.41%. The assessment has also assumed a worst case coal composition for the other elements assessed, based on historical data and available assessments from potential future supplies.

The existing environment has been characterised through an analysis of the location of sensitive receivers along with a review of the meteorology and current air quality of the study area. The assessment has demonstrated that the meteorological and background air quality inputs to the modelling are representative and acceptable. Allowance has been made for new approved emission sources that are likely to overestimate the additional contribution of these sources to air quality.

The analysis of the existing environment has shown that the air quality through this region is good. An assessment of the air quality data has shown that only a very small percentage of the records are above what is regarded as a low baseline. This record includes the effects of the currently operating Munmorah Power Station.

The extent of worst case predictions of air quality impacts has been illustrated in the plots, provided in Appendix C, and the worst case predictions at the identified sensitive receivers has been assessed.

The primary conclusions from this study are discussed in the following sections. The air quality impacts presented represent the predicted worst case, which is well in excess of the air quality effects that might be expected under normal operating conditions.

9.1 Local air quality impacts

There is likely to be little to no adverse impact upon local air quality as a result of the rehabilitation. Following rehabilitation the contribution of Munmorah to local air quality is expected to either remain similar or in the case of NO_x be reduced. The consideration of cumulative impacts has shown the importance of contributions from the other sources in the region.

Based on modelling using maximum expected emission rates and inputs from new sources at maximum predicted contribution rates, the modelling has predicted very infrequent exceedances of short term assessment criteria for SO_2, NO_2 or PM_{10}. These predicted exceedances would be most unlikely to occur in reality as all the factors contributing to these predictions are unlikely to coincide in time and space.

The majority of any exceedances of fine particle (PM_{10}) limits will be associated with local wind blown dust events and bushfires. The assessment has demonstrated the negligible contribution that emissions from Munmorah make to cumulative PM_{10} levels.

The assessment is based on the coincidence of maximum coal sulfur levels occurring with maximum power station output under very infrequent adverse meteorological conditions with contributions from new sources not represented in the existing air quality.

9.2 Regional air quality impacts

There is likely to be little to no adverse impact on regional or inter regional air quality in terms of peak ozone and NO_2 ground level concentrations.

This conclusion is based on a significant body of work undertaken by the CSIRO, for the Greater Sydney Metropolitan region as a whole and more specifically for the Central Coast region.

9.3 Other pollutants

Emissions of other substances would be at or within the Group 6 emission limits. At the modelled emission rates the predicted ground level concentrations are well within air quality goals.

9.4 Proposed emission limits

Based on consideration of the Group 6 emission limits provided in Schedule 3 of the POEO (Clean Air) Regulation, the preceding investigations of air quality impacts and consultations with DECCW, the following pollutant discharge concentrations from the stack are proposed to ensure the impact of the rehabilitation on air quality is acceptable. The following proposed emission limits indicated in Table 9.1 are at or more stringent than Group 6 emission limits.

Table 9.1 Proposed Emission Limits to Apply to Munmorah Power Station

Pollutant	Units of Measure	POEO Regulation Group 6 Emission Limit	Proposed 100 Percentile Concentration Limit[1]	Averaging Period	Reference Conditions
Cadmium	mg/m3	0.2	0.04*	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Chlorine	mg/m3	200	100*	1- hour block	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Flourine (F2) and any compound containing fluorine as total fluoride (HF) equivalent	mg/m3	50	30*	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Hydrogen Chloride	mg/m3	100	50*	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Mercury	mg/m3	0.2	0.2	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Nitrogen dioxide (NO2) or nitric oxide (NO) or both, as NO2 equivalent	mg/m3	500	500	1-hour block	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Solid Particles (total)	mg/m3	50	50	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Sulfuric acid mist and sulphur trioxide as (SO3)	mg/m3	100	40*	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Sulfur dioxide	mg/m3	N/A	1700		dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)

