AIR QUALITY ASSESSMENT
STAGE 2 DEVELOPMENT OF KEROSENE VALE ASH REPOSITORY

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Prepared for

Parsons Brinckerhoff

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1 Introduction

This report has been prepared by Holmes Air Sciences for Parsons Brinckerhoff. Its purpose is to assess the air quality impacts associated with the development of Stage 2 of the Kerosene Vale Ash Repository (KVAR), near Lidsdale in NSW. The location of the repository is shown in **Figure 1.**

The report follows the assessment procedures set out in the New South Wales Department of Environment and Climate Change's (NSW DECC) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC**, **2005**). This involves the following:

- A qualitative analysis of the proposal to identify emissions that need to be considered in the assessment
- A review of dispersion conditions and a review of climatic elements for the study area (the area shown in **Figure 1**)
- A review of existing air quality in the area to determine maximum increments in pollutant levels that will still allow the DECC's assessment criteria to be met
- A quantitative analysis of the proposal to develop an emissions inventory suitable for use with the dispersion model
- The development of a terrain file for use with a dispersion model
- Modelling of the dispersion of emissions from the operation of the ash repository
- An assessment of the air quality effects of the ash repository.

2 Description of the proposal

Stage 1 of the KVAR was approved in 2002. It was designed to operate for a period of five years and is now reaching design capacity. It accepts ash from the pulverised coal-fired boilers at the Wallerawang Power Station (WPS). Stage 2 of the ash repository has been the subject of a preliminary environmental assessment and will involve the storage of an additional 5.5 million cubic metres of ash bringing the total storage capacity at the KVAR Stages 1 and 2 combined to 8.0 million cubic metres. This would be sufficient ash storage for an additional eleven years of operation of the WPS. The location of the ash repository and the areas affected by the Stage 1 and 2 operations are shown in **Figure 2**.

The operation of Stage 2 would be similar to that for Stage 1. Fly ash would be pneumatically conveyed from the WPS to a storage silo where it would be conditioned to approximately 15% moisture content for dust suppression and to enhance its compaction properties. It would then be transported from the storage silo via the existing haul road in semi trailers or trucks with dog trailers. Approximately 60 vehicle trips per day would be required. Fly ash would be deposited at the ash placement area and taken up in 1 – 2 metre lifts using compactors and bulldozers to construct a suitable landform and drainage system. **Figure 2** shows the areas involved in Stages 1 and 2 and the haulage route.

Emplacement will progress in an easterly direction initially and then in a northerly direction. Ash would be progressively capped once the design height of 940 AHD was reached. Topsoil taken from the area to be covered would be used for the final capping.

All trucks would pass through a vehicle wash before leaving the ash emplacement. The operation is proposed to be undertaken 24-hours a day and the assessment has been undertaken with this assumption however it is noted that there may be some constraints on operations depending on the results of the noise impact assessment.

3 Assessment criteria

The only significant emission from the ash repository operations will be particulate matter and so the relevant measures of air quality are those that relate to particulate matter (dust). In order for air quality to be considered acceptable, current practice requires that particulate matter concentrations and deposition levels comply with a number of criteria.

The relevant criteria are those specified in the NSW DECC's "*Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*". These are listed below in **Tables 1**, **2** and **3**.

Table 1. Impact assessment criteria for pollutants (for use in modelling)

Pollutant	Averaging period	Concentration
		$\mu g/m^3$
PM_{10}	1-day	50
	Annual	30

In addition, the guidelines provide assessment criteria for total suspended particulate matter (TSP) (see **Table 2**) and for the insoluble component of deposited dust (see **Table 3**).

Table 2. NSW EPA amenity based criteria for total suspended particulate matter (TSP)

Pollutant	Averaging period	Concentration
TSP	Annual	90 $\mu g/m^3$

Table 3. NSW EPA amenity based criteria for dust fallout

Pollutant	Averaging period	Maximum increase in deposited	Maximum total dust deposition
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

4 Dispersion conditions and review of climatic elements

This section describes the dispersion meteorology and general climatic conditions in the area. This includes information on prevailing wind patterns, historical data on temperature, humidity and rainfall. These data will be used in the estimation of emissions and the modelling of the transport and diffusion of the emissions.

4.1 Dispersion Meteorology

The closest meteorological monitoring station is operated by the Mt Piper Power Station. It is located approximately 1 km to the north of the Mt Piper Power Station and approximately 7.5 km to the north-northwest of the site of the ash repository (see **Figure 1**). Meteorological conditions in the study area would be influenced by several factors including the local terrain and land-use. On a small scale, winds would be largely affected by the local topography (see **Figure 3** for a representation of the local terrain). At larger scales, winds are affected by synoptic pressure gradients which would be expected to be similar at both the ash repository and at the location of the meteorological station.

Figures 4 to **7** show seasonal and annual wind roses for 2001, 2002, 2003 and 2004 prepared from the hourly data collected at the Mt Piper Meteorological Station. The data for 2003 is the most complete with a data recovery rate of 95.6%. This satisfies the DECC requirement for 90% data capture for data used in dispersion modelling and these data have been used in the modelling discussed later.

For all years the predominant winds were from the west-southwest. All seasons recorded winds from this sector however in summer there were also winds from the east-southeast and southeast. Winds in autumn, winter and spring were generally from the west-southwest with winds from the north are also common in spring. Annually, the frequency of calm periods (when winds were 0.5 m/s or below) was about 5%. Winter had the highest proportion of calm periods with 8.7%. The mean wind speed in 2003 at the Mt Piper site was 2.5 m/s.

Because of the blocking effect of the topography to the southeast of the ash repository, the southeast winds observed at Mt Piper may not be as common or as strong at the ash repository site as they are at Mt Piper. However the predominant west-southwest winds would be expected to occur at the ash repository and Mt Piper sites. In practice using the data from Mt Piper to assess the transport of dust from operations at the ash repository would be expected to be slightly conservative at least as far as impacts on the closest residential area (which lies to the west of the ash repository) is concerned.

4.2 Atmospheric Stability

Dispersion models typically require information on atmospheric stability class[1] and mixing height[2]. Stability has been determined from measurements of sigma-theta using methods specified by the **US EPA** (**1996**). Hourly estimates of mixing height have been determined using a method described by **Powell** (**1976**).

[1] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford-Turner stability class assignment scheme there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

[2] The term mixed-layer height refers the height of the turbulent layer of air near the earth's surface, into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

Table 4 provides the frequency of occurrence of the six stability classes as determined by US EPA procedure.

It can be seen from **Table 4** that the most common stability class is D-class. Dispersion of pollutants is rapid under these circumstances. D-class stabilities are generally associated with strong winds during day or night-time, or with periods when the percentage of the sky obscured by cloud is high. These conditions inhibit the formation of inversions with the associated poor dispersion conditions.

Table 4. Frequency of occurrence of atmospheric stability class

Pasquill-Gifford-Turner stability class	Frequency (Mt Piper, %)
A	14.4
B	7.8
C	12.6
D	28.8
E	10.6
F	25.8
TOTAL	100

Joint wind speed, wind direction and stability class frequency tables and other statistics generated from the Mt Piper meteorological data for 2003 are presented in **Appendix A**.

4.3 Local Climatic Conditions

The Bureau of Meteorology collects climatic information at Lithgow the outskirts of which are approximately 10 km southeast of the ash repository. Selected observations from this station are presented in **Table 5** (**Bureau of Meteorology, 2004**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm observations. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

The annual average maximum and minimum temperatures experienced at Lithgow are 18.3°C and 6.3°C respectively. On average January is the hottest month with an average maximum temperature of 25.5°C. July is the coldest month, with an average minimum temperature of 0.7°C.

The annual average relative humidity reading observed at 9 am from the Lithgow site is 70 percent, and at 3 pm the annual average is 55 percent. The month with the highest humidity on average is June with a 9 am average of 82 percent, and the lowest is December with a 3 pm average of 47 percent.

Rainfall data collected at Lithgow shows that January is the wettest month, with an average rainfall of 92.9 mm falling over 10.5 days. The average annual rainfall is 860 mm over an average of 126 raindays.

Table 5. Climate information for the study area

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum temperature - deg C	25.5	24.7	22.5	18.4	14.3	11.1	10.4	12	15.4	18.7	21.6	24.5	18.3
Mean no. of days where Max Temp >= 40.0 deg C	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean no. of days where Max Temp >= 35.0 deg C	0.8	0.4	0	0	0	0	0	0	0	0	0.2	0.1	1.5
Mean no. of days where Max Temp >= 30.0 deg C	6.4	4.4	1.3	0	0	0	0	0	0	0.1	1.5	4.1	17.9
Highest daily Max Temp - deg C	37.7	38.4	35.1	30.8	24.6	21.3	21.5	22.5	27.6	33.1	37.2	36.2	38.4
Mean daily minimum temperature - deg C	11.8	12.1	10.1	6.7	3.9	1.8	0.7	1.3	3.4	5.9	8	10.4	6.3
Mean no. of days where Min Temp <= 2.0 deg C	0	0	0.3	2.6	9.5	14.8	19.6	16.8	10.1	4	1.2	0.3	79.3
Mean no. of days where Min Temp <= 0.0 deg C	0	0	0	0.9	4.4	9.1	13.3	10.3	4.6	1.1	0.2	0	44
Lowest daily Min Temp - deg C	2.8	3.5	0	-4	-6.1	-7	-8	-7.7	-5	-2.3	-1.7	0.6	-8
Mean 9am air temp - deg C	18.7	17.8	15.9	12.4	8.5	5.6	4.7	6.4	10	13.5	15.7	18.1	12.3
Mean 9am wet bulb temp - deg C	14.8	14.7	13.2	10.3	7.1	4.4	3.3	4.5	7.1	9.8	11.6	13.9	9.5
Mean 9am dew point - deg C	12.2	12.8	11	8.5	5.8	3.1	1.3	2	3.6	6	7.9	10.1	6.8
Mean 9am relative humidity - %	64	71	72	75	81	82	77	72	64	60	60	60	70
Mean 9am wind speed - km/h	6.9	6.3	6.6	7.6	7.4	8.4	8.5	10.3	11.1	9.9	9	7.9	8.3
Mean 3pm air temp - deg C	23.6	22.9	20.8	17.3	13.3	10	9.3	10.8	13.7	17	19.5	22.5	16.8
Mean 3pm wet bulb temp - deg C	17.1	17.2	15.3	12.5	9.8	7.2	6.1	6.9	9	11.6	13.3	15.3	11.6
Mean 3pm dew point - deg C	12.1	13	11.1	8.2	6	3.7	1.8	1.6	3.2	5.8	7.7	9.6	6.8
Mean 3pm relative humidity - %	51	56	56	55	62	65	60	54	51	50	49	47	55
Mean 3pm wind speed - km/h	10.3	9.1	8.9	9.3	9.8	10.7	11.5	13.4	12.9	11.8	11.5	11.3	10.9
Mean monthly rainfall – mm	92.9	84.3	84.8	63.7	64.2	67.1	67.7	64.2	59	66.9	69.1	76.3	860.1
Median (5th decile) monthly rainfall - mm	79.8	65.6	66.8	50.5	45.6	52	48	48.6	53.4	58.9	65.6	67	858.6
9th decile of monthly rainfall – mm	183.5	179.6	159.4	125.6	132.3	149.2	140	136.8	105.1	133.2	144	146.8	1117.7
1st decile of monthly rainfall – mm	25.2	10.8	20.9	11.3	16.3	16	15	14.7	20	19.1	17.8	18.1	612.7
Mean no. of raindays	10.5	10.3	10.6	9.2	10.5	11.7	11.7	11.1	10.2	10.2	9.9	9.8	125.7

Climate averages for Station: 063224 LITHGOW (BIRDWOOD ST), commenced: 1889; Last record: 2004; Latitude (deg S): -33.4901; Longitude (deg E): 150.1498; State: NSW

Source: Bureau of Meteorology, 2004

5 Ambient Air Quality

No PM_{10} or TSP monitoring data are available for the area, however existing air quality is monitored at a number of dust deposition gauges. The gauges most relevant for the ash repository assessment are shown in **Figure 2**. **Table 6** summarises the results of the dust deposition monitoring for the period commencing January 2002. It should be noted that Stage 1 is in operation and was operating during much of this period. Stage 2 would be operated in a similar manner but would involve different areas extending the emplacement to the north and east of the existing Stage 1 emplacement (see different shading on **Figure 2**).

In 2002 all five monitoring sites recorded deposition levels that complied with the DECC's annual average assessment criterion for insoluble solids of 4 g/m^2/month.

In 2003, DG29 recorded an annual average deposition level of insoluble solids of 7.4 g/m^2/month. DG29 is approximately 350 metres to the east of the residential areas in Lidsdale. DG30, which is on the western side of the residential area, recorded an annual average deposition rate of insoluble solids of 0.8 g/m^2/month; the same deposition rate recorded in the previous year. It is not possible to use these data to precisely estimate the deposition levels at the closest receptors, but it would be conservative[3] to assume that the effect of emissions from the ash repository decreased linearly with distance from the repository. Taking the distance from DG29 to DG30 to be 680 m, it can be estimated that the deposition levels at the eastern edge of the Lidsdale residential area would have been 4 g/m^2/month [7.4 – 350 m/680 m (7.4 -0.8)]. Since this is likely to be a conservative estimate it can be concluded that the eastern-most residence in Lidsdale did comply with the DECC assessment criterion for dust deposition.

In 2004 DG29 recorded an annual average deposition (insoluble solids) level of 5.3 g/m^2/month and DG30 recorded 0.7 g/m^2/month similar to, but slightly less than the previous two years. Again it is estimated that the eastern-most residences would have met the DECC criterion.

In 2005 DG27 recorded a deposition rate of insoluble solids of 5.7 g/m^2/month due mainly to high levels in July and September. DG27 is not near residences. In 2005 DG29 recorded an annual average deposition level of insoluble solids of 4.9 g/m^2/month; also above the DECC's assessment criterion. Once again it can be inferred that the residences in Lidsdale would have recorded deposition levels in compliance with the DECC's criterion.

In 2006 DG28 was the only dust gauge to experience an annual average deposition level of insoluble solids above the 4 g/m^2/month assessment criterion. This gauge is not in a residential area.

The data for 2007 suggest that all gauges will comply with the assessment criterion although the following discussion shows that this conclusion could be changed if one or two elevated monthly values were to be recorded.

[3] Dust deposition levels from a particular source will show a faster than linear decrease with distance and so this assumption will overestimate the deposition levels at the closest residences.

Generally monthly deposition levels appear to be low and the exceedances that do occur, appear to be caused by one or two months in the year when very high levels are recorded. The most recent data provided for this study (since February 2006) included data on the ash and combustible matter in the sample. These indicated that the high recordings were associated with high proportions of combustible matter. For example in July 2006 DG28 recorded an insoluble solids deposition level of 39.9 g/m^2/month of which 39.5 g/m^2/month was combustible material and slightly over half of the material collected by DG27 in January 2007 was combustible material. This suggests that at least some of the elevated levels are due to vegetable matter, bird droppings, coal dust, or other combustible materials not directly associated with operation of the ash repository.

Overall it is reasonable to conclude that the dust deposition levels in the residential areas of Lidsdale would comply with the DECC assessment criterion and based on the data collected at DG5 (the closest monitor) the levels are likely to be in the range 0.7 to 1.1 g/m^2/month.

Table 6. Dust (insoluble solids) monitoring data - g/m^2/month

Date	Dust Gauge Name (see Figure 2)				
	DG5	DG27	DG28	DG29	DG30
Jan-2002		1.3	2.6	0.8	0.9
Feb-2002		0.2	0.3	0.6	0.2
Mar-2002		0.7	0.9	1.4	0.8
Apr-2002		0.5		0.5	0.3
May-2002		0.9	0.8	1.2	0.7
Jun-2002		1.0	0.9	0.6	0.4
Jul-2002		5.4	2.5	0.7	0.3
Aug-2002		2.5	1.3	1.3	0.5
Sep-2002		1.6	2.2	1.0	0.5
Oct-2002		2.0	2.5	1.6	1.4
Nov-2002		2.0	5.1	1.7	1.7
Dec-2002		2.2	4.6	2.4	2.4
Annual 2002		**1.7**	**2.2**	**1.2**	**0.8**
Jan-2003		1.6	6.4	3.1	2.3
Feb-2003		1.0	1.4	2.8	1.1
Mar-2003		0.7	1.2	7.1	1.0
Apr-2003		1.0	1.0	9.6	1.1
May-2003		0.2	0.3	6.5	0.5
Jun-2003		1.0	1.2	6.4	0.4
Jul-2003		1.8	2.4	12.3	0.9
Aug-2003		0.9	0.8	11.7	0.3
Sep-2003		2.1	1.6	8.6	0.5
Oct-2003		3.0	2.7	11.4	0.5
Nov-2003		2.0	3.9	5.6	0.5
Dec-2003		0.8	1.9	3.3	0.8
Annual 2003		**1.3**	**2.1**	**7.4**	**0.8**
Jan-2004		3.1	1.8	4.3	1.7
Feb-2004		1.7	0.6	6.0	0.7
Mar-2004		0.9	1.0	5.8	0.5
Apr-2004		1.2	0.9	6.3	0.7
May-2004		1.1	2.2	11.0	0.5
Jun-2004		1.1	0.7	5.6	0.2
Jul-2004		0.9	1.0	8.0	0.7
Aug-2004		1.8	1.7	6.7	1.3
Sep-2004		1.4	1.6	2.5	0.5

Date	Dust Gauge Name (see Figure 2)				
	DG5	DG27	DG28	DG29	DG30
Oct-2004		4.6	1.5	2.4	0.7
Nov-2004		1.2		2.4	0.5
Dec-2004		2.6	1.6	2.2	0.8
Annual 2004		**1.8**	**1.3**	**5.3**	**0.7**
Jan-2005		1.3	3.9	4.3	1.4
Feb-2005		1.0	2.3	5.4	1.7
Mar-2005		0.2		4.2	0.1
Apr-2005		0.8	2.1	3.8	0.0
May-2005		1.0	0.6	5.1	0.1
Jun-2005		1.5	1.7	6.0	1.5
Jul-2005		11.3	3.4	8.3	1.4
Aug-2005		3.9	2.3	9.2	0.9
Sep-2005		31.9	0.9	5.0	0.7
Oct-2005		7.6	0.3	3.1	1.1
Nov-2005		3.9	1.2	2.2	0.8
Dec-2005		4.4	3.7	2.7	1.7
Annual 2005		**5.7**	**2.0**	**4.9**	**1.0**
Jan-2006		0.9	2.6	2.7	1.3
Feb-2006	5.6	2.1	1.2	2.5	1.6
Mar-2006	0.8	3.6	1.1	2.6	0.6
Apr-2006	0.6	5.6	1.3	3.6	0.6
May-2006	0.8	1.2	1.2	3.5	1.7
Jun-2006	0.5	0.9	1.2	5.8	0.5
Jul-2006	0.2	2.9	39.9	2.2	0.1
Aug-2006	0.4	7.5	1.1	4.3	1.0
Sep-2006	0.7	6.6	2.0	2.2	1.0
Oct-2006	1.4	3.8	2.5	2.0	0.9
Nov-2006	0.6	1.9	2.7	1.7	1.3
Dec-2006	1.4	1.5	1.7	2.5	1.6
Annual 2006	**1.2**	**3.2**	**4.9**	**3.0**	**1.0**
Jan-2007	1.0	14.7	1.9	2.4	1.0
Feb-2007	0.6	2.3	0.7	2.4	1.1
Mar-2007	0.9	1.8	1.0	2.9	0.6
Apr-2007	1.9	2.4	1.0	6.7	1.0
May-2007	0.2	0.5		2.8	0.4
Jun-2007	1.2	0.8	0.8		1.8
Year to date	**1.0**	**3.9**	**1.8**	**3.0**	**1.1**

Blank cells – No data

As general rule[4] areas experiencing annual average deposition levels of insoluble solids of 4 g/m^2/month would be expected to experience annual average TSP concentrations of 90 µg/m^3. An annual average insoluble solids deposition level of 1.1 g/m^2/month (the highest levels observed so far in DG30) would be expected to be associated with a TSP concentration of 25 µg/m^3.

PM_{10} concentrations are typically 40 to 60% of TSP concentrations and if a value of 60% is assumed, a TSP concentration of 25 µg/m^3 would be associated with a PM_{10} concentration of 15 µg/m^3.

[4] This is based on TSP and deposition data collected in Sydney over the period 1973 to 1981 and reported in the New South Wales' State Pollution Control Commission's Annual Report for 1982 (see Figures 4.3 and 4.4).

Given the nature of these estimates, it would be reasonable to add a small margin to the estimated levels and for assessment purposes it has been assumed that annual average PM_{10} concentrations would be of the order of 20 µg/m^3 and annual average TSP concentrations of the order of 30 µg/m^3.

As noted previously there are no PM_{10} or TSP monitoring data. The DECC operates a PM_{10} monitor at Bathurst (approximately 50 km to the west of Lidsdale). The data provide an indication as to 24-hour average background PM_{10} concentrations likely to be experienced in the area. (The Bathurst monitor is the closest background data set known to us and while there is a significant distance between Lidsdale and Bathurst the air quality in the two locations is probably reasonably similar.) The data are summarised in **Table 7**. The maximum levels associated with exceedances are due to the effects of bushfire smoke. It can be seen that high 24-hour concentrations (up to 621 µg/m^3) can be experienced in these circumstances.

Table 7. PM_{10} monitoring data from DECC's Bathurst site (maximum 24-hour an percentile levels based on 24-hour averages)

Year	Data availability (%)	Exceedances of the 50 µg/m^3	Max.	99th	98th	95th	90th	75th	50th	25th
2000	32.5	0	35.2	33.6	32.4	27.6	22.4	17.7	12.2	8.9
2001	30.1	0	35.6	35.3	35.0	31.3	27.5	22.7	16.5	12.3
2002	91.8	**15**	**258.2**	**83.6**	**68.8**	45.7	35.2	25.0	16.6	12.5
2003	90.4	**12**	**621.7**	**103.4**	**75.0**	34.4	26.8	17.0	12.8	8.8
2004	88.5	4	**72.9**	49.9	46.1	37.9	33.3	24.2	15.3	9.7
2005	93.2	0	44.9	38.3	36.6	30.5	25.2	18.3	12.8	8.8
2006	98.6	2	**61.3**	45.5	43.8	34.4	28.4	21.9	15.2	11.3

Source: NSW DECC (2006)

6 Estimating emissions

Emissions of fugitive dust from ash handling operations can be estimated using emission factor equations published by the **US EPA (1985 and updates available from the web)**. Emission factor equations relate the quantity of TSP generated by a particular operation to the type of operation, its intensity (e.g. the quantity of material handled per unit time) and the properties (e.g. silt content, moisture level etc) of the materials being handled.

Dust sources on the site would include:

- vehicles travelling on paved areas to and from the ash handling facilities on the WPS site to the ash disposal area
- emplacing ash in the repository
- shaping the emplaced ash material using dozers
- wind erosion from the emplaced ash.

Dust emissions from the ash handling system at the WPS will be minimal due to the enclosed design of the ash handling and conditioning system. The 15% moisture content of the ash would ensure that ash loaded to trucks for transport to the ash emplacement area would be negligible.

Dust at the emplacement site is controlled using a number of control measures. There are two water carts available onsite 24-hours a day. They normally follow dozers and trucks but can be deployed to any area where emissions are occurring or anticipated to occur. Emplaced ash is permanently capped using topsoil once the volume available for emplacement has been used. Temporary PVA capping is applied to seal ash areas where ash is not currently being emplaced and sprinklers are used for uncapped areas that have not been stabilised by other means. Further to this, an irrigation system is currently used within the ash emplacement/repository area. This replicates continual wet conditions on all work areas, and enables the control of dust emission particularly when periods of elevated wind speeds are present at the site.

The estimated emissions of dust provided below takes these control measures into account, where possible.

Vehicles carrying ash on paved roads

It is assumed that 1,500 tonnes of ash will be transported to the ash emplacement area each day in 25 t loads. For the purpose of assessment, the emplacement has been assumed to be occurring in the area of the emplacement closest to the residential area. This will involve a return haulage route of approximately 2 km. Approximately 60 return trips would be required each day. An emission factor from the sealed roads of 0.2 kilograms of dust for each kilometre travelled (0.2 kg/VKT[5]) should be easily achievable. The total quantity of dust generated per year from vehicle movements will be 8,760 kg [(365 days/year x 60 return trips x 2.0 km/return trip x 0.2 kg/VKT].