Pollutant	Units of Measure	POEO Regulation Group 6 Emission Limit	Proposed 100 Percentile Concentration Limit[1]	Averaging Period	Reference Conditions
Type 1 and Type 2 substances in aggregate	mg/m3	1	1	1-hour or the minimum sample period specified in the test method, whichever is the greatest	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)
Volatile organic compounds as n-propane equivalent	mg/m3	40 VOCs or 125 CO	40 VOCs or 125 CO	1-hour rolling	dry, 273 K, 101.3 kPa, and 7 % oxygen (O2)

Note 1 - Measurement of pollutant concentrations shall be undertaken in accordance with reference sample methods specified in the 'Approved Methods for Sampling and Analysis of Pollutants in NSW' at a frequency specified in the Proponent's Environment Protection Licence issued under the Protection of the Environment Operations Act 1997.
Note *: Substances with emission limits that are proposed to be reduced to be less than the Group 6 limits.

9.5 Mitigation measures and monitoring

9.5.1 Construction

Dust sources during the rehabilitation works include vehicle emissions, and dust generated from demolition of redundant structures, construction associated with the rehabilitation works and upgrading of the existing conveyors.

The assessment has recognised that much of the construction work associated with the rehabilitation will occur within the existing buildings and involve the replacement of existing components and systems. As such these activities are equivalent to normal maintenance operations at the plant. These activities would not be expected to involve the generation of significant quantities of dust.

Potentially dusty activities would be identified in the Construction Environmental Management Plan (CEMP) and appropriate control measures implemented.

Dust suppression measures are proposed to minimise impacts on local air quality throughout the construction period. These would be incorporated in an air quality management plan prepared by the nominated construction contractor as part of the construction EMP.

9.5.2 Operations

Mitigation

The assessment has examined current operational practises and the proposed rehabilitation of Munmorah Power Station includes a number of mitigation measures to control atmospheric emissions, including the use of fabric filters, retrofitting of "low-NO_x" burners and limiting the maximum sulfur content of the coal.

Additional measures available include allowing for the incorporation of post combustion carbon capture technology should it be required and installation of a gas delivery system to enable gas firing.

It is expected that the increased efficiency of the plant resulting from the rehabilitation will result in a reduction in the emissions to atmosphere per unit of electricity generation, particularly the emission of greenhouse gases.

The dust mitigation and control techniques employed to control the emission of “fugitive” dust have been discussed and shown to be acceptable and would continue to protect local air quality.
This has included specific measures adopted to reduce fugitive dust emission associated with the management of coal and ash.

Air quality monitoring network

The assessment has demonstrated that current air quality monitoring network is able to adequately capture the worst case air quality impacts from Munmorah Power Station.

A consideration of the long term monitoring results combined with the predicted results from the current dispersion modelling indicates that it may be an appropriate time to review the existing ambient monitoring network to ensure that it continues to provide an adequate level of coverage for the protection of human health and the environment.

Such a review would best be undertaken cooperatively with DECCW and should include consideration of other major sources in the region and other existing monitoring sites.

Stack emissions monitoring

The Proponent would continue to carry out continuous and manual in-stack emissions monitoring, as has been done historically, for the regulated pollutants stipulated within its POEO (Clean Air) Act licence, in order to monitor compliance with the regulated emission limits. The details of any changes to the monitoring program would be negotiated with the DECCW, prior to the rehabilitation.

The Proponent has proposed that the rehabilitation will include a requirement to upgrade sampling to improve in-stack sampling to meet the current DECCW Approved Sampling Methods. This will provide better quality data and better monitor performance monitoring.

10. References

Aurecon, 2009. Munmorah Rehabilitation Draft Technical Investigation Report Delta Electricity. Draft report to Delta Electricity, 33 pp.

Blanchard, C.L., Fairley, D., 2001. Spatial mapping of VOC and NO_x-limitation of ozone formation in central California. Atmospheric Environment, 35, 3681-3873.

Cox, J., 2009, email 25 June 2009, Attachment: Extract_from Draft2_ESTIMATED AIR EMISSIONS.docx. judith.cox@paeholmes.com.