Unloading ash in the emplacement area

Approximately 1,500 t of ash will be dumped to the emplacement area each day. Each tonne of ash unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 2** (**US EPA, 1985 and updates**) shows the relationship between these variables.

Equation 2

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad \text{kg/t}$$

where,
$k = 0.74$
U = wind speed (m/s)
M = moisture content (%)
[where $0.25 \le M \le 4.8$]

For the hourly data from the Mt Piper meteorological station in 2003 the average value of $(U/2.2)^{1.3}$ is 1.2166

Assuming a moisture content of 15% for the ash, the emission factor is: 8.578×10^{-5} kg/t. (Note, assuming a 15% moisture content means that Equation 2 is being extended beyond the range for

[5] VKT vehicle kilometres travelled

which it has been tested, but dust emissions at 15% moisture should be low and it would seem unreasonable to make a highly conservative assumption given that the 15% moisture level is the level determined by operational experience to be a level that controls dust to a satisfactory extent.)

The annual emission associated with dumping ash to the emplacement area is estimated to be 47 kg/year [365 days/year x 1,500 t/day x 8.578 x 10^{-5} kg/t].

Topsoil is also emplaced onto the completed ash storage cells when they are full. Assuming that the topsoil is maintained at a moisture level of at least 1% (towards the lower end of the range expected for topsoil), the estimated TSP emission factor using Equation 2 is 0.013 kg/t. This is used later.

Bulldozer shaping the emplaced ash

Emissions from dozers on ash have been calculated using the US EPA emission factor equation) US **EPA (1985 and updates available from the web)**. The equation is as follows:

Equation 3

$$\mathrm{E}_{\mathrm{TSP}} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad \text{kg/hour}$$

where,

$\mathrm{E}_{\mathrm{TSP}} = TSP\ \ emissions$

$\mathrm{s} = \text{silt content (\%), and}$

$\mathrm{M} = \text{moisture (\%)}$

Assuming that the silt content (sub-75 micron size range) of the ash is 80% and that the ash moisture level is maintained at 15% during the period when dozers are working it, the estimated emission factor for annual emissions will be 14.8 kg/h. Assuming that the dozer will operate 9 hours per day the estimated TSP emission will be 48,618 kg/year [365 days/year x 9 hours/day x 14.8 kg/h]. This is likely to be a conservative estimate since the dozing operation only has to emplace approximately 1,500 t of ash per day. It will of course be important to ensure that the ash moisture level is maintained at 15% during this process because the ash contains a high proportion of fine particles, which would become air borne if allowed to dry and if disturbed either by the wind or mechanically by a dozer, or both. The proposed equipment available to maintain the moisture at 15% is sufficient for this purpose.

Emplacing topsoil on top of ash

Once the emplacement of the ash in a given area is completed, it is capped with topsoil. Approximately 0.055 cubic metres of topsoil are used for every tonne of ash emplaced. This is 82.5 m^3 of topsoil per day [1,500 t x 0.055 m^3/t]. Assuming that topsoil has a density of 2 t/m^3, the total mass of topsoil emplaced per day will be 165 t. This would result in an annual TSP emission of 783 kg/y [165 t x 365 days x 0.013 kg/t] approximately.

Since the same equipment is used for spreading the topsoil as for spreading the ash no separate estimate of emissions has been estimated for the spreading of topsoil. It has been assumed that this is covered in the hourly allowance for the use of this equipment.

Wind erosion

The emission factor for wind erosion is given in Equation 5 below.

Equation 5

$$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \qquad \text{kg/ha/day}$$

where,

E_{TSP} = *TSP emissions*

s = silt content (%)

p = number of 'rain days' per year, and

f = percentage of the time that wind speed is above 5.4 m/s

Assuming a silt content of 80% and the number of natural 'rain days' at 126 (see data from the Bureau of Meteorology's station at Lithgow (**Table 4**)) and the percentage of winds above 5.4 m/s is 4.5% (from Mt Piper Power Station's Meteorological Station), the emission factor is 30.9 kg/ha/day. Assuming that 4 ha of ash repository (the total Stage 2 area is 38 ha) would be would susceptible to wind erosion at any one time, the total estimated annual TSP emission is therefore 45,114 kg/year.

Based on current management measures implemented at the Stage 1 ash repository, the wind erosion emission estimate provides a conservative approach to assessing impact potential from the Stage 2 activities at KVAR. In particular, the irrigation system within the ash placement area provides the opportunity for water application on an 'as-needs' basis and further wet suppression mitigation during periods of elevated wind speed events. If used and operated effectively, this control measure provides an artificial increases to the number of effective 'rain days' present. Material moisture content would therefore be higher with an anticipated increase in stockpile surface crusting (and erodible material binding) present.

Summary

- Hauling ash vehicles travelling on paved areas - 8,760 kg/year
- Unloading ash to emplacement – 47 kg/year
- Unloading topsoil cover to emplaced ash – 783 kg/year
- Shaping ash with bulldozer etc – 48,618 kg/year
- Wind erosion from ash repository surface – 45,114 kg/year
- Total – 103,322 kg/year.

The total annual emission is estimated to be 103,322 kg/year (283 kg/day) assuming operations occur every day of the year. The primary emission source, that is wind erosion from the ash repository surface, would be reasonably expected to cause lower volumes of dust release when considering the correct use, application and performance of the current wet suppression irrigation system within the site. This means that the estimated emission from wind erosion is likely to be significantly overestimated. However to be conservative the modelling and subsequent assessment has been based on the raw calculations for wind erosion.

A significant fraction of the calculated emissions would also be expected to fall within the area of the KVAR site and have a limited impact beyond the Delta Electricity's site boundary. The conservative emission values calculated, used in the compiling the whole of year inventory outlined above, have been used as the input into modelling to determine potential off-site worst-case impacts as outlined in Section 7. This modelling indicates a limited impact beyond the KVAR site as described below and illustrated in the figures provided at the end of this report.

7 Modelling

This section provides the results of model predictions based on the estimated emissions in **Section 6**, the 2003 meteorological data described in **Section 4** and the US EPA dispersion model known as ISCMOD. ISCMOD is based on the US EPA's Industrial Source Complex (Short-term) model (ISCST3, which is specially designed to simulate the dispersion of dust). ISCMOD involves minor changes to the dispersion curves[6] used by ISCST3. These have been changed to improve the performance of the model in predicting 24-hour average concentrations. The model has been used for a number of coalmine EIS's. The adjustments, the reasons for making them and the performance of the model are discussed by **Holmes et al. (2007)**. The approach to the modelling is described in detail in a number of reports (see for example **Holmes Air Sciences (2006)**).

The complete emissions file, terrain information and meteorological data file used in the assessment will be provided in computer compatible form on request. Part of the input file showing the model set up and source parameters including the coordinates of the sources is provided in **Appendix B**.

Model predictions have been made showing the effects of operations at the proposed facility assuming an ash emplacement of 1,500 t/day and assuming 365 days of operation per year and using the emissions estimated in **Section 6**. It has been assumed that the operator applies reasonable dust controls, i.e. maintains sealed haul roads in a clean condition and maintains moisture levels in the ash at 15% until the material is placed in the emplacement area. Moisture levels in the emplaced ash have been assumed to be 5%. If the ash does not form a stable surface it may be necessary to cover the emplacement area with a soil-like cover however on most occasions it is expected that the cement-like properties of the ash if sufficiently damp when emplaced will allow it to form a surface that is stable against wind erosion. The results of the model predictions are shown in **Figures 8** to **11**. These are discussed briefly below.

7.1 Maximum calculated 24-hour average PM_{10} concentrations

Testing for compliance with the DECC's 24-hour average PM_{10} assessment criterion can present complications in many places in NSW where natural events such as bushfires can, on occasions, cause the 24-hour average PM_{10} concentrations to exceed the 50 $\mu g/m^3$ by an order of magnitude or so. The Air-NEPM standard allows five exceedances of the goal before air quality is considered to have exceeded the NEPM standard and, although the DECC's criteria does not explicitly allow for any exceedances, there will inevitably be some (due to bushfires, dust storms and other unusual

[6] The changed dispersion curves are the same as those used by AUSPLUME.

conditions) even if the KVAR operations did not exist. To demonstrate that the 24-hour assessment criterion is not exceeded the DECC's approved methods suggest that the model predictions are added to an estimate of the maximum 24-hour PM_{10} concentrations for the area or the predictions are added to a time-series of 24-hour average PM_{10} measurements made contemporaneously with the meteorological data used in the model. The approved methods require that the proposal should either not cause any exceedances of the 24-hour average 50 µg/m^3 concentration of PM_{10}, or should not cause any additional exceedances over and above those that already occur. No on-site PM_{10} concentrations are available and so neither of these approaches cannot be followed in this case.

Maximum calculated 24-hour average concentrations due to emissions from the site are shown in **Figure 8**. The maximum calculated PM_{10} concentrations at the most affected residential area, due to operations at the KVAR are of the order of 17 µg/m^3. This is less than the DECC 24-hour assessment criterion for PM_{10} and would allow a background of 24-hour average PM_{10} concentration due to other sources of 32 µg/m^3 to exist before the 50 µg/m^3 criterion would be exceeded. Bathurst is the closest DECC monitoring site with PM_{10} monitoring data and the data from this site were reviewed in **Section 5**. Four of the past seven years experienced 24-hour PM_{10} concentrations above the DECC 50 µg/m^3 assessment criterion and in 2003 the maximum 24-hour average recorded was 622 µg/m^3 in the presence of bushfire smoke. In the absence of strong contributions from bushfire smoke the maximum 24-hour PM_{10} concentrations would appear to be of the order of 35 to 36 µg/m^3 (see data for 2000 and 2001). If these days with the highest background levels were to correspond with the highest calculated contribution from the operation of the ash repository (17.3 µg/m^3) a marginal exceedance of the order of 3 µg/m^3 would occur. A model run to predict the time series of 24-hour PM_{10} concentrations at a receptor located at 228900 mE and 6301425 mN (see Special Receptor on **Figure 8**) was undertaken with the objective of identifying the frequency with which "high" concentrations occurred. The second highest calculated 24-hour concentration was 13.6 µg/m^3 and this would not give rise to an exceedance. Thus, assuming that the air quality at Lidsdale is similar to that at Bathurst, the probability of an exceedance occurring in a year without unusual air pollution events (e.g. a bushfires, dust storms etc), is extremely small; of the order of 0.27% (i.e. 1/365).

7.2 Calculated annual average PM_{10} concentrations

Calculated annual average PM_{10} concentrations due to emissions from the site are shown in **Figure 9**. The annual PM_{10} concentrations due to operations at the KVAR at the most affected residence is 3 µg/m^3. Given an existing annual average PM_{10} concentration of 20 µg/m^3 the total would become 23 µg/m^3, which is less than the DECC's assessment criterion of 30 µg/m^3 for annual average PM_{10} concentrations.

7.3 Calculated annual average TSP concentrations

Calculated annual average TSP concentrations due to emissions from the site are shown in **Figure 10**. The annual TSP concentrations due to operations at the KVAR at the most affected residence is 4 µg/m^3. Given an existing annual average TSP concentration of 30 µg/m^3 the total would become 34 µg/m^3, which is less than the DECC's assessment criterion of 90 µg/m^3 for annual average TSP concentrations.

7.4 Calculated annual average dust (insoluble solids) deposition

Calculated annual average deposition levels due to emissions from the site are shown in **Figure 11**. The annual dust (insoluble solids) deposition level due to operations at the KVAR at the most affected residence is 0.5 g/m^2/month. Given that existing annual average deposition levels are less than 3 g/m^2/month the total would be less than the DECC's assessment criterion of 4 g/m^2/month.

The model prediction indicates that deposition levels would be below the DECC's criterion of 4 g/m^2/month provided the background-level did not exceed 3.5 g/m^2/month (annual average).

8 Conclusions

This report has assessed the potential impacts on air quality of dust emissions associated with the operation of Stage 2 of the KVAR near Lidsdale.

Existing air quality with respect to PM_{10} and TSP concentrations is not well characterised but deposition levels are monitored at five sites. An analysis of these data from these five sites indicates that the dust deposition levels in the residential areas of Lidsdale would comply with the DECC assessment criterion and based on the data collected at DG5 (the closest monitor) the levels are likely to be in the range 0.7 to 1.1 g/m^2/month.

Stage 2 will involve similar levels of activity as Stage 1. Model prediction of the worst case operations for Stage 2 suggest that the emissions will contribute only very minor increases to long-term dust concentrations or deposition levels in the residential areas of Lidsdale. The probability of the DECC's 24-hour PM_{10} assessment criterion of 50 µg/m^3 being exceeded, in the absence of bushfire smoke, is estimated to be of the order of 0.27%. Based on the last seven years of DECC monitoring data at Bathurst, this is significantly lower than the chance of the criterion being exceeded due to unusual conditions such as the presence of bushfire smoke. Thus provided PM_{10} data at Bathurst is a reasonable surrogate for conditions at Lidsdale it can be concluded that there is a low probability of the DECC's 24-hour PM_{10} assessment criterion being exceeded.

To provide a further safeguard, works undertaken during Stage 2 ash emplacement within the repository area should be carried out in accordance with a documented management plan. The plan will detail all approaches adopted to minimise dust emissions and specific mitigation measures incorporated during emplacement activities. The plan should also include an operating protocol for the repository irrigation system, at a minimum; the wet suppression technique should be activated when 15 minute averge wind speed thresholds exceed 5 m/s. Application rates and coverage area should be such that no visible emissions from the repository area occur.

9 References

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Appendix A

Joint Wind Speed Wind direction and stability class tables and other statistics for Mt Piper Data for 2003.

STATISTICS FOR FILE: C:\Jobs\KeroseneValePB\Met\MPiper03.isc
MONTHS: All
HOURS : All
OPTION: Frequency

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.015124	0.027867	0.009408	0.000595	0.000715	0.000119	0.000000	0.000000	0.053829
NE	0.009765	0.016911	0.007503	0.000119	0.000000	0.000000	0.000000	0.000000	0.034298
ENE	0.006669	0.011909	0.007026	0.000357	0.000000	0.000000	0.000000	0.000000	0.025962
E	0.005359	0.018578	0.020007	0.002739	0.000000	0.000000	0.000000	0.000000	0.046683
ESE	0.006431	0.021079	0.028701	0.008813	0.000476	0.000000	0.000000	0.000000	0.065500
SE	0.005835	0.022865	0.017625	0.005716	0.000000	0.000000	0.000000	0.000000	0.052042
SSE	0.006431	0.019650	0.012862	0.001310	0.000000	0.000000	0.000000	0.000000	0.040252
S	0.008098	0.019412	0.006669	0.001310	0.000000	0.000000	0.000000	0.000000	0.035489
SSW	0.013695	0.015482	0.005240	0.000595	0.000000	0.000000	0.000000	0.000000	0.035013
SW	0.039300	0.022627	0.014648	0.006550	0.001072	0.000238	0.000000	0.000000	0.084435
WSW	0.079195	0.022151	0.022865	0.015244	0.004287	0.001191	0.000476	0.000000	0.145409
W	0.022270	0.017744	0.016315	0.017744	0.008217	0.000834	0.000000	0.000000	0.083125
WNW	0.009884	0.016911	0.019054	0.009527	0.003692	0.000238	0.000000	0.000000	0.059307
NW	0.012385	0.015124	0.008574	0.002977	0.001072	0.000000	0.000000	0.000000	0.040133
NNW	0.017387	0.039062	0.008217	0.002144	0.000595	0.000000	0.000000	0.000000	0.067405
N	0.014410	0.034417	0.009765	0.001548	0.000953	0.000000	0.000000	0.000000	0.061093
CALM									0.070025
TOTAL	0.272240	0.341789	0.214481	0.077290	0.021079	0.002620	0.000476	0.000000	1.000000

MEAN WIND SPEED (m/s) = 2.42
NUMBER OF OBSERVATIONS = 8397

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005955	0.005955	0.000476	0.000000	0.000000	0.000000	0.000000	0.000000	0.012385
NE	0.003335	0.004287	0.000357	0.000000	0.000000	0.000000	0.000000	0.000000	0.007979
ENE	0.001667	0.003573	0.001548	0.000000	0.000000	0.000000	0.000000	0.000000	0.006788
E	0.001786	0.004049	0.001667	0.000119	0.000000	0.000000	0.000000	0.000000	0.007622
ESE	0.001667	0.003335	0.000953	0.000000	0.000000	0.000000	0.000000	0.000000	0.005955
SE	0.001310	0.001667	0.000357	0.000000	0.000000	0.000000	0.000000	0.000000	0.003335
SSE	0.001310	0.002739	0.000476	0.000000	0.000000	0.000000	0.000000	0.000000	0.004525
S	0.001667	0.003692	0.000715	0.000000	0.000000	0.000000	0.000000	0.000000	0.006074
SSW	0.002620	0.004287	0.000595	0.000000	0.000000	0.000000	0.000000	0.000000	0.007503
SW	0.002382	0.004168	0.001786	0.000000	0.000000	0.000000	0.000000	0.000000	0.008336
WSW	0.002501	0.002263	0.001786	0.000119	0.000000	0.000000	0.000000	0.000000	0.006669
W	0.002620	0.002144	0.001429	0.000357	0.000000	0.000000	0.000000	0.000000	0.006550
WNW	0.002025	0.003096	0.001191	0.000000	0.000000	0.000000	0.000000	0.000000	0.006312
NW	0.003573	0.002144	0.000834	0.000000	0.000000	0.000000	0.000000	0.000000	0.006550
NNW	0.005002	0.010837	0.000357	0.000000	0.000000	0.000000	0.000000	0.000000	0.016196
N	0.004287	0.009765	0.000953	0.000119	0.000000	0.000000	0.000000	0.000000	0.015124
CALM									0.016315
TOTAL	0.043706	0.068000	0.015482	0.000715	0.000000	0.000000	0.000000	0.000000	0.144218

MEAN WIND SPEED (m/s) = 1.80
NUMBER OF OBSERVATIONS = 1211

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000715	0.002739	0.001191	0.000000	0.000000	0.000000	0.000000	0.000000	0.004645
NE	0.000238	0.002025	0.001191	0.000000	0.000000	0.000000	0.000000	0.000000	0.003454
ENE	0.000119	0.001429	0.001905	0.000000	0.000000	0.000000	0.000000	0.000000	0.003454
E	0.000000	0.001667	0.003335	0.000119	0.000000	0.000000	0.000000	0.000000	0.005121
ESE	0.000119	0.002144	0.001191	0.000357	0.000000	0.000000	0.000000	0.000000	0.003811
SE	0.000000	0.001191	0.001905	0.000119	0.000000	0.000000	0.000000	0.000000	0.003215
SSE	0.000119	0.001548	0.001905	0.000000	0.000000	0.000000	0.000000	0.000000	0.003573
S	0.000119	0.001191	0.000119	0.000000	0.000000	0.000000	0.000000	0.000000	0.001429
SSW	0.000238	0.001429	0.000834	0.000000	0.000000	0.000000	0.000000	0.000000	0.002501
SW	0.000476	0.001310	0.001191	0.000119	0.000000	0.000000	0.000000	0.000000	0.003096
WSW	0.000357	0.000476	0.002858	0.000715	0.000000	0.000000	0.000000	0.000000	0.004406
W	0.000000	0.001191	0.002144	0.002263	0.000000	0.000000	0.000000	0.000000	0.005597
WNW	0.000119	0.002263	0.003335	0.000953	0.000000	0.000000	0.000000	0.000000	0.006669
NW	0.000238	0.002144	0.003096	0.001072	0.000000	0.000000	0.000000	0.000000	0.006550
NNW	0.000953	0.006074	0.003811	0.000476	0.000000	0.000000	0.000000	0.000000	0.011314
N	0.000595	0.005478	0.002620	0.000119	0.000000	0.000000	0.000000	0.000000	0.008813
CALM									0.000119
TOTAL	0.004406	0.034298	0.032631	0.006312	0.000000	0.000000	0.000000	0.000000	0.077766

MEAN WIND SPEED (m/s) = 3.06
NUMBER OF OBSERVATIONS = 653

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002144	0.002858	0.002739	0.000238	0.000000	0.000000	0.000000	0.000000	0.007979
NE	0.000476	0.001667	0.002501	0.000000	0.000000	0.000000	0.000000	0.000000	0.004645
ENE	0.000238	0.000357	0.001786	0.000357	0.000000	0.000000	0.000000	0.000000	0.002739
E	0.000000	0.001786	0.003692	0.001072	0.000000	0.000000	0.000000	0.000000	0.006550
ESE	0.000000	0.001667	0.005955	0.002501	0.000000	0.000000	0.000000	0.000000	0.010123
SE	0.000000	0.000715	0.004168	0.001548	0.000000	0.000000	0.000000	0.000000	0.006431
SSE	0.000000	0.001072	0.003573	0.000834	0.000000	0.000000	0.000000	0.000000	0.005478
S	0.000238	0.001072	0.001310	0.000357	0.000000	0.000000	0.000000	0.000000	0.002977
SSW	0.000119	0.001310	0.001429	0.000238	0.000000	0.000000	0.000000	0.000000	0.003096
SW	0.000357	0.001905	0.004764	0.002620	0.000000	0.000000	0.000000	0.000000	0.009646
WSW	0.000119	0.001191	0.005716	0.006669	0.000000	0.000000	0.000000	0.000000	0.013695
W	0.000000	0.001191	0.003930	0.008455	0.000000	0.000000	0.000000	0.000000	0.013576
WNW	0.000000	0.001072	0.007264	0.005478	0.000000	0.000000	0.000000	0.000000	0.013814
NW	0.000119	0.001072	0.002739	0.001786	0.000000	0.000000	0.000000	0.000000	0.005716
NNW	0.000000	0.005121	0.003573	0.001429	0.000000	0.000000	0.000000	0.000000	0.010123
N	0.000238	0.003335	0.004645	0.000715	0.000000	0.000000	0.000000	0.000000	0.008932
CALM									0.000357
TOTAL	0.004049	0.027391	0.059783	0.034298	0.000000	0.000000	0.000000	0.000000	0.125878

MEAN WIND SPEED (m/s) = 3.72
NUMBER OF OBSERVATIONS = 1057

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001310	0.008098	0.005002	0.000357	0.000715	0.000119	0.000000	0.000000	0.015601
NE	0.001191	0.002977	0.003454	0.000119	0.000000	0.000000	0.000000	0.000000	0.007741
ENE	0.000357	0.000715	0.001786	0.000000	0.000000	0.000000	0.000000	0.000000	0.002858
E	0.000000	0.005121	0.011314	0.001429	0.000000	0.000000	0.000000	0.000000	0.017864
ESE	0.000357	0.008694	0.020484	0.005955	0.000476	0.000000	0.000000	0.000000	0.035965
SE	0.000357	0.012504	0.010480	0.004049	0.000000	0.000000	0.000000	0.000000	0.027391
SSE	0.000238	0.009170	0.006788	0.000476	0.000000	0.000000	0.000000	0.000000	0.016673
S	0.000119	0.006907	0.004287	0.000953	0.000000	0.000000	0.000000	0.000000	0.012266
SSW	0.000953	0.004168	0.002144	0.000357	0.000000	0.000000	0.000000	0.000000	0.007622
SW	0.005597	0.007503	0.006431	0.003811	0.001072	0.000238	0.000000	0.000000	0.024652
WSW	0.014886	0.009051	0.011552	0.007741	0.004287	0.001191	0.000476	0.000000	0.049184
W	0.001191	0.005121	0.008455	0.006312	0.008217	0.000834	0.000000	0.000000	0.030130
WNW	0.000119	0.003454	0.006431	0.002858	0.003692	0.000238	0.000000	0.000000	0.016792
NW	0.000119	0.003215	0.001786	0.000119	0.001072	0.000000	0.000000	0.000000	0.006312
NNW	0.000715	0.006312	0.000476	0.000238	0.000595	0.000000	0.000000	0.000000	0.008336
N	0.000715	0.003215	0.001548	0.000595	0.000953	0.000000	0.000000	0.000000	0.007026
CALM									0.001786
TOTAL	0.028224	0.096225	0.102418	0.035370	0.021079	0.002620	0.000476	0.000000	0.288198