Cope, M.E., Physick, W.L., 2005. Photochemical pollution assessment of a proposed gas-fired power station at Munmorah. CSIRO Report to Parsons Brinckerhoff, 28pp.

CSIRO 1997 Central Coast and Hunter Valley Acid Deposition Study. December 1992 - December 1996. Final Report to Macquarie Generation, Delta Electricity and Pacific Power

European Parliament and the Council 2001. Directive 2001/80/EC - on the limitation of emissions of certain pollutants into the air from large combustion plants. Official Journal of the European Communities.

European Commission Jul 2006. Integrated pollution prevention and control Reference document on Best Available Techniques for Large Combustion Plants. The European IPPC Bureau.

Holmes Air Sciences, 2005. Air Quality Impact Assessment (Technical Paper 4): Proposed open cycle gas turbine plant at Munmorah Power Station. Report to Parsons Brinckerhoff, 55pp.

Hurley, PJ, Physick, WL, Luhar, AK, 2005. TAPM: a practical approach to prognostic meteorological and air pollution modelling. Environmental Modelling and Software, 20(6), 737-752.

Jin, L., Tonse, S., Cohan, D.S., Mao, X., Harley, R.A., Brown, N.J., 2008. Sensitivity analysis of ozone formation and transport for a central California air pollution episode. Environmental Science and Technology, 42 (10), 3683–3689.

Lilley, W., Malfroy, H., Physick, W., 2007. Variations in the highest predictions from approved air quality models and implications for air quality assessments. Proceedings of the 14th International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) Brisbane 2007.

Malfroy, H., 2007. Munmorah Power Station An evaluation of factors relevant to an application for the revision of the Environment Protection Licence. Report to Delta Electricity, 26pp.

Nelson, P.F., Azzi M., Cope, M.E., Lilley, W., Carras, J.N., Hurley, P.J. and Hyde, R., (2002). Inter-regional Transport of Air Pollutants Study (IRTAPS). CSIRO Report to Pacific Power International, 94pp.

NEPC, 1998. National Environment Protection Measure. Prepared by National Environment Protection Council, June 1998.

NEPC, 2004. National Environment Protection (Air Toxics) Measure. Prepared by the National Environment Protection Council, April 2004.

NSW DEC, 2005. Approved methods and guidance for the modelling and assessment of air pollutants in NSW, August 2005.

NSW DEC, 2005. Approved methods for the sampling and analysis of air pollutants in NSW. NSW DECC.

NSW DEC, 2005, Quarterly air monitoring report 1-4 Part A: DEC Data, 2004. NSW DEC 2005.

NSW Department of Planning, 2009, Director General's Requirements (project Application: MP 09_0117)

Pielke R.A. (1984). 'Mesoscale Meteorological modelling', Academic Press, Orlando, 612 pp.

Rae, M., Lilley, W., Malfroy, H., 2008. Air quality results for a proposed coal sulfur option May 2008 addendum to Coal sulfur levels on the Central Coast – Air quality management options Nov 2007. CSIRO report to Delta Electricity, 30pp.

Roads and Traffic Authority, NSW, 2006. Traffic volume maps for noise assessment for building on land adjacent to busy roads. Map produced by RTA, RIAMT, SIS Unit.

SA EPA, 2004. EPA Information – Photochemical Smog – what it means for us. EPA 90/04 Govt. of SA Mar 2004.

Sinclair Knight Merz, 2009. Munmorah Units 3 & 4 Rehabilitation Studies Stage 1 – Finalised Scope List Draft 3. Report to Delta Electricity, 27pp.

Wilmott, C.J., 1981. On the validation of models. Physical Geography (2) 184-94.

Worley Parsons, 2008. Munmorah power station – Plant upgrade – Review of issues associated with NO_x emission requirements on Units 3 & 4 in accordance to the clean air regulations Rev 0. Report to Delta Electricity, 47pp