MEAN WIND SPEED (m/s) = 3.43
NUMBER OF OBSERVATIONS = 2420

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000595	0.004525	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005121
NE	0.000119	0.002263	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002382
ENE	0.000595	0.002977	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003573
E	0.000238	0.002739	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002977
ESE	0.000595	0.003335	0.000119	0.000000	0.000000	0.000000	0.000000	0.000000	0.004049
SE	0.000119	0.004645	0.000715	0.000000	0.000000	0.000000	0.000000	0.000000	0.005478
SSE	0.000357	0.002263	0.000119	0.000000	0.000000	0.000000	0.000000	0.000000	0.002739
S	0.000595	0.002739	0.000238	0.000000	0.000000	0.000000	0.000000	0.000000	0.003573
SSW	0.000834	0.002620	0.000238	0.000000	0.000000	0.000000	0.000000	0.000000	0.003692
SW	0.009646	0.003930	0.000476	0.000000	0.000000	0.000000	0.000000	0.000000	0.014053
WSW	0.016554	0.005002	0.000953	0.000000	0.000000	0.000000	0.000000	0.000000	0.022508
W	0.002739	0.005121	0.000357	0.000357	0.000000	0.000000	0.000000	0.000000	0.008574
WNW	0.000834	0.003573	0.000834	0.000238	0.000000	0.000000	0.000000	0.000000	0.005478
NW	0.000834	0.002739	0.000119	0.000000	0.000000	0.000000	0.000000	0.000000	0.003692
NNW	0.002025	0.005359	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007384
N	0.001072	0.007026	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008098
CALM									0.002501
TOTAL	0.037752	0.060855	0.004168	0.000595	0.000000	0.000000	0.000000	0.000000	0.105871

MEAN WIND SPEED (m/s) = 1.78
NUMBER OF OBSERVATIONS = 889

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.004406	0.003692	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008098
NE	0.004406	0.003692	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008098
ENE	0.003692	0.002858	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006550
E	0.003335	0.003215	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006550
ESE	0.003692	0.001905	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005597
SE	0.004049	0.002144	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006193
SSE	0.004406	0.002858	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007264
S	0.005359	0.003811	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009170
SSW	0.008932	0.001667	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010599
SW	0.020841	0.003811	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.024652
WSW	0.044778	0.004168	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.048946
W	0.015720	0.002977	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.018697
WNW	0.006788	0.003454	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010242
NW	0.007503	0.003811	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011314
NNW	0.008694	0.005359	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.014053
N	0.007503	0.005597	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.013100
CALM									0.048946
TOTAL	0.154103	0.055020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.258068

MEAN WIND SPEED (m/s) = 1.08
NUMBER OF OBSERVATIONS = 2167

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.015124	0.027867	0.009408	0.000595	0.000715	0.000119	0.000000	0.000000	0.053829
NE	0.009765	0.016911	0.007503	0.000119	0.000000	0.000000	0.000000	0.000000	0.034298
ENE	0.006669	0.011909	0.007026	0.000357	0.000000	0.000000	0.000000	0.000000	0.025962
E	0.005359	0.018578	0.020007	0.002739	0.000000	0.000000	0.000000	0.000000	0.046683
ESE	0.006431	0.021079	0.028701	0.008813	0.000476	0.000000	0.000000	0.000000	0.065500
SE	0.005835	0.022865	0.017625	0.005716	0.000000	0.000000	0.000000	0.000000	0.052042
SSE	0.006431	0.019650	0.012862	0.001310	0.000000	0.000000	0.000000	0.000000	0.040252
S	0.008098	0.019412	0.006669	0.001310	0.000000	0.000000	0.000000	0.000000	0.035489
SSW	0.013695	0.015482	0.005240	0.000595	0.000000	0.000000	0.000000	0.000000	0.035013
SW	0.039300	0.022627	0.014648	0.006550	0.001072	0.000238	0.000000	0.000000	0.084435
WSW	0.079195	0.022151	0.022865	0.015244	0.004287	0.001191	0.000476	0.000000	0.145409
W	0.022270	0.017744	0.016315	0.017744	0.008217	0.000834	0.000000	0.000000	0.083125
WNW	0.009884	0.016911	0.019054	0.009527	0.003692	0.000238	0.000000	0.000000	0.059307
NW	0.012385	0.015124	0.008574	0.002977	0.001072	0.000000	0.000000	0.000000	0.040133
NNW	0.017387	0.039062	0.008217	0.002144	0.000595	0.000000	0.000000	0.000000	0.067405
N	0.014410	0.034417	0.009765	0.001548	0.000953	0.000000	0.000000	0.000000	0.061093
CALM									0.070025
TOTAL	0.272240	0.341789	0.214481	0.077290	0.021079	0.002620	0.000476	0.000000	1.000000

MEAN WIND SPEED (m/s) = 2.42
NUMBER OF OBSERVATIONS = 8397

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

- A : 14.4%
- B : 7.8%
- C : 12.6%
- D : 28.8%
- E : 10.6%
- F : 25.8%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0124	0064	0161
02	0000	0000	0000	0122	0087	0140
03	0000	0000	0000	0120	0066	0163
04	0000	0000	0000	0121	0059	0169
05	0000	0000	0000	0113	0063	0173
06	0016	0008	0004	0105	0040	0176
07	0077	0020	0051	0077	0024	0099
08	0123	0059	0090	0061	0007	0010
09	0115	0072	0114	0048	0000	0000
10	0126	0076	0118	0030	0000	0000
11	0141	0063	0109	0037	0000	0000
12	0147	0073	0081	0050	0000	0000
13	0134	0081	0096	0039	0000	0000
14	0129	0062	0096	0064	0000	0000
15	0096	0056	0128	0071	0000	0000
16	0071	0050	0118	0104	0002	0006
17	0027	0027	0049	0165	0037	0046
18	0009	0006	0003	0168	0060	0105
19	0000	0000	0000	0154	0063	0133
20	0000	0000	0000	0146	0063	0141
21	0000	0000	0000	0130	0061	0159
22	0000	0000	0000	0131	0057	0162
23	0000	0000	0000	0123	0066	0161
24	0000	0000	0000	0117	0070	0163

STABILITY CLASS BY MIXING HEIGHT

Mixing height	A	B	C	D	E	F
<=500 m	0223	0090	0205	0414	0827	2066
<=1000 m	0420	0270	0441	0831	0014	0020
<=1500 m	0568	0293	0411	0962	0048	0081
<=2000 m	0000	0000	0000	0149	0000	0000
<=3000 m	0000	0000	0000	0063	0000	0000
>3000 m	0000	0000	0000	0001	0000	0000

MIXING HEIGHT BY HOUR OF DAY

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to 3200	Greater than 3200
01	0149	0073	0010	0030	0071	0016	0000
02	0132	0088	0016	0030	0067	0016	0000
03	0158	0066	0012	0023	0074	0016	0000
04	0156	0071	0009	0030	0071	0012	0000
05	0178	0063	0011	0016	0070	0011	0000
06	0140	0101	0065	0007	0032	0004	0000
07	0107	0065	0107	0067	0001	0001	0000
08	0000	0062	0129	0159	0000	0000	0000
09	0000	0000	0094	0183	0072	0000	0000
10	0000	0000	0000	0234	0116	0000	0000
11	0000	0000	0000	0134	0216	0000	0000
12	0000	0000	0000	0084	0267	0000	0000
13	0000	0000	0000	0000	0350	0000	0000
14	0000	0000	0000	0000	0351	0000	0000
15	0000	0000	0000	0000	0351	0000	0000
16	0000	0000	0000	0000	0351	0000	0000
17	0003	0007	0002	0005	0332	0002	0000
18	0053	0045	0007	0019	0220	0007	0000
19	0095	0072	0013	0031	0124	0015	0000
20	0123	0078	0010	0031	0095	0013	0000
21	0142	0075	0006	0025	0092	0010	0000
22	0144	0067	0016	0035	0078	0010	0000
23	0150	0069	0016	0028	0070	0017	0000
24	0144	0085	0010	0031	0064	0016	0000

Appendix B
Input files for ISCMOD simulation

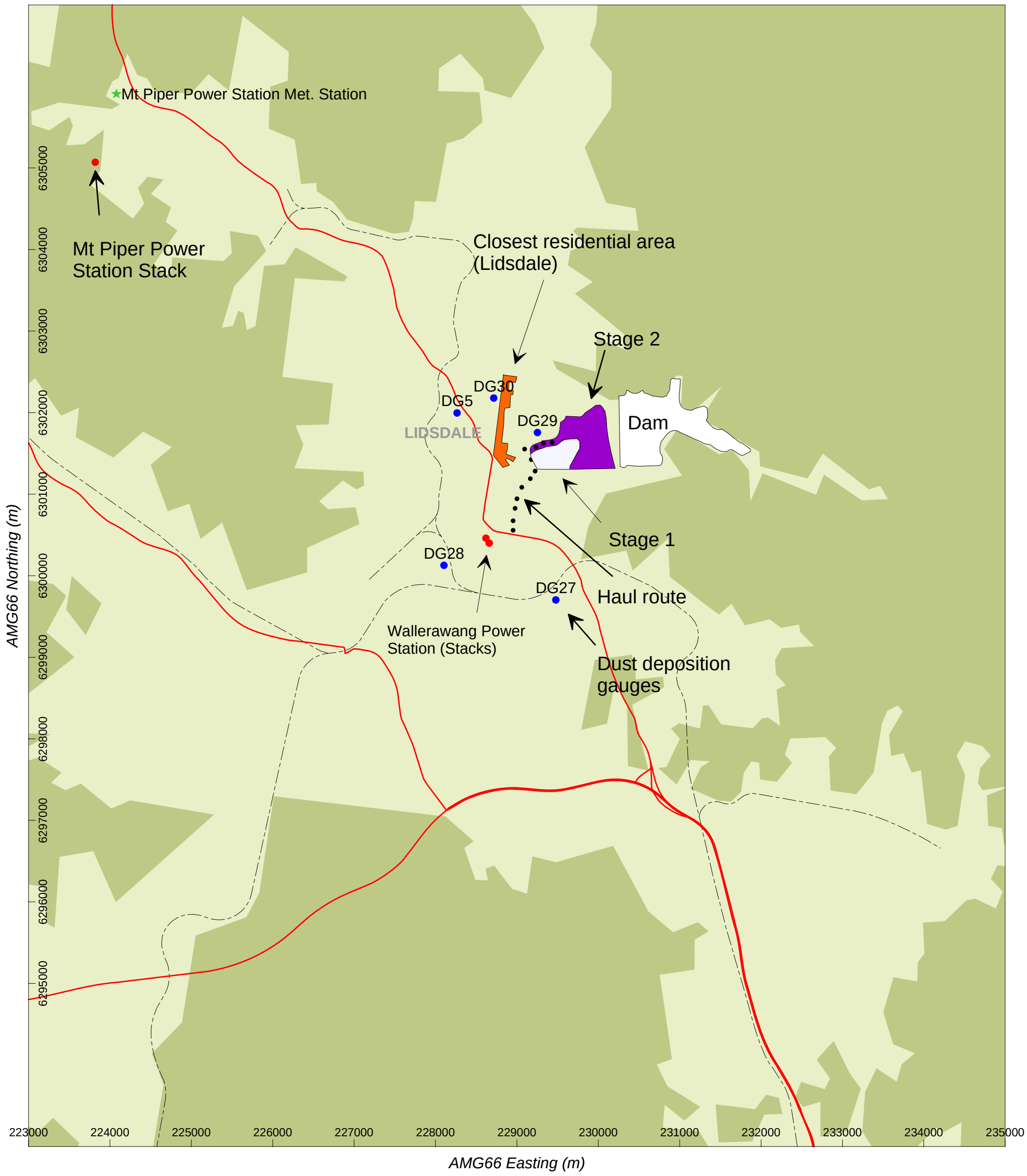
```
**  ISCST3 model input runstream : Dust
CO STARTING
   TITLEONE ISCST3 Dust Model Run
   MODELOPT RURAL CONC DDEP DRYDPLT
   AVERTIME 24 PERIOD
   POLLUTID TSP
   ERRORFIL error.log
   TERRHGTS ELEV
   RUNORNOT RUN
CO FINISHED

SO STARTING
   LOCATION  POINT1  VOLUME  228954 6300557 0.0
   LOCATION  POINT2  VOLUME  228954 6300674 0.0
   LOCATION  POINT3  VOLUME  228978 6300826 0.0
   LOCATION  POINT4  VOLUME  229001 6300944 0.0
   LOCATION  POINT5  VOLUME  229060 6301084 0.0
   LOCATION  POINT6  VOLUME  229165 6301190 0.0
   LOCATION  POINT7  VOLUME  229224 6301283 0.0
   LOCATION  POINT8  VOLUME  229177 6301424 0.0
   LOCATION  POINT9  VOLUME  229095 6301553 0.0
   LOCATION  POINT10  VOLUME  229236 6301576 0.0
   LOCATION  POINT11  VOLUME  229329 6301623 0.0
   LOCATION  POINT12  VOLUME  229435 6301635 0.0
   LOCATION  POINT13  VOLUME  228954 6300557 0.0
   LOCATION  POINT14  VOLUME  228954 6300674 0.0
   LOCATION  POINT15  VOLUME  228978 6300826 0.0
   LOCATION  POINT16  VOLUME  229001 6300944 0.0
   LOCATION  POINT17  VOLUME  229060 6301084 0.0
   LOCATION  POINT18  VOLUME  229165 6301190 0.0
   LOCATION  POINT19  VOLUME  229224 6301283 0.0
   LOCATION  POINT20  VOLUME  229177 6301424 0.0
   LOCATION  POINT21  VOLUME  229095 6301553 0.0
   LOCATION  POINT22  VOLUME  229236 6301576 0.0
   LOCATION  POINT23  VOLUME  229329 6301623 0.0
   LOCATION  POINT24  VOLUME  229435 6301635 0.0
   LOCATION  POINT25  VOLUME  228954 6300557 0.0
   LOCATION  POINT26  VOLUME  228954 6300674 0.0
   LOCATION  POINT27  VOLUME  228978 6300826 0.0
   LOCATION  POINT28  VOLUME  229001 6300944 0.0
   LOCATION  POINT29  VOLUME  229060 6301084 0.0
   LOCATION  POINT30  VOLUME  229165 6301190 0.0
   LOCATION  POINT31  VOLUME  229224 6301283 0.0
   LOCATION  POINT32  VOLUME  229177 6301424 0.0
   LOCATION  POINT33  VOLUME  229095 6301553 0.0
   LOCATION  POINT34  VOLUME  229236 6301576 0.0
   LOCATION  POINT35  VOLUME  229329 6301623 0.0
   LOCATION  POINT36  VOLUME  229435 6301635 0.0
Note: emission sources are represented by volume sources located at 12 places (see
black dots on Figure 8 to 11) each source emits particles in one of three size
categories 0 to 2.5, 2.5 to 10 or 10 to 30 microns, hence there are 36 sources.
** Point Source       QS   RH  IL   IV
** Parameters        ----  --- ---  ---
   HOUREMIS  C:\Jobs\KeroseneValePB\Model\c1vem.dat POINT1-POINT36
   SRCPARAM  POINT1  1.0 2.0 10.0 2.0
   SRCPARAM  POINT2  1.0 2.0 10.0 2.0
   SRCPARAM  POINT3  1.0 2.0 10.0 2.0
   SRCPARAM  POINT4  1.0 2.0 10.0 2.0
   SRCPARAM  POINT5  1.0 2.0 10.0 2.0
   SRCPARAM  POINT6  1.0 2.0 10.0 2.0
   SRCPARAM  POINT7  1.0 2.0 10.0 2.0
   SRCPARAM  POINT8  1.0 2.0 10.0 2.0
   SRCPARAM  POINT9  1.0 2.0 10.0 2.0
   SRCPARAM  POINT10  1.0 2.0 10.0 2.0
   SRCPARAM  POINT11  1.0 2.0 10.0 2.0
   SRCPARAM  POINT12  1.0 2.0 10.0 2.0
   SRCPARAM  POINT13  1.0 2.0 10.0 2.0
   SRCPARAM  POINT14  1.0 2.0 10.0 2.0
```

```
   SRCPARAM  POINT15  1.0 2.0 10.0 2.0
   SRCPARAM  POINT16  1.0 2.0 10.0 2.0
   SRCPARAM  POINT17  1.0 2.0 10.0 2.0
   SRCPARAM  POINT18  1.0 2.0 10.0 2.0
   SRCPARAM  POINT19  1.0 2.0 10.0 2.0
   SRCPARAM  POINT20  1.0 2.0 10.0 2.0
   SRCPARAM  POINT21  1.0 2.0 10.0 2.0
   SRCPARAM  POINT22  1.0 2.0 10.0 2.0
   SRCPARAM  POINT23  1.0 2.0 10.0 2.0
   SRCPARAM  POINT24  1.0 2.0 10.0 2.0
   SRCPARAM  POINT25  1.0 2.0 10.0 2.0
   SRCPARAM  POINT26  1.0 2.0 10.0 2.0
   SRCPARAM  POINT27  1.0 2.0 10.0 2.0
   SRCPARAM  POINT28  1.0 2.0 10.0 2.0
   SRCPARAM  POINT29  1.0 2.0 10.0 2.0
   SRCPARAM  POINT30  1.0 2.0 10.0 2.0
   SRCPARAM  POINT31  1.0 2.0 10.0 2.0
   SRCPARAM  POINT32  1.0 2.0 10.0 2.0
   SRCPARAM  POINT33  1.0 2.0 10.0 2.0
   SRCPARAM  POINT34  1.0 2.0 10.0 2.0
   SRCPARAM  POINT35  1.0 2.0 10.0 2.0
   SRCPARAM  POINT36  1.0 2.0 10.0 2.0
   PARTDIAM  POINT1-POINT12  1.0
   PARTDIAM  POINT13-POINT24  5.0
   PARTDIAM  POINT25-POINT36  17.3
   MASSFRAX  POINT1-POINT36  1.0
   PARTDENS  POINT1-POINT36  2.5
   SRCGROUP  FP  POINT1-POINT12
   SRCGROUP  CM  POINT13-POINT24
   SRCGROUP  REST  POINT25-POINT36
SO FINISHED

RE STARTING
RE DISCCART  228954.  6300557.  0.
RE DISCCART  228954.  6300674.  0.

Deleted text to save paper – full file can be provided in a computer compatible form

RE DISCCART  229095.  6304002.  0.
RE DISCCART  227314.  6305736.  0.
RE DISCCART  225204.  6304998.  0.
RE DISCCART  225076.  6303088.  0.
RE DISCCART  224935.  6298260.  0.
RE FINISHED

ME STARTING
   INPUTFIL  C:\Jobs\KeroseneValePB\Met\MPiper03.isc
   ANEMHGHT  10  METERS
   SURFDATA  99999 2003
   UAIRDATA  99999 2003
ME FINISHED

OU STARTING
   RECTABLE  ALLAVE  FIRST-SECOND
   MAXTABLE  ALLAVE  50
   PLOTFILE  24 FP FIRST  FP1D.PLO
   PLOTFILE  24 CM FIRST  CM1D.PLO
   PLOTFILE  24 REST FIRST  RE1D.PLO
   PLOTFILE  PERIOD  FP  FP1Y.PLO
   PLOTFILE  PERIOD  CM  CM1Y.PLO
   PLOTFILE  PERIOD  REST  RE1Y.PLO
OU FINISHED
```

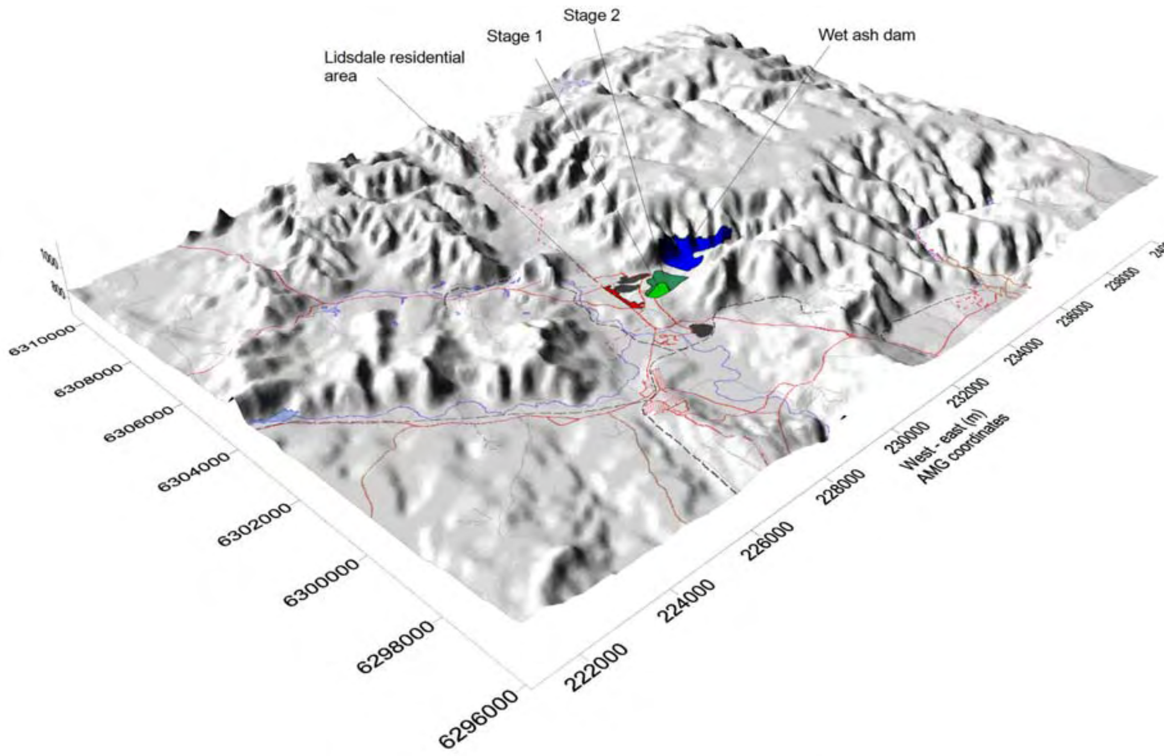
FIGURES


QUEENSLAND
LOCATION
NEW SOUTH WALES
Sydney
VICTORIA
CULLEN BULLEN
PORTLAND
Mt Piper Power Station Met. Station
Mt Piper Power Station stack (1)
BLACKMANS FLAT
Project area Ash Repository (see Figure 2 for detail)
LIDSDALE
Wallerawang Power Station
WALLERAWANG
6315000
6310000
6305000
6300000
6295000
AMG66 Northing (m)
215000
220000
225000
230000
235000
AMG66 Easting (m)

Location

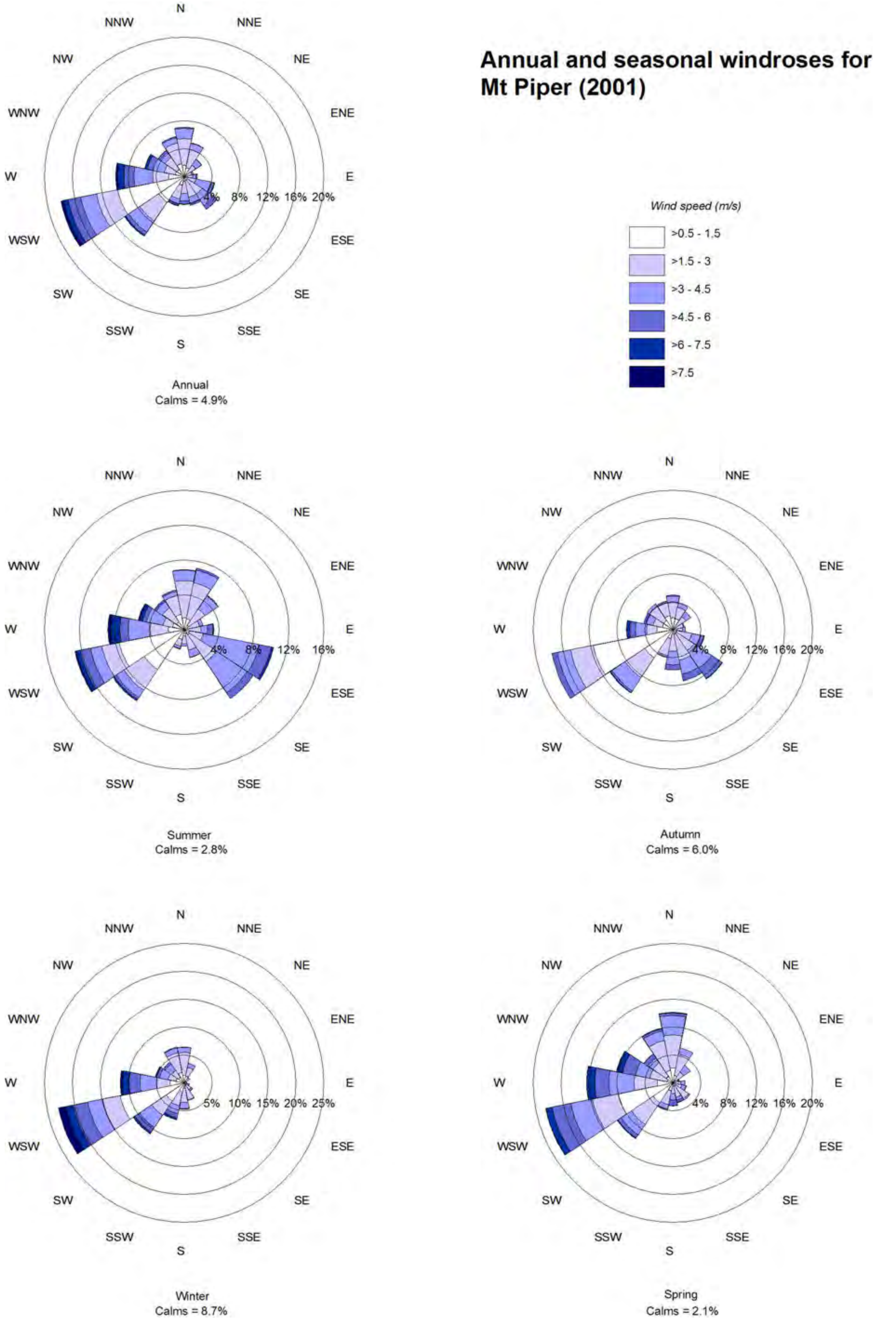


Stage 1 and Stage 2 ash emplacement areas

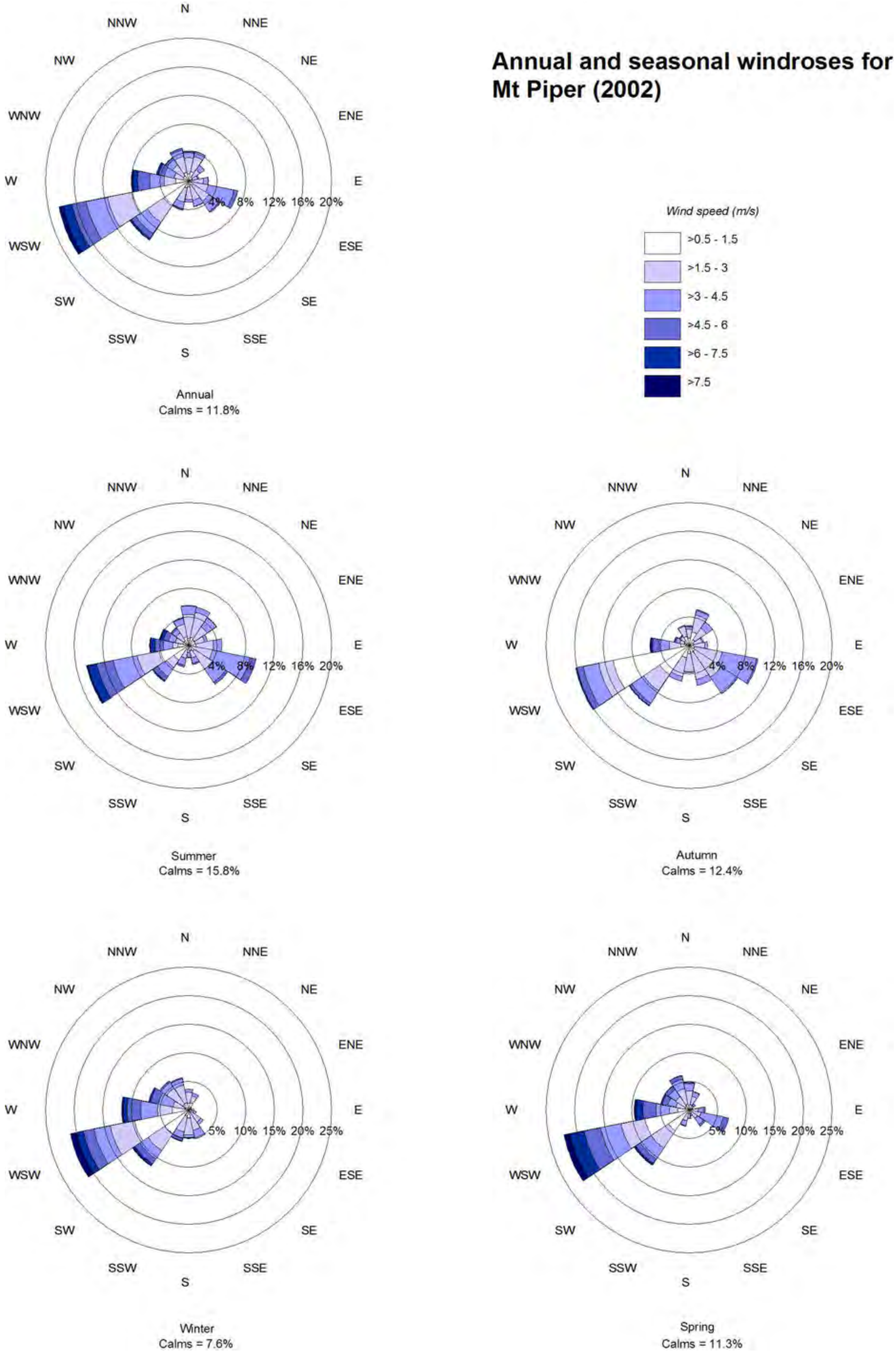


Pseudo 3-dimensional representation of study area

Annual and seasonal windroses for Mt Piper (2001)

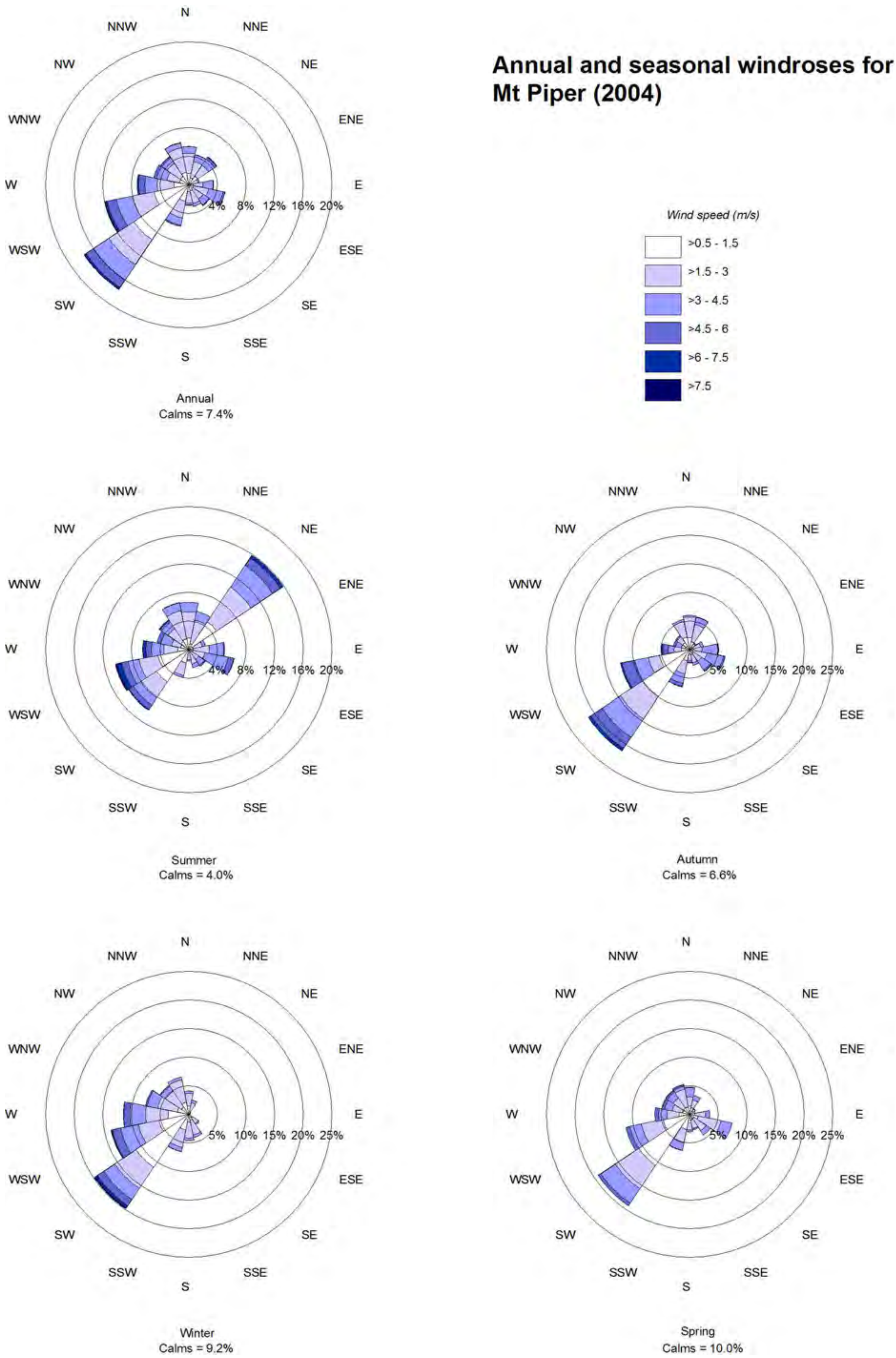


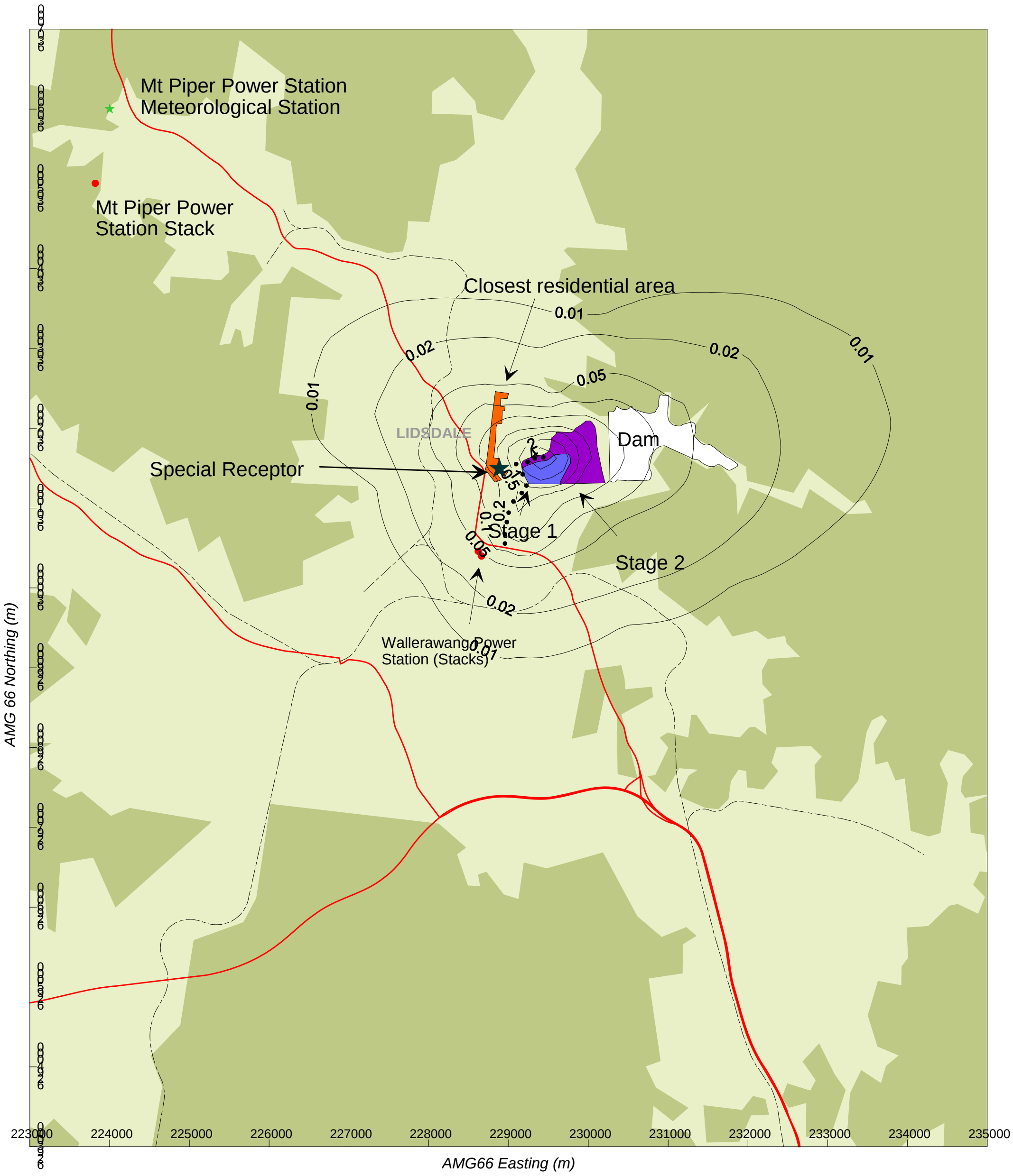
Annual and seasonal windroses for Mt Piper (2002)



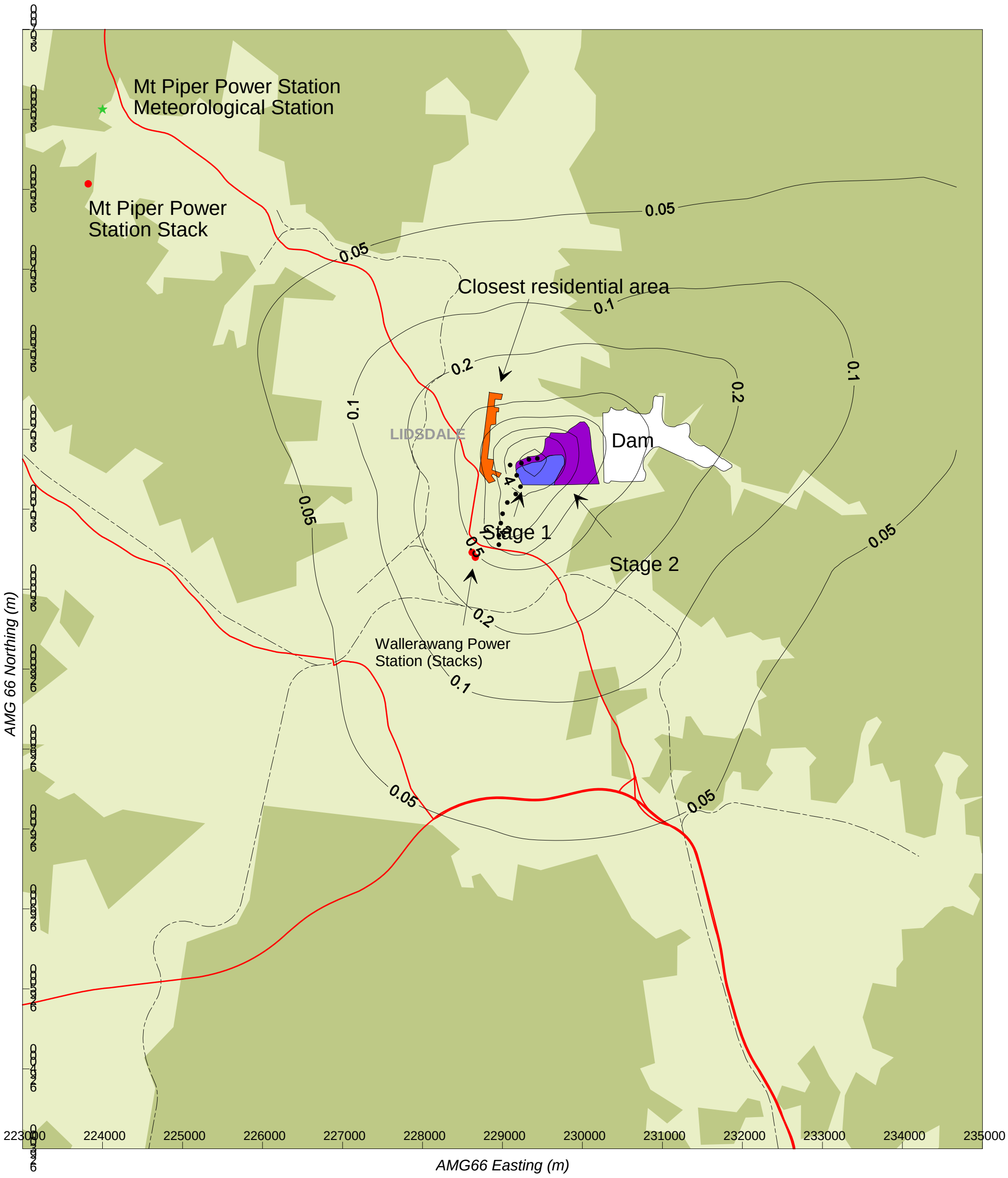
Annual and seasonal windroses for Mt Piper (2003)

Annual and seasonal windroses for Mt Piper (2004)

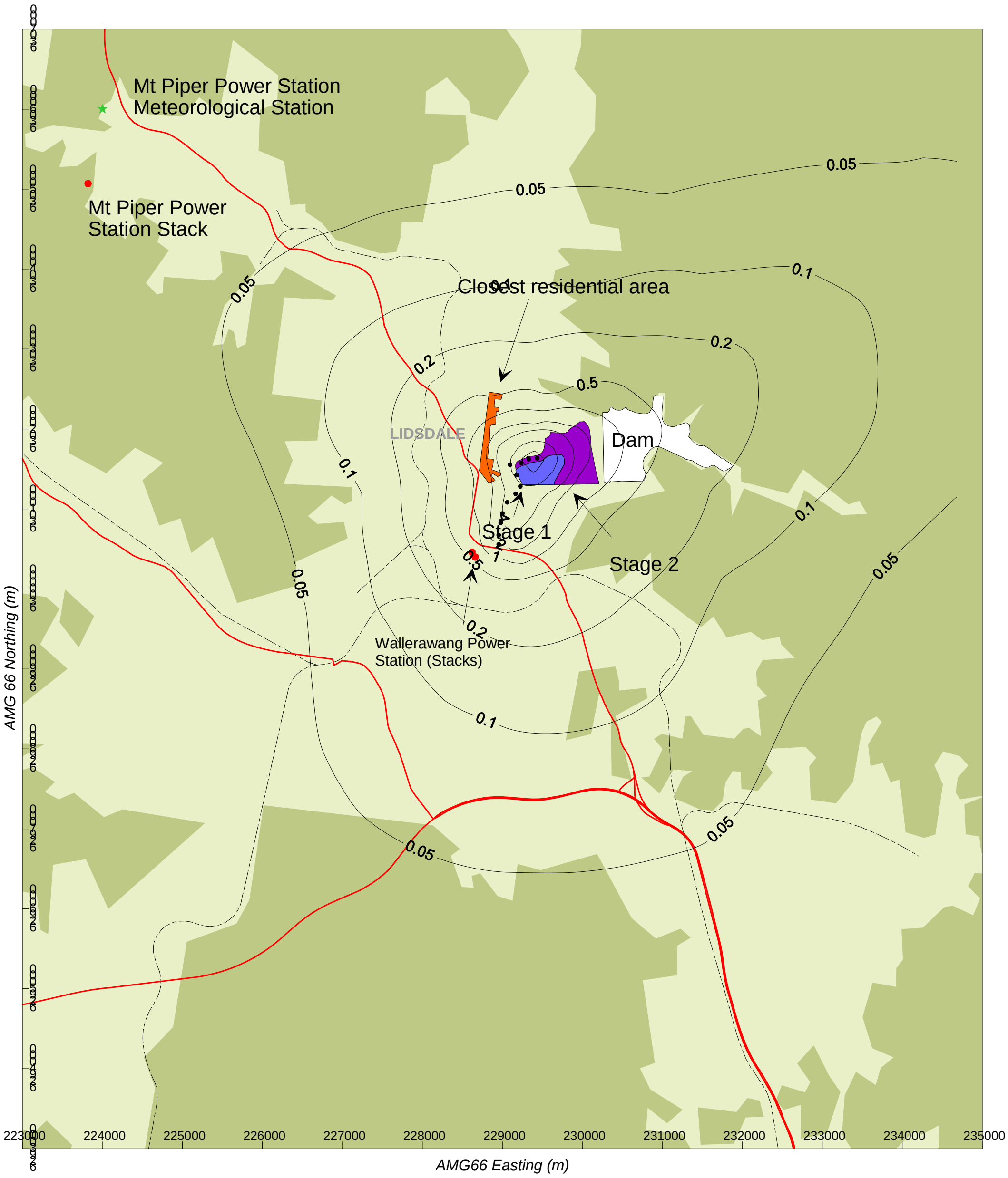




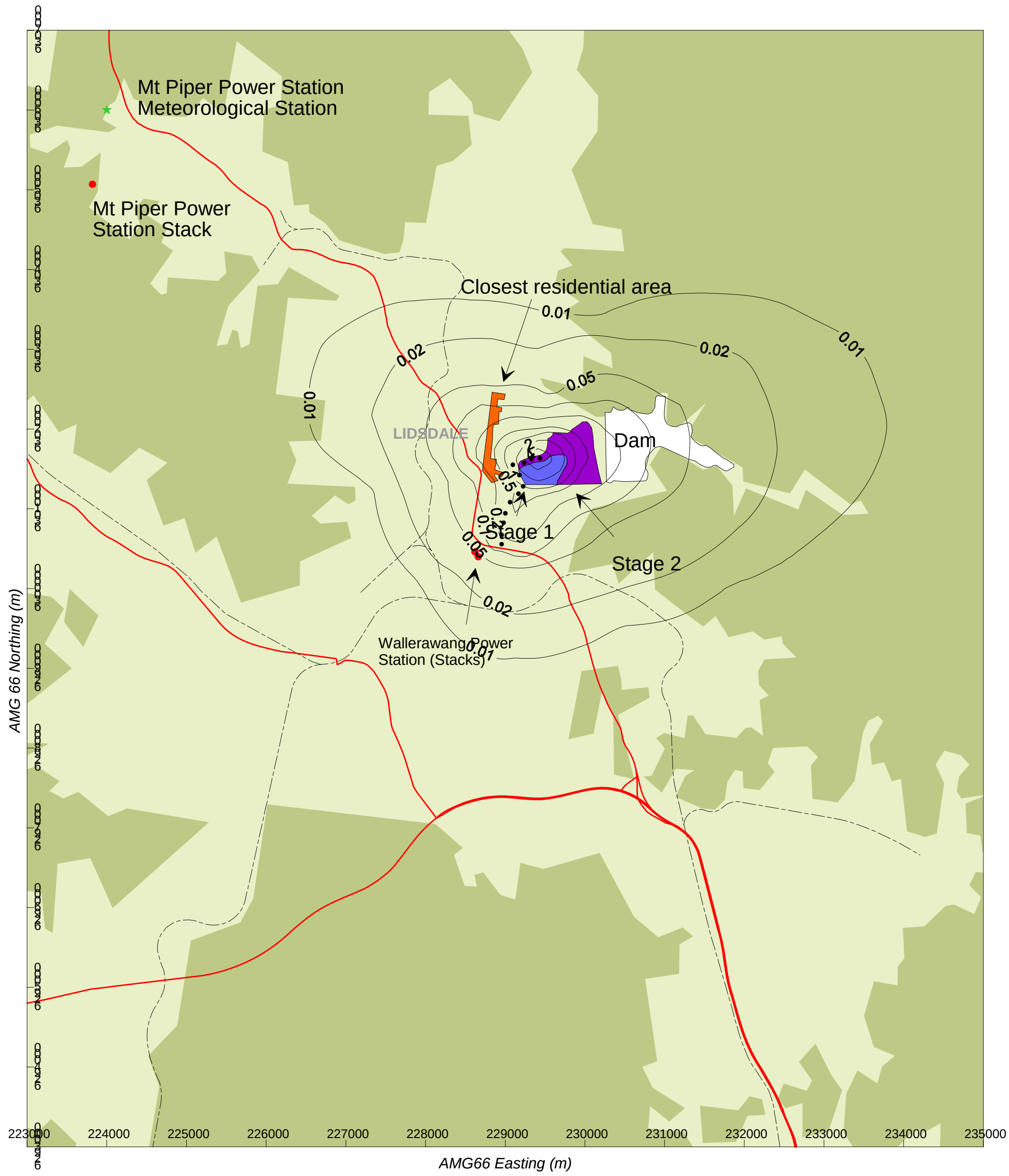
Calculated maximum 24-hour average PM_{10} concentrations due to operations at the KVAR - µg/m^3



Calculated annual average PM_{10} concentrations due to operations at the KVAR - µg/m^3



Calculated annual average TSP concentrations due to operations at the KVAR - µg/m³



Calculated annual average dust (insoluble solids) deposition due to operations at the KVAR - g/m^2/month